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IEEE - IESM'2015

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EDITORS

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The Road Ahead:
Understanding Challenges and Grasping Opportunities in Industrial and Systems Engineering.

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Preface

Dear colleagues and friends,

Welcome to the International Conference on Industrial Engineering and Systems Management (IESM) 2015, hosted by the University of Seville.

IESM is a series of biennial conferences celebrated since 2005, under the patronage of the International Institute for Innovation, Industrial Engineering and Entrepreneurship (I^3e). It is one of the key international conferences in Industrial Engineering, with delegates from more than 30 countries.

The IESM 2015 conference theme is *The Road Ahead: Understanding Challenges and Grasping Opportunities in Industrial and Systems Engineering*. Undoubtedly, Industrial and Systems engineers live challenging times: From the shift of paradigms in manufacturing, transportation and logistics, to the rapid advances in information technologies and communications, or from the need of real-time decisions to the ever decreasing life cycle of products and services -- just to mention a few--, nowadays’ industrial environment poses a number of challenges that can be hardly addressed with the tools and methodologies employed in the past. At the same time, exciting opportunities emerge from these advances, which may pave the way for a brilliant future in the field of Industrial and Systems Engineering.

The proceedings of the IESM 2015 Conference include over 170 papers (selected from about 268 submissions) on different topics of Industrial Engineering and Systems Management. Furthermore, 65 papers were submitted for the Student Competition, and 16 of them were selected for the final phase.

The Scientific Programme incorporates 36 Parallel Sessions. In addition there are 12 Special Sessions providing unique opportunities for engagement and insights on industrial engineering and system management.

The scientific programme is enriched by two keynote speakers, Prof. Rafael Martí and Prof. Teodor Gabriel Crainic, and one special speaker, Prof. Philippe A. Coucke, who will provide insightful reflections on the conference theme from their academic and industry perspectives respectively.

The Social Programme included (1) the Welcome Party at School of Engineering (ETSI) on 20 October, (2) the Seville Tapa Tour on 21 October, and (3) the Gala Dinner at Abades Triana on 22 October, where one discovers its unique position seeing the exclusive view from the panoramic terrace on the Guadalquivir River.

As conference chairs, we have been assisted by many able colleagues and we thank all of the individuals and organizations that have made this conference possible. They include the I^3e Board and its Event and Meetings Team, the Scientific Committee, our Keynote Speakers, the contributors to the Special Sessions, the Session Chairs and the Local Organising Committee.

Finally, we acknowledge gratefully the financial support of our sponsors and advertisers and the support of the University of Seville.

Framinan J.M., Perez P., Artiba A.
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Key notes and guest sessions - IESM2015

This part contains the abstracts and biographies of the two key notes proposed to our participants (Professor Rafael Martí and Professor Teodor Gabriel Crainic) and the guest session organized for the special talk of Professor Philippe A. Coucke.

We also proposed a guest session about sponsors and industrial perspectives (Invest in Andalucia-Spain and Railenium).

I. The key notes

- October 21 - Rafael Martí
  Black-Box solvers in combinatorial optimization

- October 23 - Teodor Gabriel Crainic
  Service Network Design for Intermodal Freight Transportation

II. The guest sessions

- October 23 - Philippe A. Coucke
  The endless journey to excellence can be structured with the EFQM model in the health care sector

- October 23 - The IRT Railenium
  Some proposals of training programs in logistics and transports
  Amina Alaoui, Mohammed Bouallaga, Abdelhakim Artiba, Mourad Abed, Adnane Boukamel
Black-Box solvers in combinatorial optimization

Rafael Martí

Abstract

Black box optimizers have a long tradition in the field of operations research. These procedures treat the objective function evaluation as a black box and therefore do not take advantage of its specific structure. Black-box optimization refers to the process in which there is a complete separation between the evaluation of the objective function—and perhaps other functions used to enforce constraints—and the solution procedure. The challenge of optimizing black boxes is to develop methods that can produce outcomes of reasonable quality without taking advantage of problem structure and employing a computational effort that is adequate for the context.

Holland’s (1975) genetic algorithms proposal was in fact a black-box optimizer that used an array of bits as the generic representation. The proposed procedure did not include local search and the standard genetic operators (such as single-point crossover) were not linked to the problem context. As GAs became more popular and researchers and practitioners applied them to many hard optimization problems, the context-independent nature of the original proposal began to vanish when improved outcomes were obtained by the addition of problem structure. Hence, most modern GA implementations are hybridized (e.g., coupled with local searches) and incorporate domain-specific knowledge into the search process.

The black-box optimization framework is the OR (operations research) community response to the need for modeling flexibility and the separation between the modeling environment and the solution method. Achievements and progress in the solution of mathematical models of various types, including integer programs, are numerous and well-documented in the OR literature. Nonetheless, casting a problem as a mathematical model (integer or continuous, linear or nonlinear, or mixed) remains an exercise of imagination, abstraction and compromises.

During the last years we worked on the adaptation of metaheuristic methodologies to deal with combinatorial optimization problems. In order to treat them with a black-box tool, we classified these problems according to their solution representation: permutation, binary, and integer. In this talk we will review commercial black-box solvers, such as Opttek’s OptQuest, Palisade’s Evolver and Frontline’s Premium Solver, and compare their performance with our metaheuristic implementations based on the Scatter Search methodology on many different optimization problems.

Biography

Rafael Martí

Professor of Statistics and Operations Research at the University of Valencia
Departamento de Estadística e I.O. Facultad de Matemáticas
Universitat de València, Spain

Rafael Martí is Professor of Statistics and Operations Research at the University of Valencia, Spain. He received a doctoral degree in Mathematics from the University of Valencia in 1994. He has done extensive research in metaheuristics for hard optimization problems. Dr Martí has close to 200 publications, and almost have of them are in indexed journals (JCR), including EJOR, Inform Joc, IIE Transactions, JGO, C&OR and Discrete and Applied Maths. He is the co-author of Scatter Search (Kluwer 2003) and The Linear Ordering Problem (Springer 2011) monographs, and has secured an American patent. Prof. Martí is currently Area Editor in the Journal of Heuristics, and Associate Editor in the Math. Prog. Computation, TOP, and the Int. Journal of Metaheuristics. He coordinates HEUR, the Spanish network on metaheuristics with more than 400 members in Spanish and Latin-American universities. He has been invited Professor at the University of Colorado (USA), University of Molde (Norway), University of Graz (Austria), and University of Bretagne-Sud (France).
Abstract

Multi and intermodal freight transportation refers to moving loads by a sequence of transportation modes linked by mode-to-mode transfers performed at intermodal terminals, generally without directly handling the goods. Such transportation systems and the carriers that provide the associated services are often organized according to consolidation principles. Consolidation of the shipments of different shippers into the same vehicles and of several vehicles into blocks (railroads) and convoys (rail, road and barge trains).

Intermodal transportation is a core activity enabling global trade and supporting economic growth and social development. It is also also a mean toward more efficient and sustainable supply chains and transportation networks, within the city as well as for long-haul intercity exchanges. Achieving these goals requires the planning and management of efficient and timely transportation and terminal services, as well as of the resources required to provide these services. Operations research offers the modelling frameworks and solution methods to build these advanced planning methods.

In this presentation, we discuss the complex issue of designing the tactical transportation plan for intermodal carriers, that is, to select the services that will be operated over the next activity season, their schedules and the associated transportation itineraries for the forecast demand. We focus on recent developments to enrich the scope of the planning activities and associated models, by integrating a number of operational issues.

On the supply side, we examine the integration of the management of the resources required to provide the selected services while, on the demand side, we touch on the issue of the management of revenues.

We conclude with a number of challenging research directions.

Biography

Teodor Gabriel Crainic
Professor of Operations Research, Logistics and Transportation School of Management, PhD, FRSC
Université du Québec à Montréal and CIRRELT - The Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation
Canada

Teodor Gabriel Crainic is Professor of Operations Research, Transportation, and Logistics, School of Management, Université du Québec à Montréal. He is also Adjunct Professor with the Department of Computer Science and Operations Research of the Université de Montréal, and senior scientist at CIRRELT, the Interuniversity Research Center for Enterprise Networks, Logistics and Transportation, where he is Director of the Intelligent Transportation Systems Laboratory. Professor Crainic is Associate Editor for Transportation Science, Area Editor for the Journal of Heuristics, and serves on several other editorial boards. He co-founded the TRISTAN (TRienial Symposium on Transportation Analysis) and Odysseus (International Workshop on Freight Transportation and Logistics) series of international meetings. He was President of the Transportation Science and Logistics Society of INFORMS (2010), received the 2006 Merit Award of the Canadian Operational Research Society, and is a member of the Royal Society of Canada – The Academies of Arts, Humanities and Sciences of Canada.

The research interests of Professor Crainic are in network, integer, and combinatorial optimization, meta-heuristics, and parallel computing applied to the planning and management of complex systems, particularly in transportation and logistics. Major contributions targeted methods for national/regional planning, the design and scheduling of services for consolidation-based carriers (railroads, motor carriers, land and sea intermodal carriers, etc.), operations management for modal and intermodal carriers and terminal operators, routing and scheduling, Intelligent Transportation Systems and City Logistics. He authored or coauthored more some 225 scientific articles and book chapters. He coauthored STAN, a method and software system for strategic planning of multimodal multicommodity transportation systems used by planning institutions in several countries, and a combinatorial e-auction mechanism for transportation markets.
The endless journey to excellence can be structured with the EFQM model in the health care sector

Philippe A. Coucke

**Abstract**

Management of quality and safety (MQS) in the industrial systems is a cornerstone of high reliability organizations (HRO’s). These HRO’s are relentlessly coping with a high intrinsic risk, do function with success and achieve high performance levels and handle the safety issue systematically and systemically.

In the Health Care Sector (HCS), there is at the start resistance to consider it as an “industrial system” although it responds to all the basic characteristic of the “system” as defined by von Bertalanffy. This cultural particularism is one of the major reasons for the “pandemic” outbreak of iatrogenic accidents (i.e. induced by the system failures). In 2013, John James from Patient Safety America, report at least 400’000 death yearly in the hospital sector in the USA which are due to system failures. What basically differentiates industrial HRO’S from the HCS is the integrated quality management (IQM). IQM is according to the National Association of Healthcare Quality, a planned, systematic approach to the monitoring, analysis, and correction and improvement of performance, which increases the likelihood of desired outcomes by continuously improving the quality of care and services provided.

All too often, the workers in the HCS are with their nose in the grindstone and do claim they have “no time or money” to dedicate to what does not seem priority. Moreover, as they do not accumulate data on the performance of the system they do lack situational awareness.

In 2008, the radiotherapy service at CHU-Liège, decided to be trained by safety officers issued from civil aviation in methodologies to improve safety and operational performance. To structure the long way to excellence, the generic model of the European Foundation for Quality Management was adopted. To motivate the “ecosystem” to adopt this for the HCS unnatural approach, the leader decided in 2009 to participate to the regional contest in Wallonia taking place every 2 years (MWQ = Mouvement Wallon pour la Qualité, based on the EFQM-model). The basic advantage of this “transversal” benchmark, is rapidly gaining expertise and knowledge from other sectors. In 2015, the last level of the four at MWQ is underway and the department did obtain the first prize at level one, two and three.

This is a hard time for leadership as in the HCS there are 5 very resistant myths of medical infallibility: medicine is something “special” and cannot be compared to industry, MD’s are totally free in a well-known and mastered environment, extensive theoretical knowledge is an excellent safeguard against error, hierarchical structure is an excellent safeguard against error, SOP’s and standards restrain MD’s in using their professional skill. Because of the observed pandemics and its enormous economic burden on society, it is high time to provoke a cultural earthquake in the HCS and to embrace at large IQM.

**Biography**

Philippe A. Coucke
Professor, Dr, Head of Radiation Therapy, Department of Medical Physics. University Hospital Liège – Belgium.

Born in 1959 in Ghent – Belgium, he was promoted as an MD in 1984 at the Faculty of Medicine of the State University in Ghent – Belgium. He started his fellowship in radiation-oncology at the same university and switched to Besançon-France to end it in 1989. As a board certified radiation oncologist, he moved to “Centre Hospitalier Universtaire Vaudois” (CHUV) in Switzerland, where he became "Privat Docent & Maître d’Enseignement et de Recherche”. From 2005 to 2006, he headed the department of radiotherapy at Hospital Maisonneuve-Rosemont (HMR) at Montréal-Oc Canada and was appointed as clinical professor at the University of Montréal. In October 2006, he moved to Liège to become the acting head of the Radiotherapy Department at the University Hospital (CHU) as well as professor at the Faculty of Medicine of Liège University in Belgium. He followed training in Safety Management with AFM-42, Belgian Air Force, Southern California Safety Institute. Recently he has been appointed to lead the process of quality and safety management of the brand new Integral Cancer Center in Liège. He obtained with his department 4 awards in 3 participations to Mouvement Wallon pour la Qualité, a broad multi-sector regional contest based on the EFQM approach. He is the author of more than 200 publications, mostly in international peer reviewed journals.
Guest session - IESM2015

Some proposals of training programs in logistics and transports

The IRT Railenium

Today, the development of the logistics and transports sector needs new skills. These skills rely on a good understanding of business needs and also on the tools of new technologies and management. The objective of this round-table is to highlight some training cycles, based on trans-Mediterranean partnerships and dealing with new teaching tools like ICT (e-learning, serious games ...). A special focus will be given on training curricula for the railway sector.

Proposed by Amina ALAOUI, Aurélie DELEMARLE (École des Ponts Paris Tech, France), Abdelhakim ARTIBA (University of Valenciennes, France), Adnane BOUKAMEL (IRT Railenium, France).

I. Special talks

Chair: Mourad Abed, Professor, University of Valenciennes, France

• Transports and logistics programs at École des Ponts ParisTech
  Amina Alaoui, Françoise Manderscheid, École des Ponts ParisTech

• About the Master of Railway and guided urban transports systems at Ecole des Ponts ParisTech: a testimony of a laureate Mohammed Boullaga, IRT Railenium

• Euro-mediterranean Institute of Logistics and Transports (IMLT) in Morocco: an example of Euro-mediterranean structural cooperation
  Abdelhakim Artiba, Valenciennes University.

• SIGMA-RAIL: an Erasmus+ project for developing Serious Games and e-learning modules for railway infrastructure maintenance
  Mourad Abed, Valenciennes University and Dr Adnane Boukamel, IRT Railenium

• Training projects and strategic education programme of RAILENIUM Institute of Research and Technology
  Adnane Boukamel, IRT Railenium.

II. Partners
Interoperability, performance and resilience of railway transport systems

Simon Collart-Dutilleul and Francesco Rotoli

The rail transport mode is the more effective and efficient by the fact it connects the most populated areas at increasingly high speeds, providing social cohesion at national, European and international level.

The interoperability and resilience of the rail systems are the key challenges to strengthen the competitiveness of rail products and operations. Moreover, the increasing speed opens the door to new services, crossing borders.

The aim of this track is to provide a forum for presenting and discussing recent research in transportation interoperability, performance and resilience and bring together the operational research and dependability communities.

This special track is an integral part of the conference program and will be subject to the same high standards and rigorous review. In the proceedings, the special track papers will not be distinguished from the main track technical papers. This track has its own submission process and includes a program committee of reviewers with appropriate backgrounds.

I. Special talks - "Perfect Project" - Project certified by i-Trans.

The session chaired by Francesco ROTOLI proposes the development of the research project "Perfect".

• Industrial needs concerning the safety analysis of a French implementation of ERTMS
• Towards an experimental testbed for interoperability analysis of railways regulation policies : methodological experiments and first retex.
• Integrated approach using formal models and simulation environment
• Evaluation of human error probabilities in railway systems

II. The paper session

The session chaired by Khaled MESGHOUNI is related to transportation safety and interoperability as passengers, freight and logistics; rail punctuality, capacity and accessibility; modelling and traffic management; transport information systems.

III. Partners

Many partners were involved in this project.
Industrial needs concerning the safety analysis of a French implementation of ERTMS

Philippe Bon, Simon Collart-Dutilleul

The study is based on an industrial expression pointing a usual way of performing a safety analysis: one consults the national railway accident database in order to evaluate the defense capacity of the system against scenarios of real past accidents.

This first analysis can be complemented by considering the quasi-accident scenarios. The data corresponding to this second step are critical because they correspond to industrial data which are not public.

A first result of this study is the identification of a class of accident. The main argument is that the similarities of two accidents or quasi accident allow defining some critical elements of a typical class of accidents. A case study of an analysis of the accident that occurred in “St Romaine en Giers” is proposed. The corresponding documentation may be found in [1]

A second step towards a safe implementation assessment is the definition of a typical railway infrastructure. The idea is to play the scenario on an infrastructure embedding the main design assumptions which are used in the considered railway line. The specification of this infrastructure has to be detailed such a way that the simulation can be considered as realistic.

Then, we are facing a security problem related to industrial confidentiality. It may be dangerous and consequently forbidden, to communicate safety critical information corresponding to an industrial infrastructure.

The proposed solution is to identify a virtual infrastructure which is fully documented in order to be able to communicate. This infrastructure was named an “academic benchmark”, as it allows testing some technologies and scenarios avoiding all problems mentioned above [2].

The result of the study is the specification of a typical scenario that can be played on a typical infrastructure. Then, this system can be modelled using various modelling tools in order to assess various safety related aspect of the system [3]. Anyway, this academic benchmark is one of the main deliverable embedding most of the safety related industrial needs.

Proposing a safety methodology using several formal methods is the challenging goal of the next study.

Bibliography


Towards an experimental testbed for interoperability analysis of railways regulation policies: methodological experiments and first retex.

Agnès Lanusse, Alain Faivre

Safety and security are major issues for the generalization of ERTMS (European Rail Traffic Management System) in Europe.

Many studies have been conducted in the past for the analysis and verification of the ETCS (European train Control System) principles underlying onboard equipment and track signaling systems. Fewer works have considered regulation issues and the analysis of interoperability of new European rules with national or local regulations.

The goal of the PERFECT project is to provide a test bed to study such issues, and help regulation authorities to analyze the impact of regulations changes in specific local policies, in the context of potential accident situations. This test bed can be considered as a laboratory to study actual scenarios and help suggest preventive actions or adapt local regulations.

The aim of Task2 is to provide guidelines and experimental tooling composed of a set of complementary evaluation tools to support such studies. In the session three presentations will illustrate experiments conducted in the project using different formalisms (UML/SysML, HPCN, B) and techniques (symbolic execution, model-checking, simulation, proof).

We present how these techniques can be combined and how they can assist expert engineers evaluate regulation policies in specific contexts.
Integrated approach using formal models and simulation environment

Simon Collart-Dutilleul, Antoine Ferlin and Philippe Bon

The approach of this study which is the third step of the Perfect project is based on the ERTMS simulation framework compliant with the official European specifications. The aim of this study is triple.

We firstly want to validate the assumption used by the safety proofs produced by the formal models coming from the previous steps of the project.

We secondly propose to play the critical scenarii in the 3D environment of the ERTMS simulation framework. Different sources are used to build the scenarii. Some elements are defined using the analysis of the accident database. These critical elements are paired with the scenarii generated from a formal analysis.

Thirdly, the scenarii are filtered with regard to the local specificity including national operating rules. So, only the scenarii consistent with the real functioning of the line are considered for the 3D simulation step. Then a multi-site distributed simulation allows the validation of the different aspects coming from the different points of view such as the train driver one, the traffic-operator one, and the interaction between the both.

The multi-site aspects allow the reproduction of the real conditions where the operators are separated.
In railway systems, human error has been defined as a behavior of the human operator which leads to accidents in railroad systems. During the last years, human error is an increasingly significant factor in train accidents.

Therefore it is necessary to model human operators involved in the railway system. In the literature, there exist a variety of Human Reliability Analysis (HRA) models. HRA models are used to evaluate the Human error probability (HEP) throughout the completion of a task. A model is not developed to handle all the issues addressed in human reliability. Each model is developed only for certain issues. Thus, an appropriate HRA model should be chosen according to the characteristics of the research subject.

In this task of our project, an experimental protocol is developed to conduct an experiment on a railway platform, Route Control Centre System (RCCS), provided by Ansaldo STS.

The main objective of the experiment is to assess the HEP of human operators. Several experimental subjects are invited to conduct the experiment under different conditions.

The obtained experimental results are later analyzed by some classical Human Reliability Analysis (HRA) methods which estimate the HEP of each subject.
Railway track - IESM2015
Special session

Transportation safety and interoperability
Khaled Mesghouni

Topics

Researchers and practitioners were invited to submit their original and unpublished work that are related to transportation safety and interoperability, including (but not limited to):

- Passengers, freight and logistics
- Rail punctuality, capacity and accessibility
- Modelling and traffic management
- Transport information systems
- Applications and Requirements in Traffic and Transportation (Safety and Security, Simulation...)
- Safety, Methods for Risk Analysis; Risk Acceptance, Risk Measures, Signalling Applications.
- Methods and Tools for Modelling, Validation / Verification and Tests

Presented papers

- Colored Petri Nets formal transformation to B machines for safety critical software development
- Model transformation from coloured Petri nets with prioritized transitions to B machines
- Parallel verification of temporal properties using dynamic analysis
- Enclosing rail capacity/punctuality in accessibility measures: a two-step approach by using Data Envelopment Analysis and Analytic Hierarchy Process
- Two methods for modeling and verification of safety properties of railway infrastructures
- Real-time railway traffic management optimization and imperfect information: preliminary studies
- Performing Enhanced Rail Formal Engineering Constraints Traceability: Transition Modes
Colored Petri Nets formal transformation to B machines for safety critical software development
(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4E2 2015

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Abstract—Reaching the critical software safety requirements is one of the most important and complex tasks for the safety-related industry. This fact explains, as it was highly recommended by the CENELEC standard, the increasing use of formal means in the development process. However, industrial environments are still reticent facing difficulties in incorporating those formal methods in a larger scale of application, especially because of their mathematical modeling complexity. The present paper proposes a Petri Nets-based approach for safety critical software development using a formal transformation into B abstract machines. This work presents formal definitions for the translation of Colored Petri Nets to B abstract machines. As part of the French research project called “PERFECT”, it aims at enabling a stronger combination of formal design techniques and analysis tools in order to cope with the real complexity of critical software development and to prove in an automated manner that the final software product satisfies all safety requirements. Therefore, the use of the B method will broaden the scope of its applicability by providing a new input modeling alternative. An illustrative application of the transformation practical use is shown in this paper for a railway level-crossing case study.

Keywords—Colored Petri Nets, B method, Railway safety, Critical software

I. INTRODUCTION

Software is present in almost all daily life aspects such as transportation systems, finance, health care, and telecommunications. In this regard, the reliability of such software is critical when failures may jeopardize human life. Developing such critical software is consequently a difficult and complex task, especially in dealing with safety requirements verification and validation. For this matter, the convenience of formal methods has been pointed repeatedly and their use is highly recommended in critical software development. In fact, formal methods are techniques based on mathematics and formal logic used for performing appropriate modeling, elaborate design and rigorous analysis and aiming to increase the quality of software systems. Formal methods research has also helped software engineering to effect many improvements such as structured development. Nevertheless, the high-level mathematical and analytical notions required for such techniques prevent from their applicability in a larger scope of software engineering and does not help clear representations of the requirements.

Transportation sectors such as aviation and especially railway systems were the primary domains to apply formal methods [1], followed by finance [2, 3]. For instance, in France, the B language was used for the functional requirements formal specification related to the SACEM system of RER Line A in Paris [4 and 5] as well as it was the case for the automatic train system of the metro line 14, the first driver-less metro line in Paris [6, 7]. Accordingly, in the trend of enhancing the use of formal techniques in critical software and systems construction, one of the ultimate goals of this study is to embody Colored Petri Nets (CPNs) in critical software development process using a conversion methodology, which produces B abstract machines and preserves all the information contained in the Petri Net models. Indeed, the use of Petri Nets in railway requirements modeling is very common within industrial and research stakeholders [8, 9, 10, 11, 12]. Thus, having Colored Petri Nets models as inputs for the development process is reinforcing the understanding of the system requirements, enriching the use of the B method and providing an interesting combination of Petri Nets graphical modeling power and the B formal verification tools. Furthermore, one of the most important aspects of this contribution is to enable safe code generation from Colored Petri Nets specification.

The present work is part of the national French project called “PERFECT” (Performing Enhanced Rail Formal Engineering Constraints Traceability). This research project focus is to provide formal techniques and approaches in order to determine, if possible, the compliance between the ERTMS (European Rail Traffic Management System) specifications and National railway safety properties.

This paper will present, at first, a brief overview on conventional software development processes explaining the proposed approach that includes CPNs. The following section will introduce Colored Petri Nets and point out their interest in railway requirements modeling. Afterwards, the B method and its tools will be described before presenting the basic aspects of...
Abstract—In model driven engineering, model transformation is the "heart and soul". The purpose of using a model transformation is to save efforts and reduce errors by automatically building the models that conform to different modelling languages. In the French railway industry, the Petri nets and the $B$ method are two recognized formal methods for safety critical systems, having their own successful applications. The Petri nets are a mathematical modelling language for describing the distributed systems, and they offer superior graphical notations for stepwise processes. The $B$ method is a software development method based on abstract machine notations and the concept of refinement. There are already some tools supporting $B$ language. The Petri nets are accepted by the French railway specialists, because they have user-friendly notations. Consequently, various railway systems and key components have been specified by Petri nets and have been validated by railway experts. For a better model representation, the “prioritized transitions” can be a useful mechanism in such models. In order to produce the final executable codes and to make use of all the existing valid models, this paper introduces a transformation method, which could take advantage of both formal languages and transform a valid Petri net model to an abstract $B$ machine. This transformation is presented with a systematic mapping process and illustrated by a case study.

I. INTRODUCTION

In model driven engineering, everything is a model. Thus, the model transformations are considered as the "heart and soul" [1] of model driven engineering, and can be used for a variety of purposes, such as the generation of models on different levels of abstraction, the creation of different views on a system and automation of model evolution [2]. To save efforts and reduce errors, this paper presents a transformation method from the Coloured Petri nets with prioritized transitions to abstract $B$ machines. This method could assist people to quickly shift from a valid design solution to a valid input of $B$ development process in the design phase. In this paper we mainly focus on the transformation process and do not deal with the refinement of $B$ machine.

The Petri nets [3] are a behaviour-oriented modelling language that provides superior graphic notations to specify the distributed systems. The coloured Petri nets (CP-nets) [4] are a backward compatible extension of the concept of Petri nets, and have widened the usage in practical work by their dedicated tool — CPN Tools. To enhance the specification ability of CP-nets, the CPN Tools version 4.0, supporting the transition priority, could specify priority $P_{\text{HIGH}}$, $P_{\text{NORMAL}}$ or $P_{\text{LOW}}$ [5], [6] for transitions, and could also assign to each transition a natural number as its priority level. Normally, in railway applications, processes could have different priorities. In order to describe such systems more efficiently, we need to introduce different priorities. And with such prioritized transitions, system specifications can be described more accurately and concisely. That also means the state-space of the system would be smaller. The $B$ method [7] is a state based, model-oriented method that is based on rigorous mathematical semantics, which has robust, commercially available tool support for specification, design, proof and code generation. The $B$ method offers a well-defined software development procedure which allows a system to be specified into a set of components called abstract machines or $B$ machines, and then refines all the machines into the implementation codes.

In French railway practice, both formal method have successful implementations. For example, Petri nets have been used to develop a new-type railway interlocking control system by M. Antoni [8], [9], an expert engineer of the French national railway company (SNCF). Also the SNCF verifies some high-level systems by using CP-nets, such as the performance assessments for the European railway signalling standards [10], [11]. The reason experienced engineers prefer to use the Petri nets and other high-level extensions is the powerfulness of their language, which has the ability to express a complex system with a compact size. In addition, as a graphic language, the Petri net language has the similar advantage as UML, that is having a clear formalism for communicating. Nevertheless, for urban railway systems, which are more independent and closed systems, the $B$ method has been accepted and has been applied in such critical systems and some key components. The early success stories are [12]: KVB, an Automatic Train Protection system for SNCF since 1993; SAET-METEOR [13], a driverless Train Automation and Operation system in metro Line 14 in Paris in 1998; Roissy VAL, a Section Automatic Pilot system for light driverless shuttle for Paris-Roissy airport in 2006. A recent application is the COPPILOT system [14], [15], which is a metro platform screen door controlling system of the ClearSy company. It has been installed in the Paris Metro and the Sao Paulo Metro. The safety and robustness of $B$ language developed systems convince people of the reliability of the $B$ method. So providing a model that is proved by $B$ method is considered as a strong contribution to global safety proof in the French railway context [16], [17].

So far, many railway systems have already been specified and validated by the Petri nets [18]. Still, it is a long way to go...
Parallel verification of temporal properties using dynamic analysis

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Abstract—Verification methods can be classified according to two kinds of criteria: static or not - i.e. dynamic - and formal or not. This paper follows a work about verification of temporal properties using dynamic analysis. The approach proposes to transform an LTL property into a Büchi automaton and to run the automaton on an execution trace to be verified. Because traces are finite, the end of trace problem can be bypassed with computation of statistical information about the verified trace if and only if the property follows a predefined given pattern. For very big traces, this approach is well-adapted, but traces have to be sequentially verified. This paper proposes to parallelize the verification approach by splitting the execution trace and executing the Büchi automaton on each sub-trace separately analysable, which allows a significant time saving.

I. INTRODUCTION

The development of critical software is constrained by certification standards. The standard depends on the application domain. For instance, DO-178 is the certification standard for avionics software. In railway transportation, IEC 50128 is the certification standard. Even if standards define goals for each step of the software development, companies have responsibility for choosing the methods to achieve these goals. Known methods are proposed by standards but are not mandatory.

The verification phase is one of the steps of the software life-cycle. Several kinds of verification methods exist and can be classified using two criteria: formal or not, static or dynamic. Formal verification means the use of computable mathematical rules based on a language with unambiguous grammar and a defined semantics. These rules allow a mathematical verification of a given property. Static verification means that the program to be verified is not executed. On the contrary, dynamic verification requires the execution of the program.

For instance, classic verification means are typically not formal: the test is dynamic whereas reviews are static. We can notice that a lot of formal techniques are static: B methods [2], abstract interpretation [11], model checking [10]. RuntimeVerification¹, which is the purpose of this paper, can be classified as formal and dynamic.

¹Runtime Verification, 2001-2014, www.runtime-verification.org

This work follows a PhD thesis done at AIRBUS and at ONERA, the French aerospace lab, about verification of temporal properties [15], [16]. Several proprietary embedded programs have been studied in order to determine the properties which are difficult to be verified. But for reasons of industrial confidentiality, the detailed results cannot be published. According to this study, it appears that temporal properties are complex to be verified with the current industrial practices. No automatic verification method is currently used. Indeed, only code reviews are processed. The goal of the work was to propose a new equipped method to verify these temporal properties, in order to reduce time and cost of verification.

The resulting method is based on runtime verification. A specific language has been defined to formalize encountered temporal properties. This one is grounded on an aggregation of Linear Temporal Logic (LTL) and regular expressions, which are well adapted for sequence properties. The defined approach consists of two major steps: transforming the temporal property into a non-deterministic Büchi automaton, using Ltl2ba [17], and then executing the Büchi automaton on an execution trace to verify the property. Because LTL has a semantics on infinite traces, the finite execution trace is transformed into an infinite one by looping over the last state of the trace. In order to counter the side effects, statistical information is computed to help to the interpretation of the results, for unclear cases. The topic of this paper is not the language definition, the verification phase or the finite trace problem. Readers interested in this topic will find this information in [16].

This approach has been reused in the railway context. In order to save time during the verification phase, this paper presents a parallelized version of this method. This new method is based on the divide-and-conquer strategy using parallel execution and the result should be predictable. But, this strategy has to be validated, because we cut a partial execution trace, and because the analysis of a sub-trace naturally depends on the previous sub-traces. In addition, the fusion operation of each sub-trace analysis requires the computation of additional features in comparison with the classic sequential method. We aim to test this approach on traces coming form an European Rail Traffic Management (ERTMS) proprietary simulator[1]. However, because this platform is currently evolving with the
Enclosing rail capacity/punctuality in accessibility measures: a two-step approach by using Data Envelopment Analysis and Analytic Hierarchy Process

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Abstract— European Commission is encouraging a modal shift towards rail in order to achieve a more competitive and sustainable European transport system; anyway as the traffic will increase many parts of existing railway infrastructure which are operated almost at full capacity could not be capable of offering adequate levels of service. On the other hand the characteristics of a transport system in terms of capacity, connectivity, travel speeds etc. determine the advantage/disadvantage of an area (i.e. a region or a city) relative to other locations. In such a context, this article tries to integrate fundamental operational and performance parameters in a wider accessibility analysis by rail. Information related to the 'congestion' of the line is introduced in the evaluation of the travel time, thought as an impedance parameter for the accessibility analysis; several accessibility indicators have been explored, including a composite approach combining Data Envelopment Analysis (DEA) and Analytic Hierarchy Process in order to consider and embrace all the complementary information delivered by the other four 'partial' accessibility measures. The overall outcomes provide a valuable tool for decision makers to identify areas more or less accessible from/to other zones and how/where improvements in infrastructure and levels of service could benefit users.

Keywords— capacity; punctuality; delay; analytic methods; accessibility; transport policy;

1. INTRODUCTION

In order to reinforce and enlarge the role of the rail sector in the global transport market, there is a strong need of addressing issues such as customer's satisfaction and efficiency of the system through targeted actions, i.e. rising reliability and quality of services; anyway many parts of existing railway infrastructures are reaching their maximum capacity thus shrinking their capability to provide users and customers a higher and/or adequate level of service. Furthermore transport infrastructure endowment influences competitiveness of a region since the characteristics of a transport system in terms of capacity, connectivity, travel speeds etc. determine the location advantage/disadvantage of an area relative to other locations. This contribution is connected to the authors' recent research activities focusing on accessibility and level of service by rail (see [1-5]); the driving idea behind this work is to propose a user-oriented evaluation of the travel time by railway, seen both as a significant impedance indicator in accessibility analysis and as an operational and performance index of the service. The travel time between two stations along a line could be treated as sum of time on board, waiting time depending on the frequency of the services and waiting time for delays of trains (depending on the utilized capacity, i.e. congestion, of the line between i and j):}

$$t_{ij} = t_{board} + t_{waiting, frequency} + t_{waiting, delay}$$  (1)

According to the available data and to the scope of the analysis, each term of the previous formula can be calculated with a different level of detail. A manageable way to evaluate the time on board could be based on the actual timetable proposed by the Rail Undertakings, while most accurate calculations require more detailed data or assumptions. Based on infrastructure and/or rolling stock characteristics it is possible to evaluate (or even better simulate with software tools) the speed-diagrams along each section of a line for each train type. For the evaluation of the waiting time related to service frequency (scheduled departures), it could be easy and straightforward to use a deterministic approach, as already proposed in many scientific contributions (see [6], [7] and [8]). However to better represent this parameter or to propose different and more detailed analyses for peak or off-peak hours, it could be useful to extend the approach by including the actual (continuous or discrete) distribution of the departures (scheduled timetable) and the distribution of passengers' preferred time of departure based on a model (e.g. the logit deviation sin–cos schedule delay [9]) or on estimations by means of Revealed Preference (RP) – Stated Preference (SP) surveys [10]. Finally several capacity and punctuality assessment methodologies (see [2]) could allow evaluating the unscheduled waiting time and the infrastructure utilization rate.

Based on (1) (i.e., calculated travel time along the rail network between each couple of zones) this article explores several accessibility indicators. Accessibility is a complex concept with various facets: it has been widely treated in the scientific literature of the last years [11-21] and also in several European and international research projects or studies [22-24]. Inter alia accessibility could be defined as 'the amount of effort for a person to reach a destination' or 'the number of activities which can be reached from a certain location'; indicators of accessibility measure the benefits households and firms in an area enjoy from the existence and use of the transport infrastructure relevant for their area.

Disclaimer: The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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Two methods for modeling and verification of safety properties of railway infrastructures

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Abstract — This paper presents and compares two model-based approaches to ensure the dependability of a rail system in the context of ERTMS (European Rail Traffic Management System). V&V activities against safety properties are carried out by simulating train operations on State machine models of railway infrastructures. This paper presents this approach by means of a comparative study between two tools which analyze the models with various verification strategies. The tools used are Matlab Simulink environment and the DIVERSITY symbolic execution tool from CEA LIST.

Keywords—ERTMS; State Machine; UML; Simulation; Property Verification; Test Case Generation;

I. INTRODUCTION

A. PERFECT

This work was realized within the framework of the ANR project PERFECT\(^1\). Future generalization of ERTMS (European Rail Traffic Management System) in Europe has led to many studies related to safety and security issues. Amongst them, a large number concerned the analysis and verification of the ETCS (European train Control System) principles that will be supported by future onboard equipment and track signaling systems. Fewer works have considered regulation issues and the analysis of interoperability of the new European rules with national or local regulations [1]. The goal of the PERFECT project is to provide a test bed to study such issues and help regulation authorities to analyze the impact of regulations changes in specific local policies in the context of potential accident situations. This test bed can be considered as a laboratory to study actual scenarios and help suggest preventive actions. It is composed of a set of complementary evaluation tools dealing with a common UML based specification modeling platform. In this paper we illustrate one of the experimental studies conducted in this project, it concerns the analyses of an interlocking system using both simulation based property verification and scenario generation using symbolic execution techniques. Two implementation models of a same case study have been developed in order to evaluate the respective benefits of verification techniques using different tooling supports and determine how used together they can help evaluate dangerous situations in different regulation policies contexts.

B. Objective

Ensuring dependability of the system is often one of the most important tasks in rail projects. A rail system is composed of three essential elements:

- the infrastructure which constitutes the tracks (the rails, the switches, the beacons, etc.), the stations, the signaling equipment and the overhead catenaries or a third rail electrification
- the rolling stock which is made of locomotives and wagons
- the signaling system which is defined by operating rules and procedures for a safe and efficient rail operation

This work focuses on the infrastructure (tracks, switches, etc.), the sub-systems of which raises many issues in terms of dependability, integration or complexity. To travel between two points a train must generally traverse an itinerary or route defined by the traffic control authorities (a signaler). The switches and the signal lights must ensure its safe passage through the track section under consideration. How the signaling devices ensure the safety of the train are normally country specific regulations. French national rules more roughly specify the following conditions [2]:

- Generally there is only one given route between a given origin and a given destination.
- Each set of points (switches) within the route becomes free to be moved after the passage of the train.
- Points (track sections) can be released (to be occupied by another train) progressively as soon as the train releases them.

\(^1\) Performing Enhanced Rail Formal Engineering Constraints Traceability, Transports Durables et Mobilité (TDM) 2012, ref. ANR-12-VPT-0010.
Real-time railway traffic management optimization and imperfect information: preliminary studies

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Abstract—Railway traffic is often perturbed by unexpected events and appropriate train routing and scheduling shall be applied to minimize delay propagation. A number algorithms for this routing and scheduling problem have been proposed in the literature and they have been tested in different traffic situations. Nonetheless, their performance are almost always studied considering perfect knowledge of future traffic conditions, which is almost impossible to achieve in reality. In this paper, we propose an experimental analysis assessing the usefulness of these algorithms in case of imperfect information. We consider RECIFE-MILP as a traffic management algorithm and advanced or delayed train entrance times in the control area as the source of imperfect information. The results show that the application of traffic management optimization allows outperforming the first-come-first-served management strategy even if the actual traffic conditions are not perfectly known by the optimization algorithm.

I. INTRODUCTION

When railway traffic is perturbed by unexpected events, trains experience what is called primary delay. Primary delays may propagate with a snowball effect due to the emergence of conflicts: when a train is late, it may claim a track section in concurrence with another train and one of them must then slow down, or stop, to ensure safety. In this case, one of these trains will suffer a secondary delay due to the traffic perturbation.

Nowadays, operating to minimize delay propagation is the main task of railway dispatchers. They manually tackle conflicts by possibly re-scheduling trains, i.e., changing the planned train order at critical locations. Where alternative routes are available, also train routes may possibly be changed with respect to the planned ones (re-routing).

A noticeable number of academic studies have been devoted to finding effective algorithms for real-time railway traffic management [1], [2], [3], [4], [5], [6], [7], [8], [9]. These papers deal with this scheduling and routing problem based on different modeling choices as: the inclusion, limitation or exclusion of re-routing options; the consideration of train speed variation dynamics with different levels of simplification; the level of detail used for the infrastructure representation; the minimization of the total secondary delay, of the maximum one, or of the time to get back to the planned traffic situation.

Among this works, we proposed a mixed-integer linear programming (MILP) formulation for solving to optimality the problem of routing and scheduling trains in case of railway traffic perturbation [7], [10], [11], [12], [13], [14]. Although very often this MILP formulation quickly finds the optimal solution to realistic instances, it fails sometime in delivering it within a computation time in line with real-time purposes. Hence, in the real-time applicable algorithm, we set a time limit to the MILP solution process so that when this limit is reached, the best solution found is returned. This algorithm is named RECIFE-MILP [15].

The great majority of the papers proposing and studying algorithms for real-time railway traffic management suppose a perfect knowledge of the initial perturbation to be tackled. If, for example, the perturbation studied consists in a set of trains entering the infrastructure considered late with respect to the timetable, then the entrance delays are supposed to be perfectly known in advance, when deciding on train re-routing and re-scheduling. However, this perfect knowledge is indeed an unrealistic assumption and the decisions made by the algorithms may have an unexpected impact on traffic. Along the just mentioned example, if a train A enters the considered infrastructure with a 5 min delay, it may be able to pass through a critical location before another train B without perturbing its trip, in case the headway time remains sufficiently large despite A’s delay. The schedule imposing this order might be preferable (resulting in smaller delay propagation) with respect to the one allowing B passing first. In a real application, such a schedule would be implemented by constructing A’s itinerary across the critical location first, and by constructing B’s itinerary only after A has cleared the location itself. Nonetheless, if the expected delay is not fully precise and train A actually enters 5 min and 30 sec late, this schedule may result in a strong penalization of train B, which may have to stop and wait for A to pass. In this case, the assessment done by an optimization algorithm for selecting the preferable schedule would be based on an imprecise hypothesis (5 min delay rather than 5 min and 30 sec), and might then not be able to appropriately assess the possible alternatives.

Of course, in reality at least a slight deviation between train expected and actual delays is almost unavoidable. For coping with it, a possibility would be to include some techniques
Performing Enhanced Rail Formal Engineering Constraints Traceability: Transition Modes

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Abstract—As defined in the Council directive of 1996, the European Rail Traffic Management System (ERTMS) aims to provide the basic framework to the interoperable rail signaling and train control. Besides, traffic safety depends closely on the analysis, checking and validation of the ERTMS specifications and in the human behavior. These deals are considered on the ANR Project: PERFECT, in which this work fits. Thereby, in this paper it is proposed to use a state model approach to check and validate mode transitions of the ERTMS level 2 specifications. A scenario mode transition example is used to describe the steps of the state model algorithm and to validate it.

Keywords—ERTMS; Interoperability; Safety; State model; Specifications.

I. INTRODUCTION

The interoperability aims to generate a non-interrupted rail system, while safety is respected and system performance is ensured. It is the key element for the competitiveness of the European railway sector. Indeed, when a train has to cross countries boarders, it has to switch to another onboard signaling system, which engenders important financial costs.

The rail system has to comply with the technical as well as the operational rules in order to ensure an essential respect of the different countries regulations. Signaling management in the European Rail Traffic Management System (ERTMS) is governed by the national rules of each country and not by global rules. This makes it very difficult to evaluate the rail system in terms of safety requirements system. Thus, in this project labeled, Performing Enhanced Rail Formal Engineering Constraints Traceability (http://perfect.ifsttar.fr/Site), it is aimed to provide methodological tools for an overall assessment of the consistency of the specification and operating rules with regard to safety requirements.

Despite of the crucial aspect of the efficient and safe operation of the rail system, it has had a little attention in literature. Yet, thanks to the ANR-Project: PERFECT several models and approaches are proposed and developed dealing with this aspect.

Sun et al. [1], are interested to the Railway Interlocking System (RIS). The RIS, as it is known, plays a vital role in enabling safe transportation in Railway system. Thus, a detailed verification and then a validation are essential for each RIS system before its startup.

In this context, the authors propose a Hierarchical Colored Petri Net (HCPN) modeling approach for the RIS logics. In their model, they consider the RIS operation procedure and several others components of the RIS components (track section, turnout, signal control rules and procedures).

Moreover, they model an example of a normal station zone under French interlocking rules and in their future works, they propose to integrate human behaviors and to consider time factors.

In [2], Qiu presents and studies the ERTMS as a Systems of Systems (SoS). She defines the SoS as large systems whose components are themselves systems which interact to realize a common goal, and for which the malfunction of a single system can have some serious consequences on the performance of the whole SoS. In [3], Qiu et al. propose a methodology to model and evaluate SoSs. Then, they consider the ERTMS Level 2 as a SoS and evaluate its dependability parameters by considering the unavailability of the whole SoS as an emergent property. In addition, they model quantitatively different kinds of uncertainties in the proposed previous models [4]-[5].

Ben Ayed et al. analyze the European specification in front of national operating rules using formal models to determine whether a given scenario fulfils the specification regarding the functional and safety requirements.

The authors choose two case studies from the document of the description of principles and operating rules of European Train Control System (ETCS), and apply it on the French European LGV-Est line.

The two case studies are modelled with the semi-formal UML language and formally validated with the B method [6]-[7].

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Track - IESM2015

The Road Ahead: Understanding Challenges and Grasping Opportunities in Industrial and Systems Engineering

Jose Manuel Framinan, Paz Perez Gonzalez, Abdelhakim Artiba

Undoubtedly, Industrial and Systems engineers live challenging times: From the shift of paradigms in manufacturing, transportation and logistics, to the rapid advances in information technologies and communications, or from the need of real-time decisions to the ever decreasing life cycle of products and services -- just to mention a few--, nowadays’ industrial environment poses a number of challenges that can be hardly addressed with the tools and methodologies employed in the past. At the same time, exciting opportunities emerge from these advances, which may pave the way for a brilliant future in the field of Industrial and Systems Engineering.

In the IESM'15 conference, the main objective is to share the knowledge, research and experience of the most relevant researchers and professionals from all industrial engineering disciplines. Researchers and practitioners were invited to submit their original and unpublished work. Finally more than 250 papers were reviewed through EasyChair system.

I. Topics

Original contributions are sought in the numerous topics (see IESM2015 Web site: www.iesm15.org) as: logistics, transportation, and distribution systems, decision analysis and decision support systems, production planning and scheduling, E-Services and Technologies, Heuristics and meta-heuristics.

Many other topics are developed in the papers' collection: health care systems, maintenance and reliability, manufacturing systems, product life cycle management, supply chain design and performance evaluation, warehouse and inventory management.

II. The student competition

The papers have passed the two selection steps of the competition (the review process and the oral presentation at Seville). Sixteen papers were selected for the oral presentation.

It is a very great pleasure for us to announce the award of the Student Competition for IESM2015 Conference.

The Best Student Paper was awarded to

Quentin Tonneau

for the paper titled:

Multimodal multi-flow problem with transformation: application to waste supply chain

Congratulations! And Best Wishes for a distinguished and bright future.

III. Papers sessions

The papers of the final collection is distributed in 34 (special, regular, student) sessions.
The gap between scheduling theory and practice has been long known, recognized and studied. More often than not, elaborated scheduling models and procedures are proven to be extremely effective in controlled and synthetic laboratory problems but rarely applied in practical manufacturing scheduling. Real scheduling problems are varied, big and rich in the number of constraints and special characteristics.

It is fairly common, even for modern and large manufacturing companies, to use simple spreadsheets to schedule production. In many cases the scheduling process is mostly human-based with little to no optimization. The application of modern and effective algorithms and techniques, like for example metaheuristics, has remained elusive. Such algorithms are capable of producing near optimal production schedules even for sophisticated problems in little CPU time.

This session aims at gathering the latest contributions to the study of complex and real production and manufacturing scheduling.

Presented papers

- Algorithms for the Unspecified Unrelated Parallel Machine Scheduling Problem with additional Resources
- Simple greedy methods for scheduling hybrid flowshops with due date windows
- Rescheduling flowshops under simultaneous disruptions
- Efficient Constructive procedures for the distributed blocking flowshop scheduling problem
- Metaheuristics For Multiobjective Goods Routing
- A Metaheuristic based on Simulation for Stochastic Job-Shop Optimization
Algorithms for the Unspecified Unrelated Parallel Machine Scheduling Problem with additional Resources

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Abstract—In this paper we study the unspecified unrelated parallel machine scheduling problem with additional resources. Jobs can be processed at any machine, using a certain number of units of a scarce resource. The objective is to schedule jobs in parallel machines, so that the makespan is minimized, and the use of resources does not exceed a given limit, at any time. We propose an ILP program to solve this problem to optimality. Due to the complexity of the problem, this program explodes for medium-size instances. Therefore, we introduce a heuristic procedure. Both algorithms are tested over a computational experience.

I. INTRODUCTION

The unrelated parallel machine scheduling problem (UPMS) consists of processing a set of jobs in a set of available machines. A typical objective in these problems is the minimization of the latest job completion time, also known as makespan. In other words, the objective is to find the assignment of jobs to machines so that the latest job being processed finishes as soon as possible. The machines are parallel because any two of them can process jobs simultaneously, and unrelated because job processing times need not be the same for all machines. Examples of real situations in which the UPMS arises are production systems in which two or more tasks need to be done and you do not have to wait for the end of the processing of one task to start the processing of another one. Ever since the first papers related to this topic, see [1], the interest of the scientific community on the UPMS has not stopped increasing. The reader interested in general applications and reviews of the UPMS is referred to [2], [3], [4], among others.

In this paper, we assume that the during the length of time in which a job is processed in a machine, a discrete amount of a scarce renewable processing resource is needed. This amount depends on the job and the machine, and is given as input data. An example of this additional resource is the operators that are required to perform tasks that need to be fixed for the whole processing time. The static version has been already proposed and studied in the literature. For instance [8] study the static identical parallel-machine flexible-resource scheduling problem with unspecified job assignment, for which ILP programs and heuristics are proposed. The dynamic version has been studied by [9], [10] and [11].

We start our research by proposing an ILP program to solve our UUPMSR. Due to the complexity of the problem, such ILP program fails in finding feasible solutions to instances of moderate size (16-20 jobs and 2-6 machines), and even when able to find one, the quality of these solutions is not always good. For this reason, in this paper we devote some efforts to find more efficient and reliable procedures. More in particular, we propose a heuristic that exploits the UPMS problem (without additional resources).

The rest of the paper is structured as follows: Section II is devoted to define the UUPMSR problem, which is later modeled as an Integer Linear Programming (ILP) program in Section III. A two-phase approach based on first solving the UPMS problem is presented in Section IV. Both approaches are tested and compared in Section V.

II. PROBLEM SPECIFICATION

The UUPMSR problem takes the following input data:

• A list of available machines, indexed by $i$.
• A list of $n$ jobs to be processed, indexed by $j$.
• $R_{\text{max}}$ units of a certain resource.
• discrete because a discrete amount of them need to be assigned to job-machine pairs.
• processing because they are needed while the job is processed at the machine.

The resulting problem is called the Unspecified Unrelated Parallel Machine Scheduling problem with additional Resources (UUPMSR), of which a number of papers are available (the reader is referred to [7] for a review of the state of the art). The problem is unspecified because there is no pre-fixed job-machine assignment, that is, priori the machine $j$ that is to process job $i$ is unknown, and must therefore be considered as a variable. We study the dynamic version of the problem, meaning that the allocation of resources to machines need not be fixed for the whole processing time. The static version has been already proposed and studied in the literature. For instance [8] study the static identical parallel-machine flexible-resource scheduling problem with unspecified job assignment, for which ILP programs and heuristics are proposed. The dynamic version has been studied by [9], [10] and [11].

We start our research by proposing an ILP program to solve our UUPMSR. Due to the complexity of the problem, such ILP program fails in finding feasible solutions to instances of moderate size (16-20 jobs and 2-6 machines), and even when able to find one, the quality of these solutions is not always good. For this reason, in this paper we devote some efforts to find more efficient and reliable procedures. More in particular, we propose a heuristic that exploits the UPMS problem (without additional resources).

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Simple greedy methods for scheduling hybrid flowshops with due date windows
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Abstract—In real life due dates are intervals rather than points in time. In this paper we deal with hybrid flowshops where jobs do not incur in penalties if they are completed inside given due windows. The objective to minimize is the weighted earliness and tardiness from the given due window. We propose simple heuristics based on iterated greedy and iterated local search. We present some procedures: an optimal idle time insertion and a two stage local search which considers a limited local search on a exact representation. We carry out a complete computational experiment, including a reimplementation and comparison of other 9 competing algorithms. A benchmark of more than 3000 instances is used to show that our presented methods are statistically better than existing approaches. Experiments are also conducted to analyze the contribution of each part of the presented procedure.

I. INTRODUCTION AND LITERATURE REVIEW

The scheduling of production orders is a crucial step inside operations management. Manually obtained schedules without optimization techniques are known to be far from optimal[1]. Applying optimization methods might result in large gains ([2], [3], among others). As commented by [4], every year all major journals publish hundreds of papers about different scheduling problems and settings. However, the application of such research developments in real industry remains elusive ([5], [2], [6]).

We are interested in what is probably the most commonly found production layout in real industries, which is the combination of the parallel machines and flowshop problems. The addition of the two is usually referred to as hybrid flowshop and is defined as follows: There is a set $M$ of $m \geq 2$ production stages where $M = \{1, \ldots, m\}$. The stages are disposed in series. At each stage $i$, $i \in M$ we have a set $M_i$ of $m_i$ identical parallel machines where $M_i = \{1, \ldots, m_i\}$ and $m_i \geq 1, \forall i \in M$ and $\exists i \in M, m_i > 1$. A set $N$ of $n$ jobs has to be processed on the stages. More precisely, each job $j$, $j \in N$ visits first stage 1, then stage 2 and so on until stage $m$. At each stage $i$, each job is to be processed by exactly one of the available $m_i$ parallel machines. As a result, a job is made up of $m$ different tasks, one per stage. The processing time of any job $j$ at any stage $i$ is a positive integer denoted by $p_{ij}$. Jobs are processed without interruptions.

The hybrid flowshop or HFS in short has attracted a lot of interest in the literature, given its potential practical applications. As such, there are several reviews published. Some recent reviews are [7] and [8]. The most commonly studied optimization criterion is the minimization of the makespan or ($C_{\text{max}}$), defined as $C_{\text{max}} = \max_{j=1}^{n} C_j$ where $C_j$ is the time at which job $j$ is finished at stage $m$. The HFS with makespan criterion can be represented as $((PM(1))_{i=1}^{m})/C_{\text{max}}$, following the notation of [9].

In the HFS for each job and stage we have to decide to which machine the job is assigned. Then, for each machine at each stage, a sequence for the processing of the assigned jobs has to be determined. The simplest possible HFS with only two stages where one stage has one single machine and the other has just two parallel machines is already $NP$-Hard. While makespan minimization is the most studied objective in the scheduling literature, it is not the most appropriate objective to study nowadays. As explained in [1], makespan minimization increases machine utilization. Presently, service level objectives are much more important. We define by $d_j$ the due date of job $j$, $j \in J$. If $C_j > d_j$ then job $j$ is tardy by $C_j - d_j$ units of time. The tardiness of job $j$ is $T_j = \max\{C_j - d_j, 0\}$ and the total tardiness objective is $TT = \sum_{j=1}^{n} T_j$. Additionally, not all jobs are equally important. Therefore, we can use a weighted tardiness version by defining $w_j$ as the weight of job $j$, $j \in J$ and the total weighted tardiness objective as $TW = \sum_{j=1}^{n} w_j T_j$. Note that when $C_j < d_j$ the tardiness is always 0 regardless of how small $C_j$ is. In real problems, finishing products early results in tied up inventory and financial burden. A possibility is to account for the earliness as well, defined as $E_j = \max\{d_j - C_j, 0\}$ or $TWE = \sum_{j=1}^{n} w_j E_j$ with weights. Note the different weight for earliness $w_j$ and tardiness $w_j$. Minimizing earliness only potentially negates the tardiness and the solution is to minimize the total earliness and tardiness or $TW = \sum_{j=1}^{n} (w_j E_j + w_j T_j)$. Only 1% of the reviewed
Rescheduling flowshops under simultaneous disruptions

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Abstract—Production planning and scheduling systems are pervasive in manufacturing systems to increase productivity, variety and customization without incurring in high costs. A large number of impromptu disruptions frequently affect the scheduled operations and invalidate the original schedules. Rescheduling actions have to be triggered in order to reduce the impact on the performance of the system. A large body of research covering miscellaneous problem characteristics can be found in the scheduling literature. Even so, the application of scheduling techniques is still infrequent in real-life scheduling problems. In this work we generate eight types of disruptions that affect the original schedules simultaneously. We apply three rescheduling methods and compare their results with simple rule based repair actions typically employed in production environments. Statistical analysis is used to demonstrate that the proposed methods outperform the rule based approaches by a significant margin, highlighting their effectiveness in real life manufacturing settings.

I. INTRODUCTION

Operations scheduling, in the decision making ranking, represents the final stage in the transformation process of raw materials into final finished goods. Therefore scheduling decisions are marked by the constraints established by other longer-term previous decisions such as facility layout definition, equipment acquisition and aggregate planning etc. Moreover, different types of uncertainties affect real life operations in manufacturing plants. The majority of the research on scheduling under uncertainties, addresses some of the disruptions that affect actual schedules only independently and does not span a wide range disruptions [1], [2], [3], [4], [5], [6], [7]. Simulation is often employed to validate the proposed methods and approaches [8], [9], and hence, results remain well-grounded only within the simulated context. In the rescheduling literature authors propose many techniques and approaches that tackle the problem of hedging uncertainties in scheduling problems. However, these approaches can hardly be extended to real life manufacturing settings. Firstly, many authors employ mathematical models to generate optimal solutions [10], [7]. The validity of their results depends on the specific considered problem. Secondly, many other approaches use simulation techniques to validate the proposed rescheduling methods and similarly, their performance is context dependent. Moreover, real manufacturing plants are affected by many sources of disruptions simultaneously. Finally, there is a big gap when defining the efficiency measures for the proposed methods. Measures like makespan, maximum flow time, earliness and tardiness, etc. are comprehensively studied and have appeared in academic research for years. However, they do not reflect the total performance of the rescheduling system. Continuous schedule changes can produce supplementary costs such as material handling costs and additional setup times etc. Hence, it is also crucial to reduce the schedule nervousness originally defined by [11] as a measure of significant changes in Material Requirement Planning (MRP) plans.

In particular, in this work the permutation flowshop rescheduling problem (PFSP) is tackled, where there is a set \( N = \{1, \ldots, n\} \) of \( n \) jobs to be processed on a set \( M = \{1, \ldots, m\} \) of \( m \) machines. The order of the jobs on the first machine must be maintained throughout the rest of the machines, according to the permutation flowshop definition. In an earlier paper [12] we tackled the flowshop rescheduling problem and developed three rescheduling techniques that seek a good trade-off between schedule quality and stability, since the two objectives together have an impact on the real performance of the scheduling decisions. We also generated a benchmark of three types of disruptions including machine breakdowns, new job arrivals and job ready time variations. This set of disruptions can be downloaded from http://soa.iti.es/ and used for algorithm comparison purposes. We compared the performance of the three methods against the simple reactive rule based actions typically employed in real manufacturing settings. The statistical analysis of the results evidenced the outperformance of the Iterated Greedy algorithm (IG) of [13] over the rest of the methods. The results depend neither on the type of disruption affecting the system nor on the relative importance of makespan or instability in the objective function. The repair approach showed itself to be the poorest method among all the four tested algorithms.

In this work our objective is to consider a more realistic rescheduling problem. Firstly, we will enhance the events benchmark by considering five other additional types of disruptions that will affect the permutation flowshop together with the three ones mentioned above. Secondly, we will employ a second objective function where the efficiency measure is represented by the total weighted tardiness. As a
Abstract— the distributed blocking flow shop scheduling problem (DBFSP) allows modeling of the scheduling process in companies with more than one factory, with productive systems configured as flow shop lines where the blocking constraint has to be considered. To the best of our knowledge, this variant of the distributed permutation flow shop scheduling problem has not been studied. In this paper, we propose some constructive heuristics that will solve the DBFSP and thus minimize the maximum completion time among the factories. The proposed procedures use two approaches that are totally different from those proposed for the distributed permutation flow shop scheduling problem (DPFSP). By taking the DPFSP procedures that we adapted to DBFSP and comparing them to the new approaches that were specifically designed for DBPFSP, we find that the latter perform considerably better.

Keywords—distributed blocking flow shop; blocking flow shop; distributed permutation flow shop; constructive heuristics;

I. INTRODUCTION

Distributed manufacturing is a common situation for large enterprises that compete in a globalized market. Because of current globalization trends, production has shifted from single factory production to a multi-factory production network [1]. In this environment, the scheduling problems deal with the allocation of jobs to factories and the scheduling of jobs in each plant. Since the flow shop configuration is the most common processing layout, the flow shop scheduling problem has been studied greatly since the seminal paper of Johnson [2]. However, its extension to a multi-plant environment was first presented by Naderi and Ruiz [3], who referred to it as the Distributed Permutation Flow Shop Scheduling Problem (DPFSP). According to [3], the DPFSP is defined as follows. A set \( N \) of \( n \) jobs must be processed by a set \( G \) of \( F \) identical factories. Each factory has the same set \( M \) of \( m \) machines. The processing times of all the tasks of a given job do not change from factory to factory. The objective is to minimize the maximum makespan among factories.

After the publication of [3], several authors proposed various heuristics to solve this problem ([4]–[13]), but the blocking constraint has been considered in none of them. The blocking flow shop scheduling problem allows many productive systems to be modeled when there are no buffers between consecutive machines. In general, it is useful for those systems that have a production line without a drag system that forces a job to be transferred between two consecutive stations at pre-established times. Some industrial examples can be found in the iron and steel industry [14]; in the treatment of industrial waste and the manufacture of metallic parts [15]; or in a robotic cell, where a job may block a machine while waiting for the robot to pick it up and move it to the next stage [16]. The blocking constraint tends to increase the completion time of jobs, because the processed job cannot leave the machine if the next machine is busy. Therefore, the heuristics designed to schedule jobs in this environment have to consider this fact in order to minimize the idle time of machines due to possible blockage. Therefore, the distributed blocking flow shop scheduling problem (DBFSSP) deals with the allocation and scheduling of jobs in a multi-factory production network with the blocking constraint present in the manufacturing system. It is interesting to study this problem in order to design specific procedures, since the adaptation of those designed for the DPFSP probably perform worse than procedures which consider its characteristics.

In this paper we propose new constructive procedures built from two different approaches to solve the DBPFSP. The computational evaluation shows good performance of these simple procedures, which can be used either to obtain a fast solution to the problem or as the initial solution procedure in more sophisticated metaheuristics.

II. CONSTRUCTIVE HEURISTICS

As stated before, the DPFSP needs to deal with two related decisions: the allocation of jobs to factories and the sequence of jobs assigned to each plant. In this paper, we have compared 33 constructive heuristics. 30 of them are formed by combining ten sequencing methods with three allocation rules (two of these rules came from the DPFSP literature and the third is a new approach presented in this paper). The remaining three heuristics take a different perspective in addressing the problem considered here.
Abstract— Good transportation is a key activity within the supply chain, as it has a direct impact on the company’s total costs and in customer’s service, giving it a special interest for seeking ways to optimize these distribution processes. In the literature there is a large number of approaches to optimize these processes, which generally require advanced methods for its solution. This article reviews the most used metaheuristics for solving multiobjective problems applied in goods distribution networks and analyzes the most common objectives used in such approaches. Some trends are identified in order to suggest some areas for future research.

Keywords— Goods distribution; Metaheuristics; Logistics; Algorithms; Vehicle routing.

I. INTRODUCTION

The transportation of goods involves product transportation from one or multiple points of origin to one or multiple destination points, where it is possible to find multiple steps between suppliers and customers, or even within a single organization, such as storage areas, cross-docking, intercity steps, urban steps, international transit, among many other possibilities that are specific to the companies configuration. Multiple activities are conducted in good distribution, as loading and unloading of goods, inventory management, handling and refurbishment of materials transportation, among others [1].

To maintain or gain market share, companies must deliver products with high levels of customer service, including short delivery times, diversity in products and capacity to respond to demand and supply fluctuations in an efficient manner, this suggests that companies should strive to be flexible [2].

The nature of good distribution processes involves the use of a large number of variables, nodes, interactions between them, and many factors that determine the performance of these processes, as operating cost, service level, environmental pollution and operation reliability.

Consequently, several objectives or goals must be considered in order to design transportation solutions. These objectives are often contradictory, so it is necessary to use multiobjective approaches, and to use complex mathematical models to solve these models. It is necessary to leave simple solution methods and use heuristics and metaheuristics techniques for solving these models.

Heuristic techniques do not ensure to find an optimal solution, but to find an adequate one in a short time. Instead meta-heuristic algorithms are methods that start from an existing solution and try to find a good solution to the global problem (possibly optimal), applying to every step an embedded heuristic designed for each particular problem.

This article is part of the revision step of a doctoral thesis with the objective of optimizing city freight distribution process, and presents a review of the most representative metaheuristics techniques for solving multiobjective models to solve transport/distribution problems, according to the different approaches found in the specialized literature. The article starts with background about mathematical models used for optimizing goods transportation and the metaheuristics used to solved this models, followed by a review of works that used multiobjective approaches to solve this problems, from which the most frequently used metaheuristics and objectives are identified.

II. MATHEMATICAL MODELS USED FOR THE DISTRIBUTION OF GOODS

The good distribution is a business’ complex activity because it involves the use of company resources and the available transport networks. A proper distribution process helps to reduce operating costs in the supply chain; therefore finding the optimal operation will always be attractive to companies [3, 4, 5].

In the literature is possible to find multiple approaches to mathematical optimization to solve the problem of goods distribution, which can be classified into three major branches, each with multiple variations: the problem of vehicle routing (VRP); the joint problem of locating facilities and vehicle routing (LRP) and el problem of simultaneously assign routes and make inventory decisions [6], where the most studied model is IRP (Inventory Routing Problem - IRP).

VRP determines the sequence to visit a set of clients within a region, so that the distribution process is as economically as possible. In this model the decision is to assign customers to be visited by the same vehicle and how many routes are required. In this model the decision is to assign customers to be visited by the same vehicle and how many routes are required to supply all of them [7].

LRP finds at the same time the facilities location and the vehicles routing to supply the customers. This model is used...
A Metaheuristic based on Simulation for Stochastic Job-Shop Optimization

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Abstract—This paper deals with stochastic Job-shop with random processing times where the objective is to find schedules robust enough in order to minimize the total completion time of all the operations. The problem is handled by use of a multi-start metaheuristic and a simulation software. At each iteration of the metaheuristic the best deterministic schedule is tested using the SIMAN simulation language; at this given schedule is then adjoined the average simulated makespan. The metaheuristic is then searching for another different schedule in the deterministic space— which could be worse than the previous one. The proposed approach is applied to a small instance for demonstration. A set of instances for job-shop problems is then adapted for stochastic use in order to validate this work. The results, both in term of computational time and of quality, show the relevance of this study.

Keywords—stochastic Job-shop; metaheuristic; simulation; random processing times

I. INTRODUCTION

A lot of works can be found in the literature concerning scheduling problems, such as Flow-shops or Job-shops. Most of the time, studies are focused on the deterministic side of these difficult problems. However, it is really difficult to forecast the behaviour of a production system in the real world since they are not deterministic and exposed to disturbances. These disturbances could be, but are not limited to, machine breakdowns or random processing times. This leads to the consideration of stochastic production systems. As stressed in [1], fewer works are done on stochastic production systems than deterministic ones whereas decision makers need efficient tools to correctly manage the production under uncertainty. Since the laboratory is involved in a project which aim is to define tools combining the ARENA simulation software and optimization methods, this study is a first step into proposing a way of integrating both approaches. Thus, a stochastic Job-shop with random processing times where the objective is to propose a schedule with smallest average makespan is presented. The resolution consists in embedding a simulation model into a metaheuristic. First the optimization method explores the solution space in order to find a good solution from the deterministic viewpoint, where the processing times are constant. This solution is then tested according to random processing times in the simulation model in order to obtain its average makespan. The process is then repeated in order to find different solutions which could be worse from the deterministic point of view but better from the stochastic one. At the end of the process the algorithm returns the best visited solution.

The paper is as follows: in the next section is presented a literature review on simulation and stochastic production systems. In the third section the stochastic job shop problem is presented. The combined optimization/simulation framework is presented in section four. In section five, a short example is presented, followed with results on various job-shop instances adapted to the studied problem. Finally, the last section consists in a conclusion and research perspectives.

II. RELATED WORKS

[2] consider a job shop with random processing times where the objective is to minimize penalties relevant to storage and tardiness in jobs delivering. They use heuristic decision-making for choosing a job between several ones to be proceeded on a given machine. [3] proposed a neural network hybridized with simulated annealing in order to obtain near-optimal solutions for a stochastic Job-shop. [4] studied a dynamic flexible Job-shop subject to machine failures. They use the simulation as an evaluation function. The simulation model is embedded inside a genetic algorithm. [5] worked on a stochastic flexible job-shop by using a discrete-event stochastic simulation optimization. They note the fact uncertainty induces the impossibility to find optimal solutions to such problems. [6] proposed a genetic algorithm which purpose is to find a solution with minimal makespan in a stochastic job-shop subject to random machine breakdowns. [7] considered random processing times in the context of a stochastic job-shop with the objective of minimizing the total lateness. An artificial bee colony is developed in their work. Using discrete-event simulation model [8] study the impact on job scheduling of different rules based on due dates or queue management in a dynamic job-shop like manufacturing environment. [1] worked on a stochastic job shop with random processing time where the objective is to minimize the sum of storage costs and delivery delays penalties. In [9,10] is studied the impact of different objective functions (makespan, tardiness,..). A simulation software was used to develop a model for a stochastic dynamic job shop, where processing times
The gap between scheduling theory and practice has been long known, recognized and studied. More often than not, elaborated scheduling models and procedures are proven to be extremely effective in controlled and synthetic laboratory problems but rarely applied in practical manufacturing scheduling. Real scheduling problems are varied, big and rich in the number of constraints and special characteristics.

It is fairly common, even for modern and large manufacturing companies, to use simple spreadsheets to schedule production. In many cases the scheduling process is mostly human-based with little to no optimization. The application of modern and effective algorithms and techniques, like for example metaheuristics, has remained elusive. Such algorithms are capable of producing near optimal production schedules even for sophisticated problems in little CPU time.

This session aims at gathering the latest contributions to the study of complex and real production and manufacturing scheduling.

Presented papers

- Variability Aspects in Flowshop Scheduling Systems
- Heuristic algorithms to minimize the total tardiness in a flow shop production and outbound distribution scheduling problem
- Production and outbound distribution scheduling: a two-agent approach
- Heuristics for a Distributed Parallel Machine Assembly Scheduling Problem with Eligibility Constraints
Variability Aspects in Flowshop Scheduling Systems

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Abstract—In this paper different aspects of variability in a job scheduling system are discussed. Unlike an ideal manufacturing system a real-world system requires an efficient mix of different buffers to balance the influence of variability. The focus in this paper is to observe the effects of non-uniformity of processing times on the performance measures Makespan, Flowtime and Squared Variability of Completion Time Differences (=CTDVB2). In addition, the behavior of Waiting Time and Idle Time regarding these measures is analyzed. An example is used to illustrate the influence of variability: A nonuniform permutation flow shop is smoothed in different ways. First a linear step-by-step harmonization is executed. Furthermore, non-uniform processing times are modified with a logarithmic and a quadratic optimization model.

I. INTRODUCTION

Referring to Little’s Law, which is well-known as Work in Process = Cycle Time × Throughput, the same Throughput is achieved with high Work in Process and long Cycle Times on the one hand or with low Work in Process and short Cycle Times on the other hand. Choosing the alternative with low Work in Process and short Cycle Times is obviously preferable if possible, because it yields an efficient manufacturing system. The reason why even an inefficient mix of Work in Process and Cycle Times leads to the same Throughput (and therefore is supposable) is variability [12, p. 264].

In general variability is a common statistics measure. It is usually expressed by the coefficient of variation (CV) which is defined as the standard deviation (σ) divided by the mean (¯¯) [15, p. 21]. Variability can occur in many different ways, like fluctuation in processing times, random setups and breakdowns of machines and rework. Especially the flow variability depends on how the jobs are released and moved through the system [12, p. 277 ff].

Hopp and Spearman suggested two fundamental laws of variability. The first one refers to:

“Increasing variability always degrades the performance of a production system.” [12, S.309]

I.e. the ability to deal efficiently with non-uniformity, and hence variability, in manufacturing systems is an important issue to achieve a good performance and reliable forecasts. The performance of such a system is measured by the time indicators Makespan, Flowtime, Waiting Time and Idle Time. Variability needs to be buffered by a mix of capacity, time and inventory which leads to the second fundamental law:

“Variability in a production system will be buffered by some combination of Inventory, Capacity and Time.” [12, S.309]

The buffers of the so-called Magic Buffer Triangle have to be selected carefully, because every manufacturing system needs an individual strategy which has to match its requirements [12, S.309]. There exists no general solution.

As an extreme case with respect to buffer requirements, an ideal manufacturing system is given by total uniformity and requires no buffers. This situation is quite different from real-world systems, where an efficient mix of buffers is indispensable to reduce the effects of variability [13]. One way to deal with this problem is to observe the variability of system output (= departure variability of jobs) using Queuing Approaches [12]. It can be shown that minimization of Flowtime and Makespan yields more variable inter-departure times of jobs [13]. Therefore a link between stochastic Queuing Theory and (static-deterministic) Scheduling Approaches is subject of current research, for example the development of an additional variability-oriented objective function [13]. This function uses the Squared Variability of Completion Time Differences (= CTDVB2) which is the coefficient of variation of the completion time differences of consecutively scheduled jobs in a (permutation flow shop) schedule.

The research of uniformity-oriented objective functions and non-regular measures, namely variance of completion times, started in 1972 with the paper written by MERTEN AND MULLER. They dealt with the minimization of mean flow time and waiting time and the respective variance in the easiest machine environment, a single machine. They showed that the mean flow time and mean waiting time achieve their minima at the same job sequence. Referring to the variance minimization both measures attain different optimal job sequences [2].

After SCHRADE dealt with minimizing completion time variance for up to 5 jobs on a single machine in 1975 [3], EILON UND CHOWDHURY extended this approach in 1977. They showed that for minimizing completion time variance the processing times have to be V-shaped. If the jobs placed before the job with the smallest processing time, e.g. job j, are in a descending order of processing times and the jobs placed after job j are in an ascending order of processing times, the processing times are V-shaped [4]. Furthermore, KANET in 1981 dealt with the minimization of the average deviation of job completion times and BAGCHI ET AL. in 1987 dealt with minimization of the mean squared deviation of completion
Heuristic algorithms to minimize the total tardiness in a flow shop production and outbound distribution scheduling problem

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Abstract—In this paper, we consider a production and outbound distribution scheduling problem, coming from a real life problem in a chemotherapy production center. Only one vehicle with infinite capacity is available for delivery. The production workshop is an \(m\)-machine flow shop. To each job is associated a processing time per machine, a location site and a delivery due date. The travel times are known. The problem is to define a production schedule, batches of jobs, and delivery routes for each batch, so that the sum of tardiness is minimized. Heuristic algorithms are proposed and evaluated on random data sets.

I. INTRODUCTION

We consider in this paper the permutation flow-shop scheduling problem and vehicle routing problem (VRP) integrated, also called 'production and outbound distribution scheduling problem' in the literature. The jobs have to be delivered to the customers after their production by using a single vehicle. This problem comes from a real life application in the domain of chemotherapy production ([17], [12]). In this production environment, the coordination of production and delivery at an operational level is very important for several reasons: the patients are waiting for their treatment, and avoiding stress and useless lost of time is important, and injectable products in syringe or pouch have to be delivered without lost of time. The production process is complex [3], but it can be easily approximated by a flow shop process with one stage for the sterilization, one stage for the production of the pouch or syringe, and one stage for the control. In the problem that we consider (and in the case of the hospital of Tours where around 150 preparations are daily performed), there is only one delivery man, so we consider that there is only one vehicle.

More precisely, we consider that there is a set \(J = \{J_1, ..., J_n\}\) of \(n\) jobs to schedule on a set \(M = \{M_1, ..., M_m\}\) of \(m\) machines organized in a flow shop environment. We denote by \(p_{i,j}\) the processing time of \(J_j\) on machine \(M_i\) and \(d_j\) the delivery due date of \(J_j\). To each job \(J_j\) is associated a site \(j\), where the job has to be delivered. The travel time matrix between sites is known and \(t_{1,2}\) denotes the travel time between site \(1\) and site \(2\) (\(\forall j, j' \in [0, n]\)). It is assumed in the following that the production center is associated to site 0. Notice that in practice, if the delivery to the patients is done inside the hospital, there is not one site per job. The number of sites is limited, and several jobs can be delivered to the same site. However, if the delivery to the patients is done outside (home care services), there is potentially one site per patient with non negligible transportation times.

The problem is to define a schedule of the jobs on the machines, to define batches of jobs (one batch corresponds to one trip of the vehicle). For each batch, the vehicle routing problem consists in defining a route starting from the production site, visiting the customers associated to the jobs in the batch, and finishing at the production site. We define the variables \(C_{i,j}\) to denote the completion time of job \(J_j\) on machine \(M_i\) (\(\forall i \in [1, m], \forall j \in [1, n]\)), \(D_j\) to denote the delivery completion time, \(T_j\) to denote the tardiness of \(J_j\), defined by \(T_j = \max(D_j - d_j, 0)\). The objective is to minimize the total tardiness of delivery denoted by \(\gamma = \sum_j T_j\).

This problem is clearly an \(NP\)-hard problem [15].

The paper is organized as follows. Section II presents a survey of the literature in this domain. In Section III, a linear integer programming formulation of the problem is proposed. In Section IV we present the resolution methods. Three heuristic algorithms are proposed. In Section V some computational experiments are proposed.

II. LITERATURE SURVEY

There are few papers in the literature dealing with integrated production scheduling and vehicle routing problems at an operational level. These problems are also known under the denomination 'production and outbound distribution scheduling'. The survey paper of [5] introduces the problem and proposes a five-field notation \(\alpha/\beta/\pi/\delta/\gamma\) to describe the problem. The notation of the problem that we consider is \(Fm|V(1, \infty), routing|[\pi]nJ\gamma\), where the field \(\alpha = Fm\) means that we consider an \(m\)-machine flow-shop scheduling problem, \(\beta = \emptyset\), the field \(\pi\) contains \(V(1, \infty)\) meaning that there is only one vehicle with infinite capacity, and \(\delta\) meaning that orders going to different customers can be transported in the same shipment. In the field \(\delta\) we have \(n\) to indicate that each job belongs to one customer. Finally, \(\gamma = \sum_j T_j\) is the objective function, here the total tardiness of delivery.
Production and outbound distribution scheduling: a two-agent approach

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Abstract—The problem considered is an integrated production and distribution scheduling problem with two agents: a manufacturer and a third-party-logistics provider. The manufacturer workshop is a flow-shop and the problem is to minimize a cost function composed by inventory, vehicle and tardiness penalty costs. The 3PL provider solves a vehicle routing problem for each vehicle, to minimize a total cost composed by routing costs and tardiness penalties paid to the manufacturer. A general framework is presented and a particular scenario is considered, where the manufacturer dominates and the 3PL provider adjusts. MILP models are proposed and illustrated by a numerical example.

I. INTRODUCTION

In today business environment, defined by globalisation, fierce competition and increasing customer demands, companies are forced to find innovative ways in order to keep costs down and stay competitive while providing high quality of service for their customers. The complexity and interconnectedness of this globalised environment makes planning and logistics important tasks that can cut costs and ensure smooth operations for a business, considering that inventory and transportation/distribution costs make up a substantial amount of a company’s cost function.

Supply chain management is concerned with the coordination and planning of the supply chain of a business and considers all activities that are involved in the production of a product/service from the supplier up to the delivery to the customer. Supply chains are generally very complex networks consisting of several stages, links and players, however, the main two areas of focus in supply chain management are production and distribution planning.

The goal is to optimise the planning decisions for both production and distribution, such as scheduling and routing decisions, according to a set of objectives. While these two areas are traditionally dealt with individually, they are highly interconnected and more recent considerations have shown that integrated supply chain approaches, that consider both production and distribution decisions at the same time, hold various benefits for organisations both in terms of cost as well as time management. The objective of these considerations is to find an optimal global solution to the supply chain scheduling problem for all agents by integrating the two individual problems of production and distribution scheduling into one model. Over recent years, such approaches have been more and more covered in the literature. However, one of the difficulties associated with this is the complexity of the two individual models, often resulting in too simplified models.

The problem considered here is an integrated production and distribution scheduling problem at an operational level. The problem is considered as a multi-agent decision problem, consisting of two sub-problems: a permutation flow-shop scheduling problem for the production problem and a vehicle routing problem concerned with the minimisation of total tardiness in terms of the distribution problem. The model also includes the notion of inventory costs that occur during the production phase, in order to obtain a more realistic model. Inventory costs even though often neglected in production scheduling models play a major role in production planning. Two kinds of inventory are considered here: work in progress inventory and finished products inventory.

The paper is organised as follows. In Section II, we present a state-of-the-art survey on integrated production and outbound distribution scheduling. Section III formally describes the problem that we consider and introduces some notations. In Section IV we propose resolution methods: a mixed integer linear programming model and some (basic) heuristic algorithms. These methods are illustrated with an example. In Section V we present a coordination scenario where the manufacturer dominates and the 3PL provider adjusts. Section VI contains concluding remarks as well as some directions for future research.

II. LITERATURE REVIEW

While there is a vast amount of literature available on the individual problems of production and distribution scheduling, the integrated approach of supply chain scheduling has only been covered to a greater extend in the literature more recently. Graves (1981) [11] for example gives a classification and early review of the different approaches to production scheduling problems. The classification is mainly done according to the
Abstract—In this paper we study a production scheduling problem with production and assembly stages. There is a set of distributed identical factories, each one with a set of unrelated parallel machines at the production stage and a single assembly machine in the assembly stage. Jobs have to be assigned to one of the distributed factories and processed by one of the unrelated parallel machines. Processed jobs are assembled into final products through a defined assembly program in the assembly stage. This problem is referred to as the Distributed Parallel Machine Assembly Scheduling Problem or DPMASP. The goal is to minimize the makespan of the products in the assembly stage by selecting machines at factories and processing jobs in the most efficient way. We present a mathematical model, four simple, fast and high performing heuristics to solve the considered problem. CPLEX and GUROBI as two state-of-the-art commercial solvers are used to solve the mathematical model. Comprehensive computational experiments and ANOVA statistical analyses are performed to evaluate the performance of the proposed mathematical model and heuristics. Our results show that the mathematical model is able to solve moderately-sized instances and some of the heuristics report solutions that are very close to optimality in negligible CPU times.

I. INTRODUCTION

Today, the manufacturing industry faces numerous challenges and is beleaguered by obstacles in the marketplace. Some of the significant challenges are: intense global competition, technological changes, product life cycles reduction, increasing product variety, demand of customized goods instead of mass production, consumer needs diversity, faster delivery, higher products quality, cost pressures, uncertain and dynamic global market, etc. In order to overcome these challenges, the consideration of efficient production strategies is necessary and essential. One of these strategies is to employ distributed manufacturing environments able to produce the variety of products that the customer demands. Presenting diversified product offerings is one of key advantages for companies to compete in the unpredictable global market. On the other hand, scheduling and optimizing such systems is a complex task which directly affects production performance.

Assembly systems have attracted the attention of practitioners and researchers. Different manufacturing systems have adopted them in their production structure to meet a high variety of customer demands through an increase in the flexibility and capability level of the system. Various components are produced through different independent operations in parallel. These components are later assembled into finished products in assembly lines. Assembly systems are capable of producing a high variety of finished products by assembling different combinations of produced components. These types of manufacturing settings are referred to as Assembly Scheduling Problems (ASP). Tozkapan et al. [1] presented a two-stage assembly scheduling problem with the objective function of minimizing the total weighted flow time. Later, Al-Anzi and Allahverdi [2] addressed the model presented by Tozkapan et al. [1] minimizing the total completion time of all the jobs and proposed metaheuristics to solve it. A small extract of the many existing papers in this regard are presented here.

Distributed Manufacturing Systems (DMS, [3]) consist of several factories with different machines and tools at different geographical locations. It is one of the effective approaches to improve the levels of flexibility, reconfigurability and productivity of the manufacturing systems and to remove the traditional manufacturing systems weakness and bottlenecks in order to meet the aforementioned challenges ([4]). Different research results (e.g., [5], [6], [7], [8]) have shown that DMS achieve better product quality, lower production costs and reduced management risks for the system. From the viewpoint of the manager, scheduling in DMS is more complicated than the scheduling of a single manufacturing factory. In DMS, the first decision that has to be made is to select a factory for each job and then determine a job schedule for each factory, while for a single manufacturing system only a job schedule for each set of machines has to be determined.

A Distributed Permutation Flowshop Problem (DPFSP) for
This session aims to highlight some different research areas with regards to the reliability and maintenance problems.

Some topics developed in this session:

• Test Planning and failure Distribution Data.
• Optimization and Maintenance under Stochastic Conditions.
• Proportional Hazards Modeling
• Multi-objective particle swarm optimization for preventive maintenance.

Presented papers

• Reliability Growth Test Planning of Repairable Systems Using Subsystem Failure Distribution Data
• Optimization of Power Generation and Maintenance for a Wind Turbine under Stochastic Climatic Conditions
• Cox Regression Model Applied to Pitot Tube Survival Data
• Multi-objective optimization for Periodic Preventive Maintenance
Reliability Growth Test Planning of Repairable Systems Using Subsystem Failure Distribution Data
(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4e2 2015

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Abstract— Reliability growth testing has been widely used for assessing the reliability of complex systems in the automotive, aerospace, and oil and gas industry. The traditional common and practiced approach of RGT is to assess the initial reliability of the system by building and testing few prototypes for a period of time that extends from few months to years. Based on the initial reliability, initial testing time, and reliability target; the total testing time is determined using power law based models such as Dune and AMSAA/Craw models. Although this approach has been used for many years, it has been challenged by project managers (PM’s) since it hinders them from planning upfront the time and cost it takes to finish RGT and commercialization.

A new alternative to traditional RGT planning using non-repairable component failure distribution data for system initial reliability assessment is proposed in this article. The proposed method will be demonstrated using real-life example of hydraulic system composed of several non-repairable subsystems with different failure distributions. The proposed method provides practitioners a mean to estimate total testing time required for RGT plans.

Keywords— Reliability Growth Testing; Duane; Repairable systems;

I. INTRODUCTION
Reliability Growth Testing (RGT) is a valuable tool to measure product reliability improvement either through planned and dedicated testing or through gradual upgrade and improvement of the fielded product [1]. RGT involve planning and execution of test plans, data collection, modeling, fixing, and re-testing to validate reliability requirements of products or systems. The majority of RGT models are either based on Duane empirical graph model, or AMSAA/CROW model which is considered to have higher mathematical fidelity than Duane [2]. Both models are based on the non-homogenous Poisson process (NHPP) assumption which can be modeled using the power law model. Mathematically, this means that the expected number of failures $E[N(t)]$ at some test time $t$ can be fitted through a power model such as Weibull shown below:

$$E[N(t)] = \theta t^\beta$$

where $\theta$ and $\beta$ represent the system Weibull scale and shape parameters respectively, the failure intensity or failure frequency at time $t$ can be represented by $u(t)$ as shown in equation 2 below:

$$u(t) = \beta t^\beta-1$$

Depending on the value of the shape parameter $\beta$, the failure rate can be decreasing over time (reliability grow) or constant, or increasing (reliability decay). Scale and shape parameters of the intensity function can change only if a hardware or software change is imposed on the system which will change the system reliability performance. For a repairable system following NHPP process, the probability that a system of age $t$ fails between $t$ and $t + \Delta t$ is given by the intensity function $u(t)\Delta t$. Unlike component probability of failure, repairable system probability of failure is not conditioned on no-system failure up to time $t$.

II. PROBLEM STATEMENT
To plan an RGT test for a system, initial values for $\beta$ and $\theta$ are assumed to be known at some initial time $t_i$. These initial values are obtained based on previous experience of a similar product or after engagement of system testing for some time. The AMSAA/CROW planning model is one of the most popular models and calculated as a function of the initial and desired failure frequency as shown in equation 3:

$$u(t_f) = u_i \left(\frac{t_f}{t_i}\right)^{\alpha+1}$$

Hence, the required testing time to demonstrate a certain failure frequency is:

$$t_f = \text{Exp} \left( \frac{\ln(u_f) - \ln(u_i)}{\alpha-1} + \ln(t_i) \right)$$

The model in equation 3 above uses a growth rate parameter $\alpha$ which represents the rate of reliability improvement, or failure rate reduction. Mean time between
Optimization of Power Generation and Maintenance for a Wind Turbine under Stochastic Climatic Conditions

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Abstract—This paper presents an optimal integrated energy production and maintenance policy for a wind turbine under stochastic climatic conditions. A mathematical cost model is developed in order to determine, for a given random demand over a finite horizon and a required service level, the amount of energy to be produced and periodic preventive maintenance to be performed on the wind turbine. The model takes into account the influence of stochastic climatic conditions on the wind turbine failure rate. Costs related to operations and maintenance are considered along with energy storage capacity. Obtained numerical results illustrate the use of the proposed model.

Keywords—renewable energy; stochastic climatic; reliability; Management decision-making; operations; maintenance; service level.

I. INTRODUCTION

Nowadays, in response to economic growth and continuously increasing power demand, power generation systems using renewable energy sources have become increasingly complex. This high complexity is due to the need to make energy economically available with reduced carbon emission [1]. In this context, the wind and solar energies are considered among the renewable energies that have become the most efficient to achieve sustainable development. The technology and equipment used for wind power generation are generally operated under more or less stationary conditions. For example, wind turbines suffer from stochastic loadings. [2] and [3] showed that the wind speed varies from season to season and day to day. Theses stochastic factors will influence the degradation of equipment that becomes rather complex. [4] presented the factors that influence the reliability deterioration of such systems. They noticed that there is a seasonal and spatial variability of wind in a significant part of the year. This yields low equipment availability leading to an increase in unserved energy. In addition, performing preventive and corrective maintenance actions is constrained by the random variation of climate.

Maintenance strategies in the energy production sector have been studied by several researchers. [11] examined an optimal maintenance policy for wind turbines operating under stochastic weather conditions. The objective of their study is to derive an optimal preventive maintenance policy that minimizes the expected average cost over an infinite horizon based on the information collected from sensors. [5] presented deterministic and stochastic maintenance optimization approaches for wind turbines and nuclear power plants. [6] determined a deterioration model using a Markov chain and optimized the maintenance costs for hydro power plants using a Monte Carlo simulation. [7] and [8] take into account the influence of seasonality and weather on optimal maintenance. They use dynamic programing and a partially observed Markov process. In the same context, [9] studied the maintenance optimization problem in the case of wind power generators. The authors provide an extensive overview of approaches in which the delay-time model is used for optimizing the inspection intervals.

Recently, [10] presented a stochastic model to estimate the effects of different maintenance strategies on wind turbine availability as well as operations and maintenance costs, and production losses due to turbine downtime. The authors used a field-data based reliability analysis method (Reliability-Centered Asset Maintenance (RCAM)).

Several studies worked on the critical stochastic factors which affect the operations and maintenance (O&M) costs of wind turbines. The first factor is weather conditions, which may constrain the feasibility of maintenance actions. The second factor is repairing interruption and delay. The third factor is long lead time for gathering maintenance crews, and obtaining spare parts, which also significantly affects wind turbine downtime.

We can also note [11] that presented the effects of several factors such as the age, the size and the location of the turbine. The authors discuss key performance indicators in wind turbines management.

Motivated by our previous work [12], in which we proposed an integrated production and maintenance model for wind turbines, this work investigates the possible impacts of stochastic climatic conditions on the degradation rate of wind turbines in the perspective of establishing an economical
Cox Regression Model Applied to Pitot Tube Survival Data

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © 1982 1985

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Abstract—The Pitot tube is a pressure measurement sensor used to measure flow fluid velocity. Cox proportional hazard model is widely used in analysis of time to event data. Model is applied to study the probability of failure of a component at different times. The idea of the model is to define this probability as a product between a baseline hazard function and covariates-related component. In this paper, we develop proportional hazard models to estimate Pitot tube reliability and hazard rate in a finite time horizon. The reliability estimated function is used after to define the optimal number of preventive maintenance actions in a finite time horizon. Two groups of models are considered: first group ignores interactions between covariates and the second takes these interactions into account.

I. INTRODUCTION

Survival analysis is a class of statistical methods for studying the occurrence and timing of events and is useful for studying several kinds of events in social and naturel sciences. Many proposals for modeling the reliability and the aging of equipment can be found in the literature [1],[2],[3]. In some cases, the reliability model considers only the effect of the operational conditions. Instead, others consider only the effect of maintenance actions on the equipment. Proportional hazard model is one of the most common models introducing the above factors into the components reliability model. Regression models for survival data have traditionally been based on the Cox regression model. Cox’s proportional hazard model proposed by David Cox 1972 [4] is widely used in analysis of time to event data. Cox assumed a semi parametric form for the hazard function of the distribution of the failure time T. The Cox proportional hazards model specifies that:

\[ \lambda(t, X) = \lambda_0(t) \cdot e^{(\beta \cdot X)} \]  

(1)

Where X denotes a row vector of n measured covariates, \( \beta \) is a column vector of n regression parameters and t is the associated failure time. \( \lambda_0(t) \) is an arbitrary unspecified baseline hazard function for \( (X = 0) \). In this model, the covariates act multiplicatively on the hazard function. The reliability function is specified by the following relationship:

\[ R(t, X) = \left( \frac{1}{\lambda_0(t)} \right)^{e^{(\beta \cdot X)}} \]  

(2)

Where \( R_0(t) \) is the baseline reliability function.

If the choice of \( \lambda_0(t) \) is arbitrary, the Cox Model is sufficiently flexible for many applications. There are, however, two important generalizations that do not substantially complicate the estimation of \( \beta \). First, base line hazard function can be allowed to vary in specific subsets of the data. The second important generalization allows the regression variable X to be time dependent. Proportional hazard model has been extensively used with regard to inferential problems. Dale [5] demonstrates the advantages of using the proportional hazard model in failure time data analysis and recommends his application in the reliability field. Cox [6] proofs that his proportional hazard model is also convenient for studying the interactions between covariates. Regression modeling time to event data was the interest of many studies. Many proposals can be found in the literature for studying extensions of the Cox model for Proportional and Non Proportional purpose [7], [8]. A preventive maintenance (PM) model describes the effect of preventive maintenance activities. Several models assume that the action of preventive maintenance is perfect and it restores the system in a state As Good As New. In this context, the most recent proposals defining maintenance policies based on perfect preventive maintenance actions are those of Hajjej et al. [9]. Imperfect maintenance has also permitted to define new maintenance policies. The most known policies are those of Nakagawa [10] and Wang [11]. Planning the preventive maintenance actions in a finite time horizon was the interest of many proposals. Schutz et al. [12] defines a periodic preventive maintenance policy in a finite horizon based on the optimization of maintenance actions costs. This paper focuses on modeling the Pitot tube hazard and reliability functions. The model is based on the Cox proportional hazard model. Once the model is established, one can define the optimal preventive maintenance policy for the Pitot tube system.

II. PROPORTIONAL HAZARDS MODEL

The idea of the model is to define hazard level as a dependent variable explained by the time-related unknown component called baseline hazard and covariates-related component. Cox model is based on several restrictive assumptions. The most important is the assumption of proportional hazard that the name of the model refers to and which results directly from the Hazard Ratio RH defined as follow:

\[ RH = \frac{\lambda(t, X_1)}{\lambda(t, X_2)} = \frac{\lambda_0(t) \cdot e^{(\beta \cdot T \cdot X_1)}}{\lambda_0(t) \cdot e^{(\beta \cdot T \cdot X_2)}} = e^{\beta(X_1-X_2)} \]  

(3)
Multi-objective optimization for Periodic Preventive Maintenance

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Abstract— This article investigates a JIT single machine scheduling problem with a periodic preventive maintenance. Also to maintain the quality of the products, there is a limitation on the maximum number of allowable jobs in each period. The proposed bi-objective mixed integer model minimizes total earliness-tardiness and makespan simultaneously. Due to the computational complexity of the problem, multi-objective particle swarm optimization (MOPSO) algorithm is implemented. Also, as well as MOPSO, two other optimization algorithms are used for comparing the results. Eventually, Taguchi method with metrics analysis is presented to tune the algorithms’ parameters and a multiple criterion decision making (MCDM) technique based on the technique for order of preference by similarity to ideal solution (TOPSIS) is applied to choose the best algorithm. Comparison results confirmed supremacy of MOPSO to the other algorithms.

Keywords— scheduling; single machine; periodic maintenance; total earliness-tardiness; multi-objective optimization; MCDM

I. INTRODUCTION.

Most of the manufacturing organizations try to implement some of the ideas adopted by Just in Time (JIT) philosophy, like on time delivery or minimum inventory [1]. In this paper we introduce and formulate a JIT single machine scheduling problem with a periodic preventive maintenance on the machine. In most of the scheduling problems it is assumed that the machine is available interruptedly while, in practice, it may be unavailable due to causes like breakdown or preventive maintenance. According to the British Standard Institute (BSI), “Maintenance is a combination of any actions to retain an item in, or restores it to an acceptable condition” [2]. Periodic preventive maintenance, which is a fundamental part of JIT production, consists of regular preventive measures to increase machine reliability and to decrease breakdown probability during manufacturing process. In some of the manufacturing processes, overuse of the tool might decrease quality of the work piece. Therefore, when the work piece is expensive or when the accuracy is necessary, we change the tool before it is amortized. A well-known example is the printed circuit board manufacturing process in which the drilling machine is one of the most important devices. Thus not only should the machine stop to maintain after a period of processing time, but also the machine should stop to change the micro-drill after fixed times of using. Accordingly, the proposed model holds a limitation on the maximum number of processed jobs during each period. The objective of the proposed bi-objective mixed integer model is minimizing total earliness-tardiness costs and makespan simultaneously

Machine unavailability problem has been investigated in the literature due to causes like machine breakdown, tool change or preventive maintenance. Machine breakdown or product quality loss is probable when a machine continues to work unceasingly for a long time. To avoid this situation, preventive maintenance is conducted on the machine which may be periodic or flexible [3]. In a flexible maintenance the earliest and latest start time are determined and the maintenance process is allowed to start during this period. Yang et al. were the first to study a single machine scheduling problem with a flexible maintenance [4]. They investigated the problem to minimize makespan and provided a proof for NP-Hardness of the problem. Qi et al. [5] studied a problem in which multiple maintenance processes and jobs are to be scheduled on a single machine. They proposed heuristics as well as Branch and Bound based approaches to determine the sequence of jobs and maintenance start times while total completion time is minimized. Furthermore, Chen proposed a mixed binary integer programming and a heuristic to minimize mean flow time [6]. Also, Wan [7] investigates on minimizing total earliness and tardiness in a single machine scheduling problem with a common due date for all jobs and a flexible maintenance. Luo et al. proposed polynomial algorithms for a single machine scheduling with flexible maintenance and various objective functions [8]. Low et al. studied a single machine scheduling with flexible maintenance under two strategies, the first one was the flexible maintenance and the
This session aims to highlight some different research areas with regards to the reliability and maintenance problems.

Some topics developed in this session:

- Risk assessment and dynamic risk modeling;
- Preventive maintenance scheduling and production;
- Production planning;
- Reliability assessment and failure rate factor;
- Prediction system and volunteer computing system.

Presented papers

- Cross-correlation analyses toward a prediction system of CPU availability in volunteer computing system.
- Reliability assessment based on energy consumption as a failure rate factor
- Modelling a large scale system for risk assessment
- Dynamic risk modeling and assessing in maintenance outsourcing projects with FCM
- Generalizing of the integration of noncyclical preventive maintenance scheduling and production planning for a series-parallel production line
Cross-correlation analyses toward a prediction system of CPU availability in volunteer computing system

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Abstract—Computing resources in volunteer computing grid represent a big under-used reserve of processing capacity. However, a task scheduler has no guarantees regarding the deliverable computing power of these resources. Predicting CPU availability can help to better exploit these resources and make effective scheduling decisions. In this paper, we draw up the main guidelines to develop a method to predict CPU availability in a large-scale volunteer computing system. To reduce solution time and ensure precision, we use simple prediction techniques, precisely Autoregressive models and tendency-based strategy. To address the limitations of autoregressive models, we propose an automated approach to check whether time series satisfy the assumptions of the models and to construct the prediction model. At each prediction, we consider autoregressive models over three different past analyses: first over the recent hours, second during the same hours of the previous days and third during the same weekly hours of the previous weeks. We analyze the performance of multivariate vector autoregressive models (VAR) and pure autoregressive models (AR), constructed according to our approach, against the tendency prediction technique. We study the impact of the cross-correlation between the CPU availability indicators on the performance of VAR models. We used traces of a large-scale Internet-distributed computing system, termed seti@home.

Keywords—CPU availability prediction; distributed computing system; multivariate time series; cross-correlation; subseries extraction

I. INTRODUCTION

Computers, especially desktops, connected to the Internet represent a considerable reserve of computing resources. These resources are idle for most of their time. Volunteer computing systems aim to harness this extensive number of underused computers and to reach high computing throughput. While these world-wide distributed resources are heterogeneous, unreliable and belong to independent administrative domains, appropriate middleware are deployed to aggregate, on-demand, the unused processing power. Tasks, submitted to a volunteer computing system by independent users, should be scheduled on the appropriate computing resources. However their availability, for volunteer computing system usage, is highly variable depending on demand, owners' behavior, their time zones, their location at home, school or work, etc. [27, 12]. Consequently, the scheduler has no availability or speed guarantees. The scheduling optimization in such environments requires forecasting the future CPU resource availability.

A review of related work shows that there is no single prediction model which is optimal for all the considered CPU time series [21, 15, 4, 26, 25]. Consequently, due to the diversity of the world-wide distributed resources, the precision is not always ensured using a single predictor. So, the optimization of the prediction, for the whole computing grid, requires a prediction system which automatically selects the appropriate predictor for each CPU resource among several integrated predictors. However, usual prediction systems are time consuming and consequently inappropriate to large-scale computing infrastructures [21]. Besides, most comparative empirical studies are carried out using their specific and limited sets of CPU time series, not necessarily obtained from large scale volunteer systems [8, 22, 16, 23, 5].

Earlier characterization study on distributed hosts revealed that CPU load is strongly correlated over time [7]. Recent researches showed that some CPU of the grid exhibit random or auto-correlated behavior of availability or a combination of both of them [27, 12]. Thereby, considering these characteristics, time series models were used in many works to predict CPU availability [8, 16, 4, 14, 25]. Vector autoregressive models (VAR) have been shown to be among the simplest prediction models considering both autocorrelation and cross-correlation between multivariate time series [18, 25]. Like pure autoregressive (AR) models, VAR models assume that time series are stationary. However, this assumption is not always fulfilled mainly because of trends and seasonality.

In this work, we are particularly interested in predicting CPU availability of computing resources in large-scale volunteer computing systems. For each computing resource, we predict precisely two CPU availability indicators (i.e. variables) that are the number and the mean duration of CPU
Reliability assessment based on energy consumption as a failure rate factor

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Abstract— The present study defines a methodology to analyze the relationship between the failure rate of any component and the factors that can influence it, in order to link time independent operating variables to the reliability study. Characterizing the failure rate using these variables is especially useful for changing time operational contexts. To do this, a study of traditional and modern methods of analysis, together with the assumptions that must be fulfill for its implementation and the methodology for testing the assumptions is performed. Specifically, the methodology proposed in this paper is used to develop a complete study of the influence of the energy consumption of a component, at the rate of engine failure. As can be inferred, there is a relationship between energy consumption and the rate of failure; the practical experience reveals that companies frequently use the energy expenditure variable, but documented studies that corroborate their decision are not found in the literature

Keywords—failure rate, reliability, energy, maintenance, methodology

I. INTRODUCTION

Knowledge about the reliability of a system, takes a very important role, as it provides the availability for the exploitation that can be performed over a manufacturing equipment, a mining asset, etc. Having a clear knowledge of the amount of time the equipment will be available, it is possible to determine the actual production capacity, the amount of products to be manufactured and therefore, the potential income received by the company. Understanding the impact of reliability in production and operations, the importance of estimating the time that the component will fail (behavior of the failure rate) is understood, as well as for plans of preventive and corrective maintenance to run [1].

The study of the failure rate of the systems, composed of arrangements of elements, depends on the reliability of their components. Systems consist of a large number of components, and in many cases, it is enough that one of them fails to make the system becomes disabled, creating opportunity costs and other associated losses [1].

Due to the importance of studies in this area and knowing that there are a number of factors that can affect the reliability of systems, this paper proposes a methodology to develop a model of the failure rate, based on all the variables in the system that affect their performance. Historically, the variable used to study the behavior of the failure rate has been time [1], so it has been detected a gap in the literature regarding models that consider the impact of other variables that characterize the operational differences between equipments [28]. Specifically, this study focuses on a methodology to study the relationship between the energy consumption of a system and the failure rate of the components. In many cases, the reliability is correctly explained by the operation time, and the operation time is directly correlated with the energy consumption. However, there are several cases, such as the large mining trucks, included in the case of study, where this correlation is not as straightforward because of the large variability of the operational conditions in different mining sites. In some open-cast mines, the maximum slope is 12°, while in other mines it exceeds 35°. There are also factors such as altitude, which in some cases is near 4,000 meters above sea level, the characteristics of the manufacturing process, the presence of moisture and oxygen in the air, etc. These factors make that the operation interval measured in time on a task, it could be not necessarily comparable to the same period in another location. This justifies the search for measuring other variables, beyond time, to model wear and reliability of the elements. The proposed methodology, involves the analysis of operational
Modelling a large scale system for risk assessment
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Abstract—The aim of this communication is to present an earlier study of how to structure modelling process of complex and large scale systems for risk assessment and management purpose. The approach, in a first stage, uses ontology paradigm to determine variables (or concepts) characterizing system locally and the nature of relationships relating them and, in a second stage, object oriented Bayesian network (OOBN) to characterize the strength of these relationships in terms of conditional probabilities tables given that one of main feature of complex systems is the uncertainty that affect the relationships between different variables. A case study in the domain of risk assessment of flash floods effect on the infrastructures inoperability is considered to show potential applicability of the developed approach.

Keywords—complex systems; interdependency; modelling; ontology; OOBN

I. INTRODUCTION

Capabilities of many systems (transportation infrastructures, energy and water supply infrastructures, communication infrastructures, production infrastructures, financial infrastructures, etc.) that facilitate modern life in many ways are highly interdependent, complex and evolve on a large scale. Within this context, disturbances of any entity in such formed network is likely to affect other entities by risk propagation mechanism. Integration of risk factors in decision making or risk informed decision making is receiving a great attention by researchers and decision makers in many domains such as engineering (designing technical systems that meet some requirements in terms of quality), finance (setting up norms to monitor finance activities in order to avoid companies collapse), environment (developing sustainable agriculture and natural resources extraction actions), science and medical research (monitoring scientists activity by the society to avoid creating new threats); because national and international opinions are being more and more concerned by risk issues from all human activities as well as natural phenomena (earthquake, hurricane, tsunami, floods, etc.). Risk comes from the incapacity of human beings to correctly predict the outcomes of some events from the environment of the system under consideration or their actions on this system. Indeed, risk and uncertainty are fundamental elements of modern life so they must be addressed properly to protect people from injury. Today an ever-increasing number of professionals and managers in industry, government, and academia are devoting a larger portion of their time and resources to the task of improving their approach and understanding of, risk-based decision making. Indeed, decision-making under uncertainty (risk) literally encompasses every facet, dimension, and aspect of our lives. Any decision maker needs to cope with uncertainty in order to rationally act in the sense of risks reduction. To correctly and scientifically address risk management process that is assessing, filtering risk factors, selecting and prioritizing appropriate actions, one needs to dispose of sound models able to reproduce the functional and dysfunctional aspects associated with an anthropic or natural system. These models should permit manager to take decisions of three types: pre-active decisions, these decisions consist in doing things to prepare the system under consideration to face potential adverse events (one knows that such events will occur soon or later). Actions such as transferring risk by contracting insurances, editing anti-seismic construction norms in the case of natural disasters, preparing population on how to behave in the case of an earthquake, constructing and organizing emergency facilities, etc. are proactive decisions. One may need also need reactive decisions that are real time decisions to be made when the undesirable event does really occurs and pro-active decisions that consists in doing things to avoid the occurrence of catastrophe when possible for instance [1]. This necessity of disposing of sound models is of great importance in the case of complex interdependent systems evolving on a large scale. The remainder of this communication is organized as follows: in the second section, main features of complex interdependent systems are briefly presented together with the necessity of disposing of a structured tool for the modelling process; section three presents a state of the art on ontology and object oriented Bayesian network (OOBN) approaches as structuring tools that can potentially respond to our needs; and finally section four considers applying these approaches for modelling flash floods phenomena in order to assess risk faced by infrastructures in zone where these phenomena take place.

II. COMPLEX SYSTEM

A. Main features of a complex system

A complex system is constituted by many entities, components or variables with mutual relationships. The complexity is exacerbated by the uncertainty that may affect these relationships. The behavior of the system is highly unpredictable without a sound model. The purpose of this communication is therefore to develop an approach that can be used for the modelling of complex systems with the ultimate purpose to assess the risk facing some components of the systems when one of the components is destabilized by an external event for
Dynamic risk modeling and assessing in maintenance outsourcing with FCM

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Abstract—Maintenance outsourcing is a common practice in many industries, such as aviation and medical equipment manufacturing. However, there is always some dynamic risks associated with outsourcing. Risk analysis of maintenance outsourcing projects is a complex task due to consisting of many risk factors with dependencies among them. Although there are some studies on maintenance outsourcing risks, no attention has been paid to the risk analysis of maintenance outsourcing by considering the dependencies among risk factors. Considering the dependencies among risk factors could lead to more precise risks analysis and increase the success rate of outsourcing projects. To address this, we are proposing an advanced decision support tool called “Fuzzy Cognitive Maps” (FCM) which can deal with risks of such complicated systems. FCM represents the behavior of complex systems accurately and is able to consider uncertainties, imprecise information, the interactions between risk factors, information scarcity, and several decision maker’s opinions. In addition, it could be applied in different decision making problems related to outsourcing projects such as provider selection problem. Therefore, the proposed tool would help practitioners to manage maintenance outsourcing risks in a more effective and proactive way and offer better risk mitigation solutions.

Keywords—Risks analysis; Maintenance outsourcing; Fuzzy cognitive maps; Aviation; Medical equipment.

I. INTRODUCTION

Outsourcing is comprehensively used by many U.S. companies. Two common examples of the practice are outsourcing IT jobs to India and outsourcing product manufacturing to China [1]. However, outsourcing does not guarantee business success. While outsourcing is a powerful tool to cut costs, improve performance, and refocus on the core business, it is associated with some major risks including; (1) outsourcing activities that should not be outsourced; (2) selecting the wrong vendor; (3) writing a poor contract; (4) overlooking personnel issues; (5) losing control over the outsourced activity; (6) overlooking the hidden costs of outsourcing; and (7) failing to plan an exit strategy (i.e., vendor switch or reintegration of an outsourced activity). Outsourcing failures are rarely reported because firms are reluctant to publicize them [2]. Maintenance outsourcing is one of the best solutions or strategies available for each company that can lead to greater competitiveness and it has a major part to play in the design, installation and commissioning of an asset, and is instrumental in driving post commissioning improvements. In terms of maintenance outsourcing, a set of potential and attractive benefits can be reached such as to increase labour productivity, to reduce maintenance costs, to focus in-ho use personnel on “core” activities, to improve environmental performances, to obtain specialist skills not available in house, to improve work quality, etc. [3].

However, maintenance outsourcing is a complex arrangement associated with uncertainties in dynamic business environments. This uncertainty and complexity could lead to critical risks that can impact on the enterprises’ performance. Risk evaluation of maintenance outsourcing is a complex and critical task since several tangible and intangible risk factors should be considered in this process. In addition, there are always some dependencies among risks that can influence each other mutually and these dependencies make the evaluation process more complex and challenging. Therefore, an effective method for evaluating the risks is fundamental and essential. Many
Generalizing of the integration of noncyclical preventive maintenance scheduling and production planning for a series-parallel production line

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\textbf{Abstract}—In this paper, we propose to generalize the model of the integration of noncyclical preventive maintenance scheduling and production planning from a single machine to a series-parallel production line. As in the case of a single machine, we consider, a set of products that must be produced in lots during a given horizon. As maintenance strategy, we consider the possibility of preventive replacements at the beginning of each period (maintenance period), and minimal repair at machine failure. The model addressed determines the optimal production plan and preventive remplacement for each component of the series-parallel production line. The objective is to minimize the total cost consisting of preventive and corrective maintenance costs, setup costs, holding costs, backorder and production costs, while meeting the demand of each product over the entire horizon.

\section{I. INTRODUCTION}

Production scheduling and preventive maintenance planning are certainly among the most important challenges facing the industry. It is true that for some production systems, it is possible to perform some maintenance actions during production. However, most production systems need to be shut down to perform maintenance. Thus, coordination between production and preventive maintenance is no longer a choice but an obligation for each company. Indeed, a poor planning of preventive maintenance combined with random shutdowns of production lines lead to a loss in availability and therefore a loss in productivity. Unfortunately, this increases the probability that the company does not meet its commitments in terms on due dates and therefore lead to potential loss of customers. In practice, production is planned optimally regardless of preventive maintenance. This separation between these two fields can lead to conflicts (unsatisfied demand in production due to the interruptions resulting from the preventive maintenance or random shutdowns) when the two planes are executed.

\section{II. LITERATURE REVIEW}

Many researches have addressed separately production and maintenance decisions. Pierskalla and Voelker \cite{Pierskalla1975} have examined different models which involve an optimal decision to procure, inspect, and repair or replace items with stochastic failure. Thereafter, in the early nineties, another interesting survey was presented by Cho and Parlar \cite{Cho1994} where they discuss optimal maintenance and replacement models for multi-unit systems. Garg and Deshmukh \cite{Garg1995} have proposed a classification of modelling approaches related to maintenance planning. Recently, Aghezzaf et al. \cite{Aghezzaf2003} have proposed an iterative solution procedure consisting basically in calling the mixed integer solver of CPLEX to deal with production planning model once the maintenance periodicity has been fixed. The authors have considered cyclical preventive maintenance with minimal repair at failure. An extension of this work presenting an approximate algorithm based on Lagrangian decomposition has been treated in Aghezzaf and Najid \cite{Aghezzaf2010}. Very few studies have focused in integrating production and preventive maintenance decisions for multi-state systems (i.e. systems able to perform their task with partial performance, more details are given in Lisnianski and Levitin \cite{Lisnianski2002}), for instance, see Nourelfath et al. \cite{Nourelfath2005} where the authors suggest cyclical preventive maintenance policy.

However, few works make a state of the art on the combination between production planning and maintenance. To the best of our knowledge, the book edited by Rahim and Ben Daya \cite{Rahim2005} and the report Budai et al. \cite{Budai2011} are the only works presenting a survey of integrated model in production planning and maintenance. Lately, Chouhan et al. \cite{Chouhan2012} have discussed and summarized in their survey a variety of existing maintenance policies adapted to a single and multiple-units systems. To the best of our knowledge, the only works that deals with general preventive maintenance in the sense that it can be either
According to the Organization for Economic Cooperation and Development (OECD) countries, total expenditures on health services is constantly growing. Health structures are increasingly facing changing health demands and economical and political pressure.

The objective of this session is to discuss health care systems and new and efficient decisional and optimization techniques to improve healthcare services. Both, scientists and practitioners were invited to present their research in the areas of healthcare systems management and optimization.

Topics for the session include the following:

- Home health care: Routing caregivers problem, home health care resources assignment problem, ambulatory surgery, etc.
- Health care services management: Patient flow management, Scheduling (staff, operating room, emergency, etc), Health disaster management, etc.
- Forecasting and optimization: Approaches to forecasting in health care operations, locating health care services, health care services simulation, etc.

Presented papers:

- *Early Detection of Abnormal Patient Arrivals at Hospital Emergency Department*
- *Modeling and analysis of triage nurse ordering in emergency departments*
- *Comparing feature selection methods for high-dimensional imbalanced data: identifying rheumatoid arthritis cohorts from routine data*
- *Detection and Analysis of Tremor Using a System Based on Smart Device and NoSQL Database*
- *Hospital’s Vulnerability Assessment*
- *Optimal bed-control in an ICU when elective patient’s arrivals are known. A simulation-based optimization approach*
Early Detection of Abnormal Patient Arrivals at Hospital Emergency Department

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Abstract—Overcrowding is one of the most crucial issues confronting emergency departments (EDs) throughout the world. Efficient management of patient flows for ED services has become an urgent issue for most hospital administrations. Handling and detection of abnormal situations is a key challenge in EDs. Thus, the early detection of abnormal patient arrivals at EDs plays an important role from the point of view of improving management of the inspected EDs. It allows the ED managers to prepare for high levels of care activities, to optimize the internal resources and to predict enough hospitalization capacity in downstream care services. This study reports the development of a statistical method for enhancing detection of abnormal daily patient arrivals at the ED, which able to provide early alert mechanisms in the event of abnormal situations. The autoregressive moving average (ARMA)-based exponentially weighted moving average (EWMA) anomaly detection scheme proposed was successfully applied to the practical data collected from the database of the pediatric emergency department (PED) at Lille regional hospital center, France.

I. INTRODUCTION

Nowadays, with the growing demand for emergency medical care, the management of hospital emergency departments (EDs) has become increasingly important [1], [2], [3], [4]. The anticipation and/or management of patient influx is one of the most crucial problems in emergency departments (EDs) throughout the world. To deal with this influx of patients, EDs require significant human and material resources, as well as a high degree of coordination among human and material elements [5]. Unfortunately, these resources are limited. The consequences of this influx of patients has resulted in problems of ED overcrowding [6]. Consequently, EDs managers need to continuously monitor the ED behaviour and abnormal situations that may be occurs by using control strategies. These strategies may help managers to control the problems related to the demand and to organize resources better.

Handling abnormal situations is a key challenge in building safe and reliable EDs. Detection of abnormal situation plays an important role from the point of view of improving management, reliability, and safety of the inspected emergency department. The purpose of abnormal situation detection is to identify any event indicating a distance from the ED behaviour compared to its normal behaviour. For example, detection of significant patient flows, allows to ED to manage and optimize the internal resources, and to predict enough hospitalization capacity in downstream being able to absorb the occasional flow without pledge the quality of care for patients.

This paper presents statistical technique for detecting signs of abnormal situation generated by the influx of patients at emergency department. The remainder of this paper is organized as follows: Section II briefly describes the state of the art in time-series modelling and SPC-based monitoring techniques. Section III outlines the methodology used for the detection of abnormal situations in EDs. Section IV presents the application of the proposed methodology in the early detection of abnormal patient arrivals at the PED in Lille regional hospital centre, France. Finally, Section V reviews the main points discussed in this work and concludes the study.

II. STATE OF THE ART

This section presents briefly a time series analysis and how it can be used for predicting in a hospital emergency departments, and the monitoring techniques based on the statistical process control (SPC).

A. Time Series Analysis

The literature review shows that time series analysis has been largely applied in the hospital field to forecast the patient arrivals (day, month, year), length of stay, and for projecting the utilization of inpatient days. In this regard, some of the research efforts made by the some researchers deserve mentioning. [7] used three statistical methods (moving average and seasonal decomposition methods) to predict the number of ED presentations at any hour of the week in a university hospital in New Mexico. [8] developed a statistical model for an emergency department at a hospital in Israel based on 3 years of daily time series data. They used a regression model with a linear trend, and 3 types of seasonal factors that represent the effects of the day of the week, the month of the year, and the type of day (holiday, half working day, or full working day). [9] employed two univariate time-series analysis to model and forecast the monthly patient volume over the interval 1986 to 1996 at the family and community medicine primary health care clinic of King Faisal University, Al-Khobar, Saudi Arabia. [10] used Box-Jenkins models for forecasting the number of daily emergency admissions, and...
Modeling and analysis of triage nurse ordering in emergency departments

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Abstract—Emergency departments are facing a worldwide problem that affects their performance, namely Overcrowding. Triage Nurse Ordering appears to be a promising approach in addition to be cost effective. This paper proposes a process-based triage nurse ordering model and assesses its efficiency on the ED performance through simulation while considering the length of stay as the key indicator. The study examines the impact of triage nurse ability, system load and triage time extension on the benefits that might be derived from triage nurse ordering.

Keywords—emergency departments; triage nurse ordering; simulation; length of stay

I. INTRODUCTION

Emergency Department (ED) is the service within hospitals responsible for providing care to life-threatening and other emergency cases over 24 hours daily, 7 days a week. Nowadays, EDs are facing a recurrent worldwide crisis, namely overcrowding. Using various methods, healthcare practitioners and researchers in operations management try to alleviate this overcrowding.

In order to improve ED performance, an extensive body of the literature consists on introducing additional resources (physicians, beds, etc.). This includes either resource allocation issues [1,2,3] or process modification issues [4] such as some interventions in triage (team triage and physician at triage), point of care testing, etc. This is the most direct way to alleviate crowding and improve responsiveness. However, as reported in [5], because it is also the most expensive approach, it is generally not the preferred option. High salaries of doctors and high costs of medical equipments [6,7] combined to budgetary restrictions has prompted practitioners and researchers to investigate new methods that are cost-effective. Among these, Triage Nurse Ordering (TNO) appears to be a promising approach that does not require any resource investment. It can be achieved using existing staff with little additional training [8].

TNO is an advanced triage intervention that consists on allowing triage nurse to order tests and treatments before the patient is seen by the physician [9,10,11]. The common protocol in the ED is that triage nurse cannot order diagnosis tests. He/she is essentially responsible of making a first assessment of patients’ state and categorizing them into different acuity levels. The decision of requiring diagnosis tests or not is traditionally under the responsibility of the ED physician. However, the medical literature suggests that with an appropriate education and training, and adapted protocolled guidelines, triage nurses could be able to order some tests to a level comparable to that of physicians [9,12,13,10]. Diagnostic imaging and laboratory tests are time-consuming processes in the ED that are associated with longest length of stay (LOS) [9,14,15]. If tests are early requested in the triage process, they could be undergone without waiting for the first examination by the ED physician, and test results could be reviewed by the latter as soon as he becomes available.

TNO has been related to enhanced patient satisfaction [16,17,18]. However, “little is known about the effectiveness of this intervention in improving ED time metrics” [8]. Only few medical papers reported that TNO could possibly reduce the ED LOS [19,20,10,18]. As mentioned in [4], there is only limited scientific evidence that having nurses to request certain tests results in shorter waiting time and LOS. Moreover, as highlighted by [8], the existing LOS improvements revealed in the literature may range widely (from 2.45 to 74 minutes). There is a real need to conduct studies that will legitimize the use of TNO in EDS in terms of LOS reduction [9,8].

In the present paper, the objective is to analyze the effect of TNO on ED time metrics taking into consideration the key parameters of such an intervention. We relied on an online survey that we performed with EDs from different countries in order to understand the current practices and obtain specialists’ opinions. The survey’s questions focused on the relevancy of TNO, on which types of diagnosis tests exactly it could be applied and why. This survey helped us to understand the whys and wherefores of this problem in order to delimit the framework and include the most relevant parameters related to TNO in our model. Using simulation, we assess the effectiveness of TNO as a function of triage nurse ability.
Comparing feature selection methods for high-dimensional imbalanced data: identifying rheumatoid arthritis cohorts from routine data

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Abstract— Linkage of routine and administrative databases from multiple sources provides an advantageous form of understanding chronic diseases, such as arthropathy conditions. Data mining classification algorithms can be a cost-effective approach to identify patients’ cohorts with certain disorders within these complex databases. However, selecting good potential predictors, given a certain condition from a patient’s history with huge health records, can be challenging, particularly with small prevalence proportion, which leads to a high-dimensional imbalanced data space. A Feature Selection (FS) methodology is proposed to overcome this problem, providing a fast way to find relevant predictors, improving potentially the performance of the classifiers. This study compared the performance of five FS methods - Binomial distribution, Chi-square, Information Gain, GINI and DKM - using as the exemplar a dataset with routine data from the Abertawe Bro Morgannwg University Health Board (UK) linked to a rheumatoid specialized database (CELLMA) for Rheumatoid Arthritis patients identification. Preliminary results showed that it was possible to reduce an initial list of 36243 possible predictors to less than 200 to obtain a desirable performance in identifying RA patients. Chi-square and GINI selected combinations of predictors with highest accuracy and positive predictive values earlier than the other methods.

Keywords— data mining, feature selection, rheumatoid arthritis, high-dimensional data, imbalanced data

I. INTRODUCTION

Linking electronic records from routine/General Practitioners (GP) and administrative data sources provides a major opportunity to improve our understanding of chronic diseases development and outcomes, such as arthropathy or kidney conditions [1, 2]. Data mining based classification algorithms can be a cost-effective approach to identify patients with certain disorders within these complex databases [3]. However, detecting risk factors/predictors for a certain disease from a patient’s history with large health records can be challenging and time consuming, particularly when the prevalence proportion is small, which results in a high-dimensional imbalance data space. In high imbalanced datasets, the classification algorithms will generally give more importance to the majority class. In medical diagnosis, this can cause serious problems when miss classifying the minority class, which would correspond to the patients having a certain disease. In addition, classifiers’ performance and processing time can be affected negatively when handling high-dimensional data. Therefore, there is a need to identify the appropriate predictors for the minority class before applying a classification technique [4, 5].

A FS methodology can be employed to overcome this problem by selecting a subset of features/predictors that allows the classifier to obtain an optimal performance [6]. FS methods can be divided into separate classes depending on whether they use a learning algorithm to select the subsets, wrapper methods, or if they are embedded in the learning algorithm, embedded methods, or they work independently from the learning algorithm, filter methods [7]. The filter methods score and rank the predictors utilising a defined rule or function relying on certain properties of the data.

FS methods have become increasingly popular as previous step to the use of classifiers or predictive models [3]. However, in most of the studies only one FS method was chosen and therefore there was no comparison with other methods [8, 9]. In the few cases where different methods were compared, authors used embedded FS methods and they only utilised the ranking given by the particular method to select the predictors. Thus there was no performance measure to choose which predictors should be selected from the list [10]. In addition, not basing the cut-off point of the predictors selected on an performance measure could potentially introduce unnecessary process time during the classification if too many predictors are chosen.

Ongoing work by the authors tries to establish a methodological framework to develop and validate data mining
Detection and Analysis of Tremor Using a System Based on Smart Device and NoSQL Database

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Abstract—Tremor is the most common symptoms of Parkinson’s Disease (PD) and Essential Tremor (ET). Its detection and analysis during daily living plays a crucial role in the treatment of PD and ET patients. It is typically assessed in the clinic with certain tremor rating scales, which are qualitative, subject-dependent and do not necessarily reflect the real situation of the patient. In this paper, a system composed of a smartwatch, a smartphone and a NoSQL database sever is used to monitor the movements of the patients. A novel data analysis method is proposed to detect tremor and identify the connected actions. Tremor can be detected on the basis of the movement frequency difference and voluntary actions can also be recognized based on the rich information from the collected data. It helps clinicians to analyze the relationship between the tremor and a certain action. A series of simulated experiments are conducted to demonstrate the feasibility of the proposed system and data analysis method. The result shows that tremor happened during different situations can be detected with an adequate accuracy with the data collected by the proposed system. The actions around the tremor can also be identified.

Keywords: tremor; smart device; NoSQL database; Parkinson’s Disease; Essential Tremor; accelerometer

I. INTRODUCTION

Parkinson’s Disease (PD) is a chronic, progressive, neurodegenerative disorder [1], [2]. It affects the movement of those suffering from the disease and it is typically characterized by a loss of motor function, increased slowness and rigidity [3]. Essential Tremor (ET) is another widely known disorder involving an action/posture tremor. Although ET is not a life threatening disease, it may result in functional disability and social inconvenience [4]. Tremor is the most common symptoms of PD and ET, which is one of the most common movement disorders encountered in clinical practice [5], [6], [7]. Tremor can be defined as a rhythmic shaking [8] or an involuntary oscillation [4] of a body part. The detection and analysis of tremor during daily living plays a crucial role in the treatment of PD and ET patients [9]. Currently, it is usually assessed in the clinic with certain tremor rating scales [2], [10], [11], [12], [13], [14]. While these rating scales have clinical utility, they require the presence of a clinician for scoring, are subject to clinical judgment and bias, and cannot be used for continuous monitoring of tremor fluctuation patterns throughout the day or in home environments [7], [9]. Previously, different methods have been developed to detect and quantify tremor. For example, accelerometers [15], [16], [17], [18], [19], [20], [21], gyroscopes [22], and electromyography (EMG) [23], [24], [25] have been used extensively to obtain quantitative measurements of tremor. Despite of the difference of devices and systems, all of these methods are focusing on the tremor itself. In fact, with the fast development of mobile computing and wearable technology, more information can be obtained to better analyze tremor.

In this paper, a human movement monitoring system based on smart devices and NoSQL databases [26] is used to collect data from individuals with tremor. Besides the tremor data, more related information is also collected with this system, such as the time, the location and the arm angle and so on. Using these data, not only the tremor can be detected quantitatively, but also the actions of the individual when the tremor happened. It is valuable in helping clinicians to find the relationships among different actions and tremor, and then to analyze the cause of tremor. A series of simulated experiments are conducted to demonstrate the feasibility of the proposed system and data analysis method. The result shows that tremor happened during different situations can be detected with an adequate accuracy with the data collected by the proposed system. The action around the tremor can also be identified.

The rest of this paper is organized as follows: an overview of the data collecting system and data analysis method is presented in section 2. The simulated experiments and results are described section 3. Conclusions of the paper are given in section 4.

II. METHODOLOGY OVERVIEW

A. Data Collecting System

The adopted movement monitoring system [26] is composed of three layers: (1) a Pebble smartwatch [27], which contains a tri-axis accelerometer and Bluetooth 4.0, for recording the user’s arm movement data; (2) an Android smartphone for receiving data from Pebble and sending them to remote server after integrated with data collected from the GPS sensor and accelerometer inside the smartphone; (3) a NoSQL data search and analytic engine [28] on remote server for data storage and analysis. The structure of the collected data is as shown in Table I.

All the data collected from the smartwatch and smartphone are integrated in the smartphone and then uploaded to remote server through Internet. On the remote server, Elasticsearch [28], is used to manage the data received from the smartphone. It is a flexible and powerful open source, distributed, real-time...
Hospital’s Vulnerability Assessment

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Abstract—As many public institutions, hospitals are open spaces. Patients, staffs, visitors..., can access a lot of care units without control and can be in contact with many people. The most crowded places are often the most vulnerable areas where terrorist attacks can be the most damageable. This paper proposes an approach to evaluate the most crowded places in order to implement countermeasures against terrorist attacks. Firstly, a static model is constructed using the IDEF0 method in order to identify the different units of a hospital with their processes, and the accesses between units. Secondly by extracting the units and the accesses between the units, a flow model is specified to calculate the traffic in the hospital per hour. A linear program allows us to implement our dynamic model and to evaluate the most crowded areas. This communication relates one of the first results of the CIPS European Project called "THREATS". This project aims to increase the resilience of EU hospitals as a critical infrastructure, by improving their protection capability and security awareness against terrorist attacks.

Keywords—Risk management; IDEF0 method; Linear programming; Defense

I. INTRODUCTION

The THREATS project aims to increase the resilience of EU hospitals as a critical infrastructure, by improving their protection capability and security awareness against terrorist attacks. Its aims are: (1) to develop a reliable method for assessing the risks and vulnerabilities of major EU health infrastructures to terrorist attacks; (2) to prepare specific security and threat assessment models and tools applicable to the Health sector using other EU projects, (3) to challenge these tools through application to the San Raffaele Hospital in Milan, and (4) to disseminate guidelines designed to optimize the preparedness of hospitals’ healthcare infrastructures against terrorist attacks.

Hundred terrorist attacks have been counted all over the world in 43 countries during these last 20 years [1]. Hospitals are an attractive target for terrorists because an attack will produce a large number of causalities due to the large number of patients, of visitors and employees. Furthermore, an attack will receive a large media coverage and it will make a lot of impression among inhabitants. The terrorist attacks are perpetrated by bombs, armed assaults, dispersion of biological agents, chemical agents, radiological agents... They took place: in United kingdom (Musgrave Park British Army Hospital in 1991) where it caused 2 deaths and 11 injured people, in Rwanda (Kigali main hospital in 1994) where 100 persons died, in Russia (Budennovsk hospital in 1995) where it caused 129 deaths and 415 injured people, in Iraq (Tikrit Hospital in 2011) where 11 people were killed and 30 people were injured...

As many public places (Universities, Town-halls, shopping centers...) hospitals are open spaces. Patients, employees, visitors..., can access a lot of care units without control and can be in contact with many people. The most crowded places are often the most vulnerable areas where terrorist attacks can be the most damageable. This communication proposes an approach to evaluate the most crowded places in order to implement countermeasures against terrorist attacks. Firstly, a static model is constructed using the IDEF0 method in order to identify the different units of a hospital with their processes, and the accesses between units that are allowed by corridors, lifts, stairways... Secondly, by extracting the units and the accesses between the units, a flow model is specified to calculate the traffic in the hospital per hour. A linear program allows to implement our dynamic model and to evaluate the most crowded areas i.e. the most vulnerable areas. The tools are part of a generic vulnerability approach.

II. THE STATIC MODEL

A. Methodologies dedicated to Health Care

Since there is no particular modeling approach dedicated to vulnerability analysis, we have listed methodologies coming from industrial management and that were already applied to health care sectors. Among the enterprises’ modeling languages, there are the IDEF family languages that have been developed by the ICAM (Integrated Computer Aided Manufacturing) program. Ducq uses IDEF0 [2] to describe the different processes within a hospital. This method is useful in order to specify the "as-is" situation of a system during a Business Process Reengineering (BPR) approach [3]. UML (Unified Modeling Language) is a standardized specification language for object modeling. It fits for the analysis and design of information systems. It was used by Staccini [4] to create a data model for the blood transfusion process. ARIS, along with ARIS toolset, is an engineering tool based on modeling languages, using a process view. It allows representing the different views of an enterprise (functional, informational, organizational and control) based on different levels.
Optimal bed-control in an ICU when elective surgery patient’s arrivals are known. A simulation-based optimization approach
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Abstract—Early discharge of patients is frequently used as means to control the ratio of rejected incoming patients due to a full Intensive Care Unit. These patient discharge decisions are discussed in the medical literature but few mathematical works have included them in their models. Recently, pioneering works modeled these decisions and obtained different bed-control policies. The so-called cautious policy was accepted by the physicians as the closest one to their own practice. However, this policy does not emerge when the expected Length-of-Stay shortening is minimized. The purpose of this research is to extend the mathematical model including a representation of the real discharge procedures as well as the knowledge of the near-future elective patient’s arrivals from surgery.

Discharge probabilities are modeled by using a logistic function of the number of expected arrivals and the number of occupied beds. To prevent the early discharge of patients not sufficiently recovered the LoS is modeled by using a phase-type distribution with the states representing the health status of the patient. Optimal policies are obtained by a simulation-based optimization methodology. The coefficients of the logistic function are interpreted in terms of odd ratios. Cautious policy is now obtained even when minimizing the expected LoS shortening.

Keywords—healthcare; simulation; optimization; intensive care unit; length of stay.

I. INTRODUCTION

The early discharge of patients has been recognized as a means to control the ratio of rejected incoming patients due to a full Intensive Care Unit (ICU). These patient discharge decisions are already implicit in much of the medical literature analyzing the consequences of premature discharge (see, for example, [1] to [5]). Nevertheless, only very few mathematical models include this decision making process. Simulation models are mathematical models which have been used to analyze different managerial problems in healthcare systems. The reader is referred to [6], [7] and [8] for some reviews in the use of simulation in healthcare. There are also simulation models representing Intensive Care Units with the purpose of analyzing ICU capacity problems ([9], [10] and [11]), the adjustment of staffing to reflect current bed occupancy [12] and the need to optimise the distribution of beds and elective admissions ([13] and [14]). The need to include the patient’s discharge decision-making process in order to get valid simulation models has been expressed in [15]. In [16] the authors carried out a sensitivity analysis of the effects of such discharge decisions on the ICU performance measures: ratio of rejected patients and length of stay (LoS). These pioneering works opened the need to model the way in which medical decisions concerning the discharge of patients are made. First attempts were made in [17] where a set of parameters defining discharging rules were estimated by using LoS and bed-occupancy historical data. As these results were not completely satisfactory from a medical point of view, in a subsequent work the principle of minimum medical intervention was also considered in the associated calibration problem [18]. Efforts to model the patient’s discharge decision process from a normative point of view are made in [19], where the solution of appropriate optimization problems dictates how to proceed to get a fixed ratio of rejected patients while shortening the LoS as minimum as possible. The analysis of the practical implementation of these optimal discharge strategies are discussed in [20].

Three different types of discharge managing rules emerged from those studies, namely, aggressive, equitable, and cautious discharge policies, when considering three different objective functions related with the shortening of the LoS. In aggressive discharge policies the only dramatical increase in the service rate occurs at full occupancy, while, in the other cases, the service rates are moderately (cautious discharge policies) and evenly (equitable discharge policies) increased in all states.
According to the Organization for Economic Cooperation and Development (OECD) countries, total expenditures on health services is constantly growing. Health structures are increasingly facing changing health demands and economical and political pressure.

The objective of this session is to discuss health care systems and new and efficient decisional and optimization techniques to improve healthcare services. Both, scientists and practitioners were invited to present their research in the areas of healthcare systems management and optimization.

Topics for the session include the following:

- Home health care: Routing caregivers problem, home health care resources assignment problem, ambulatory surgery, etc.
- Health care services management: Patient flow management, Scheduling (staff, operating room, emergency, etc), Health disaster management, etc.
- Forecasting and optimization: Approaches to forecasting in health care operations, locating health care services, health care services simulation, etc.

Presented papers

- *Optimization of Dynamic Operating Theatre Facility Layout.*
- *Value Stream Mapping on Healthcare.*
- *A performance evaluation of some collaborative inventory management practices in the healthcare supply chain.*
- *A new optimization approach for a home health care problem.*
- *Risk-based decision making framework for prioritizing patients’ access to healthcare services by considering uncertainties.*
- *New concept of nurse education for service innovation-A perspective of internal marketing.*
Optimization of Dynamic Operating Theatre Facility Layout

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Abstract—The Operating Theater (OT) is known to be a fluctuating production system. The unpredictability of populations’ needs has an impact on the required human and material resources. This makes the Operating Theater a dynamic environment. Thus, use of dynamic models is getting more realistic to solve OT layout problems. The Dynamic Operating Theater Layout Problem (DOTLP) has a main objective, to minimize the interdepartmental travel costs among facilities and to minimize the rearrangement costs, by studying an individual layout for each distinctive period based on patients demand, subject to a set of constraints of distances, available areas, and non-overlapping facilities according to international medical standards and specifications. In this paper, we propose a mixed integer linear programming (MILP) model for solving DOTLP. For this, we generate a set of data to determine the optimal positions as well as the orientations of facilities on several illustrative multi-section Operating Theater cases.

Keywords—Operating Theatre, Facility Layout Problem, Mixed Integer Programing, Multi-section layout, Dynamic formulation, Multi Objective Optimization, Fixed and Variable Activity Layout Problem.

I. INTRODUCTION (Heading I)

The constant and rarely predictable surgical activity progress requiring each time more complex material and technologies, the fight against hospital infections also known as “nosocomial infections” and the continuing growth of population demand for care services are some of the aspects of the evolution of operating theaters in recent years that directly impact on their conception.

The construction of an operating theater is not a frequent process, it may result either from the creation of a new hospital, the renovation of an existing OT or by the grouping of activities on a common Medical-Technique platform. Thus, Layout planning for Operating Theater is a long-term decision that should be taken carefully, because once the construction is done; it is difficult to change it.

Most hospitals in the world are designed using old techniques and their layouts are planned manually. Looking at real-world projects, [13] argues that the planning and design of hospitals is most often based on benchmarks and experiences. Those methods have proven to be inefficient; there is a high cost of maintenance, and poor patient services are usually present.

Hospitals are invited to use intelligent tools as decision-making systems to well design their organizations and specially their OT in order to provide high health care quality for patients at lower cost while maintaining the wellbeing of staff. In literature, this kind of problem is called Facility Layout Planning (FLP).

The Operating Theater Layout Problem (OTLP) consists of a set of n activities or services to be placed on the floor-layout of departments in a hospital. The positions and orientations for each facility must be determined subject to a set of constraints on distances, available areas, and non-overlapping facilities according to international medical standards and specifications [21].

The main characteristic of today’s health care systems is inconstancy. Under such conditions, some parameters as patients demand is not stable and the facilities must be adaptive to demand change requirements. From a layout point of view, such problem requires the use of the dynamic layout planning (DLP).

The dynamic facility layout problem is concerned with the design of multi-period layout plans. We distinguish two type of planning horizon: fixed or rolling one. In planning period of m, rolling horizon consists on replacing the date at the end of period 1, by data for period m+1, and it continues after finishing each period. In contrast, fixed planning horizon just considers the first m period data without any replacement [5].

After some works on the Static Operating Theater Layout Problem [9] & [10]), this work deals with the Operating Theater Layout Problem (DOTLP) and aims to arrange facilities in an effective layout to minimize the traveling building and rearranging costs taking into account the unpredictability of patients demand in different periods. However, the design of DOTLP in hospitals has different objectives beyond classical manufacturing requirements. It aims to find a layout design that reduces operating expenses and the duration of the health care process, enhances the quality of work environment, increases the
Value Stream Mapping on Healthcare
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Abstract—The objective of this paper is to present an overview of the literature published on the use of value stream mapping on healthcare. For that, a systematic literature review was carried out. After reviewing the literature is that several sets of research topics can be distinguished according to the purpose. Those which use value stream mapping as a support to justify improvements in new implemented technologies. Those that describe an experience improvement using Lean environment through the use of value stream mapping. Those which described an experience improvement using value stream mapping, and also propose a new methodology for this implementation in a particular environment. Future lines could extend database research in order to settle/completes the established sets.

Keywords—value stream mapping, systematic literature review, healthcare service management, lean healthcare

I. INTRODUCTION
The value stream mapping (VSM) is one of the main tools in order to plan the implementation of Lean in any environment. Lean is a bound of philosophies, principles, and methods for redesigning organizations to maximize value and minimize waste, thus improving performance [1]. Derives from the Toyota Production System [2] and was popularized in 1990 [3]. Their use in industrial environments is very extended and also has been implemented in other areas, such as software development, information management, service industry, public sector, and product development

In the healthcare area, lean health care is a management philosophy to develop a hospital culture characterized by increased patient, and other stakeholder, satisfaction through continuous improvements, in which all employees (managers, doctors, nurses, laboratory people, technicians, office people etc.) actively participate in identifying and reducing non-value-adding activities (waste) [4]. In this context value stream mapping is an enterprise improvement tool to help in visualizing the entire production process, representing both material and information flow [5]. VSM is a potent tool to reduce patient time in the hospital and traditional management costs [6]. The major benefits of VSM over other techniques are: (1) VSM helps visualize the process using iconic representation; (2) VSM helps identify the sources of waste in the process; (3) VSM shows the linkage between information flow and material flow; and (4) VSM helps form the basis of an implementation plan [7].

VSM begins to be appointed in the late 90s by different authors, but it is not until the emergence of “learning to see” [8] when its use is standardized as nowadays used. In this paper a condensed systematic literature review is conducted about the use of VSM on Healthcare.

II. METHODS
The protocol for the systematic literature review (SLR) has been generated including the following steps: a) Conceptual discussion of the problem; b) Literature review purpose; c) Search strategy; d) Paper selection criteria; e) Single paper analysis; f) Descriptive analysis of the extracted database; g) Synthesis and content analysis. Summary of the phases a) and b) of this SLR is showed in the above section, named introduction.

According to the search strategy, the academic database searched was Web of Science (ISI), concretely Science Citation Index Expanded (SCI-EXPANDED) and Social Sciences Citation Index (SSCI). The key terms researched in the topic of the papers are (HOSPITAL OR HEALTHCARE) AND (VALUE STREAM MAPPING OR VALUE STREAM MAP OR VSM). The topic of the paper includes: title, abstract, author keywords and keywords plus. The time span was all the years. Both this search as the searches realized in the papers reviewed are restricted to papers in English language.

According to the paper selection criteria, the retrieval and assessment of articles for inclusion in the literature review consisted of stages following. Firstly, 29 references was retrieval from WOS database according research strategy. Secondly, the titles and abstract of these 29 articles were screened, excluding 7 papers. The papers excludes are refer to those whose employs another meaning of the word VSM, such as Video Self-Modeling Ventricular septal myomectomy, vertical strips method, VSM MedTech Ltd etc. and those whose uses words value or map but not as a component of the value stream mapping. As a result 22 articles were assessed for eligibility. After a full -text review another 4 articles were excluded. In this stage, the papers excluded presented a descriptive summary of lean tools including VSM approach in

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A performance evaluation of some collaborative inventory management practices in the healthcare supply chain

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Abstract—The work presented in this paper intends to show the impact of collaborative partnerships between the hospitals on the improvement of the healthcare supply chains configurations. In particular, we present an approach that support the implementation of new alternatives for inventory management ranging from the inventory centralization to the emergency lateral transshipment practices within a group of nearby hospitals. This approach was developed around a simulation-based optimization model in order to assess the cost savings and the operational efficiency of these collaborative schemes. The flexibility of our model allows its application to supply chains with different topologies, atypical cost characteristics and various rules for inventory sharing.

Keywords—Collaborative strategies, healthcare supply chain; inventory pooling, emergency lateral transshipment; simulation; optimization; efficiency; cost saving.

I. INTRODUCTION

Over the last decades, healthcare systems have been subject to significant reforms within their governance, their infrastructure and their organization [1]. The improvement of their operational efficiency in terms of added-value activities, high service levels and cost savings becomes a main concern for the authorities, the administrators and the health professionals [2]. Particularly, the decision regarding resources management represents an important issue because it influences both clinical and financial outcomes [3]. The consequent trade-offs among effectiveness, efficiency and equity objectives have fostered the development of new concepts and the adaptation of some industrial tools [4].

Since the hospital operating expense is invested in logistics activities [5], [6], many experts and researchers have been claiming that hospitals would benefit by focusing on effective Supply Chain Management (SCM) practices as an intrinsic part of their organizational strategy [2], [7], [8], [45]. Therefore, the healthcare sector are now facing new logistics trends and is getting to be more and more reticular [9],[45]. New concepts have appeared such as “Healthcare Networks” (HN), “Healthcare Supply Chain” (HSC) or “Collaborative Healthcare Supply Chain” (CHSC) [9], [10], [11], [45]. Indeed, several healthcare structures (public/private) belonging mostly to the same geographical area have resorted to share services, resources or third-party logistics (3PL) providers [9], [10]. Thus, each health organization can be seen as “a node of contracts” striving to achieve a set of common goals within the members of the healthcare supply chain [11]. However, though those enthusiastic trends, there is few papers that discuss the real benefit of these collaborative initiatives in the healthcare context [45]. The upstream and downstream integration of the healthcare network especially through the notion of resource pooling seems to be more challenging compared to other industries [9], [45].

Actually, the healthcare operations must deal with a complex distribution network characterized by an over procurement of medical supplies that follow a variety of regulations pressures and storage locations multiplicity [12],[45]. The more and more scarce resources are another blow to the already tight profit margins in healthcare sector. It involves many partners (i.e. public providers, physicians, pharmacists, nurses, managers, services, wards…) that operate with a high level of autonomy [13], [15]. The physicians are the key decision-makers regarding the evaluation of the demand of medical supplies for each patient [12]. This multi-faceted environment causes problems in determining accurate demand forecasts and sharing information between the operational and strategic levels leading to several inefficiencies such us out-of-stocks, lack of storage space, high frequency of reorders, shrinkage, excessive manual labor and high costs [10], [15], [16], [45]. Indeed, many studies and visits conducted in some French hospitals confirm that one of the most common inefficiency in the healthcare centers is the neglected inventory management system and the valuable time spent by nursing staff on non-value-added activities [2], [9], [37], [38], [45].

In this paper, we focus on the inventory management issues in the healthcare institutions and we try to evaluate substantial savings garnered while improving their clinical process by better managing their supplies, equipments and facilities. We propose a performance comparison of three inventory management strategies in a hospital network: the traditional non collaborative strategy, the total centralization of inventories and the emergency lateral transshipment of inventories. To the best of our knowledge, the consideration of downstream and upstream integration of the hospital supply
A New Optimization Approach for a Home Health Care Problem
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Abstract—This paper deals with the home health care services. The home health care services are defined as a set of medical, paramedical and social services delivered to patients in their domicile rather than in hospital. In this paper, a new Mixed Integer Linear Programming (MILP) model is proposed to make a planning for a home health care problem. The model is optimizing routes and rosters for the health care staffs, while problem specific constraints are satisfied. This model integrates an original concept related to the human behavior (e.g. patient behavior). The MILP model is solved using the commercial optimization software Ilog-Cplex of IBM. Computational results on several benchmarks, generated from a real living-lab (GIS MADONAH) in Bourges (France), proved that the proposed model can solve real large-sized problems within acceptable computational time.

Keywords—Home health care problem, Planning, MILP model, Optimization, Human behavior

I. INTRODUCTION

The hospital system is facing several problems. Some of them are related to operating rooms management and planning [1], doctors and nursing schedules, care demands of hospitalization, pressure in the hospital when several patients arrived simultaneously (e.g. problems of management, resources availability) [2], durations of stays which are often unknown in advance, and so on.

However, in order to shorten the hospital stay times and improve access to health services, while the demand of hospitalization is still increasing, several alternatives to hospitalization were proposed over the past fifty years. One of these alternatives is the Home Health Care (HHC) structures. They consist on providing medical or paramedical services in the patient's home. The main factors of its appearance are:

- Economic factors, where the aim is to control costs, safe the quality of healthcare services and reduce the overcrowding of hospitals.
- Social factors, which are related to the increase in life expectancy, the aging population and the development of several chronic diseases.

The alternative of the HHC aims to reduce health costs and satisfy patient. This alternative is complex due to the integration of the patient's home in the supply chain of care, the diversity of its activities and the multitude of uncertainties which are related to the care process (i.e. demand, new state of patient, journey times, durations of care, and so on).

Over time, this area arouses the curiosity of several researchers in the field of industrial engineering and operations research. The HHC's problematics is dividing into two classes as proposed in [3]. These classes are organized around two categories of decision making, including decisions on the implementation of patient care and on organizational decisions. The decisions of organizational types have been divided into three different levels of decision [4]. The first level is strategic one, it defines the long-term decisions taken by the leaders of the institution. Other, it presents the objective of the HHC. The second one is tactical. It is defined by the decisions of the middle managers to do work for the strategic management decisions. The third one is operational. It traduces all the decisions on the personal organization, which are defined by the scheduling care planning activities, nursing visits, stock management...

Besides, on a set of existing models from literature, some researchers identified in [5] a set of characteristics related to resources, patients and criteria. First, the characteristics related to resources include the types of resources (doctor, nurse, physiotherapist, ...), the preferences of the patients, of resource breaks (e.g. lunch breaks), unavailability of resources (e.g. predetermined work schedule), the regular resources (regular care of a patient), the mode of transport (public transport, private car, bicycle, ...), the maximum workload, the qualification of resources and the contract type (full or part-time). Secondly, characteristics related to patients include the availability of patients (e.g. one or more visits per day), the level of dependence (e.g. patient in bed, wheelchair...), the order of activities and the synchronization of activities when one or more treatments require multiple resources.

This paper deals with Home Health Care (HHC) planning resources. The proposed approach consists in elaborating a Mixed Integer Linear Programming (MILP) model to find a...
Risk-based decision making framework for prioritizing patients’ access to healthcare services by considering uncertainties

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Abstract— Because of insufficient capacity of hospitals, all patients on waiting lists can’t be treated immediately. Then, patients must be prioritized for treatment based on variety of factors. But, current decisions regarding patients’ prioritization have been criticized as being highly subjective and inadequate to assess urgency and case-mix of patients. This study presents a new risk based prioritization framework using fuzzy soft sets in an attempt to overcome the limitations of current approaches. The proposed framework can aid hospitals’ decision makers to evaluate and select the high-risk patients in uncertain and complex environments. In order to show the effectiveness of the proposed framework, a numerical study for surgical patients’ prioritization is considered. The numerical study suggests that the proposed framework not only considers various perspectives and risks in determining patients’ priorities, but also remains noticeably robust as shown by sensitivity analysis. This framework can increases patients’ safety, quality of care, and decrease uncertainties and total risks that threaten patients on waiting lists. Besides it can have significant impact on both the medical community and the public’s faith in justice and equity.

Keywords— Access to health care, Prioritization, waiting lists, Risk, Fuzzy soft set theory, Analytical Network Process, Surgical patients, Uncertainty.

I. INTRODUCTION

Limited and delayed access to care for patients is a multifaceted and universal problem in public health. Long waiting lists are among the most heard patients’ complaints especially for those requiring surgeries [1]. Currently hospitals use first come first serve, points system or maximum waiting period before treatment approaches for prioritizing patients; but, current decisions regarding patients’ prioritization have been cited as being highly subjective and inadequate to assess and compare urgency and case-mix of patients, highly political and extremely controversial. Fraser Institute reported, wait times for surgical and other therapeutic treatments across the Canada rose in 2013 to an average of 18.2 weeks [2]. They mentioned that, the total wait time in 2013 was 95 % longer than in 1993. Based on Esmaiil et al.’s [3] estimations, 44273 Canadian women have lost their lives between 1993 and 2009 as a result of lengthy delays in receiving care. In many medical procedures, these long waiting times effect directly on patients’ health and quality of care. Many Canadians are forced to suffer long pain, disability, and death because of long waiting times. Day [4] mentioned that delayed diagnosis and treatment can be highly destructive or damaging for individuals, their relatives, and those who rely on them. Day [4] indicated that for some diseases delayed treatment can cause reduction in effectiveness of treatment, and often transforms an acute and potentially reversible illness or injury into a chronic, irreversible condition that involves permanent disability. Reports regarding harms related to long wait times are increasing; these harms include poorer medical outcomes from care and an increased risk of adverse events. The relationship between wait times and undesirable outcomes in different fields (like cardiovascular surgery, cancer treatment, spine surgery and etc.) has been studied widely (e.g. [5 & 6]). Studies found relationship between long wait times and undesirable outcomes (like injury or death). They examined the risk of death or injury of patients while waiting for treatment and found that patients with shorter wait times experienced a greater health improvements and long waits in various fields caused increase in mortality risk for patients after acceptance for treatment. Waiting lists management and prioritization can play an important role in decreasing undesirable outcomes like patients’ injury or death. It helps to reduce burden of waiting lists [7].

At this time, mainly individual decision maker (physician) prioritizes patients which may cause biased decision-makings (prioritization of patients). For instance in surgery ward, in most of the cases individual surgeons keep waiting lists with no reference to any precise and systematic standards for priority, no group collaborative management, and with rare consideration of risks and uncertainties. A good prioritization rule may contribute to decrease risk of death and injuries faced by patients while waiting for their surgery, at the same time, maximizing the welfare of all the patients and clinical staff. The lack of specific methods ensuring patients’ equity and priority of access to treatment, supporting healthcare professionals’ decisions, and managing waiting lists efficiently by considering risks and limited resources is an important limitation of the current systems [1]. Then, accurate prioritization of patients on waiting lists based on equity, urgency, benefit and more importantly
New Concept of Nurse Education for Service Innovation- A Perspective of Internal Marketing

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Abstract—In this empirical study, we draw on concepts of internal marketing to provide nursing managers of hospitals with an effective education method for healthcare service innovation. A cross-sectional study was used. Subjects for this study were nurses at two district hospitals in Taiwan. Internal marketing practices significantly affect service innovation. In particular, service training, rewarding employee performance, and a clear organizational vision are positively correlated with service innovation. To increase a hospital’s internal resource capacity, education and training are often used to positively influence the innovative ability of employees. Nursing managers of hospitals could apply education and training strategies derived from internal marketing practices to increase nurses’ knowledge, improve their nursing care and innovation skills and improve the quality of service to patients.

Keywords—human resource management, internal marketing, service innovation, healthcare management

I. INTRODUCTION

Today, the variables within the healthcare environment are undergoing such a rapid change that hospital administrators have found it necessary to develop competitive strategies in order to survive in the increasingly competitive healthcare environment [1]. The primary objective of a good healthcare service is to create value for patients by attending to their needs through the provision of quality services [2]. Hospitals interact with patients through their front-line employees, who serve as the most proximal deliverers of healthcare value to patients. When patients make use of healthcare services, they evaluate the quality of those healthcare services according to their predetermined expectations of the behavior of the healthcare staff that deliver this healthcare to them. Therefore, front-line healthcare staff plays an integral role in the organization’s attempts to meet customers’ expectations in relation to service delivery [3].

Internal marketing is one of the useful human resource management policies that nursing managers can improve the quality of nursing care. Internal marketing refers to the managerial emphasis on a clear organizational vision transmitted to nursing staff through education and training [4].

Through these human resource management policies, internal marketing can strengthen service capacity and efficiency of nursing staff, thereby can improve service quality and ultimately achieving patient satisfaction[5]. Given its benefits in relation to patient satisfaction, internal marketing is particularly important for hospitals.

Some researchers have explored the influence of internal marketing on organizational commitment and service quality [6,7]. Although the objectives of these studies were different, most of them focused on how internal marketing influences employees’ work attitudes and behaviors. A hospital is an organization where provides healthcare services to patients. Healthcare staff plays an important role in delivering high quality healthcare services to patients [8]. Healthcare staff is often faced with patients suffering from various diseases. This requires staff to be patient and compassionate when dealing with patients. For nursing managers, knowing how to leverage internal marketing practice to improve the nursing care capacity and quality of services provided by nursing staff has become a vital issue.

Following the advances in technology, healthcare technology and equipment has consequently developed at a rapid pace. Examples of this include the Medical Information System (MIS), Electronic Medical Records (EMR), and Mobile Nursing care. These developments not only enable nursing staff to provide better nursing care, but also to have better access to patients’ nursing care information in a more timely manner. This consequently, has a positive impact on improving the quality of nursing care and efficiency. Nurses also need to consistently update themselves with the new equipment, learn new nursing care skills, and provide innovative healthcare services to meet the patients’ needs [9]. Manuel et al. [10] believed that front-line employees’ caring attitude could influence the overall performance of the healthcare service. The front-line employees’ innovation behavior also influences the service innovation. Nursing managers must leverage incentive policies to improve the innovative behavior of nurses.
This conference session invites reflection on how to design and/or manage a supply chain system from supply chain dynamics perspective. It emphasizes the interactions between supply chain players and the economic consequences. The most popular topic of supply chain dynamics is called “bullwhip effect”. It is the term used to describe the scenario that orders upstream tend to have large fluctuations than the sales downstream. It produces severe impact on the suppliers’ performance such as excessive capacity, labor idling and over-time; eventually these costs will be passed onto customers. The area has received considerable attention in the past two decades, but there are still many open questions. Although many reasons jeopardize the performance of the supply chain, the issue of supply chain dynamics might be universal. A local farm would be vulnerable facing the bullwhip effect due to the products’ perishable feature. A multinational might suffer because of the geographical dispersion.

Therefore, the session would be inclusive of local and global views. The session include the innovative studies addressing supply chain dynamics issues on inventory control, manufacturing, logistics and transport. The session also proposes the applications to the real world to improve supply chain performance. By embracing theoretical, methodological and practical papers, the session provided the opportunities to both researchers and practitioners to share the knowledge, research, and experience about supply chain dynamics. Meanwhile, it may provide future directions in the field of industrial and system engineering.

Presented papers

- *Assortment decision in the Multi-Product News-Vendor Problem with Demand Substitution*
- *Reducing Order and Inventory Variability under Stochastic Lead-time and Correlated Demand*
- *On Net Stock Amplification in the Damped Trend Order-Up-To System*
- *A supply chain dynamics model for managing perishable products under different e-business scenarios*
- *What are the critical success factors for the implementation of supply chain performance measurement system in SMEs*
- *Insights on partial information sharing in supply chain dynamics.*
Assortment decision in the Multi-Product News-Vendor Problem with Demand Substitution

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Abstract—Retailers are confronted to make ordering decisions for a large category of products offered to end consumers. In this paper, we extend the classical mono-product News-Vendor Problem to a multi-product News-Vendor Problem with demand transferring and demand substitution. We focus on the joint determination of optimal product assortment and optimal order quantities. Computational algorithms are presented to solve the problem. We compare the global optimization policy with some other policies used in practice by numerical examples.

I. INTRODUCTION

Product variety is a key element of competitive strategy. Many retailers become successful by offering a wide selection of products. Supermarkets such as Wal-Mart and Carrefour are good examples from grocery retailing. Demand for variety comes from both the taste of diversity for an individual consumer and diversity in tastes for different consumers. However, despite the advantages of product variety, the full degree of variety cannot be supplied generally, owing to the increase of cost in inventory, shipping, and merchandise presentation, etc. Thus, the optimization of product assortment (the products to sell), and the order quantity for each product, is a relevant decision that retailers face.

The News-Vendor Problem is a classical problem in inventory management aiming at finding the optimal order quantity which maximizes the expected profit under probabilistic demand [1], [2]. The demand for products is unknown, thus the order quantity for each product should be optimized due to the trade-off between two situations: if the order quantity is not enough, underage happens and lost sale causes lost profit; if the order quantity is too large, overstock happens. The classical mono-product News-Vendor Problem is in the situation that only one product is considered. In our case, we consider multiple products. Thus, to optimize the assortment, two other important factors should also be considered. First, product variety brings possible substitution when underage happens: different colors or styles, for example, act as substitutes when the client finds a product is out of stock. Second, beside of the purchasing cost which increases with the order quantity, other fixed costs are associated with stocking a product, e.g. the cost related to a fixed space for each product, the related labor cost, etc. In these situations, the fixed cost will clearly reduce the assortment size.

This paper extends the classical News-Vendor Problem to determine the product assortment and product order quantities considering product substitution. We develop a model for the demand transferring effect when some products are abandoned. We use the Monte Carlo method to solve the multi-product News-Vendor Problem under substitution. Analysis of illustrative examples shows that assortment optimization and substitution have significant effects on the optimal order quantities and on the expect profit. The rest of the paper is organized as follows. Section 2 presents the related literature review. In section 3, we formulate the News-Vendor Problem with multi-products under demand substitution. In section 4, we solve the joint optimization of assortment and optimal order quantities and give computational algorithms. In section 5, numerical examples are provided. Section 6 contains concluding remarks.

II. LITERATURE REVIEW

A survey of the literature on the News-Vendor Problem is provided by [1], [2]. Over the last decades, interest for multi-product News-Vendor Problem continues unabated. The special case where different products have independent demand and no possible substitution is considered by [3]. The topic of substitution in inventory management first appears in [4]. Papers on this topic can be divided into 3 categories according to their substitution types: papers of the first category deal with one-direction substitution or firm-driven substitution, where only higher grade product can substitute a lower grade product, because the supplier makes decisions for consumers on choosing substitutes (see, e.g., [5]–[9]). For example, the retailer provides a high quality product as a substitute for a consumer who prefers a product with lower quality but it is out of stock. The second category consists of papers where arriving consumers’ number follows a stochastic function and consumers make purchasing decisions under probabilistic substitution when their preferred product is out of stock (see, e.g., [10] and [11]). Here the consumers come one by one and choose their substitutes within the remaining products by themselves. The third category consists of papers considering that each product can substitute for other products and the fraction that one out-of-stock product is substituted by another product is deterministic. Moreover, this category can be divided into subcategories as either the two-product (see [4], [12]–[15]) or multi-product case (see [16]–[19] and centralized or competitive case. [17] obtained optimality conditions for both competitive and centralized versions of the single period multi-product inventory problem with substitution. [20] study a multi-product competitive News-Vendor problem with shortage...
Reducing Order and Inventory Variability under Stochastic Lead-time and Correlated Demand

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Abstract—Logistic volatility is considered to be an important contributor to supply chain inefficiency. In this paper we investigate the amplification of order and inventory fluctuations in a state-space model with stochastic lead time, ARMA($p$, $q$) demand and a proportional order-up-to policy. We derive the exact distribution functions for order and inventory. For i.i.d. Gaussian demand, we prove that the proportional outperforms the classical order-up-to policy in reducing inventory and order variances simultaneously. Numerical experiments are carried out to show the complex interaction between demand correlation and stochastic lead-time.

I. INTRODUCTION

We investigate the ability of the proportional order-up-to policy to reduce variance amplification under stochastic lead time. Variation in inventory systems is commonly generated by uncertainties in demand, supply, transportation, and manufacturing, and can be amplified by poorly designed inventory control mechanisms [1] [2]. Variance amplification in inventory systems, which can be understood as quadratic costs representing diseconomies of scale [3], pose a large threat to companies at the operational level. High order variance (a.k.a. the bullwhip effect) brings more uncertainty to the upstream supplier, and induces costs associated with production adjustment and capacity utilization. High inventory variance requires more safety stock to accommodate increased stock-out risk, reducing supply chain efficiency.

Uncertainty in logistics, i.e., stochastic shipping delays, is a major component of supply chain risks. In recent years, production and distribution systems have become increasingly global, exposing supply chains to more volatility than ever before. Global transportation modes, such as air, truck, rail and ocean freight, have long and variable lead times, due to external factors such as seasonality effects, security and customs delays and slow steaming. Uncertain lead-times sometimes trigger another effect called order crossover, when replenishments are received in a different sequence than they were ordered. Whilst these two concepts do not necessarily imply each other, a highly variable lead time often results in order crossover [4] [5].

Both stochastic lead time and order crossover are common in practice. Figure 1 contains data from a company who manufacturers products in the USA and ships them in China for assembly. The histogram shows statistics of the transportation time used for 827 containers by truck and ship between 2004 and 2011. We see the possible lead time ranges from 3 to 11 weeks. The mode of lead time is 5 weeks which has only a probability of 0.5. In the upright sub-figure, the sequence of dispatches is compared to the sequence of the receipt. It shows the change of the position of an order in the dispatch and receiving sequences, from which we see a significant number of order crossovers.

Ref. [6] classified the research on stochastic lead times into three schools: The Hadley-Whitin School, which assumes that the probability of order crossover is so small that it can be totally ignored [7]. The Zipkin-Song School, which assumes that goods are transported sequentially so that order crossover cannot happen [4] [8]. And the Zalkind School, which takes order crossover into account and discovers that inventory cost as well as safety stock can be reduced by considering this effect [9] [10] [11]. The non-crossover scenario is more frequently observed in manufacturing contexts, where servers (production facilities) are often serially linked. On the other hand, the crossover phenomenon can be discovered...
On Net Stock Amplification in the Damped Trend Order-Up-To System

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Abstract—In this paper we characterize the frequency response of net stock amplification when the Damped Trend forecasting is used in the Order-Up-To replenishment policy. We prove that the invertibility regions from forecasting perspective are identical to the stability regions in control theory. From these stable and invertible regions, we explore the desirable parameter regions that the forecasting and inventory control policy is able to avoid the bullwhip effect and reduce net stock amplification for any lead-times. The simulations of 62 sets of real-world demand verify our analytical results.

Keywords—damped trend forecasting; order-up-to; net stock; bullwhip; invertibility; frequency response

I. INTRODUCTION

Since Damped Trend (DT) forecasting method was proposed [1], it has received considerable attentions in the literature. By dampening a linear trend, the method improves long-term forecast accuracy without significantly degrading short-term accuracy. A number of popular forecasting models such as Naïve, simple exponential smoothing, Holt’s linear trend method can also be accessed by tuning the parameters of the general DT model. This allows for model detection and forecasting of a wide range of time series with or without trends. Its superior accuracy has been recognized in many empirical studies [2] [3] and academic reviews [4] [5] [6].

The DT method deserves more attention from supply chain management viewpoint. Economic benefits in terms of inventory, production, and shipping costs were reported in the applications in a real inventory scenario [7] and a real supply chain [8].

Reference [9] is the only one discussed the DT method in supply chain or operations management journals. They focused on the supply chain dynamics induced by the DT method, and found the bullwhip avoidance behavior that has never been seen before when other forecasting methods are used in the order-up-to (OUT) policy. The bullwhip effect is important in supply chains. It describes the scenario that the demand fluctuations are amplified from downstream to upstream throughout a supply chain. It creates severe consequences such as excessive capacity investment, inefficient use of transportation, labor idling and over-time.

In this paper, we focus on another important supply chain metrics, net stock amplification (NSAmp). NSAmp is related to the popular safety stock and fill rate concepts [10]. This paper also provides a proof that for the DT forecasting the invertibility regions and stability regions are identical, which means any stable DT forecasting model produces feasible forecasts. This allows us to study the model over the complete stability region from both control theory and forecasting perspectives.

The paper is organized as follows: §2 introduces the model setup, §3 discusses the invertibility of the DT method, §4 investigates the NSAmp of the DT/OUT system, §5 presents some simulation results and §6 concludes.

II. MODEL SETUP

A. Damped Trend Forecasting

The single source of error correction form of Damped Trend forecasting is given by

\[
\hat{A}_t = A_t + \alpha B_{t-1} + \alpha \epsilon_t,
\]

\[
B_t = \phi B_{t-1} + \alpha \beta \epsilon_t,
\]

\[
\hat{D}_{t+1} = \tilde{A}_t + \sum_{i=1}^{t} \phi_i B_i.
\]

\[
\tilde{D}_{t+1} \text{ is the forecast for } D_{t+1} \text{ made at time } t. \text{ It is a product of } A_t \text{ (level) and } B_t \text{ (trend). } \{\alpha, \beta, \phi\} \text{ are systems parameters in the DT model.}
\]

The z-transfer functions of (1) are

\[
A(z) = \frac{z^2 \alpha + z \alpha \phi (\beta - 1)}{z^2 + z (\alpha - \phi - 1 + \alpha \beta \phi) + \phi (1 - \alpha)}
\]

\[
B(z) = \frac{z^2 \alpha \beta - z \alpha \beta}{z^2 + z (\alpha - \phi - 1 + \alpha \beta \phi) + \phi (1 - \alpha)}
\]

\[
\hat{D}_t(z) = \frac{z^2 \alpha \left(1 + \beta \sum_{i=1}^{t} \phi^i \right) + z \alpha \left(\phi (\beta - 1) - \beta \sum_{i=1}^{t} \phi^i \right)}{z^2 + z (\alpha - 1 - \phi + \alpha \beta \phi) + \phi (1 - \alpha)}.
\]

For stability,
A supply chain dynamics model for managing perishable products under different e-business scenarios

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Abstract—This paper models a traditional supply chain with three levels, manufacturer and retailer, for managing the orders and inventories of perishable products. A hybrid approach, based on systems dynamics and optimization, was used to reduce the bullwhip effect along the supply chain, increase fill rates and reduce total costs (order, inventory and stockout costs). The hybrid approach, with optimization, was able to improve the results for perishable products. This model was also tested by using an electronic point of sales (EPOS) collaborative supply chain structure, which gave improved results.

Keywords—supply chain; systems dynamics; perishable products; simulation; optimization

I. INTRODUCTION

Perishable products in supply chains are even more complex to manage because of stricter requirements for orders and inventory, required for maintaining satisfactory fill rates without increasing costs due to high inventories or stockouts. Such products have a maximum usable lifetime and are subjected to deterioration, which can be defined as damage, spoilage, vaporization, dryness, etc. of items [1]. The inventory management of perishable products has been studied extensively by many researchers in recent decades, and several literature reviews are highlighted that have a general purpose [1]–[6] or focus on certain sectors, e.g., blood management [7], [8] or agri-food supply chains [9].

The replenishment process of perishable products can be dealt with using analytical approaches, mainly based on EOQ expressions, dynamic programming approaches and simulation models, among others. Dye and Ouyang [10] proposed an EOQ-based inventory model for perishable items with stock-dependent demand to consider lost sales and a decreasing time-proportional backlogging rate. Taleizadeh et al. [11] developed a replenishment EOQ model to determine optimal ordering amounts for a perishable item with temporary price discounts by assuming that shortages were allowed and all unsatisfied demand would be backordered. Rajurkar and Jain [12] proposed a dynamic programming-based algorithm for determining the best ordering policy for retailers which sell shelf-life perishable products to their customers. Haijema [13] put forward a new class of stock level-dependent ordering policies for perishable products based on a periodic review with the order quantity restricted by a maximum and a minimum. This problem was modeled as a periodic Markov decision problem and was solved by using stochastic dynamics programming. This solution approach was also considered by Hendrix et al. [14] for decision making on the replenishment of fixed shelf life products with nonstationary random demand by considering service-level constraints.

According to Karaesmen [15], simulation approaches can present more opportunities in terms of model richness. Yu and Ma [16] developed an inventory control system for perishable electronic products by including reverse logistics activities and using a hybrid discrete event simulation model with optimization properties. Bottani et al. [17] proposed a spreadsheet-based simulation model that they applied to a real two-echelon supply chain with perishable food products to compare different traditional reorder policies. Lee and Chung [18] developed a systems dynamics simulation model to analyze relations among inventory costs in a multi-echelon supply chain with perishable products. Similarly, Wang [19] used a system dynamics simulation approach to study causes of bullwhip effects in a supply chain with perishable items, and concluded that these effects can be considerably reduced by sharing inventory information, reducing lead and delivery times, and coordinating orders. The literature provides other real world applications of system dynamics models. For example, Afshar et al. [20] developed a simulation model for a blood supply chain by comparing several scenarios based on safety stocks, supplier lead time, in transit time and separating time in order to improve the average inventories level with zero backlogged orders. Taimoury et al. [21] proposed a system dynamics simulation multi-objective model to study the impact of the supply, demand and price interactions on a supply chain of perishable fruits and vegetables to determine their best corresponding import quota policy. Potter and Disney [22] demonstrated how the bullwhip effect can be used in a grocery supply chain with perishable products. The authors concluded that for short life products and low demand, the dynamic performance of the replenishment process could not be
What are the critical success factors for the implementation of supply chain performance measurement systems in SMEs

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Abstract— In an attempt to cope with an economic environment that doesn’t seem to slow its development and while under the pressure of being more competitive, every company takes in a new strategy enabling it to be in better conditions in its business sector. Research has shown that performance measurement systems, especially those deriving from the mission of the supply chain and the process of strategic planning, have a key role in the development of the companies’ management and performance. There is a growing literature concerned with the design and the implementation of supply chain performance measurement (SCPMS) systems and plenty of them mention the difficulties of their implementation especially in SMEs. Using a critical success factor (CSF) approach and based on the analysis of the existing literature, we investigate this crucial issue in-depth and we put forward and define CSFs that are crucial for implementing SCPM systems in SMEs throughout this article. The empirical investigation is still ongoing and it will be carried out by using critical thinking, inductive reasoning and in-depth interviews in Moroccan small and medium enterprises (SMEs).

Keywords— Supply chain performance measurement system, critical success factors, small and medium enterprises, performance measurement system, Supply chain

I. INTRODUCTION

Organizations grow through expanding their range of products and services in response to more mature and saturated markets. The increasing in product and market heterogeneity involves a more decentralized structure and, therefore, an evolution in managerial system becomes essential especially for small and medium enterprises (SMEs), which need to be extremely flexible and reactive to market changes while being characterized by lack of resources and managerial expertise [1].

Performance measurement systems (PMS) is often mentioned as an important support to managerial development in SMEs [1]. According to Ramaa et al (2009) performance measurement of supply chain (SCPM) can provide important feedback information to enable managers to monitor performance, reveal progress, enhance motivation and communication, and diagnose problems. It also provides insight to reveal the effectiveness of strategies and to identify success and potential opportunities [2]. However, many barriers seem to obstruct its implementation in SMEs.

In the literature the subject of performance measurement mostly treated regardless of the size of the business and even if many performance measurement approaches have been proposed, few are the publications focusing specifically on performance measurement in small and medium-sized enterprises [3] and scarce are the works treated the success or failure of SCPM systems implementation.

The purpose of this paper is to answer the question: what are the relevant critical success factors (CSFs) for SCPM system implementation in SMEs? The structure of the article is subordinated to this question. The paper identifies the term of SCPMS, characteristics of SCPMS, and various perspectives of their development. Thereafter, we analyze the role of PMS in SMEs and the obstacles of their implementation, then, the existing CSFs of PMS and SCPMS projects suggested by different authors in literature are revised. We find that plenty of factors are mentioned as obstacles to performance measurement systems implementation and use in SMEs. Based on the findings, we established a list of CSFs to support the empirical study where we will use critical thinking, inductive reasoning and in-depth interviews to define CSFs that are crucial for implementing SCPM systems in SMEs.
Insights on Partial Information Sharing in Supply Chain Dynamics

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Abstract—This paper provides an assessment of partial Information Sharing (IS) in Supply Chain (SC). We study the dynamics of collaborative multi-echelon structure, characterized by an increasing level of information visibility among partners. To do so, we mathematically model six four-echelon serial SCs via difference equations and conduct numerical simulations on the basis of a robust design of experiment. Results shows how (1) as the extent of IS increases, the performance of whole SC improves as well, and (2) the impact of IS depends not on which particular members are involved but on the number of collaborative members.

Keywords — asymmetric information sharing; supply chain collaboration; demand amplification; supply chain dynamics; simulation; ANOVA

I. INTRODUCTION

Collaboration in Supply Chain (SC) refers to the coordination and management of flow of goods, information and funds to improve SC performance and relationship across the channel partners [1]. Collaboration is realised by the alignment of decision making among members in their planning and inventory management [2]. This alignment is allowed by Information Sharing (IS) [3-5].

Several authors have shown how SC collaboration and IS increase members’ performance by limiting noxious phenomenon such as the costly bullwhip effect [6-14].

However, practical implementations of collaborative practices present relevant difficulties [15]. Modern SCs are decentralized in nature (due to high customization of products, high customer expectations, outsourcing paradigm, etc.), and companies are often reluctant to share private information with other partners, due to lack of trust and information leakage [16]. In fact, in practice, full IS remains an exception, while partial or total lack of IS are prevalent [17-18].

However, majority of studies dealing with the impact of collaboration and IS of multi-echelon SCs assume that all members participate in IS process [19-21].

Currently, there is a lack of consistent studies focusing on how different extents of IS (i.e., number of collaborative members) and degrees of IS (i.e., type of shared data among partners) may impact on the dynamics of SC.

Motivated by these considerations, we explore the impact of different extents of IS on the dynamic performance of SCs. To fulfil the research objective, we model, simulate and compare the behaviours of six four-echelon SC, characterised by increasing extent on IS, i.e., one SC with no IS, two SC with low extent of IS, two SC with high extent of IS, and one full IS SC.

SCs are modelled by a set of difference equations [22]. In order to provide comprehensive data inputs, we adopt a factorial experimental design [23]. As performance metric, we adopt the bullwhip slope, which concisely provide information on the response of the whole SC.

We show how as the extent of IS increases, the performance of whole SC improves as well. Furthermore, results suggest that the impact of information sharing depends not on which particular echelons participate on a collaborative practice but on the number of the involved collaborative echelons.

The rest of the paper is organized as follows. Section 2 presents the six SCs characterised by an increasing level of information sharing. The modelling assumptions and the mathematical formalisms are presented in Section 3. Section 4 reports simulation experiments, performance metrics and numerical output. Sections 5 provide discussions. Finally, conclusions and suggestions for future research developments are presented in Section 6.
Wastes identification and removing has become a key issue to achieve competitiveness and to survive in the modern manufacturing environment. In order to achieve this goal, several manufacturing paradigms have been proposed. Amongst these paradigms, lean production has increased its importance, and it is now recognized as the most influential one. The concept of lean is based on the dichotomy of value and wastes, and its main goal is to meet customer’s expectations in a better way, by focusing on a continuous waste elimination process. Although Lean originated in Low-Variety-High-Volume manufacturing companies, it has been frequently applied also in other contexts, especially in the non-Make-To-Stock sector, where its application is particularly challenging. Indeed, those manufacturing environments are characterized by a high level of variability, and their performances depend on several interrelated parameters. Within this context, it is widely recognised that no “fool proof” way is available for implementing lean principles, because they must be properly reinterpreted to fit the specific requirements of the industry where they need to be applied. Generally speaking, the non-MTS sector can be broadly parted in two clusters: (i) Make-To-Order companies, where most or all operations to manufacture an end item are only performed after a customer order has been received and (ii) Engineer-To-Order companies, where products are manufactured to meet a specific customer’s needs and require unique engineering, or at least a significant and specific customisation. Within both these clusters, several lean tools can be applied.

As an example, the lean approach in (i) focuses on lead time stabilisation and WIP control to optimise production (e.g. CONWIP, Workload Control, synchro-MRP, POLCA etc.). Conversely, the typical lean approach in (ii) endorses both organizational and technical issues: during project planning the main goal is to foster cooperation and synchronization of office activities, e.g. scrumban and lean office tools, while during project execution it is important to simplify engineering through standardization and product communalities, e.g. design for lean and knowledge management tools. Unfortunately, scientific literature in these two clusters is rather disparate. Although a great amount of literature is available in (i), several research questions still exist:

- given a production environment, no framework is available to select the most appropriate production planning and control system;
- once this system has been selected, it needs to be fine-tuned: how to do so is still not clear;
- to our knowledge, no production module of commercial ERP systems exists to support such an implementation.

On the other one hand, the situation in (ii) is even more confused: literature is very scarce on this subject, and lean tools themselves still need to be adapted to this sector. Thus, it is needless to say that no lean oriented project management software exists.

Presented papers

- Relationships between national culture and Lean Management: a literature Review
- Assessing performance of Workload Control in High Variety Low Volumes MTO job shops: a simulative analysis
- The automation of an assembly system: a business process re-engineering (BPR) perspective
- Adaptability into Supply Chain Strategy: the adaptable PCSA framework
- Simulation of two hybrid production planning and control systems: a comparative analysis
Relationships between national culture and Lean Management: a literature Review

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4e2 2015

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Abstract - In an increasingly volatile, globalized, and demanding market, Lean is the differential factor that could increase companies’ competitiveness and efficiency. In spite of the abundant literature addressing Lean system’s technical aspects, there has been little discussion on the importance of national culture in Lean’s implementation process. It has been proven that the implementation of lean practices do not always produce the intended results and national culture has been highlighted as one of the contextual variables that may explain the success or failure of Lean practices. Since companies are influenced by the culture of the country where they’re located, some comparative advantages may occur due to their location, making it necessary to adjust Lean’s implementation process to national culture. The purpose of this article is to propose a literature review to examine the relationship between national culture and Lean Management. This study explores the assertions and/or contradictions found in the literature regarding the cultural dimensions that may act as enablers or withholders to the lean principles and practices.

Keywords—Lean; practices; national culture; multicultural management; globalization

I. INTRODUCTION

In the last decades, the market has become even more volatile and competitive, demanding constant efforts of organizations in order to evolve towards the achievement of managerial excellence. In this scenario of change and even instability, the ability to adapt is crucial and decisive for the survival of firms. As a result, new management methods emerged to agilely drive the development of organizations with robust rules adapted to the evolving economic and societal configurations.

One of the major approaches used by companies to achieve efficiency and improvement of their industrial system is the implementation of Lean Management. The term “Lean” was first proposed by Womack et al. [1] in the book “The machine that changed the world”. Nonetheless, the foundations of Lean Management were practically introduced in the Toyota factories in the 70s named TPS (Toyota Production System). The goal of Lean is to maximize customer value while minimizing waste. Simply, lean means creating more value for customers with fewer resources.

A common mistake made by many companies is focusing the Lean implementation on the deployment of tools and technology without considering human, social and cultural aspects. This mistake can cause Lean implementation failure [2]. The historical, philosophical and cultural heritage of Lean Management is linked to the uniqueness of the Japanese model. Consequently, it is not simple to implement such approach in companies based in other countries. Indeed, cultural factors are essential when it comes to the understanding of Lean practices whenever they are implemented in different cultures.

Tanure [3] suggests that the notion of the Lean model itself changes when it is to be implemented in a different culture. Important differences arise from local translations and interpretations resulting from the interaction between the organizational structures. In this sense, the understanding of the cultural differences between the Japanese society (source of the original model) and the local culture of the system application must be considered [4].

Several managers and researchers state that culture is a key factor when developing and applying management techniques [2, 5, 6, 7, 8, 9, 10, 11]. It has been proven that cultural differences can affect the approach and speed of change [12]. The nature of management skills needs to be adapted to cultural specificities, i.e., a management technique or philosophy that is appropriate in one national culture is not necessarily appropriate in another [13].

The aim of this article is to propose the state-of-the-art to examine the relationship between national culture and Lean Management, seeking to identify the main cultural characteristics that impact the lean approach and furthermore propose research perspectives.

The state-of-the-art intends to answer the following questions:

- Do studies find a relationship between cultural influences and the implementation of Lean Management process?
Assessing performance of Workload Control in High Variety Low Volumes MTO job shops: a simulative analysis

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Abstract — This paper deals with Workload Control (WLC), one of the best techniques to control Work In Process (WIP) and to stabilize Lead Time (LT) in job-shop systems. Our focus is on the job release strategy and, specifically, on the selection and dimensioning of suitable norms; a challenging problem, which is often the cause of the little industrial use of WLC. Specifically, our aim is to assess whether or not the use of easy to implement norms, appealing also from an operating point of view, may be enough to boost performance of a productive system. To this aim, a thorough discrete events simulation was made, considering a realistic job-shop environment in different operating conditions. Job release was subjected by WLC, regulated by two consolidated norms (i.e., Shop-Load and Bottleneck-Load) and by a novel one, which leverages on the grouping of jobs into families. Obtained outcomes are highly satisfactory, since good performances, in terms of WIP minimization and Due Dates compliance can be obtained, especially in highly constrained productive environments.

Keywords—Bottlenecks, Due Dates, Products’ Families, Workload Control.

I. INTRODUCTION

Nowadays, lean production is emerging as one of the main operating technique to boost performance of a manufacturing process. The main idea is to detect and, next, to remove all form of wastes, so as to develop a fully value added manufacturing process, or, using a more appropriate lean terminology, a perfect value stream, where jobs flow uninterrupted from a value added activity to the next one. In this respect, there is no doubt that queues and, especially, excessive inventories are the main and most common wastes of push-oriented manufacturing processes. In the first place these wastes represent a tangible cost for the firm, but also, and perhaps more important, they increase Lead Times (LT) and make them extremely variable, so that defining reliable Due Dates (DDs) becomes hard if not even impossible. It is useless to say that both these issues greatly contribute to reduce the competitiveness of a company, since nowadays, more than ever, flexibility, rapidity and costs’ reduction are the key elements to succeed in a dynamic and ruthlessly competitive environment. To solve these problems, Just in Time deliveries, Work In Process (WIP) control and LT stabilization are generally advocated as the main options; indeed, using the words of Hopp and Spearman [1] “protecting throughput from variance is the key of lean systems” and “WIP control is essential for a pull oriented manufacturing system”. These basic lean principles are quite easy to be implemented in Make-To-Stock (MTS) Low-Variety-High-Volumes (LVHV) production environments, where, not surprisingly, lean manufacturing was originally introduced. As known, if demand is rather constant and the production mix is not too diversified, cells formation and the use of simple coordinating techniques (such as dual kanbans) are straightforward ways to synchronize flows and to pull production starting from a pacemaker process, where levelled orders are released.

Unfortunately, the same is not true for Make-To-Order (MTO) High-Variety-Low-Volumes (HVLV) manufacturers. In these conditions, products are not standard (but are made on customers’ specifications) and so, in order to preserve an adequate degree of flexibility, a job shop oriented layout, with WIP accumulating between work centers, must be maintained. Consequently, since one piece flow and other basic lean techniques are almost impossible, the adoption of alternative pull oriented Production Planning and Control systems (PPC) becomes vital to assure system’s leanness [2].

Among pull oriented PPC systems, Workload Control (WLC) is receiving a great deal of attention, not only for its potential practical implications, but also because it can be applied even in case of job-shops with shifting bottlenecks and with very varied routings; a condition, this last one, which is very frequent for MTO-HVLV manufacturers. For the above mentioned reasons, research on WLC is rapidly increasing [3]. Nonetheless, and quite surprisingly, practitioners are not yet familiar with WLC [4-5] and, success stories of WLC are still rare [6]. Certainly, considering that WLC is a fairly recent technique, such low pervasiveness can be attributed to the time lag that always exists between theory and practice. However, our belief is that the real reason should be sought in the nontrivial order release mechanism, on which WLC is based. More specifically, in order to control WIP and LT, accepted jobs are released to production keeping workload levels on the shop floor within limits or norms. Thus, unless the norms are
The automation of an assembly system: a business process re-engineering (BPR) perspective  
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Abstract—The purpose of this paper is to automate a manual assembly line following a structured framework, in a motorcyclist industry. Process re-engineering is implemented in order to improve and automate the assembly process of a manufacturing company. The transition from the manual process to the new semi-automated assembly line is composed of 4 main steps: the as-is analysis, the Process reengineering and layout design, the training and finally the mass production. The study has shown that the line automation yields significant improvements: sizeable increase of the workstations saturation, better cohesion with Just in Time principles, reduction of the employed working force, and increase of the quality control process rigor. The scope of the study was limited to one of the firm assembly line. In future, the company plans to perform similar studies on the other lines. This investigation shows significant benefit associated with a structured implementation automation in the field of assembly process. The findings will mainly be relevant for process and logistics managers involved in the planning of a new assembly line or in the redesign of an existing one. This paper provides an original case study of as-is analysis, re-design, training and testing of an improved assembly line.  

Keywords—Assembly systems, process re-engineering, layout design, Assembly Line Design, automation.  

I. INTRODUCTION  

Assembly process plays a key role in production systems. The improvement and optimization of the assembly process is vital to manufacturing competitiveness [1]: about 50% of the product cost should be ascribed to the assembly phase [2].  

The increasing degree of automation in industrial facilities is a modern trend in manufacturing. The current trend to assembly automation is evident in both the planning of new assembly line and the redesign of an existing one [3]. Automation is defined as the performance of tasks by machines rather than human operators [4]. Automation results in reduction of operator workload, errors and labour costs [4]; [6]. Under low uncertainty environment, manufacturing system automation has significant positive impact on manufacturing performance [7]. Reference [8] detected nine reasons for automating: Increase labour productivity, Reduce labour cost, Mitigate the effects of labour shortages, Reduce or eliminate routine manual or clerical tasks, Improve worker safety, Improve product quality, Reduce manufacturing lead time, Accomplish processes that cannot be done manually, Avoid the high cost of not automating. On the other hand, process consciousness may decrease under high automated environment [9] and high level of automation means to loss the flexibility of human operators [10].  

The automation as competitiveness source also attracted the attention of national government policy. The role of government in promoting the automation adoption should be an effective and can lead to tangible benefits. As instance, the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs in Taiwan has been promoting the program “Manufacturing Automation Promotion Policy (MAPP)” for more than 10 years [11].  

The identification of the proper level of automation for best system performance results from a balanced and holistic approach to automation [12]. Decision about the level of automation is not a planned and structured activity and there are not support decision systems to adopts, on the contrary it is mainly an ad hoc nature activity [13] [14].  

Frequently, it is possible to notice a lack of strategy formulation and little use of methods to design, introduce and evaluate automation projects [15] [16]. More, the assembly line design is often complex due to the high number of variables involved such as line efficiency, cost, reliability and space [17] [18].  

This context leads us to follow a structured approach to the assembly re-design shown in this paper. The adopted methodological approach is described in Section 2. In section 3 the case study is illustrated in detail with a specific attention to each of the four step implemented. Then, in section 4 the results are reported, taking into account both quantitative and qualitative aspects. Section 5 presents conclusions summarizing the information presented.  

II. METHODOLOGICAL APPROACH  

This redesign was done using the approach illustrated in Figure 1. The transition from the manual circular process to the new semi-automated linear assembly line is composed of 4 main steps: the as-is analysis, the Process reengineering and layout design, the training and finally the mass production.  

The project schedule is reported in a Gantt chart (Figure 2).
Adaptability into Supply Chain Strategy: the adaptable PCSA framework

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Abstract—In today’s uncertain and complex business environment, where an high variability of production is requested, supply chain strategy is playing an important role in the success of a firm’s product and market growth strategy. Once considered the meanings of supply chain adaptability, it is easy to understand how much is important to provide a supply-chain that is able to let the company survive to the World’s quick sands due to several given listed uncertainties in a complex global-business environment.

This paper supplies a review of the Progressive Conceptual System (PCSA) approach, making it able to formulate a supply-chain strategy with the ability to shift properly through the threads and changes of the business environment. The challenge has been transforming a static PCSA methodology into a dynamic one then.

Keywords—adaptability; supply chain; Progressive Conceptual System Assembly.

I. INTRODUCTION AND RESEARCH BACKGROUND

As reported by several authors [1] the economic boost caused by the globalization during the ’80s and ’90s forced many manufacturers to rethink their strategy, mainly in terms of a new global approach to markets which had to take into account new factors.

Many events may motivate a firm to rethink its supply chain strategy. Aitken et al. [2] for example, argue that changes to the supply chain strategy are necessary as a product proceeds through its life cycle, in order to maintain competitiveness.

Since new markets have started to emerge in different areas of the world (and they still are), the need for closeness in terms of product-service specificities became progressively inevitable and more complex. Such an issue, together with several other factors, have created pressure on supply chain strategic evaluations: this pressure is rapidly becoming greater than ever before. Financial markets’ volatility, as well as the instability (i.e., non-predictability) of energy resources provide additional examples of today’s world turmoil. When it comes to think about a supply chain on a worldwide basis, it becomes clear that reduction of working capital could be a key-factor for a company’s finance leverage. Adaptability has become another “key-word” involving the development of new features: for instance, a country’s labor cost and regulations can change so rapidly that it is very often necessary to consider the possibility of a change of location [3]. Hence, it is inescapable for enterprises to address the complexity of the previously mentioned factors, especially in a context of ever-changing dynamics and global-scale competition. It is thus required, for any player doing business in the global market, to continuously monitor and improve its production strategies, depending also on specific local conditions and factors [4].

As supply-chains dynamics become more complex and more globally interconnected, the impact of external forces and disruptions in the business environment continues to grow. Such forces are placing an unprecedented pressure on supply-chains: customer-demand has become more difficult to anticipate, product lines have become more complex and the pressure to lower the cost of goods, as well as reduce working capital and improve performance, continues to mount. At the same time, and in addition to the above, the cost and availability of key-supplies and materials are becoming more volatile. All of this while macroeconomic and geopolitical maps are evolving at varying speeds, resulting in a confluence of trends that are difficult to face using the same methodology that was used in the past [5].

Globalization was the boost that has been changing the world since the ’80s. Such phenomenon, although started thirty years ago, is continuously evolving and is still influencing companies, as well as the entire human society. In other words, globalization simply does not stop. It is a never changing phenomenon that creates incredibly dynamic global rules; it generates a set of conditions that imply that an “abnormal environment” becomes the “new standard”.

In particular, the new scenario has required firms to become adaptive, i.e. to change quickly and to adapt to the environments o as to meet the new environmental needs constantly. Adaptation is in fact recognized as one of the most crucial factors for gaining and retaining competitive advantage [14].

However, it is evident that such a target cannot be easily accomplished. Many driving forces change each scenario, they are not entirely predictable and their actual impact on any scenario is not always foreseeable.

For example, some of such driving forces have been listed as follows:
Simulation of two hybrid production planning and control systems: a comparative analysis

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Abstract—The goal of this paper is to analyze and compare the performances of two Hybrid Production Planning and Control (HPPCs) systems, namely CONWIP and Workload Control. Although several implementations of HPPCs reported excellent results, in fact, many authors have discharged the concept, arguing that these systems can only reduce manufacturing lead times and control WIP to the detriment of production rate, punctuality or service level.

The paper starts from a brief review of the literature on HPPCs. Afterwards, the paper uses a common simulation model from the literature to compare two simple and easy-to-implement configurations of CONWIP and Workload Control against the baseline of a classic push system. The results of the simulations lead to important conclusions and suggest interesting improvements of simulation models and future directions of research for better understanding HPPCs.

Keywords—production planning and control system; hybrid push/pull; discrete event simulation; workload control; CONWIP

I. INTRODUCTION

Production Planning and Control (PPC) systems have been an object of research in operations management in the last 30 years or more. Although they are called by many different names, such as production control systems, ordering systems, production control policies, material planning methods, production and material flow control mechanisms and many others (see [1] for a comprehensive review), PPCs consist of a set of rules defining order release and material flow control in a manufacturing system ([2]). In this paper, they will be called with the acronym PPC, because of the twofold objective of planning and controlling production.

Several studies describe the role of Hybrid Production Planning and Control (HPPC) systems in reducing the expressions of “bad” variability and increasing manufacturing performances (e.g. [3]–[5]). These systems are referred to as “hybrid” because they operate both push (i.e. scheduling production) and pull (i.e. authorizing production), as suggested by [6], although the concepts of push and pull may have different meanings in the literature, as reported in section 2.

A large and growing body of literature has investigated on HPPCs such as CONWIP [7], Workload Control [8], synchro-
Design and Implementation of a Manufacturing Cell in a Job Shop Environment: An Action Research Study

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Abstract—Nowadays, more than ever, organisations are striving for ways to improve the production flow of different products. This is achieved at the expense of a better use of their resources, such as equipment, people, and materials, among others. Thus, the process of changing production systems, in order to make them more efficient, became a top priority to the manufacturers in the current environment of the global economy. In this context, cellular manufacturing systems arise, providing several different kinds of benefits over traditional production systems, allowing for the improvement of the customer satisfaction. In this paper the changing process, from a job shop production system to a manufacturing cellular system, at the company Durit – Metalurgia Portuguesa do Tungsténio, Lda. is presented. In addition, the gains achieved with the implementation of the manufacturing cellular system, in comparison with the production system previously used are also presented. The results after the implementation of the new production system were impressive. Two critical factors of success were the careful selection of the parts family and of the human resources.

Keywords—cellular manufacturing; group technology; job shop; lean manufacturing practices and tools; action research study

I. INTRODUCTION

In today’s global market, characterized by a competitive environment, companies are stimulated to focus on satisfying customer wants and needs in order to maintain a competitive advantage. This implies the fulfilment of the product’s requirements established with customers, namely in quality, price and lead times, among other outcomes. According to Gunasekaran, McNeil and McGaughey [1] competitive advantage can be attained through superior product performance, new product introduction or manufacturing performance. As far as manufacturing performance is concerned, lean manufacturing and continuous improvement have been used by several companies in the last decades, focusing on the identification and elimination of different kinds of waste and inefficiencies over the processes and on the creation of a pull flow over the supply chain, seeking production costs reduction and continuous improvement in processes quality and productivity. Lean manufacturing implementation is supported by a wide variety of management practices and tools that help companies in the creation of a lean environment. One of these practices contemplates the employment of cellular manufacturing.

Cellular manufacturing involves processing a collection of similar parts (which are similar either because of their geometric shape and size or because similar processing steps are required to manufacture them) on a dedicated group of machines or manufacturing processes, and can be defined as an independent group of functionally dissimilar machines, located together on the floor, devoted to the manufacture of a family of similar parts [2]. The basic concept of cellular manufacturing is that instead of production sequences, tooling and machine setups being based on single components, production planning is done for an entire group of similar components or operations. Moreover, cellular manufacturing is based on the principle that similar things should be manufactured similarly [3].

In this paper we present a project developed in a metalworking company that comprised the design and implementation of a manufacturing cell in a production department of the company, aiming at improving the operational performance of a family of products. Several lean manufacturing practices and tools were applied during the design phase and after the cell implementation. The idea was to establish a manufacturing cell using lean manufacturing practices as well as guarantee the continual use of lean and continuous improvement practices after the cell implementation. The main lean practices and tools that were used during the design phase were takt time based cell balancing, value stream mapping, visual management control and one-piece flow. Furthermore, the following lean practices and tools were settled to be routinely used: teamwork and leadership, 5S, standardized work, total productive maintenance, worker autonomy and lean performance metrics. In sections III and IV of this paper a detailed description of the project will be presented.
This session concerns the Industrial Performance Evaluation and Decision-Aiding. The presented papers accepted for this session focus on decision problems in industrial context and particularly on:

- the part of the decision-maker behavior in the decision process;
- the multicriteria and multi decision-makers aspects in such a context.

Presented papers:

- Decision Problem of Instrumentation in a Company involved in ISO 50001
- How to handle the Decision-Maker’s awareness of industrial context in his objectives declaration?
- A multiobjective approach for optimization of the multihead weighing process
- Modification to Fuzzy Extent Analysis Method and its Performance Analysis
- Multiple Regression Model for Surface Roughness Using Full Factorial Design
Decision Problem of Instrumentation in a Company involved in ISO 50001

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © 1e2 2015

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Abstract—In the context of performance management and the involvement of companies in sustainable development, energy management is a new challenge. Managing energy is a complex problem as it can potentially impact the whole company and if mishandled could be harmful for its added value. In order to assist companies in this challenge, the ISO 50001 proposes a standard for the creation of Energy Management Systems (EnMS). Such systems bring the recurring problem of decision about the choice of the actions necessary into their deployments. Notably, they rely heavily on the data related to the consumptions of energy and its usage in a given company. Hence the problem of decision, at an audit stage, can concern the choice of a sound instrumentation. This paper deals with the interest of the company adixen Vacuum Products in a standard for decision aiding in this situation. The idea is to build the model of preference of the Decision Maker and to establish a generic procedure about decision supported by a MCDA tool. Our proposition is to use the ACUTA method in order to elicit this model of preference.

I. INTRODUCTION

At the start of the 21st century, energy savings and the limitation of greenhouse gas emissions have become major challenges for many organizations including companies. Thus the International Standard Organization (ISO) estimates the potential gain to be about 30% on the energy consumption. In this context the ISO edited a specific norm for the companies involved in the control of their consumptions of energy through a system of management: the ISO 50001, published in 2011 [1].

The expectations and the major role of instrumentation for such a system of management are now presented.

A. The ISO 50001 concerning the Instrumentation

The ISO 50001, Energy Management Systems Requirements with guidance for use, gives organizations the requirements for Energy Management Systems (EnMS) as a standard. It provides a framework of requirements enabling organizations to:

- Develop a policy for more efficient use of energy
- Fix targets and objectives to meet the policy
- Use data to better understand and make decisions concerning energy use and consumption

- Measure the results
- Review the effectiveness of the policy
- Continually improve energy management.

According to [2], “ISO 50001 includes requirements for a program of energy data collection such as the installation of Automatic Monitoring and Targeting (AMT) systems, and this can be used to increase energy efficiency at different levels of a factory”. This can be seen as the application for an EnMS of the well known principle of “What you measure is what you get” [3] [4].

Usually, a company has knowledge about one point of measurement for a given energy: a single global point available directly with a counter or indirectly through the related bills. Intuition or practical observations point to the lack of information in such a single point of measurement. There is also the possibility of taking the reading directly on an equipment. This is generally considered as a time-consuming activity with many possibilities for errors. However the exhaustive instrumentation of equipments and machines in order to measure their consumptions of energy is expensive, time consuming, detrimental for the company’s activities of production or R&D… For example such an instrumentation in order to get the electrical consumption in real time of a single equipment can cost from 600€ to 1500€. So, a company which cannot afford to “measure everything” has to plan for the instrumentation of its activity in order to select the most relevant measurement points.

Before presenting the instrumentation decision problem, let us recall some key points about the general framework of improvement in companies, the so called Quality Management System (QMS) which is very similar to the EnMS. Indeed according to [1], the ISO 50001 is built with the same common elements as the other ISO standards, including the ISO 9001 which deals with QMS and is well known by many companies.

B. Quality Management System

According to the ISO 9001, the QMS is based on the PDCA cycle often illustrated by the Deming’s wheel [5]. More precisely, improvement must be made Step by Step, must be related to the company’s processes according to its Process


How to handle the Decision-Maker’s awareness of industrial context in his objectives declaration?

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Abstract - This study investigates some new approaches that concern the handling of human considerations in the decision-aiding field. We particularly look for the industrial context change and the awareness of the Decision-Maker with regards to such a change, in his decisions. Beyond the Routine regular situation, three situations are thus considered, namely the Control, the Emergency Crisis and the Loss of Control. A proposition of definition and use of the Decision-Maker Awareness is applied to the case of re-declaring initial objectives.

Awareness is defined through three parameters which are the Belief, the Level and the Graduality, which make up to the so-called Awareness Unit Cube. This is assumed to be evolving with regards to the Decision-Maker perception evolution. According to the evolving values of these parameters on the one hand, and to the characterisation of the occurred situation on the other hand, mathematical adjustments of the considered objectives values are proposed. Some illustrations of the proposal are extracted from a case study submitted by a steel manufacturer.

Keywords—industrial context; objectives declaration; Decision-Maker Awareness; Awareness Unit Cube; objectives re-declaration.

I. INTRODUCTION

Management involves a set of operational, financial and human actions, with regards to the industrial objectives achievement leading thus to making decisions according to these dimensions [1,2]. For instance, management decisions can be concerned with aspects such as the objectives declaration, the launch of improvement actions, the validation of the declared objectives, the workers’ rewards… Incidentally, one parameter that widely impacts on such decisions is the situation which is encountered by the system that deals with the objective achievement. Namely, in the industrial context, external events as well as internal events may occur and may more or less favour the achievement of the declared objectives. One can imagine the financial crisis, on a world scale, or more particularly some kinds of breakdowns and other unforeseen events related to the customer demands variability, the competitive aspect of the market… dealing thus with situations other than the classical regular situation, which is associated with “normal” business conditions. By “normal” condition, we mean that the operational system is under a routine functioning [3]. Such a system is well-controlled, i.e. it supplies the expected production by the correct processing of the resources [4].

To be more precise, the Routine situation is implicitly the reference for declaring the objectives, launching the actions, and, more generally, for all the structured decisions that are made. Hence, the risk becomes related to the focalisation on the Routine conditions, forgetting in this sense some kind of awareness of the real encountered conditions. In accordance with the topic of our paper, let us refer to the concept of Situation Awareness (SA), as it has been developed by the Human Factors community in the mid-nineties [5,6]. SA involves becoming aware (i.e. decision-makers and other responsible actors), of all that is happening in the vicinity in order to understand how information, events and one’s own actions will alter the objectives achievement, both immediately and in the near future. With a lack, an inadequacy or a weakness, SA has been identified as one of the primary factors in accidents attributed to human error [7]. According to us, the SA generally varies from not-at-all to total, with regards to the encountered situation on the one hand, the concerned Decision-Maker (DM), as well as the evolution of his perception and knowledge about the situation, on the other hand.

Hence, we choose to focus in this study on one particular aspect of management which is the objective declaration. We look for a type of handling of the soundness of such a declaration with regards to industrial encountered situations on the one hand and to the SA of the Decision-Maker (DMSA) on the other hand. To be more precise, the objective declaration is generally made by a DM, who has the authority and the control of the considered business unit or physical system that is concerned with the achievement of the objective. Moreover, knowing that an objective is declared by a target value and a temporal horizon [4,8,9], both these parameters of the objective have to be, from a technical point of view, realistic with regards to the achievement. They also have to, from a strategic point of view, make the performance perennial. Hence, the DM becomes responsible for what can be called the soundness of the objective declaration. However, declaring accurate and relevant context-dependent objectives is thornier. A reliable knowledge and a strong SA thus allow the DM to first be able to identify the right situation and then deduce the right objectives values from this diagnosis.
A multiobjective approach for optimization of the multihead weighing process

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Abstract— Packaging technology can be of strategic importance to a company, as it can be a key to competitive advantage in the modern food industry. A multihead weighing process is a packaging process based on the sum of weights from several individual hoppers. The final quality of the packaged product in a modern automated food packing system should fulfil two objectives—the quality of the packaging process itself and the sensory quality of the packaged food. The first one is often related to the proximity of the total weight to a nominal value of sale and to the variability of the packaging process, and the second one can be achieved by minimizing the total residence time of the food in the packing system. In this paper, we jointly address both objectives through multiobjective programming. More precisely, a biobjective algorithm is developed, in which a subset of hoppers is selected from the set of available ones at each packing operation, in such a way that the relative importance of both aforementioned objectives is dynamically managed and adjusted. We conduct numerical experiments to examine the quality of the solutions being produced.

Keywords— Multihead weighers; Packaging processes; Combinatorial optimization; Compromise programming; Quality control; Reduction of variability.

I. INTRODUCTION

Multihead weighers or combinational weighers are used to provide accurate weights at high packing speed and are currently the most used dosing method for many kinds of products, also including those with heterogeneous characteristics [1]. Fig. 1 shows a radial multihead weigher in a modern automated packing system, and the arrangement of feeders and hoppers.

Multihead weighers have a number of weighing heads that statically weigh the product; these weight data are fed to a computer, which calculates all of the possible combinations of product weights in order to disperse the best combination (closest match to target weight) to a packaging machine. To increase the performance of the weighing system other elements are introduced, namely:

• A system to automate product feed to the weighing stations. This is normally in the form of a belt or vibratory feeder (linear vibrators); the belt is controlled to deposit a fraction of the final target weight into a product storage hopper mounted above the weigh hopper. Depending on the layout of the machine, the feed system is configured either in a radial or in line construction.

• A system to collect product and feed it into a weighing hopper. This hopper is commonly known as a pool hopper (feed hoppers). It must be constructed in such a way as to act as a buffer store to contain the product from the feed system whilst the weigh hopper below is stabilizing. The weighing system must have static product to ensure accurate weighing results. If the pool hopper was not present it would be necessary to employ more weigh hoppers to achieve the same levels of performance, other methods would also have to be used to ensure product did not fall into the weigh hopper either during the stabilization time or immediately prior to discharge.

• The weigh hopper. The construction of the weigh hopper is such that it must robustly contain the product. The weigh hopper is supported by a suitable weight transducer. The weight data is fed to an electronic system to combine the data from the other weigh hoppers on the machine to determine which hoppers should be discharged to the downstream process (weight hoppers combination).

Fig. 1. Schematic of the basic combinational weigher components. Arrangement of feeders and hoppers of a radial multihead weigher.

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Modification to Fuzzy Extent Analysis Method and its performance Analysis

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Abstract—Analytic Hierarchical Process (AHP) is one of the most popular Multi-Criteria Decision Making (MCDM) techniques while fuzzy set theory is extensively incorporated into original AHP in order to address vagueness in human judgments. There are a number of algorithms proposed for Fuzzy AHP (FAHP), however, Fuzzy Extent Analysis (FEA) is one of the most frequently used model. This study evaluates the performance of this model against a modified FEA method which utilizes centroid defuzzification. This study shows that modified FEA method performs significantly better than its original model and thus can lead to more effective decision making.

I. INTRODUCTION

In a Multiple-Criteria Decision Making (MCDM) process, prioritizing and assigning weights to each criteria with reference to a set of available alternatives is key to effective decision making. Analytic Hierarchy Process (AHP) proposed by Thomas L. Saaty [1] is one such technique used in MCDM through which experts provide pairwise comparisons and this information is processed in a comparison matrix in order to calculate priority vector.

One of the major concerns regarding to the original AHP is, transforming human judgments, which are communicated usually by means of linguistic phrases such as “significantly more”, “slightly more” etc., into a 1-9 numerical scale, due to the inherent uncertainty in human language. Disregarding the vagueness of human language in the decision analysis process may lead to wrong decisions [2].

Since it is introduced by Zadeh [3] Fuzzy Set Theory has received extensive attention from researchers from variety of discipline in the past five decades. As opposed to the dichotomous (i.e., conventional) crisp set theory which assumes an object either belongs to a set or not, fuzzy set theory represents the belongingness with a degree of membership value. This approach allowed a more realistic representation of the nature and has been successfully applied in various fields such as control theory [4], health care [5], system modeling/data mining [6], [7], etc.

Fuzzy AHP (FAHP) is introduced as an extension of fuzzy set theory in the context of MCDM, where the linguistic variables obtained from the decision makers during the comparison matrix elicitation phase are represented with fuzzy numbers as opposed to the original crisp numbers of the infamous 1-9 scale of Saaty [1]. Utilization of the fuzzy numbers, enabled the analysts to incorporate the inherent vagueness of the linguistic variables to the decision making process.

There are number of different techniques proposed over the years which prioritize and rank the available criteria based on comparison ratios represented by fuzzy numbers [8][9][10] and a review of these techniques is provided by Buyukozkan [11]. Fuzzy Extent Analysis (FEA) proposed by Chang [12] is one of the most frequently used FAHP algorithm [13]. In this study, we propose a modification to this model and evaluate the performance of the proposed modification with an experimental analysis.

The rest of the paper is organized as follows. In section II, we will provide an extensive overview of the FEA model. In section III, we will present the proposed modification to the FEA model and discuss the details of the experimental setup in order to evaluate the performance of the proposed modification. In Section IV, the results of the experimental analysis will be demonstrated. The paper will finalize with some concluding remarks Section V.

II. FUZZY EXTENT ANALYSIS

Before providing a review of FEA model, we first provide a brief overview of the fuzzy logic and fuzzy arithmetic. Fuzzy sets can record the imprecision arising in human judgments which are neither random nor stochastic [14]. Instead of a single value, fuzzy number represents a set of possible values each having its own membership function between zero and one. A triangular fuzzy number is represented by a representation, mean value, upper value, i.e., $[l,m,u]$ with membership functions $\mu_M$ given by:

$$\mu_M(x) = \begin{cases} \frac{x-m}{m-l}, & x \in [l,m] \\ \frac{x-u}{m-u}, & x \in [m,u] \\ 0, & \text{otherwise} \end{cases}$$

(1)

The same is graphically illustrated in Figure 1.

Let $(l_1, m_1, u_1)$ and $(l_2, m_2, u_2)$ then the basic fuzzy arithmetic operations are summarized as follows:
- Addition:
  $$\min (l_1, m_1, u_1) + \max (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$
Abstract—This paper describes the modeling of surface roughness in turning of AISI 1042 Steel at four cutting parameters: cutting speed, feed rate, depth of cut and tool nose radius. Full factorial design is implemented to investigate the effects of interactions of these parameters on surface roughness. By using the multiple regression method, we developed a model with high correlation coefficient of 99.55 % and error of 0.07. Moreover, a good agreement was observed between estimated and experimental surface roughness in this model. The effects of cutting parameters and their interactions on surface roughness were investigated by using the analysis of variance.

Keywords—Full Factorial Design; Multiple Regression; ANOVA analysis; surface roughness; cutting parameters

I. INTRODUCTION

Manufacturing processes are classified into four principal types: machining, forming, casting and joining. Machining remains the most popular and easily applicable one to a large variety of material. It offers excellent dimensional tolerances, external and internal geometrical features and the best surface quality.

Machining can be defined as the process of removing unwanted material from a work piece to produce the desired shape. The work piece is cut from a larger piece, which is available in a variety of standard shapes, such as round bars, rectangular bars, round tube, etc.

Machining process includes five categories: turning, milling, drilling, grinding and boring. Turning is the process of machining external or internal cylindrical and conical surface. The work piece is rotated at a particular speed (cutting speed) and the tool is fed against the work piece (feed) at a certain level of engagement (depth of cut) as shown in Fig. 1.

Turning is one of the widely used machining processes in industries. In turning, the important task is to select cutting parameters in order to achieve the highest cutting performance such as surface roughness, material removal rate, tool wear and power consumption. Habitually, conducting experiments or using a handbook can determine the required cutting parameters. Unfortunately, these means don’t lead to optimal cutting performance for a particular machine tool and environment.

Surface roughness remains the main indicator of machined component quality. A low surface roughness improves the tribological properties, fatigue strength, corrosion resistance, and esthetic appeal of the product [1].

Various parameters are used to evaluate surface roughness. In the present study, the arithmetic average surface roughness Ra is selected to characterize the surface roughness as it is a key requirement for many relevant applications in industry.

A considerable number of studies have investigated the effects of cutting parameters on surface roughness. The three major cutting parameters evaluated in these researches are: cutting speed, feed rate and depth of cut. In addition, the roughness is affected by cutting tool geometry, e.g., nose radius, rake angle, side cutting edge angle and cutting edge. Surface roughness is not only influenced by these endogenous parameters, but also by other exogenous factors such as: work piece and tool material combination and their mechanical
This session concerns the Industrial Performance Evaluation and Decision-Aiding. The presented papers accepted for this session focus on decision problems in industrial context and particularly on:

- the part of the decision-maker behavior in the decision process;
- the multicriteria and multi decision-makers aspects in such a context.

Presented papers

- *The Effective of Lean Manufacturing and Six Sigma Implementation*
- *Material handling equipment selection: new classifications of equipments and attributes*
- *Performance Evaluation of a Closed Loop Manufacturing System Taking Into Account Delivery Activity and Degradation*
Modeling of the Stock Management System Using Batch Deterministic and Stochastic Petri Nets (BDSPNs): «Application for Performance Evaluation»

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Abstract— The work presented in this article constitutes a contribution to modeling, evaluation and analysis of the performance of inventory management systems, and more generally stochastic discrete event systems with a batch behavior, by using the Batch Deterministic and Stochastic Petri Nets. To do this, we applied this tool on a typical model of inventory management systems in order to show how this tool can help to model and analyze the performance of the inventory management systems and to provide information on their behavior and effects of their parameters.

Keywords— modeling; stochastic Petri nets; inventory management systems; performance

I. INTRODUCTION

Today manufacturers can work on improving their supply chain in two cases: either they seek to improve the performance of their current system (improved inventory management and production policies ...), or they want to develop a new configuration of their supply chain (restructuring, enlargement ...). In cases, preliminary studies and parameters for analyzes should be conducted to assess and analyze the performance of the current system or the one planned.

Petri nets (PN) were recognized as powerful tools for modeling, analysis and evaluation of discrete events systems (DES) which includes the supply chains and storage systems. The success of PN must in particular their support for both graphic and performing both mathematical analysis and analytical evaluation for the simulation of the system studied.

The PN have been widely exploited for the study of flexible production systems. However, very little research concerning their use in logistics. However, recent exploratory and preliminary studies often showed the potential choice of PN for the study of this class of systems.

However, analyzing the results of the literature reveals that the models used are unaware of important aspects in the operation of the systems studied. This is very particular batch ubiquitous phenomena in different locations of a supply chain. In such a storage system, the level of each stock is inspected according to Management policy. In general, when the stock reaches a certain predetermined threshold, a batch control of a quantity of product has passed to replenish the stock and bring it back to a fixed level. The batch command in turn leads to transportation or delivery operations in batch mode to complete the replenishment of stock. In a supply chain, the batch behavior is needed in the management of many storage areas that composes and execution of orders of different customers who are frequently in batch mode.

For this, we propose to apply the Batch Deterministic and Stochastic Petri Nets BDSPNs as a modeling tool and analysis on inventory management systems that play a major role in companies organized in supply chains.

The purpose of this paper is to propose an approach for modeling and evaluation the performance of inventory management systems, by using the Batch Deterministic and Stochastic Petri Nets BDSPNs as a very powerful modeling tool.

In this paper, we show the interest of the Batch Deterministic and Stochastic Petri Nets BDSPNs for modeling, performance evaluation and analysis of inventory management systems. Later we will present our model and inventory management system, and finally a resolution of stochastic process associated with this system will allow us to calculate the performance indicators.

II. METHODOLOGY AND TOOLS

A. SPNs and performance indicators

Many classes of SPNs are proposed for the performance analysis of production systems, [1-3]. The characteristics of the different classes are mainly in the nature of transitions used, where laws other than exponential are associated with them [4].

To model our system, we use the Batch Deterministic and Stochastic Petri Nets (BDSPNs), these latter are developed for modeling and performances analysis of logistical systems and more generally of discrete events systems with a batch behavior. They are especially dedicated for modeling flow evolution in discrete quantities (variable batches of different
The Effective of Lean Manufacturing and Six Sigma Implementation
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Abstract—In this paper, we study the performance outcomes for industries practicing lean manufacturing and six sigma. Findings indicate that company size has no influence on operational performance outcomes. Also we found that lean manufacturing and six sigma methodologies are ideal for cutting cost, improving efficiency with improved quality [11].

Combining lean and six sigma resulted in improvements in innovation and efficiency with improved quality [11]. The implementation of lean manufacturing and/or six sigma is promoted as techniques for change and quality improvement in organizations [7].

Empirical data was collected through a survey distributed among companies in France. The aim of this study was to find out which of the methodologies lean manufacturing, six sigma or a combination of lean manufacturing and six sigma was implemented by French industries. The study sought to find out the impacts that were associated with the implementation of the methodology. This study also identifies the status of lean manufacturing and six sigma implementation within French industries, such as tools and techniques, and range in the implementation of lean and six sigma and whether organizations employed a belt system or not.

II. LITERATURE REVIEW
Six sigma is related to 3.4 Defects Per Million Opportunities (DPMO) with the intention that identifying and eliminating the defects, the organization can significantly improve quality of production [2]. Six sigma methodologies are applied in an organization as a means of solving quality problems and designing new and improved processes. The framework for implementing six sigma is Define, Measure, Analysis, Improve and Control (DMAIC) [2]. On the other hand, lean manufacturing is a method that focuses on reducing cost through the elimination of the seven types of waste in all aspects of the organization, such as motion, overproduction, wait time, transportation, over-processing, defects, and inventory excess [1]. Lean manufacturing includes various tools and techniques supportive of the elimination of waste such as Value Stream Map, 5S, Total Productive Maintenance and Kaizen, Kanban, etc [1]. The essential steps in lean are identification of features that create value include identification of value stream sequence of activities, making the activities flow, letting customer pull the product or service through the process and making the process perfect [9]. The implementation of lean and six sigma can produce more efficient and effective outcomes if there was an emphasis on human beings or organizational culture as opposed to a single focus on training staff in techniques and tools [10]. Lean and six sigma methodologies are ideal for cutting cost, improving innovation and efficiency with improved quality [11]. Combining lean and six sigma resulted in improvements in
Material handling equipment selection: new classifications of equipments and attributes

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Abstract – This paper analyses the existing literature (27 articles) on material handling equipment selection through equipments and attributes aspects. It is found that the maximum material handling equipment types used by developed systems for resolving the selection problem is 50 equipment types. The greatest number of attributes used in one article is 42 attributes. However, systems should be more robust and practical by being close to the reality of the selection problem. According to the continuously growing market, much more material handling equipments exist. Therefore, more complete new classifications of individual unit load material handling equipments and attributes are provided. Equipment categories, classes and types are clarified. Reasons of the necessity for new lists are discussed.

Keywords - Material handling equipments, attributes, new classifications, material handling equipment selection

I. INTRODUCTION

A material handling system is constituted of methods using material handling equipments [1]. It could be a source of cost savings or excessive expenditure if it is not efficiently designed. Its design goes through material handling equipment selection. It is an obligatory passage and a phase among others in warehouse design [2]. Moreover, selecting material handling equipments requires facilitating more efficient tools rather than consulting equipment vendors or doing thinks as usual.

A literature review of the last 30 years researches on material handling equipment selection has identified 27 articles on this subject: Bookbinder and Gervais [3], Chakraborty and Banik [4], Chan, Ip and Lau [5], Cho and Egbelu [6], Chu, Egbelu and Wu [7], Fisher, Farber and Kay [8], Fonseca, Uppal and Greene [9], Gabbert and Brown [10], Hassan [11], Hassan [12], Hassan, Hogg and Smith [13], Kim and Eom [14], Kulak [15], Malmborg, Krishnakumar, Simons and Agee [16], Maniya and Bhatt [17], Matson, Mellichamp and Swaminathan [18], Mirhosseyni and Webb [19], Onut, Kara and Mert [20], Park [21], Raman, Nagalingam, Gurd and Lin [22], Sharp, et al. [23], Telek [24], Trevino, Hurley, Clincy and Jang [25], Tuzkaya, Gülüsün, Kahraman and Özgen [26], Velury and Kennedy [27], Welgama and Gibson [28], and Yaman [29].

Those papers have developed solutions organized in 5 groups: optimization models (4), expert systems (10), hybrid systems (2), multicriteria decision methods (4), and systemic framework approaches (2) [30]. They became new alternatives for handling systems designers. Otherwise, they dispose few decision making tools to select optimal material handling equipments for specific material handling operations in a factory or in a logistic warehouse. They are currently facing three choices: (1) using their own experiences while seeking in material handling books and handbooks, (2) trusting an equipment seller and its catalogs, (3) requesting recommendations from an external consultant [5]. The selection process is discussed in detail in the literature review of Ahmed Bouh and Riopel [30].

This work comes to begin exploring one axe of the research opportunities identified by the late literature. Classifying material handling equipments and attributes is a preliminary task between other in the process of developing a solution for warehouse material handling equipment system.

However, various schools of thought exist concerning “material handling equipment” definition. This expression returns to the definition of “material handling”. In certain papers which treat material handling equipment selection problem, it is regarded as being the fact of moving product from a point to another, while storing it on racks or manipulating it [31]. But, there is a difference between product manipulation, handling it, transporting it, and warehousing it. Material handling is “the process and systems that transfer and manage the transfer of goods from one place to another” [32]. On the other hand, "manipulating is the action to move automatically, mechanically or manually products in a work station. Transportation is the external long distance travel of goods towards other places. Storage is the action to gather and have goods constituting stocks under material conditions favorable to their conservation and their taking away” [33]. “Material handling equipment cannot be used to store products. Similarly a pallet rack is not designed for moving a pallet in a distance”[30]. This is one of constraints in developing effective and practical systems for material handling equipment selection problem resolution.
Performance Evaluation of a Closed Loop Manufacturing System Taking Into Account Delivery Activity and Degradation

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Abstract— This work studies a closed loop manufacturing system which composed of two parallel machines, a manufacturing inventory, a purchase warehouse, a recovery warehouse (customer), and which usually has great impact on the total cost of the system. Furthermore, they have determined the optimum values of the amount of products manufactured and the proportion of the remanufactured part to the returned products on the total cost of the system. Moreover, research on manufacturing has been paying attention on the return of used parts processes. Many of the works in the literature published on closed loop manufacturing systems and which deal the production control. Wang, Zhao, and Wang [1] have considered a manufacturing-remanufacturing system that deals products with short life cycle, stochastic returned products. Then they have studied the impacts of the amount of products manufactured and the proportion of the remanufactured part to the returned products on the total cost of the system. Furthermore, they have determined the optimum values of the amount of products manufactured and the proportion of the remanufactured part to the returned products which minimize the total cost of the system. Also, Shi, Zhang, and Sha [2] have proposed a stochastic model for determining the optimal production and remanufacturing quantities for a product portfolio. They have supposed that the product demands are independent, for each product new and remanufactured units are perfect substitutes, the returns are of unknown quality and the amount of returned cores is a function of their acquisition price, which is also a decision variable. Turki et al [3] determined the optimal manufacturing inventory level which allows minimizing the sum of inventory and lost sales costs, they adopted a stochastic fluid model to manufacturing-remanufacturing system composed by manufacturing inventory, two parallel machines, remanufacturing inventory and customers who demand a stochastic quantity of product. Besides, these works haven’t taken into account some important characteristics of the supply chain systems such as transport. In fact many companies are working to reduce transportation delays such as the delivery time (Turki et al [4]), which is the period of time that the part takes between a manufacturing inventory and a purchase warehouse (customer), and which usually has great impact on performance measures. Also another characteristic of the manufacturing systems is not considered, such as the degradation of the system equipment. Hence, in this paper we have the interest to consider the delivery activities and the maintenance actions in a closed loop manufacturing system and to take into account the different delivery constraints such as delivery period, vehicle capacity and warehouse capacity. Furthermore we will consider the degradation of the machines and the vehicle according respectively to them production rate and its quantity to transport. Indeed, the consideration of such system is a novelty in the supply chain research, the fact it combines the delivery activity with the production activity in forward direction and reverse logistics also it considers the maintenance actions. Hence, to describe such system and to take into account the different constraints, the stochastic fluid model will be used (Yao and Cassandras [5], Cassandras et al [6], (Turki et al [7]).

Stochastic fluid (Turki et al [8]) model is widely used to control, analyze, and improve the performance of manufacturing systems. In fact, stochastic fluid model is very useful in simulating various kinds of high speed networks, manufacturing systems and more generally, settings where users compete over different sharable resources. The robustness of a stochastic fluid model rests on its ability to aggregate multiple events. The major reasons for choosing this model, is that the stochastic fluid model allows establishing...
Scheduling is a decision making process that is used on a regular basis in many manufacturing and service industries. It plays an important role in optimizing the use of available resources in order to satisfy one or several objectives. The problem of scheduling jobs on machines is usually discussed under the assumptions of known and constant processing times and continuously available machines. However, in practice, the scheduler might have to deal with various special forms of constraints: machines may be subject to preventive maintenance, jobs might wait until a machine resets itself, processing times may increase as the machines get older, etc.

The aim of this session is to bring together specialists in order to present their relevant and recent advances in the development of scheduling problems and their applications. Authors were invited to submit complete original papers using optimization techniques such as mathematical modeling, exact methods, (meta-) heuristics, relaxations, and hybrid approaches.

Presented papers

- *New heuristics to minimize makespan for two identical parallel machines with one constraint of unavailability on each machine*
- *A two-machine flow-shop scheduling with a deteriorating maintenance activity on the second machine*
- *A joint optimization-simulation model to minimize the makespan on a repairable machine*
- *Iterative relaxation-based heuristic for the single-processor scheduling problem with time restrictions*
- *Solving the two identical parallel machine problem with a single operator*
New heuristics to minimize makespan for two identical parallel machines with one constraint of unavailability on each machine

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Abstract—This work is an extension of previous works [1], [2], [3] about scheduling jobs on identical parallel machines with constraints of unavailabilities to minimize the makespan. We are interested in this paper on the case with two identical parallel machines such that each machine is unavailable for one unavailability period such that the preemption of jobs is not allowed. We are divided this problem on five cases and for each of them we are proposed a heuristic to minimize the makespan. The obtained results, compared with those of Chien and Liao [13], show that our heuristics quit efficient in solving large problems.

Keywords—scheduling; two machines; unavailability constraint; makespan

I. INTRODUCTION

In this work we are interested with the problem of scheduling a set of \( n \) jobs on two identical parallel machines, such that each machine is unavailable for one period of maintenance. These periods are not identical, and the preemption of jobs is not authorised. The problem is to find a feasible schedule of minimum duration (makespan). See figure 1 below.

We adopt the scheduling notation of graham et al. [7] to denote our problem by \( P_2|a_1-np|C_{\text{max}} \), where \( P_2 \) indicates two identical parallel machines, \( a_1-np \) for the constraints of one period of unavailability on each machine and the no-preemption of the jobs, and \( C_{\text{max}} \) is the criteria to minimize.

The problem of scheduling jobs on identical parallel machines with constraint of unavailability has received the interest of many researchers. A complete review can be found in Schmidt [11]. But we briefly review the related research on parallel machines with nonresumable availability constraints and makespan criterion.

Chien and Liao [13] have been studied the same problem by divided it into five cases. For each case they have proposed an algorithm to solve the problem.

Lee [9] considers a parallel machine problem where some machines may not be available at time zero. He proposes a M-LPT (Modified-Longest Processing Time) algorithm and gives a tight worst-case bound.

Kellerer [8] discusses a parallel machine problem where each machine has a different beginning time, and develops a dual approximation algorithm with a tight bound.

Carlier [4] studied the case \( P|r_j,q_j|C_{\text{max}} \), where \( r_j \) and \( q_j \) are respectively release and delivery date of a job \( J_j \). He has proposed the first branch and bound algorithm for this problem.


Other variation of this problem has been studied by Lee and He [10], Webster [12].

Such as Chien and Liao [13], we have divided the problem into five different cases according to the value of the sum of the all processing time of jobs. For each case, we propose a heuristic, based on knapsack algorithm [1], for solving it optimally.

The paper is organised as follows. Section II gives the preliminaries for the problem. Section III presents the proposed algorithms for each case of our problem. Computational results are given in the section IV. Finally, a conclusion and future research are given.
A two-machine flow-shop scheduling with a deteriorating maintenance activity on the second machine

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Abstract—Simultaneously scheduling jobs and preventive maintenance is a topical subject in the scheduling literature. In this paper, we study a two-machine flow-shop makespan scheduling problem with a deteriorating maintenance period on the second machine, that is, delaying the maintenance increases the time required to perform it. We show that the studied problem is NP-hard and we establish some conditions of the optimal schedule. We also develop a branch and bound (B&B) algorithm to solve this problem. Numerical experiments show that the B&B method can solve large-size instances.

I. INTRODUCTION

In classical scheduling problems, the machines are assumed to be continuously available. However, in a real manufacturing system, machine may become unavailable during the scheduling period due to preventive maintenance. Furthermore, the period of maintenance can improve the performance of the machine.

In the literature, there are two classes of problems with availability constraints:

- The unavailability period may be fixed in advance. In [1] and [2], Lee studies scheduling problems with availability intervals under several settings. The author show that the problem of two machines flow-shop with unavailability interval on the first or second machine is \( NP \)-hard in the ordinary sense under the resumable and non-resumable cases, heuristics with error bounds and dynamic programming algorithms are provided. For survey of scheduling problems with deterministic case, refer to Schmidt [3] and Ma et al. [4].

- The unavailability constraint may be a decision variable, i.e., a simultaneously scheduling of jobs and unavailability periods. For the problem of flow-shop, Allou et al. [5] consider that one of the two machine must be maintained once during the first \( T \) units of time. They prove that the problem is \( NP \)-hard. But, in [6], the authors prove that the problem is polynomially solvable if the maintenance is on the second machine.

More recently, Hnaen et al., 2014 [7] consider the same problem in [2] : a two-machine flow-shop with an availability constraint on the first machine. The unavailability period is known in advance and it is fixed. The authors proposed two mixed-integer programming (MIP) models and a branch and bound (B&B) algorithm. The computational study reveals that most of the instances of size up to 100 jobs are optimally solved with the (B&B) method and up to 20 jobs with the first and the second MIP.

Most research on scheduling with the maintenance activity assumes that the maintenance duration is constant. In 2005, Kubzin and Strusevich [8], [9] introduced a new maintenance model in which the length of the maintenance period is defined by a non-decreasing function that depends on the starting time of that maintenance. This model has received more and more attention.

In this paper, we study a problem on two-machine flow-shop scheduling with a variable maintenance duration on the second machine. The objective is to minimize the makespan and to find the optimal maintenance position on the second machine. We show that the studied problem is NP-hard and we establish some conditions of the optimal schedule. We also develop an exact method based on branch and bound.

The remainder of this paper is organized as follows. In Section II, we introduce the problem. In Section III, we present the main properties of the problem. In section IV, we present the Branch & Bound algorithm. Finally, we reported the computational experiments in Section V.

II. NOTATION AND PROBLEM FORMULATION

The problem under study can be formally described as follows: A set of \( n \) independent jobs \( N = \{ J_1, J_2, \ldots, J_n \} \) need to be processed on two-machine flow-shop \( M_1 \) and \( M_2 \). All jobs and machines are available at time zero and preemption of jobs is not allowed.

In this paper, contrary to the problem in [5] and [6], we study the problem in which the second machine must be maintained exactly once after \( T \). The maintenance can not occur in the interval \([0, T]\) because of the unavailability of the maintenance crew/replacement parts, see Fig. 1.

The maintenance period on the second machine is considered as a Rate-Modifying Activity (RMA). RMA is an activity that changes the production rate of a machine, this model is initially introduced by Lee and Leon [10]. This model has received more and more attention. See, e.g., [11], [12], [13], [14], [15] and [16].

Let \( b_{ij}(a_{ij}) \) denote the processing time of job \( J_j \) if it is scheduled before (after) the maintenance activity on \( M_i \),
A joint optimization-simulation model to minimize the makespan on a repairable machine

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Abstract—We consider the problem of scheduling a set of jobs on a single machine subject to stochastic failures. The objective is to minimizing the makespan. The machine could be stopped for preventive maintenance occasionally to reduce the risk of failure and to improve its reliability. Furthermore, in the case of a breakdown, the machine undergoes a corrective maintenance which brings the age of the machine to zero (That is to say the machine is considered as good as new) and the current processed job is reprocessed from the beginning. Despite the fact that the scheduling problem with single or periodic preventive maintenance has been well studied, most of the studies considered only deterministic cases. In other words the machine never fails. In this paper we take into account the stochastic failures while minimizing the makespan and determining the corresponding optimal sequence of jobs and optimal preventive maintenance policy. Both the exponential and the Weibull distribution are considered to model the probability density function associated with the lifetime of the machine. We use Arena and Optquest to optimize the performance criterion which allows us choosing the best sequence of jobs and the best amount of preventive maintenance.

keywords: Stochastic scheduling, makespan, maintenance, preventive maintenance, failure, single machine, Arena, Optquest.

I. INTRODUCTION

Sequencing and scheduling decisions are of paramount importance for companies [1]. Especially with the globalization of trade and new requirements in terms of quality and competitiveness. As a consequence, the theory of scheduling has expanded rapidly during the past decades. Several models were proposed to help managers make the right decisions while dealing with these scheduling problems. That is all the more true in a stochastic environment where random events, inside or outside the company, may negatively affect the productivity rate or the the delivery process. Therefore, the manufacturing systems must be in a perfect condition whenever needed. Thus the impact of these random events can be absorbed easily and their consequences limited. Moreover, these systems are subject to random failures and to deterioration and therefore have to undergo preventive or corrective maintenance actions. In facts, taking into account maintenance constraints in scheduling problems is not systematic; many authors assume that the production system is available all the time. Foremost, because maintenance function, and until quite recently, was seen as a non-core service organization that did not contribute to competitiveness, and secondly, because the most realistic models are not easy to solve analytically. Actually, there are many reasons why machines may not be in operation. Some of these reasons are based on a deterministic process, others on a random process [1] [2]. There are few researchers that explicitly integrate maintenance and scheduling decisions on a single machine. Graves et al. [3] consider the problem of minimizing weighted completion time taking into consideration only one preventive maintenance period. More recently, Ji et al. [4] study the same problem where the objective considered was to minimization of the makespan. Wang et al. [5] consider the problem of minimizing the total weighted job completion times on a single machine with availability constraints. They show that the problem is NP-hard in the strong sense. However, they propose heuristics for the special case when the weights are proportional and when there is only a single availability constraint. Kacem et al. [6] consider the same objective with one unavailability period. They propose branch and bound algorithm and a dynamic programming to solve exactly such a problem and showed that problems with up to 3000 jobs can be solved within a reasonable computation time. Later, Kacem and Chu [7] have improved these results by proposing a branch-and-bound algorithm based on a set of improved lower bounds and three heuristics. Low et al. [8] have addressed the same problem to minimize the makespan where the unavailability of machine results from periodic maintenance activities. Each maintenance period is scheduled after a periodic time interval and the machine should stop to maintain after a periodic time interval or to change tools after a fixed amount of jobs processed simultaneously. They show that this problem is NP-hard in the strong sense and give some heuristic algorithms to solve it. More recently, Benmansour et al. [9] studied the problem of minimizing the makespan on a single machine subject to preventive maintenance and reliability constraints in a just-in-time environment. They proposed two mathematical model to solve the problem optimally. In order to take into account the stochastic failures, the authors propose a hybrid method composed of one of the mathematical models and a a simulation model. Experimental results shows the efficiency of the proposed hybrid method under several maintenance strategies. Later Elhadaf et al. [10] studied a similar problem but under different assumptions. Their objective was to schedule several jobs on a single
Iterative relaxation-based heuristic for the single-processor scheduling problem with time restrictions

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Abstract—Recently, the single-processor scheduling problem with time restrictions was investigated by several researchers, and worst-case analysis and exact methods to solve this problem were provided. The studied problem has been formulated in 2013 as follows. A set of simultaneously available and independent jobs has to be scheduled, without preemption, on a single processor. We assume that the processing times of the jobs are deterministic and integers, and that the processor is always available. Moreover, this processor cannot process more than one job at any time. In addition to these constraints, the time restrictions apply: during any time period of length $\alpha > 0$ the number of jobs being executed is at most equal to a given integer value $B$. We consider the objective of minimizing the makespan. In the present paper, we extend a previous work on the problem. First, we consider a mathematical model based on assignment and positional date variables.

II. MIP FORMULATION

In the literature, there exist several Mixed Integer Programming (MIP) formulations for scheduling problems which can be classified on the type of the decision variables: (i) completion time variables, (ii) time-indexed variables, (iii) linear ordering variables and (iv) assignment and positional date variables. For more details, we refer the reader to the papers [11], [12]. In this section, we propose a new MIP formulation for the single processor scheduling problem with time restrictions. The rest of this paper is organized as follows. First, we give the problem description and a Mixed Integer Programming formulation in section II. In Section III, we describe the iterative relaxation-based heuristic for the single-processor scheduling problem with time restrictions. Section IV is dedicated to the computational experiments. Finally, some conclusion and possible future works are discussed in section V.

I. INTRODUCTION

Scheduling is concerned with the allocation of limited resources to activities with the objective of optimizing one or more performance measures [1]. Scheduling problems have begun to emerge during the second half of the 20th century. A number of efficient algorithms have been developed to provide optimal solutions to relatively simple scheduling problems ([2], [3], [4]). Over time, the problems encountered became more complex, and researchers were unable to develop efficient algorithms for them. With the advent of complexity theory, many scheduling problems were shown to be NP-hard ([5], [6], [7]). Several researchers have tried to develop approximation algorithms in order to find good feasible solutions in a reasonable time. Among all these problems, the case of the single machine is the most studied one for many practical reasons (cf. [1], [8]).

In this paper we consider the problem of minimizing the makespan on a single processor subject to time restrictions constraint. Formally, we are given a set $N = \{1, 2, \ldots, n\}$ of $n$ jobs which have to be scheduled non preemptively on a single processor. This processor cannot process more than one job at any time. Without loss of generality, we consider the processing times of the jobs as deterministic and integers. Furthermore, during any time period of length $\alpha > 0$ the number of jobs being executed is less or equal to a given integer value $B$. This situation is encountered when each job being processed (on the processor) requires the use of one of $B$ identical subprocessors. In turn, each subprocessor needs $\alpha$ units of time to reset itself before it can be used again. This problem was first formulated and studied by Braun et al. [9]. Later Benmansour et al. [10] proposed a Mixed Integer Programming formulation model to solve it optimally. The results presented in this paper showed that even medium sized instances could not be solved efficiently by a solver in a reasonable CPU time. This observation lead to the present work in which we propose to strengthen a formulation of the problem using pseudo-cuts.

The rest of the paper is organized as follow. First, we give the problem description and a Mixed Integer Programming formulation in section II. In Section III, we describe the iterative relaxation-based heuristic for the single-processor scheduling problem with time restrictions. Section IV is dedicated to the computational experiments. Finally, some conclusion and possible future works are discussed in section V.
Solving the two identical parallel machine problem with a single operator

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Abstract—We address in this paper the problem of scheduling a set of independent and non-preemptive jobs on two identical parallel machines with a single operator in order to minimize the makespan. The operator supervises the machines through a subset of a given set of modi operandi: the working modes. A working mode models the way the operator divides up his interventions between the machines. The processing times thus become variable as they now depend on the working mode being utilized. To build a schedule, we seek not only a partition of the jobs on the machines, but also a subset of working modes along with their duration. A pseudo-polynomial time algorithm is exhibited to generate an optimal solution within the free changing mode. Polynomial and fully polynomial approximation scheme algorithms (respectively PTAS and FPTAS) are then derived.

I. INTRODUCTION

In the context of classical scheduling problems, research has mainly concentrated on machine and job characteristics such as availability, processing sequence, and so on. However, in real cases, the processing of a job on a machine may need interventions of operators. Nowadays, most machines are partially automated, and operators act as supervisors to load and unload jobs on the machines, sometimes controlling or doing short setups. Therefore, an operator is not fully assigned to a single machine, but may supervise simultaneously several ones. Unfortunately, when operators are involved to build a solution, they are usually assigned to a single machine, and when the processing time is affected by this assignment, it is used for either a learning curve or a processing time linked to a skill level. To the best of our knowledge, only a little research has been done in the direction that considers that an operator can share his working time to supervise several machines, inducing the processing times to increase in length. The scheduling details of those micro-operations (loading, unloading and controlling) would be a non-sense as most of operator interventions cannot be fully anticipated. Such scheduling problems are so far only studied when micro-operations are limited to loading and unloading, done by robots, in the context of flow-shop models ([1], [2]).

Some software give the possibility to associate a portion of an operator to the processing of operations. Those portions are summed up at each time period and the operator capacity is then checked. This model ignores the impact on the processing times. In fact, if a portion of an operator is necessary for an operation, the real processing time of this operation will depend on what this operator is doing in parallel. Either, the operator is only occupied by this operation then the processing time of that operation is not affected. Or, this operator shares his activity over one or more operations. In the latter case, the processing times of all involved operations may increase in length. Note that even if the activity ratio of an operator is used at less than 100%, supervising several machines may induce local conflicts and idle periods on the machines.

Cheurfa [5] introduced a model in which the sharing of the operator over the machines is expressed through the multiplication of the processing times by a vector of constant values (one value for each supervised machine with a sum that could exceed one). These values may differ from one machine to another. The present paper aims to generalize this model in the sense we assume that, for a given subset of machines, an operator may choose from a given finite set of modi operandi, called hereafter working modes. During the time interval a working mode is being utilized, the processing times of the jobs being scheduled are multiplied by the same set of multipliers. The set of multipliers can be changed by switching to another working mode. It is in fact a set of way to attribute priority to the different supervised machines. As long as the same working mode is utilized, processing times of the jobs are linearly increased by the same set of multipliers. A scheduling problem is thus not only an assignment-sequencing-dating problem for the jobs, but also a choice of working modes along with their duration of use. Let us note that classical scheduling problems are a particular case of this model, in the sense a single working mode is utilized with a set of multipliers all equal to one. The present work ensues from [6] in which the changing of the working mode sets occur at periodic time. We investigate here another type of changing mode: the free changing mode, i.e., the changeover of the working modes may occur at any time. Note that the model studied in this paper is also discussed in [7] in which a geometrical approach is

1Traditionally, when considering additional (renewable or non-renewable) resources, other than machines, to schedule jobs, such resources are assumed to be of different types but limited in capacity. A subset of them are then used to accompany the processing of the jobs, but do not have an impact whatsoever on the processing length. Moreover, at any time, a resource is assigned to at most one job. For more details on this issue, see e.g. ([3], [4]).
Competitive enterprises are facing increasing challenges to balance business performance and economic gains with environmental and social issues. In an age of increasing regulatory legislation for energy conservation and waste management, consumer and civil society pressures, sustainability through supply chains is not a fad but a new discipline for strategic competitiveness. Moreover, Sustainable Supply Chains and Logistics (SSCL) are important for companies seeking competitiveness on a global level.

In this context, this session welcomes original theoretical approaches and new applications to SSCL.

Presented papers

- **Reliability Analysis of Supply Chain for Contingency Operations**
- **Risk measures in a multi-stage stochastic supply chain approach**
- **Current situation of the Mediterranean container ports regarding the operational, energy and environment areas**
- **Green supply chain design and planning**
- **Optimal Number of Fishing Fleet with a Maintenance Contract for a Sustainable Fishery Industry with a Generalized Logistic Production Function**
In this paper, we propose a probabilistic analysis approach for assessing the reliability of supply chain for contingency operation consisting of several cities. We consider that the demand of cities and the quantity of products available at distribution centre are uncertain. Also, we analyze the case where the quality of products available at distribution center is considered uncertain. We evaluate the reliability of supply chain without making any particular assumption on normality of distribution of population demand and the quantity of products available at distribution center. Also, we analyse the problem with making correlation between demand of each city and quantity of products available at distribution center. To conduct a probabilistic analysis we consider the supply chain as a structure that undergoes an external load represented by the demand of population during the crisis period and resist to this load by its strength represented by the quantity of products available at distribution center. The reliability of supply chain for contingency operation is defined as the probability that the available inventory at distribution center meets all population demand during crisis period. The supply chain is considered “failed” if the quantity available at distribution center is less than population demand during crisis period. First Order Reliability Method is used to evaluate the reliability of supply chain.

Keywords: Probabilistic Analysis, Contingency Operation, Interference theory, Reliability, Supply Chain, Quality of products, First Order Reliability Method, Ferum 3.1.

I. INTRODUCTION

Climate change generates an “explosive cocktail” of natural disasters that threaten global security. According to the Red Cross world Disasters Report (2005) [1], the number of natural disasters has risen dramatically to an average of 707 disasters per year from 1999 to 2003. [2] Defines contingencies as unexpected crisis events that create a major threat to the safety and security of a population.
Risk Measures in a Multi-stage Stochastic Supply Chain Approach

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Abstract—This paper considers the optimal design and planning problem of a closed-loop supply chain (CLSC) where profit maximization is pursued while considering: adjustments in the network structure during the planning horizon providing flexibility to the network as well as uncertainty in supply and customer demands.

A multi-stage stochastic framework is developed where the effects of the uncertainty are represented by means of discrete scenarios. With the objective of achieving more robust solutions, besides the expected profit, three other risk adverse objective functions are also considered: two based on the mean absolute deviation and another centered on the conditional value at risk (CVaR) concept. In contrast to other approaches, in this work the definition of CVaR is applied to both revenues and costs.

The proposed framework is evaluated by means of several cases. The advantages of using risk adverse performance measures are explored. Thus, the characteristics of the solutions obtained with the stochastic approach considering the variability of the solutions are compared with the features of the solution obtained considering a risk neutral performance measure. Finally, a sensitivity study of the parameters associated with the objective function centered on the conditional value at risk concept is conducted.

Keywords— Mathematical modeling, robust stochastic approach, risk measures, design and planning, closed-loop supply chain

I. INTRODUCTION

Closed-loop supply chain is a more general definition of the traditional concept of forward network where the flow of new products and the path that follow the products after discarded by customers are explicitly and simultaneously considered. The shortage of natural resources, the need to reduce waste levels and the emergence of new government regulations are the main causes that have increased the interest of academics and practitioners in CLSCs.

As pointed out by [1], the coordinated management of complex systems, such as the forward and reverse supply chains, is strongly affected by the business environment volatility. Thus, the need to account for uncertainty has been widely recognized as an increasing important issue. Rigorous formulations, such as those introduced by [2], [3], [4], [5] and [6], which handle the uncertainty in CLSCs, are very advantageous. Nevertheless, most of the developed optimization frameworks lead to very large-scale formulations due to the number and space of work of the uncertain parameters considered.

A robust design and planning of CLSCs is always desirable in order to avoid the adverse effects of the volatility of certain parameters. It is important to note that some parameters fluctuations can be magnified and it could have a strong negative effect on the supply chain behavior. Therefore, the use of robust optimization techniques is widely desired in order to find the best solution among those “immunized” against data volatility. The robustness approach can be associated with the suitable selection of a utility functions or risk measures, which can be incorporated into the stochastic framework as an objective function and/or constraints. For further details about robust approaches within a variety of application problems, the authors suggest reading the review works [7] and [8].

It is important to note that, in the CLSC context, most of the stochastic formulations are risk-neutral (considering expected cost or expected profit as objective function) and, therefore, these are not adequate in order to fight against the data volatility. Few papers have been proposed to apply robust stochastic approaches with risk criteria. One of the most relevant and recent paper considering risk criteria is [9], which utilizes three risk measures in a two-stage stochastic formulation.

By comparing the present paper with the existing bibliography, it can be observed that this work includes the study of the variability impact on the design and planning problem of CLSC through three risk measures using a multi-stage stochastic approach. Thus, risk measures such as deviation risk and CVaR, which have proved their advantages in financial areas and disaster management ([10] and [11]), have been employed in order to consider the variability of costs and revenues. In addition, the formulation considers that the network structure can change during the planning horizon, which allows to adapt the network according to the market volatile conditions. To the best of our knowledge, all these features have not being considered so far in an integrated approach.
Current situation of the Mediterranean container ports regarding the operational, energy and environment areas

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Abstract—The 2020 Strategy in Europe commits to the consolidation of a SMART, SUSTAINABLE and INCLUSIVE Europe. Aligned with these priorities, the strategic importance of the smart-port holistic concept (emphasizing particularly operational and energy efficiency, competitiveness and environmental aspects) within the Mediterranean space is beyond doubt. Once defined the smart port concept, we search the data and information available in public resources about the main Mediterranean containers ports to try to describe their current situation regarding the smart-port concept. We found a significant lack of published data. Available data are often detected with different unit of measure, based on different time-scales and frequencies. The port authorities generally don’t have a clear, exhaustive and updated overview of key performance indicators’ data, with the exception of the operational KPIs. These aspects make difficult the results’ comparison and require an ad hoc elaboration.

I. INTRODUCTION

The 2020 Strategy in Europe commits to the consolidation of a SMART, SUSTAINABLE and INCLUSIVE Europe. Aligned with these priorities, the strategic importance of the smart-port holistic concept (emphasizing particularly operational and energy efficiency, competitiveness and environmental impact aspects) within the Mediterranean space is beyond doubt, but this challenge clearly requires a coordinated effort, only reachable by transnational cooperation.

The studies of [1] and, more recently, of [2] and [3] cover a wide range of experience with container terminals, including case studies, and serve to define the initial problem.

The operational process of a container terminal can be considered as a large productive process where the final element is not a tangible product but rather a specified service. The service to which we refer is the handling and storage of the containerized merchandise of a particular customer. Thus we are talking either of reception terminals (import and export) or of trans-shipment terminals, where containers are transferred from one vessel to another. The basic objective is to carry out the operations as rapidly as possible, to enable the vessel to spend the minimum time necessary in port and, consequently, to obtain maximum economic utilization as well as Energy and Environmentally efficient.

Measures of port efficiency or performance use a certain form of output relative to input which quantifies various aspects of port operation. Literature lists several benefits associated with a properly used set of port performance indicators ([4], [5]). These include improving the utilization of port resources, highlighting the cause of congestion as well as providing information for port planning and a justification for capital development and communicating with relevant stakeholders. To measure, however, port performance and to compare it between ports is a very delicate matter [6].

In November 2010, the Energy Strategy for 2011-2020 was released. This strategy will be integrated in the long-term perspective, called Roadmap 2050, to reduce EU’s greenhouse gases by 80-95% before 2050. As gateways of most of Europe’s external trade, seaports are key parts of logistic chains designed to provide a vital link between industries and their market and supply sources. Ports are often also the location where industrial activities take place, which need energy for their production processes. Energy consumption and
Green supply chain design and planning
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Abstract—A Mixed Integer Linear Programming model for the design and planning of green supply chains is developed. Strategic and tactical decisions are taken, namely on facility location and capacity installation, supplier selection, technology selection, transportation network definition, supply planning, and product recovery. The aim of this work is to study the use of environmental indicators in these decisions while accounting for profit objectives. Different objective functions concerning environmental aspects are implemented. ReCiPe quantifies the environmental performance of the supply chain and combinations of ReCiPe’s midpoint categories allow a deeper analysis of the impact of these categories in strategic and tactical decisions. The goal is to understand if focusing on selected categories affects supply chain decisions and overall supply chain environmental impact. Net Present Value quantifies the economic performance and is used for lexicographic optimization. The model is applied to a case-study and important managerial insights are obtained. From a holistic point of view, it answers the question: how should supply chain environmental impact be assessed? From a case-study perspective, insights are obtained regarding what type of improvements should be implemented to reduce the environmental impact and how this would affect supply chain strategic and tactical decisions, along with economic performance.

Keywords—closed-loop supply chain, optimization, environmental impact assessment, sustainability

I. INTRODUCTION

Governmental and societal concerns regarding sustainability issues have been pressuring industries to re-evaluate their supply chains. Reducing the environmental impact has become an objective that is now placed at the same level as economic and quality goals. The complexity involved in having two different and in some cases opposing objectives (if considering only the economic and environmental objectives) in addition to the already complex supply chain design and planning problem has defined this as a very current research path. Decisions involving several products, entities, supply chain players, legislation and several other variables have to be taken [1]. If choosing or if having to close the loop to integrate product recovery, the problem becomes even more complex and a well-designed supply chain becomes even more indispensable for a company to prosper [2].

In order to address this complexity, decision support tools need to be developed that can integrate such amount of variables. This is why optimization models such as the one present in this work play an important role. Several works have been published on closed-loop supply chain. Starting with the seminal work of Fleischmann et al. [3], which studies the impact of product recovery on logistics network design. It considers cost minimization as the objective function and studies copier remanufacturing and paper recycling concluding that the influence of product recovery on supply chain decisions is very much context dependent. While in some cases product recovery can be integrated in logistics structures, in others it may require redesigning the network. Salema et al. [4] builds on this model and incorporates capacity limits and uncertainty on demand and return in a multi-product formulation. Cardoso et al. [5] study the integration of reverse logistics activities under demand uncertainty, considering the expected net present value maximization as the objective function and modelling decisions on sizing and location of facilities, installation of processes, forward and reverse flows, as well as inventory levels. Literature is also available on closed-loop supply chain models that integrate environmental objectives, in addition to the economic ones. Paksoy et al. [6] analyze supply planning in a 5 forward plus 5 reverse echelons supply chain considering emissions costs in the economic objective function (total cost minimization) as well as profit from recycled products maximization. Chaabane et al. [7] explicitly include an environmental objective function, which minimizes global warming potential, thus minimizing carbon emissions. Total logistics costs measure the economic performance of the supply chain. Decisions analyzed include carbon management, namely carbon credits purchase or sale.

Many other interesting works are available in the literature in this line of closed-loop supply chain research. Literature reviews on this subject identified, among others, the following research gaps:

- The need for a more integrated framework that incorporates issues other than location-allocation such as technology decisions, as identified by Ilgin and Gupta [8];
- The need for closed-loop supply chain models that explicitly deal with the environmental impacts, as emphasized by Dekker et al. [9]. The authors state that simply closing the loop does not guaranty a reduction in the supply chain’s environmental impact;
- The need for multi-objective decision making that includes appropriate environmental objectives, and for
Optimal Number of Fishing Fleet for a Sustainable Fishery Industry with a Generalized Logistic Production Function

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Abstract— The paper presents a mathematical model of optimal fleet number of fishing vessels. Here we consider two aspects related to the vessels and to the fish stock to which the vessels are used to exploit to. The first aspect is the availability/reliability of the vessels. The fishing vessels are vital equipment in the fishery industry that used to extract commercial marine species from the ocean. For this reason, to maintain a high level of profitability, the vessels should be readily available when it is needed. Here we will consider a situation when there is a maintenance contract available from the owner or the owner equipment manufacturer (OEM) of the vessels. The owner of the fleet (a firm or a country) shall decide the numbers of the vessels in the fleet (it is usually called the fleet number) that should be bought from the OEM, bounded together with the available maintenance service contract offered by the OEM. The second aspect is the sustainability of the commercial fish stock in the ocean. In this paper we combine the two aspects simultaneously. Specifically, we will look for the fleet number which maximizes the net profit earn by the firm from the use of the fleet to exploit the commercial fish stock, while warranting that the fish stock is in a sustainable condition. We will assume that the growth of the fish species follows the generalized logistic production function and all the fleet maximizes the fish catch at the maximum sustainable yield (MSY).

Keywords— Optimal fleet number; maintenance service contract; fishing fleet; generalized logistic production function; Maximum Sustainable Yield

I. INTRODUCTION

Fishing vessels are among the vital equipment in fisheries, without which there will be no huge fisheries industries available. FAO estimated that the world of fishing fleet numbers is about four million vessels in 2002 alone [1]. This large number of vessels is regarded as responsible in the declining of many fishes, mollusks and marine mammals, like sword fish, abalone, and whale, respectively. It is reported that about 85% of the world's fisheries might be fully exploited, over-exploited, or even have already depleted [2]. Over-exploitation is even observed since the age of sail [3]. Since the number of vessels is positively correlated with the declining of many commercial sea creatures, an optimal number of vessels should be set out by the authority to regulate them in entering important fisheries. This action need to be done to prevent the stock from collapsing by not letting them lie near the brink of extinction.

There are a lot of numbers on how we can determine this optimal number of vessels [4,5,6]. A prudent calculation in planning to invest these expensive, yet vital, equipment often done before a company buy the equipment. The procurement of vessels in a fleet usually taking into account several important consideration, such as the price of an individual vessel, type of warranty and maintenance services and other after sales services offered by the OEM (original equipment manufacturer) to the owner.

Maintenance and repair of a vessel is regarded as an important part in any fisheries industries. Since now it is recognized that a fishing vessels used in fisheries industries are complex and expensive, the importance of maintenance a vessel is more prevalent. Due to its complexity and its expensive cost in maintaining a modern vessel, to some extent performing self maintenance by the company might not be economical. Many company consider that the economical way to carry out maintenance is to outsource maintenance works to an external agent or OEM.

There are a lot of different strategies in undertaking the maintenance and repair action. Considering that for a fishery company, the availability of the vessels is a key measure, a fishery company needs to control tightly the availability and factors influencing it, such as failure and downtime in determining the best maintenance strategy. The authors in [7] discuss a mathematical model for a two-dimensional contract offered by an OEM to an owner of a fleet of trucks used in mining industry by considering this availability issues. Since their model is generic and applicable to any other areas of industry, we will use their approach to determine the optimal number of vessels used in a fishing fleet by considering the sustainability of the fish stock to ensure the long-term
Competitive enterprises are facing increasing challenges to balance business performance and economic gains with environmental and social issues. In an age of increasing regulatory legislation for energy conservation and waste management, consumer and civil society pressures, sustainability through supply chains is not a fad but a new discipline for strategic competitiveness. Moreover, Sustainable Supply Chains and Logistics (SSCL) are important for companies seeking competitiveness on a global level.

In this context, this session welcomes original theoretical approaches and new applications to SSCL.

Presented papers

- Influence of the environmental impact of logistics operations on the centralization strategy
- Routing Problem with Pendular and Cyclic Service in a Hierarchical Structure of Hub and Spoke with Multiple Allocation of Sub-Hubs
- Problem Analysis of Logistic Platform based on Combined Forward and Reverse Flows: a Case Study
- Method to support the biofuel supplier choice: a LCA approach
- Stability around the Hyper-LSP in French distribution channel: a “Prey-Predator” modeling
- An approach for the valorization of competitive intelligence practices in SME supply chains
Influence of the environmental impact of logistics operations on the centralization strategy

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Abstract—Several factors must usually be taken into account when deciding the design of a supply chain network. In most cases, the economic impact and the resulting service quality are the most common. In this sense, one of the strategies with a big impact in both factors is which inventory centralization level is the most appropriate. High decentralization levels usually provide a better service but with a higher costs due to a more inefficient use of resources. However, the environmental impact of this decision has not been considered in this equation. Here it is analyzed whether considering environmental impact could affect the decision regarding the centralization level. An experimental framework has been designed to check the influence of two factors (the clustering of the clients and their closeness to the manufacturing plant), using a MILP model to look for the best distribution network for each instance.

Keywords—distribution strategies; inventory centralization; supply network design; environmental impact; linear modeling

I. INTRODUCTION

The definition of a distribution network is a strategic decision where many factors have to be considered. In particular, the trade-off between total costs (inventory holding, transportation, etc) and customer service appears as the central issue [1].

For instance, when the customers are spread out a good strategy to avoid delivering far away small orders is to set up warehouses close to dense customer areas so that larger deliveries can be sent, thus incurring in lower transportation costs. In addition a higher service level can be accomplished as the client can be quicker reached.

However it is assumed that overall a decentralized system like this one is more costly than a centralized one [2] which may make a more efficient use of stock (although later [3] presented a counter-example with a central depot incurring in higher costs than its equivalent two-depot system). On the contrary, transportation costs would be higher if everything is sent from one point to all the customers, in many cases ordering small amounts of material. Lead times would also increase [4].

Different authors [5, 6] have analyzed the advantages and disadvantages of one strategy over the other. Generally speaking a centralized system uses more efficiently the resources (incurred in lower costs) and is able to give an answer to demand fluctuations, whilst decentralization provides a better service level and reduces transportation costs.

The problem is so relevant that [7] state that in Assembly-to-Order systems the degree of centralization of the parts stocking point is the most important problem to face to guarantee the economic level of the production system.

All these studies focus exclusively on the cost aspect of the system topology. However currently there are some other aspects that could be also important for a company looking for the sustainability of its operations. Perhaps the most clear in this aspect is considering the environmental impact of such decision. In fact, transportation is clearly one the most pollutant activities in the industrialized world, and is the central task of any logistics activity.

The research question here proposed is: what is the influence of the environmental impact (together with the classical objective of cost) over the decisions of centralization/decentralization. With that purpose we are going to use a model described in [8] that considers both objectives using a Fuzzy Multiobjective Optimization approach, which decides the warehouses to open in a distributed network, and the optimal flow in the system.

With that tool we shall solve different instances (situations with different sets of customers and demands to attend) checking whether the results are significantly different when we consider only the costs and when also the environmental impact is included.

Since factors such as the level of closeness among the customers or the overall distance to the central plant could influence the results, different instances considering both factors are generated. Using appropriate statistical analysis we shall discuss the results.
Routing Problem with Pendular and Cyclic Service in a Hierarchical Structure of Hub and Spoke with Multiple Allocation of Sub-Hubs

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Abstract—Transport of goods is a theme that consumes a lot of time in the planning of companies, because it involves different factors that influence in the quality of result. The case of liner shipping network is considered. This one is involved with transportation of bigger volume of goods between different continents. Optimizing the service network, already is possible to reduce the number of vessels and, consequently, of crews, or the lead time of a demand, or the fuel consumption, or increase the number of customers meet in the same time interval. With a hub and spoke structure it is possible to aggregate demands of different points in some ports and it can get a bigger scale economy of transport. This work proposes a hierarchical structure of hub and spoke where the service network between hubs, representing deep sea operations, is in pendular form and the service sub-network, formed by spokes and its respective hub, representing short sea operations, is in cycle form. The use of sub-hubs linking together two sub-network, permits to create alternative paths for some demands, decreasing the travel time, and consequently decreasing the $CO_2$ emission of network, conciliating an economy of spending with a sustainable logistic.

I. INTRODUCTION

Transport of goods is a theme that consumes a lot of time in the planning of companies, because it is involved since the production, passing by storage, the way it is accompanied during the transport, the transport used, until the creation of an efficient and sustainable supply network.

All factors involved seek to meet (in the best way), customer demands in all points of planet with the smaller lead time, ensuring for the suppliers to minimize their spending and consequently to maximize their profits, while keeping the customer satisfaction in a green logistic.

Utilization of an efficient service network allows the companies to get a competitive advantage among their competitors. But to design an efficient service network is not an easy task.

In the case of liner shipping network, which is responsible of the bigger volume of the containerized goods transportation between different continents, an optimized service network is needed. It can reduce the number of vessels and, consequently, the number of crews, or the lead time of a demand, or the fuel consumption, or increase the number of served customers in the same time interval.

Fuel consumption at maritime transport makes an estimate of 2.7% of the emission of $CO_2$ of the world, where 25% this value is made by containers vessels [1]. In [2], the sentence “Reducing the energy consumption of a shipping network by only 3% is the same as an entire major Danish city not emitting any $CO_2$ for a whole year”, shows the concern of maritime companies with a green logistic.

By all these factors, several researches have been realized to optimize service networks. The hub and spoke structure proposed by [3], has been target a lot of researches, because in this structure, the goods of several customers (spoke nodes) are consolidated in depots (hub nodes) before to be distributed to their final destination, thus allowing economies of scale.

But the problem complexity is to determine where locating the hubs nodes, how to allocate spoke nodes to hub nodes and finally how to route goods from supplier through the whole network.

This paper is organized as follows: In section 2 the hub and spoke problem is explained, showing some advantages and drawbacks of a network with this feature. In section 3 the set of liner shipping operations with some of their characteristics are described. The section 4 describes the proposed model with the reasons for the development of this proposal. The mathematical model of the proposed problem is presented in section 5 using a binary integer linear programming. In section 6 the experimental results are showed and in the section 7 the conclusions are presented.

II. HUB AND SPOKE

In a service network where there are several outgoing points of goods and several destination points for this goods,
Problem Analysis of Logistic Platform based on Combined Forward and Reverse Flows: a Case Study

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Abstract— In this paper, we present the deployment of logistic platforms and analyze their issues. This proposal is motivated by the emergent need of modern cities to have an appropriate infrastructure with functional, ecological, technical and geographical features for the optimization of urban transit of goods. Nevertheless, existing solutions for logistics platforms require a big investment in terms of investment and operational cost. This presents a drawback when dealing with budget’s restrictions. To that end, we present an experiment of logistic platform solutions supporting urban freight distribution based on real scenario in Metz city (France). Based on the experiment feedback, we propose a mixed approach using reverse logistics as a solution to cover logistic platform cost. Moreover, we discuss the integration of such approach to create benefits for logistic platforms.

Keywords— Urban logistic, logistic platform, reverse logistic, reverse flow

I. INTRODUCTION

Urban logistics is essential to modern cities when dealing with operations such as supply chain, construction transport, waste collection, etc. This presents several challenges in different contexts (e.g. politic, economic, and environment). In cities, goods delivery presents several drawbacks for their residents due to delivery’s noise and traffic, also for the environment because of pollution and waste. Moreover, freight cost in urban areas, frequently called the cost of last mile, is among the most expensive and most polluted step in the logistic chain [1].

Urban freight has been discussed in several researches where various studies focused on assessing and optimizing goods delivery flows [2] [3]. Cities must have an appropriate infrastructure with functional, technical and geographical features for urban freight transport such as urban logistic platform [4]. In this context, collaborative logistics between retailers, manufacturers and logistics providers has become essential [5].

In this paper, we present a research study using logistic platforms that we have conducted within collaboration between Metz city and our research laboratory in France. This study aims at ensuring sustainable development of logistic flow. In doing so, we run a three years project in order to minimize congestion in the city; improve the quality of life for residents; and minimize pollution generated by transport of goods.

At the first stage, we mainly focus on optimizing goods delivery by presenting a diagnosis of the current state and, then, proposing a solution for the creation of new logistic platforms. In the next stage, we look at enriching our solution using a new concept: reverse flow. The idea is based on a reverse flow approach that we have developed using best practices from a waste collection project.

The paper is structured as follows. Section 2 presents the urban logistic case study for Metz city in France. We define platform logistics solutions and detail them in section 3. We discuss the reverse flow impact in section 4. The conclusion is given in section 5.

II. CONTEXT AND MOTIVATIONS

A. Urban logistics: new scientific vision

In cities, the increase levels of Traffic has continuously rising congestion. This generate also more noise and pollution. Among this traffic, we can mention urban logistics which has known a growing development due to increasing demand, e-commerce, home delivery, growing urban population (for example around 75% of the population in Europe lives in urban are) etc. For this reason, urban logistics has received growing attention in recent years [6].

Urban logistics is a global management presenting different means for economic and social development in modern cities. The analysis of urban logistics is extremely complex because of multiple and various components: housing, economic activities, urban management, and transport [7] [8].

Delivery for goods in town for business and private customers causes traffic issues. This is explained by the amount of vehicles: small vehicles for express delivery and trucks for stores deliveries. Deliveries numbers increased due to the just-in-time management, the evolution of e-commerce and the emergence of new types of delivery (home delivery, drive and delivery lockers) [9]. Just-in-time service involves providing the customer with the exact amount needed and in time which causes the complexity of the delivery of goods in city centers and which negatively affects the traffic of vehicles and public transport causing for example traffic jams.

Capgemini and GCI (Global Commerce Initiative) have conducted a study in 2008 titled ’Future supply chain 2016’ with recommendations about anticipating new collaborative models for city distribution and to create an appropriate infrastructure managing and organizing consolidated flows in the city [10]. In the following, we list specifications of future supply chain from the aforementioned report:
Method to support the biofuel supplier choice: a LCA approach
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Abstract — Many countries like the US, Brazil, Australia, Canada and some European countries have proposed policies to encourage the use of biofuels by the implementation of regulations to encourage their use in the different sectors of the economy. Among them we find the public transport sector. It is still difficult to assess the potential environmental and social benefits of the use of biofuels because they are distributed throughout the supply chain. The way to supply can influence the level of environmental and social impacts. It is possible to observe a gap in supply decision models taking into account the environmental and social impacts in the case of chains of biofuels that are already established. In the case of biodiesel used by a public transport company, its use should represent the maximum of environmental and social benefits. It is therefore possible to put our research question: "What is the ideal way to supply biodiesel to transportation companies considering environmental and social dimensions? " Our research goal is to provide an evaluation model to support the biodiesel supplier choice decision-making. We expect that the results of our study support the decision making process related to the biodiesel supply for transport companies in Quebec.

Keywords — biodiesel; supply chain; supplier selection

However, until this moment, it is difficult to measure the social and the environmental potential benefits at the consumers’ point of view, because they are distributed for all the supply chain and this information is not easy to be obtained.

This is the key information at the supplier choice decision-making process. There are different decision models used in the supply chain modeling. The location models aim to optimize the position of the actors of the supply chain. However, the consumers don’t have the power to decide where the actors must be located. The only decision they can make is to choose the supplier’s network they will use.

The supplier choice decision must consider the organization values. In the case of the public transportation industry, the biofuel must represent the minimum level of environmental impacts and the maximum social benefits.

It is therefore possible to put our research question: "What is the ideal way to supply biodiesel to public transportation companies considering environmental and social dimensions in the decision-making process?" Our research goal is to provide an evaluation model to support the biodiesel supplier choice decision-making.

This paper is organized as follow: literature review, model development and the conclusions.

I. INTRODUCTION

Actually, the supply chains can’t be established based only in the economic dimension. The environmental and the social aspects must be considered too. These impacts are distributed in all the stages of the supply chain and they must be studied at the moment of the decision making process.

In the public transportation industry, the biofuels’ use can represent significant social and environmental benefits. The governments of many countries, as United States, Brazil, Canada and the European countries proposed many regulations to force the use of this kind of fuel in the different economy sectors [1], among them the transportation industry.
Stability around the Hyper-LSP in French distribution channel: a “Prey-Predator” modeling

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Abstract—In this article, we propose a modeling of the triad composed of Manufacturers, Hyper Logistics Service Providers (HLSP), and Distributors. This modeling is based on the dynamics of the “Prey-Predator” populations. We focus the reflection on the LSP positioned as a keystone. We use a three-body “Lotka-Volterra” model with a logistic restriction for the Hyper-LSP. The aim of this model is to show that harmony is possible thanks to a third party. The model leads to a projection of the great and undeniable role of the HLSP. Could we see a logistic pattern of the future in this model? This article proves the assertion according to which the Hyper-LSP is a “keystone” in the relations of the distribution channel. The paper underlines the importance of the sustainability of the distribution channel.

Keywords—populations ecology; triad; hyper-lsp; equilibrium; stability

I. INTRODUCTION

The relations between Manufacturers and Distributors are often considered as conflictual (e.g. quasi-integration, floats before and after production, threats of withdrawal from sale, etc.). For example, the Galland French law of 1996, the agreement signed in June 2004 for lowering the prices between suppliers and distributors, the reform of the Galland law on August 2nd 2005, or even less so the 2008 Law on the Modernization of the Economy (LME), have neither settled these conflicts nor improved the manufacturers’ situation, nor managed to make the production and consumption prices fall [(1), (2) and (3)]. Likewise, it seems that the financial incentives do not suffice to regulate conflictual behaviors in a logistic environment ([4] and [5]). The question that can thus be asked is the following:

What if the emergence of a “new” player could come and interfere in the dyadic relation (Manufacturers-Distributors) and regulate the dominant position largely attributed to Distributors?

We position ourselves in the same vein as [6], [7], [8], [9], [10], [11] and [12] who take an interest in the definition of players capable of harmonizing the conflictual relations in the distribution channel. But we argue that the “legitimate leader” in this intermediation is the HLSP in its modern vision-3PL and 4PL. Thus, this HLSP would harmonize the distribution channel by modeling the power games between the Manufacturers and the Distributors. And in this context, we comprehend power games according to [16]’s definition of power. For this author, power is comprehended as the fact a person A exerts his influence on a person B. It is often represented by a Top-Down vertical relation where A decides and B executes, just like a hierarchical relation where a Distributor decides and the Manufacturers obey. In practice, this relation is justified by the difficulty to find harmony and consensus between the Manufacturers and the Distributors.

The aim of this article is thus to show that the HLSP appears as the “legitimate leader” in the intermediation of

1 Law n°96-588 from July 1st 1996, known as Galland Law, about loyalty and equilibrium in business relations, published in the July 3rd bulletin (JO).
2 Law n°2005-882 from August 2nd 2005, known as Dutreil-Jacob Law, in favor of small and medium enterprises, published in the August 3rd bulletin (JO).
3 Law n°2008-776 of the 4th of August 2008 on the Modernization of the Economy (called LME), published in the French Official Journal of the 5th of August 2008, aims at “lifting constraints that prevent the development of some businesses, the creation of jobs and the reduction of prices”.

This article lies in the ANNONA Project – Help to decision for the development of sustainable city logistics diagrams coordinated by ARMINES – Institut Henri Fayol de l’Ecole des Mines de Saint-Etienne (ARMINES-FAYOL) which LET is part of.

13 define the LSP as ‘activities carried out by a logistics service provider on behalf of a shipper and consisting of at least the management and execution of transportation and warehousing activities’., p. 59.
14 characterizes the 4PL as a « dematerialized » player which has hardly any physical assets. He proposes a custom-made offer to their customers by mobilizing their business networks, and then by ensuring their coherence through a complete mastery of the flow of information.
15 characterize the 4PL as follows (Fourth-party logistics) relies on an outsourcing provider to neutralize the entire logistics process.”, p. 318.
An approach for the valorization of competitive intelligence practices in SME supply chains
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Abstract— At the interface between supply chain management and business intelligence for SMEs, the focus of this paper is twofold: (i) it seeks to show how to develop a strategic approach and qualitative-type “business intelligence” in SME’s Supply Chain; (ii) it also aims to show how the processes of competitive intelligence can be embedded in SME’s supply chains and create value for everyone involved, or at least avoid leakage of strategic knowledge and know-how. The issues associated with business intelligence as they relate to SME’s supply chains are therefore detailed. An extension PREVA (for PROcess EVAluation approach) [7] to qualitative “business intelligence” type processes is proposed. In the third part, we present the implementation of this approach in a case study focused on the supply chain of SME based in the French area of Thiers, operating in the cutlery sector.

Keywords— Competitive Intelligence, Supply chain, SME, Supply Chain Financial Evaluation, Discrete event Simulation...

I. INTRODUCTION

T A cross-sectional approach based on pre-existing intelligence practices, competitive intelligence springs from the need to rationalize corporate strategic information flows, i.e. to organize them rationally in an effort to make them both more efficient and cost effective for the organization [1]. Whatever the differences and specificities in terms of means and objectives assigned by an organization to competitive intelligence, its ultimate objective is widely recognized as supporting strategic decisions designed to deliver sustainable competitive advantage over time for the organization ([2] [3] [4] [5]). Supply chains may be defined as a coalition of autonomous organizations that are coordinated by an integrated logistic process [7]. Collaboration between several organizations, particularly as part of Supply Chain Management-type approaches, can induce risks that may only be controlled through competitive intelligence practices covering the entire chain of partners, in order to prevent any of them from misappropriating the information disclosed in the collaborative process for their own benefit (reuse of know-how disclosed to competitors of the contractor, misappropriation of contractor’s know-how in order to manufacture cloned products, etc.). Unsurprisingly, business reviews are full of examples illustrating this risk, particularly for Small and Medium Enterprises (SME) as, unlike larger organizations, the former are ill-protected against internal and external the predators. At the interface between supply chain management and SME competitive intelligence practices, the focus of this paper is twofold: (i) it seeks, firstly, to show how to develop a strategic approach and qualitative-type "business intelligence" in SME’s Supply Chain; (ii) it also aims to show how the processes of intelligence can be embedded in SME supply chains and create value for everyone involved, or at least avoid leakage of strategic knowledge and know-how.

Accordingly this paper is organized as follows:

- In the first part, we show what are the issues associated with business intelligence for SME supply chains.

- In the second part, we propose the extension of the PREVA approach (for Process EVAluation) [7] to qualitative type "business intelligence" processes; an analytic model which takes into account competitive intelligence challenge is therefore proposed.

- In the third part, the implementation of this approach in a case study focused on the supply chain of an SME based in the French area of Thiers operating in the cutlery sector is detailed.

II. RESEARCH BACKGROUND: COMPETITIVE INTELLIGENCE IN SME SUPPLY CHAINS

Adapted from competitive intelligence practices of large companies, four types of competitive intelligence practices used by SMEs can be identified by the literature review [8], [9], [10]: 1) environmental scanning; 2) intangible assets protection; 3) environmental influence; 4) knowledge management.

The first type is designed to inform decision-makers through systematic scanning of the environment and enable them to act with full knowledge of the situation [11], [12], [13]. At corporate level, this takes the form of the implementation of thematic monitoring process (identification, collection, analysis, dissemination) based on an information acquisition plan.

The second type is designed to protect and safeguard corporate intangible assets by identifying, securing and protecting its knowledge and know-how, while taking care of periodically renew the threats analysis [14], [15],[16]. This
New developments in medical technology, costing evaluation of services, changes in consumer needs and expectations, place the optimization of the supply chain management (SCM) in a crucial perspective. This is especially true in the case of healthcare systems and services in hospitals, where complexity and uncertainty make very difficult the design and management of efficient services.

This special session intended to provide a forum for decision makers, researchers, medical practitioners and graduate students to share and exchange their experiences, discuss original ideas, and report their research on all aspects of emergency sectors management. Contributions emphasizing recent advances and new research directions were strongly encouraged.

The aim of this special session is to present new methods and models that integrate constraints of different levels of the SCM and deal with complex problems in the SCM applied in healthcare systems.

Presented papers

- Patients flow optimization in ED: an operational research on the impacts of physician triage
- Resilience-Based Performance Assessment of Strain Situations in Emergency Departments
- Operating a biomedical samples laboratories network under stochastic demand
- Implementation of a decision support system heuristic for selecting suppliers in the hospital sector
- Optimization on Human and Material Resources in Emergency Department
- Study pharmacies grouping impact on the performance of the hospital supply chain
Patients flow optimization in ED: an operational research on the impacts of physician triage

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Abstract—Emergency Departments (ED) face chronic issues such as longer length of stay and decreased quality of care. These organizations have developed the use of Lean manufacturing techniques to improve patients flow. Adaptations of Lean in healthcare almost systematically return positive results and negative potential effects are underestimated. We use the still debating issue on whether a physician should take part of the triage to explore the pros and cons of a Lean technique in healthcare. We show that triage physicians impact “low-severity” patients length of care and do not impact inpatients one. We also show that physician triage is associated with a higher length of triage that can create a waiting lines before the triage operation. We discuss these results by showing that the decision to implement Lean techniques should be taken considering a risk / benefits trade-off, which is hardly the case actually

Keywords — Emergency departments; triage; operation management; Lean manufacturing; waiting line

I. INTRODUCTION

Due to their central positions in the care process, Emergency Departments (ED) have become a key part of the healthcare system. Nowadays, these multidisciplinary care units treat important daily volume of severe incoming patients as much as ambulatory care ones. Empirical evidence have shown the structural increase in the volume and variability of demand since 20 years in most developed countries [27; 16; 23]. Mechanically, adverse phenomenon such as overcrowding, longer lengths of stay (LOS), rate of patients of patients who left without being seen tend to increase [13; 19; 7].

To mitigate these phenomenon, healthcare organizations have started to use concepts and tools from the industrial sector such as Lean manufacturing techniques in order to control the increasing flow of demand. Commonly, the implementation of Lean in healthcare returns positive impacts on quality indicators whether in single case studies or in reviews [15; 17; 18; 20; 11; 10].

Despite the actual strong knowledge on Lean in healthcare, recent works have questioned the fact that most Lean application in healthcare implies systematic positive effects [11; 9]. Authors thus, suggest that one of the main direction for investigation of Lean is to “apply a more critical view to evaluate Lean in healthcare” including negative cases of application. Yet, Some core characteristics of Lean production designs brings with valuable investigation leads to researchers.

Lean manufacturing can be summarized is a pull production system constituted of several waiting lines through the on-going production [2]. The production design is based on each operation’s capacity. If one operation has a higher cycle time (i.e. time needed to produce one piece) that the previous one, a temporary intermediate inventory will be constituted pending an opening in downstream chain capacities. If the idea of waiting line is acceptable in industrial production processes, such concept is more hardly justified in the healthcare sector. The first reason would be that increased waiting lines mean patients waiting for care i.e. potential increased length of stay, overcrowding and consequently lower quality of care [14].

In order to deal with the growing volumes and heterogeneity, the nurse triage system has been developed to early identify high risk patients and constitute several waiting lines based on the urgency of the pathology. Depending on the countries, the triage operation is produced before or after the administrative registration one [2] and constitutes the first care operation in the care process. Lately, physicians and healthcare managers have raised attention on the possible positive effects of the implementation of a Physician Triage to reduce patients LOS and general overcrowding in the ED [26]. The triage and the first medical assessment operations, which are two successive care operations in the care process are then merged into one (see figure 1). Operationally speaking, Physician triage gives extra prerogatives to the triage function such as early technically exams (e.g. X-rays) prescriptions, or immediate discharging. Most significant works on Physician triage proved limited evidence of a reduction in length of wait before medical assessment and of the number patients who left without being seen although the subject is not definitely closed [22; 28; 12; 21; 24].

In a value stream perspective, reducing the number of operations in a production process increases the process performance by reducing low added value time [6]. Thus, implementing Physician triage fits theoretically into Lean manufacturing techniques as it has been emphasized in the literature [11; 5].
Resilience-Based Performance Assessment of Strain Situations in Emergency Departments

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Abstract— In response to events and exceptional situations (e.g. health threats related to epidemics, seasonal flux, heat waves, and cold waves), hospital establishments in particular emergency departments, must be able to receive patients for medical and surgical treatments whatever the extent of the patient flow. The conventional medical resources are often outdated and ineffective in absorbing a large influx of patients, which often leads to strain situations. Hence it has become essential to strengthen the organization of hospital emergency departments so they can manage such situations. To cope with such situations, emergency departments must incorporate in their operating mode the capacity to anticipate, to react and to mobilize the necessary resources in order to have a sufficient level of resilience to meet their missions. In this paper we define and characterize the resilience of an emergency department, and propose a generic procedure to evaluate the resilience of the emergency departments.

Keywords— Emergency department (ED); Strain situation; Resilience; Performance; Simulation.

I. Introduction

Emergency departments (EDs) are often face the influx of patients generated by events and/or exceptional situations like technological or natural catastrophes and health threats related to epidemics, seasonal flux, heat waves, and cold waves. Hence, EDs must be able to receive patient flows sometimes very important for medical and surgical treatments. The conventional medical resources are often outdated and ineffective in absorbing a large influx of patients, which often leads to strain situations. Hence it has become essential to strengthen the organization of emergency departments so they can manage such situations.

Faced with threats and the growing demand for emergency medical care [1–4], traditional practices of the management of the perturbation can be beneficial and should not be neglected. However, they may be limited or ineffective in the case of major perturbations. To meet their missions; EDs must incorporate in their operating mode the capacity to anticipate, to react and to mobilize the necessary resources to best management of these perturbations.

The concept of resilience is used in different contexts, covering different interpretations like the ability to anticipate, to overcome a situation, to remain below thresholds, to adopt the original behavior under exceptional situations, etc. [5,6].

The integration of the concept of resilience in EDs plays a very important role in anticipating, reduction and effective management of perturbations that can generate crises in these establishments.

The main purpose of this article is to define and characterize the resilience of an ED and to present an approach to evaluate the ED resilience. The second section defines and characterizes strain situations, states and transition states of an ED. The third section proposes a definition of ED resilience and characterizes the ED performance based on the resilience. The forth section presents a procedure for assessing the ED resilience. The fifth section uses a case study to show results. Finally, a conclusion and perspectives are presented in the last section.

II. Strain Situation in an Emergency Department (ED)

A. Perturbation in an ED

The EDs is part of hospital establishment, which are often faced with disturbances or exceptional situations: growing ED demand due to epidemics and/or crises (natural disasters, terrorist attacks, accidents ...), development of complex diseases requiring long treatment time, and reduction of human material resources in these establishments [7]. These events have a direct or indirect impact on the performance of these EDs (quality of cares, patient’s length of stay, costs ...) and the loss of patients (not treated in time, running away, death ...). Therefore, EDs must play a key role in the response and recovery from these perturbations.

The consequences of perturbations on EDs may vary from a single peak of activity until a crisis passed by strain situations [8,9]. To characterize the perturbation in EDs, we adopted a model of perturbation proposed by [10] for the socio-technical systems. It consists of three main periods (figure 1):

1) Pre-perturbation period: the period before the occurrence of the perturbation. It consists of four phases (operational phase, incubating phase, warning phase and activation phase).

2) Perturbation period: the period when the perturbation occurs. It consists of two main phases: i) onset phase (the start of the perturbation after its activation by an initiating event), ii) response phase and recovery including...
Operating a biomedical samples laboratories network under stochastic demand

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Abstract—Management of biomedical samples plays a central role in an efficient healthcare system and requires important resources. This paper addresses an assignment problem where several types of samples are collected at clinics and other collection centers, and then transported to medical laboratories to be analysed. For practical reasons, samples of the same type collected at the same collection center are consolidated and sent to the same laboratory. However, a collection center may send different types of samples to different laboratories. Moreover, demand for each type of sample at each collection center is uncertain but modelled by a known probability distribution. In this context, collection centers need to be allocated to laboratories in order to balance the workload between them while minimizing the total collecting distance. To tackle this problem, we first formulate it as a linear integer model assuming deterministic demand. Then, a stochastic counterpart is presented, along with a solving method based on the sample average approximation technique (SAA). Numerical experiments inspired by a real-life case are conducted to illustrate how the proposed approach may contribute to help decision makers better manage the laboratories’ capacity, increasing the system efficiency.

I. INTRODUCTION

Clinical laboratory services are an essential link in modern health care delivery systems. Laboratory analyses offer an invaluable contribution to the quality of medicine in all its branches, from genetics to infectious diseases, but also in pathology, oncology and pharmacogenomics. As a result, both the number and the variety of analysis requests have increased very fast in the recent years, leading to exponential augmentations in laboratories spends and workload. Therefore, healthcare managers have recently started to study logistic issues related to the design, management and optimization of their networks of clinical laboratories. This paper inspires from the real case of the province of Quebec, Canada, where the Ministère de la santé et des services sociaux (Ministry of Health and Social Services, MSSS) is in charge of supporting and overseeing the provinces health network to ensure the well-being of Quebecers. Aiming at improving the laboratories services offered to the population and controlling the associated costs, the MSSS engaged in an optimization project named Optilab, which seeks to enhance the quality of the services provided by the network of laboratories in terms of security, accessibility, efficiency and efficacy [6]. Quebec’s laboratories network has currently 98 facilities which deals with request from more than 500 areas such as pathology, cytology, biochemistry, hematology, blood bank, microbiology, virology, genetics and toxicology. Every year, nearly 150 million procedures are performed in Quebec. From them, 143 million are of “local complexity”, meaning that tests may be accomplished in regular laboratories. The remaining 7 million are considered as “complex” and must be addressed to more specialized laboratories [6]. This study concerns only the regular analysis. Laboratories workload is an important issue which may impact the quality of the procedures, in particular their response time which is of paramount importance in healthcare. Coming back to the Quebec’s case, about 90% of the medical tests are produced in the 30 largest laboratories. On the other hand, 30 smaller laboratories produce only 3% of the total volume. Laboratories were set according to historical or geographical needs. However, recent developments in technology, quality requirements, current and anticipated wave of new diagnostic tests generated by changes in clinical practice as well as the ubiquitous budget constraints, are forcing MSSS to rethink the organization of its network laboratories to adequately meet demand. Moreover, other factors also come into play in the restructuring of laboratories, including a forecasted shortage of technical manpower, equipment acquisition and maintenance, informational interfaces, and internal and external quality controls [6]. Taking into account this complex situation, this paper focuses in the allocation of tests requests among the available laboratories. It presents three major contributions. Firstly, it models the sample-to-laboratories allocation problem arising in Quebec’s laboratories network. Secondly, it proposes a stochastic formulation which aims at balance the laboratories workload, and a solving approach. Thirdly, it discusses, based on the numerical results and a sensitivity analysis, how allocation strategies may impact the system performance and, in particular, laboratories overload. This article is structured as follows. Section II describes the problem of allocating biomedical tests requests to laboratories. Section III presents a mathematical formulation based on a deterministic model, and his stochastic counterpart. Section IV introduces a sample average approximation method to solve the stochastic formulation. Numerical experiments on an academic case are proposed in Section V. Section VI concludes this article and offers some research perspectives.

II. PROBLEM DESCRIPTION

We consider here a network composed of sample collection centers (SCCs) and laboratories (Labs). SCCs are health facilities where patients’ samples are collected according to
Implementation of a decision support system heuristic for selecting suppliers in the hospital sector

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Abstract—The purchasing function is the strongest link in the hospital supply chain. The stakes which are related to it are often complex and difficult to define. Public institutions and hospitals are all invited to master these link operations, with a particular focus on the hospital-supplier relationship. One of the most crucial is the selection of the right supplier, which is based on both qualitative and quantitative criteria. However, few methods and tools are available to guide the decision-maker to make optimal choices based on different types of criteria. Therefore, we propose in this paper a new heuristic for a common optimum work between hospitals and suppliers, in order create a value control in costs, deadlines and quality. Our paper is composed of five parts. The first shows the interest of the study. The second presents the literature review. The third explains the problematic situation. The fourth sets out our work methodology and the proposed model. In the fifth part, we illustrate the proposed methodology through a case study. And we finish our paper with a conclusion and work prospects.

Keywords—Supply chain; hospital-supplier; optimal choice; heuristic;

I. INTRODUCTION

Facing a perfectly competitive market, companies today seek to proactively manage their purchases and generate cost saving opportunities and synergies, they adopt the outsourcing strategy to benefit from cost minimization. In fact, they seek to strike up a close and highly effective link with suppliers to substitute internal services. In this context, the selection of the "best" suppliers is paramount. This selection is influenced by several criteria such as price, time, quality etc. It takes into account these criteria which are conflicting objectives, a decrease in an objective leads to increase the other. Hence the need to simultaneously optimize these objectives and choose the compromise that is the optimal decision for the entire company. In the same context and more particularly, the hospital-supplier relationship takes a great interest and represents the pillar of development in the hospital sector.

Following several concrete problems cited by Moroccan hospitals, we are interested in the supplier selection process that submits to the new constraints. Storage and distribution of medical products in Morocco cost the ministry of health over 30 million Dirhams per year [1]. Citizens do not often find drugs while other expired medications are mists. In addition, the centers of storage and distribution cost up one billion Dirhams per year. They are operated by 200-250 people [1]. As confirmed by the minister of health, these sums can build modern hospital equipments, or at least 20 clinics [1]. Also according to data obtained on medical devices in Morocco, we have found that there are 63 non-compliant consignments of 741 controlled medical devices in 2009 and 72 non-compliant consignments of 477 controlled medical devices in 2010 [2]. This explains that the rate of non-compliance of medical products is increasing more and more over the years. Consequently, it is necessary to develop a tri-objective mathematical model so the hospital can properly select suppliers and increase its capacity to respond to customer requirements in terms of cost, time and quality. It is in this perspective that our article sheds light on the suppliers selection problem in the hospital sector.

II. INTEREST OF THE STUDY

In the hospital sector, significant progress is still needed to carry out in the upstream supply chain in order to get high quality and improve its overall performance. Including the primary necessity of managing relationships with the creators and producers of medical products in a strategic dynamics, this strategy must exceed the pace of unilateral innovation laboratories and mechanized pace of contracts renewal. The hospital has often been regarded as a separate business segment, with such a different mindset of an "Ordinary" company. We talk about the "Availability" of a drug to save a person's life, a notion that makes the difference and seems nonexistent in the industrial sector. This demands a very effective control of the hospital-supplier relationship so as to make available medicines and medical devices of the required quality at the right moment with lower cost. Consequently, our study will be beneficial to all Moroccan citizens and hospitals, since it will treat and improve the upstream interface Supplier-
Optimization on Human and Material Resources in Emergency Department

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Abstract—Emergency Departments (ED) is the center of the hospital management's efforts. It constitutes a complex system with limited resources and random demands. The goal of this paper is to optimize the number of the human and material resources. We focus particularly on medical staff (physicians and nurses) and beds in emergency department. We propose a mixed integer linear programming (MILP) that minimizes the number of waiting patients. We consider simultaneously four patients' queue. To solve this model, we use the solver ILOG CPLEX Optimization Studio. The program has been tested on a set of instances. Numerical results show that the number of waiting patients decreased by optimizing the number of the human and material resources.

Keywords—Emergency department; waiting times; mixed integer linear programming; optimization; sizing.

I. INTRODUCTION

A hospital is a very complex environment with limited resources and stochastic demands, particularly in the Emergency Department (ED). It is often saturated by a continuous flow of patients, the waiting rooms are always full, and representing an excessive waiting times for the patients [12]. Therefore, the ED have to be more perform and agile while managing efficiently the allocated resources.

Some studies published in the literature address emergency problems in hospitals. Most of them focus on scheduling and assigning of patients [3] [7] [8] [10] [11]. Some works were interested in scheduling of medical staff [4] [5] and sizing of human resources [1] [9] which are considered as a bottleneck in the ED. The optimization and sizing of human and material resources has become an important issue. However all these works do not consider all levels of the process in the ED. In this context, we propose the optimization of emergency resources to increase patient satisfaction by reducing the number of waiting patients from the arrival of patients in the ED until their hospitalization.

The paper is organized as follows: Section 2 presents the related works in ED. In Sections 3 and 4, we describe the proposed mixed linear programming. In Section 5, we present the experimental results. Section 6 includes some concluding remarks and future works.

II. LITERATURE REVIEW

The problems relating to the ED addressed in the literature are essentially about sizing of human and material resources [1] [9], scheduling and assignment of patients [2] [3] [7] [8] [10] [11] and scheduling of the medical staff [4] [5]. These papers consider only some process levels of the ED: admission, triage, examination, additional tests, medical care, and hospitalization. Figure 1 represents the patient flows at the emergency department.

[8] [10] [11] are interested in emergency downstream. In [8], the authors address a stochastic problem to schedule inpatient admission in a hospital with uncertain length of stay and unexpected patients coming from the ED. Three approaches are proposed: (1) deterministic approach, (2) the second one considers service ratios and finally (3) Monte Carlo optimization approach. It consists to minimize the cost of the expected over-capacity of beds required for each period.

To find the scheduling and the resource allocation that minimizes the waiting time of patients, [10] presents six heuristic (TF, WTR, WTRSPA, EDD, SPT and TSPT). Then, the best solution, given by these heuristics, is chosen. In this approach, the physicians are available to treat patients and the main resources modeled were the beds. The problem is considered as a flow shop scheduling with parallel machines (beds).

In [11], Wang et al. use an integer linear programming to solve the problem of the planning of emergency admissions. The number of the available beds in the ED is already known. The objective is to maximize the revenue of the activity-based payment model and minimize the utilization of the additional beds. The problem addressed in [11] is the sizing of material resources.

In [4], El-Rifai et al. focus on human resources organization in the ED. They address the personnel scheduling problem (schedule simultaneously physicians and nurses) that
Study pharmacies grouping impact on the performance of the hospital supply chain.

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Abstract—The mission of a hospital is a complex task due to the multiplicity of care services offered and other factors that come into play during operation: Cost, Quality, Security.

Measuring the performance of hospital supply chain has been a major subject of study in recent years; this interest is due to the essential aspect that takes on the evaluation of the performance in the management of hospitals. In our research, we focus on the development of a decision support system for measuring organizational performance through the hospital logistics costs.

The first part of the article concerns the hospital logistics and shows previous research on performance measurement in the industrial and hospital sector. The second presents our methodology of fiscal performance measurement. The third is the subject of an application of our methodology to a practical case. We end with a conclusion and job prospects.

Keywords—Grouping, Costs, Quality, Hospital logistics, Performance indicators.

I. NOMENCLATURE

DS: Decentralized structure
CS: Centralized Structure
MAD: Moroccan Dirham

II. INTRODUCTION

Health facilities seek to provide patients they host the best service possible. Hospital performance through the optimization of quality cost and delay.

The organizational and technological innovation is a major challenge to improve their performance [1]. Place of hospital supply chain and its impact on the performance of health facilities are well recognized [2][3] Thus the hospital performance measure is now considered an indispensable element in the improvement of processes quality of care [4][5][6].

Currently, expenditure control leads health facilities to reason and to optimize physical flows and flows with corresponding information in terms of overall performance of their supply chains [7]. Logistics can contribute greatly to the performance of the hospital.

The problem of choosing a better approach for measuring organizational performance of hospital supply chain was raised by several managers of hospital systems.

In light of the importance of hospital logistics, we propose a methodology for the study of the organizational impact of logistics performance in the case of pharmacies grouping.

III. INTEREST OF THE STUDY AND LITERATURE REVIEW

A. Importance of the logistics budget in hospital

In general, hospital logistics chain consists of the following processes:

Several experts considered the importance of logistics costs in the health institutions, assessments Housley (1978) arrive at an estimate of 46% for North American hospitals [8]. According Henning (1980) by taking a similar approach as evaluating hospital logistics takes 42% of total spending of a hospital [9].

Chow and heaver arrive at an estimate of 46% [10]. This important part of logistics costs shows that logistical procedures in hospitals have become important vectors of health expenditure reduction process. These data can support decision-making for improved function in this hospital.
This special session collects papers describing scientific researches on simulation models and optimization methods for logistics and transportation. This session addresses issues relating to urban transport systems (unimodal, bimodal, multimodal), and overall the problems related to logistics systems with complexity and diversity of data to process.

The topics of this session include the following:

- Formalisms for the analysis (static and dynamic) transport systems, taking into account all specifications;
- Combinations of different formalisms and tools for modelling: by combining different models, either each model covering a part of the system, or by combining different models of the same system;
- Implementation approaches for modelling, simulation and performance evaluations.

Papers involving theory, methods, algorithms, and case studies were sought.

Presented papers

- *A Cost Based Approach for a Crane Assignment and Scheduling Problem*
- *Artificial Bee Colony Algorithm for Discrete Optimal Reactive Power Dispatch*
- *Adaptations of k-Shortest Path Algorithms for Transportation Networks*
- *On Setting Line Frequencies and Capacities in Dense Railway Rapid Transit Networks*
A Cost Based Approach for a Crane Assignment and Scheduling Problem  
(presented at the 6th IESM Conference, October 2015, Seville, Spain) @I^{4}e^{2} 2015

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Abstract—Different methods are used to address Quay Crane Assignment and Scheduling Problems (QCASPs). In current literature often the unloading time is used to optimize QCASPs. However, this approach neglects the value of the vessel’s freight. This paper therefore uses a cost based approach to optimize container terminal operations, which allows the model to focus on two objectives. The first objective is to show the impact of varying freight lead time costs on the priority of vessels and consequently the Quay Crane (QC) assignment and scheduling. The second objective is to implement adjustable QC operation costs and working rate and show the impact of particular adjustments. The model results show vessel prioritization based on the value of the vessel’s freight. The variation in crane operation cost only impacts the assignment and scheduling in the occurrence of high crane operating costs relative to the value of the vessel’s freight.

Index Terms—Quay crane assignment, Quay Crane Scheduling, Cost of Lead Time, Mixed Integer Programming

I. INTRODUCTION

The world is becoming ever more interconnected. International trade has played a major role in the increasing integration of the world economy. The rise in volume of international trade has consistently exceeded the rise of the world’s economic output. One of the most important reasons for this strong increase is the falling cost of transportation [1].

Maritime transport is very important in today's international transportation network. The trend of increasing containerization of goods is making ports and container terminals ever more important nodes in the global transportation network [2], [3].

The efficient handling of port operations is an important factor in the reduction of overall costs of transportation. The maximization of container throughput is a complex problem and requires scrupulous planning [2]. The initial stage in the process of handling an arriving vessel is designating a berthing location. A berth is a location in a port where a vessel can be moored and eventually unloaded [4], [5]. The unloading of a vessel’s container freight is done by a quay crane (QC). The assignment of these cranes is done according to a specific work schedule. Seeing as there are exceptionally high costs involved in the operation of such QCs, it is important to allocate this unloading capacity as efficiently as possible [6]. The allocation issue of the QC capacity has been the focus of much study [2], [7]–[12].

It is possible to divide port side operations problems into three stages. The first stage can be described as the berth allocation problem (BAP). This problem deals with the allocation of vessels to the different available berths in each port. The second stage is the Quay Crane Assignment Problem (QCAP). QCAP focuses on the assignment of QCs to each berth location. The final stage is described as the Quay Crane Scheduling Problem (Q CSP). This focuses on efficient allocation of the total QC unloading capacity. Each of these stages can be combined with either the former or the latter stage in the process. All layers are restricted by particular assumptions that provide different levels of complexity to the modeling approach [7], [9].

As stated, one of the most important measures to determine a port’s efficiency is the unloading time of the arriving vessels. However, this focus on time efficiency does not take vessel prioritization or the time related cost into account. Therefore, this paper uses unloading cost instead of unloading time as the measure for the ports efficiency. The unloading cost contains two main parts, the Crane Rent (CR) and the Cost of Lead Time (COLT).

Definition 1. Crane Rent (CR): a cost function per unit of time that represents the costs related with the processes needed to unload the vessel.

Definition 2. Cost of Lead Time (COLT): a cost function per unit of time that adds the opportunity costs and the decrease in freight value.

Definition 3. Opportunity Cost: a cost function per unit of time representing the missed returns on investment that could have been gained from other opportunities rather than investing in the transported freight. The opportunity cost increases as the value density of the freight increases.

Definition 4. Decrease in Freight Value: a cost function that represents the decrease in value of the transported freight per unit of time.

The objective of this paper is to study the impact of deviations in the CR and the COLT on the QC allocation and scheduling. This paper focuses on the implicitly assigned priority as derived from the COLT associated with a vessel’s freight. The second objective is to study the tradeoff between
Artificial Bee Colony Algorithm for Discrete Optimal Reactive Power Dispatch

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Abstract—In this paper one of the reliable and effective optimization algorithms called “artificial bee colony” algorithm (ABC) for solving the optimal reactive power dispatch (ORPD) problem with the discrete and continuous control variables in an electric power system is presented. In this work ABC algorithm is used to find the settings of control variables such as generator voltages, tap positions of tap changing transformers and the number of capacitors banks to be switched, for optimal reactive power dispatch. The original ABC algorithm designed for the continuous nature of optimization problems, cannot be used for discrete cases; but the real ORPD problem has two different nature types of control variables (discrete and continuous), for this reasons a simple rounding operator is included in the main steps of original ABC algorithm to ensure the discretization process. Then, the feasibility and performance of the proposed algorithm are verified by the serial simulations on the IEEE 14-bus, IEEE 30-bus and IEEE 57-bus power systems. The numerical results are compared to those yielded by the other recently published evolutionary optimization algorithms in the literature. This comparison shows that the ABC algorithm is superior to the other mentioned algorithms and can be efficiently used for solving the discrete ORPD problem.

Keywords—Artificial bee Colony algorithm (ABC); Discrete Optimal Reactive Power Dispatch (ORPD); Power Systems; Optimization.

I. INTRODUCTION

The Optimal Reactive Power Dispatch (ORPD) is an important issue in power system planning and operation and it's considered as a sub-problem of optimal power flow (OPF). The objective of the ORPD problem is to determine the optimal combination of generator voltages, taps positions of tap changing transformers and the number of capacitors banks must be switched in power system for minimizing the real power transmission losses, while satisfying certain physical and operating constraints at the same time.

The ORPD problem is formulated as a non-linear multimodal, large-scale, static optimization problem because of the presence of both continuous and discrete control variables such as switching shunt capacitor banks and transformer tap settings are presented as discrete variables.

Over the past quarter of the previous century, a variety of conventional optimization algorithms has been successfully applied for solving the reactive power dispatch problem. For example, Linear Programming (LP), Interior-Point method (IP) and decoupled quadratic programming [1-3] but these algorithms suffer from many drawbacks such as the huge computations and large execution time and the inflexibility with the practical system, and still encounter serious challenges in yielding the optimal solution. Moreover, the inclusion of discrete control variables highly increases the complexity of the ORPD problem. Therefore, it is mandatory to find more accurate and efficient algorithms able to overcome all the above-mentioned drawbacks and such difficulties.

In the past two decades, plenty of heuristic and stochastic optimization algorithms have been developed and applied successfully to deal with optimal reactive power dispatch problem, among them, differential evolution [4], teaching–learning-based optimization algorithm [5], biogeography-based optimization [6], harmony search algorithm [7], and gravitational search algorithm [8]. But, certain of these algorithms have drawbacks such as of trapping into local optima, which forced many researchers to combine between the advantages of the two previous methods in order to provide what is called the hybrid methods that bring the better results, like hybrid particle swarm optimization approach for solving the discrete OPF problem [9], Hybrid shuffled frog leaping and Nelder–Mead [10], and A hybrid artificial bee colony assisted differential evolution algorithm [11].

Recently, a new evolutionary computation algorithm, based on simulating the foraging behavior of honey bee swarm called “artificial bee colony”, has been developed and introduced in 2005 by the scientist Karaboga for real parameter optimization and it has been gaining a popularity in the community of researchers, for its effectiveness in solving some practical problems such as unconstrained numerical optimization constrained numerical optimization [12-13] aircraft attitude control [14], real and reactive power tracing in deregulated power systems [15], and made a series of good experimental results.

like all other evolutionary algorithm, the ABC also suffers in its solution search equation from poor exploitation, contrary to exploration process which is good, [16-18] but, all
Adaptations of \( k \)-Shortest Path Algorithms for Transportation Networks
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Abstract—The computation of the \( k \)-shortest paths, should they be elementary or not, has been extensively investigated in the literature, yielding to extremely performant algorithms. For elementary paths, the best known algorithm to this day is the algorithm of Yen enhanced by the extension of Lawler, while for the search of non-elementary paths, the algorithm with the best complexity is due to Eppstein but is outperformed in practice by the Recursive Enumeration Algorithm. In the context of transportation networks, graphs are time dependent, meaning that the cost of an edge depends on the time at which it is crossed. If for each edge one cannot arrive later if he departs earlier, the network is said to respect the FIFO property. Under this hypothesis, the usual Dijkstra shortest path algorithm is still polynomial. Additionally, since each edge is associated to a transportation type, one may want to restrict a path to be in a regular language. To find a shortest path under this constraint a polynomial algorithm, called DRegLC, works on the product of the regular language. To find a shortest path under this constraint a polynomial algorithm, called DRegLC, works on the product of the regular language.

In this paper, some \( k \)-shortest paths algorithms are adapted to be used on such transportation networks with a regular language constraint. Also, the computation of the \( k \)-shortest elementary paths is considered using \( k \)-shortest non elementary paths algorithms, deleting loops while searching if possible. To address this approach, a new algorithm is presented to speed-up the search of elementary paths while scanning as few paths containing loops as possible.

I. INTRODUCTION AND PROBLEM STATEMENT

Computing efficiently the shortest path in the context of transportation networks, including multimodality and time-dependency, has been the subject of intensive research in the last ten years. However, users of transportation networks can be interested not only in the shortest path between the origin and the destination of their journey but also in a set of viable paths. Moreover, public transport authorities and city planners may be interested by information about the number of paths and associated durations or costs, connecting two points or areas, in order to improve their transport offer.

This can be done by considering \( k \)-shortest paths methods producing a set of paths ordered by their costs. The \( k \)-shortest paths problem is a well-known problem and it was studied from two points of view depending on the application: producing a set of paths without cycles or producing paths with no restrictions on cycles. The former set is a subset of the later. In the literature, paths with no restriction on cycles are simply denoted paths with cycles. The \( k \)-shortest paths algorithms producing paths with cycles have lower worst-case complexities than algorithms producing only cycle-free paths.

In the multimodal transportation context, the aim is to produce \( k \)-shortest paths from a given origin to a given destination without any cycle and going through the public transportation network and the pedestrian network. Obviously, in transportation applications, users are not interested in paths having cycles. However, due to the difference in algorithms complexity when considering paths with or without cycles and due to the specific topology of transportation networks (with bus lines for instance), both approaches have merits. Of course, as we do not consider a path with cycles as an admissible solution for users, those paths have to be removed from the set of paths generated. Therefore, when considering \( k \)-shortest paths with cycles, one would have to produce a high number of paths to obtain the expected number of paths without cycles.

Let \( G(V, A) \) be a directed graph, where \( V \) is a set of \( n \) nodes and \( A \) a set of \( m \) arcs and let us consider a static positive cost \( c_{i,j} \) on each arc \((i,j)\). A path is defined by a sequence of consecutive arcs (or by the sequence of their corresponding nodes). On such graphs, given an origin node \( o \), and a destination node \( d \), solving the Shortest Path problem consists in finding the path from \( o \) to \( d \) having the minimal cost and solving the \( k \)-Shortest Paths problem consists in finding a set of \( k \) paths from \( o \) to \( d \) having minimal costs if possible: no path outside of this set has a cost lower than any path of the set. The \( k \)-Shortest Paths problem on static weighted graphs was already studied in the literature, but the specific case of transportation graphs was not studied.

A Transportation Network is not modeled using static weighted graphs, but it is based on labeled directed graphs \( G(V, A, \Sigma) \) consisting of a set of \( n \) nodes \( v \in V \), a set of \( m \) labeled arcs \((i,j,l) \in A \subseteq V \times V \times \Sigma \), and a set of \( p \) labels \( l \in \Sigma. \) Each triplet \((i,j,l)\) represents an arc from node \( i \) to node \( j \) having label \( l \). The labels on arcs represent transportation modes, such as foot, car, bus, metro, etc. Moreover a positive cost corresponding to the travel time is associated to each arc. Costs may be time-dependent (considering for example timetables or frequency of public transportation lines) and \( c_{i,j,l}(t) \) gives the cost of an arc \((i,j,l)\) when arriving at \( i \) at time \( t \).

The integration of multimodality through labels or time-dependent costs increases the complexity of Shortest Paths

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The integration of multimodality through labels or time-dependent costs increases the complexity of Shortest Paths
On Setting Line Frequencies and Capacities in Dense Railway Rapid Transit Networks

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Abstract—The tactical determination of line frequencies in railway networks is usually carried out as a by-product of the Line Planning phase within the general Railway Planning Process. The classical approach need to solve a previous network loading model in order to determine the different paths followed by users in their trips. Then, frequencies are determined assuming a fixed capacity both in vehicles and infrastructure. In this work, we present a general optimization model that simultaneously determines lines frequency and trains capacity without supposing an a priori passenger behaviour with regard to route choice decisions. The aim is to minimize travel time, transfers and operation costs considering both the user and the service provider points of view. In order to deal with infrastructure capacity, the model also allocates lines to tracks in multi-line open tracks. A little example is used in order to illustrate the model capabilities.

I. INTRODUCTION

The timetabling problem in Rapid Transit Systems consists on determining departure and arrival times of every service at each station in the network, minimizing some objective function (waiting time, travel time or operation costs) while satisfying demand constraints.

In the case of Railway Rapid Transit (RRT) networks, assuming a uniform demand during a certain period, a high number of services are usually programmed in order to attend high passenger demand. For this reason, obtaining a set of line frequencies becomes more important than designing a specific set of arrival and departure times. According to the Random Incidence Theorem- Larson & Odoni, 1981, regular timetables become optimal in case of uniform passenger arrival patterns. Within a network with different lines, there could be several alternative paths to perform trips for certain origin-destination pairs (i.e. passengers have different combination of lines to travel from their origin to their destination). In this situation, line frequencies influence the passenger choice of lines for each origin-destination pair. For example, low frequency lines may be rejected by some users. Hence, Line frequencies act over demand patterns in the network and, at the same time, the demand for each origin-destination pair is an input in order to determine the best set of frequencies. Under this perspective, the line frequency determination and the line choice problem are interlaced problems, each one influencing the other.

Traditionally, considering the classical railway planning process, frequency determination has been treated within the line planning stage considering a known train capacity (Claessens et al., 1998, Goossens et al. 2004, Bussieck &Lidner 2004). In order to determine the best frequency for each line, flows over the different segments are supposed to be known and are considered as inputs. To do so, it is supposed that passengers follow the shortest path for every origin-destination pair. When different train types are considered (Goossens et al. 2004), an a priori split of the passenger demand has to be performed as a previous step before computing frequencies. This process is called “System Split procedure” (Bouma & Oltrogge, 1994).

Outside the classical line planning stage, the problem of optimal frequency determination, TNFSP (Transit Network Frequencies Setting Problem) has received the interest of some researchers working on the transit assignment problem area. Scheele (1980) proposes a non-linear model with the objective of minimizing the total generalized passenger travel time and determine the trips assignment. Furth & Wilson (1982) present another mathematical method with the objective of maximizing the net social benefit taking into account constraints regarding fleet size, maximum headway and total budget. Constantin and Florian (1995) propose a method in order to minimize the passenger’s total expected travel and waiting times considering fleet size constraints. Gao et al (2003) propose a bi-level programming approach. In the upper-level the objective is to minimize the total transit system time and the cost caused by frequencies setting. The lower-level model is a transit equilibrium assignment model used to describe the path alternatives to transit users. Note that these works concern urban transit systems and do not take into account special characteristics of railway systems. Moreover, frequencies are treated as continuous variables and capacity is not considered as decision variable. In any case, in these approaches, in order to reduce the computational complexity of the problem, a set of potential attractive lines has to be considered for each origin-destination pair. According to the seminal paper of Chiรรก and Robillard (1975), on a simple network of one origin and one destination, passengers can select a subset of attractive lines and board the first one of these that arrives at a stop in order to minimize the expected sum of...
In this regular session we aim to highlight some different research areas with regards to the logistics problems.

Some topics developed in this session:

- Scheduling, optimization, supply chains;
- Vehicle routing problem, dynamic transportation routing;
- Neighborhood strategies, genetic algorithm.

Presented papers

- Integrating truck scheduling and employee rostering in a cross-docking platform - an iterative approach
- Vehicle Routing Problem with Time-Dependent Demand in Humanitarian Logistics
- Insertion of new depot locations for the optimization of multi-vehicles Multi-Depots Pickup and Delivery Problems using Genetic Algorithm
- An environment friendly method to generate dynamic transportation routing in a distributed context
- On the Evaluation of Arborescent Supply Chains with Inventory Errors
- Neighborhood Strategies for the Truck Dock Assignment Problem in Cross-Docks
Integrating truck scheduling and employee rostering in a cross-docking platform – an iterative approach

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Abstract—In a cross-docking platform, goods are unloaded, transferred and reloaded into trucks with little or no storage in between. The crossdock truck scheduling problem addresses the hard problem of coordinating the truck operations. However, crossdock operations are mostly done manually: it is therefore important to take staffing issues into account while building the truck schedule. This article shows how a truck scheduling model and an employee timetabling and rostering model can be combined to address both problems in an integrated manner. Three approaches are compared. The sequential approach consists in sequentially solving the two problems: from the truck schedule calculated first, a workload is deduced and used as input for the employee timetabling and rostering process. The iterative approach consists in solving both problems one after another in an iterative manner until a stable point is reached. Two iterative procedures are proposed, employees-first and trucks-first.

I. INTRODUCTION

Cross-docking is a technique used in logistic platforms (also called crossdocks) to accelerate the flow of goods while minimizing storage. Each truck arriving at the platform (inbound truck) contains products aimed at different destinations or clients. The cross-docking process consists in unloading the products from the inbound truck, sorting them by clients, then transferring and loading them to outbound trucks – each outbound truck being related to a specific client.

To operate properly, a cross-docking platform requires a very good coordination between inbound and outbound trucks. The crossdock truck scheduling problem handles this problem and also makes decisions on the transfer of goods inside the platform.

Goods can be moved inside the cross-docking platform either manually, with an automated system (e.g. conveyor belts) or with a combination of both. Automation can also be used for storage (automated storage and retrieval systems) – see e.g. Baker and Halim [1] or Granlund [2]. Note that these systems support human’s work but do not replace it. In general, automated systems represent heavy investments, but are feared to be not flexible enough to meet changing market requirements [1]. Therefore, automation is generally adopted by companies dealing with a limited range of product types, in a stable or growing market (e.g. postal and parcel services). For logistic service providers, whose survival depends on their flexibility, the operations stay mainly manual. Manpower is therefore the first cost center in logistics and especially for logistics providers (see Graham [3] and van den Berg [4]).

It is thus crucial to stick to the activity volume when dimensioning the task force; yet this activity volume depends directly on the truck schedule. Platform managers handle this issue by creating a truck schedule first, and then creating an employee timetable and an employee roster1 in order to cover the resulting workload. The underlying idea is to organize first the operations involving external stakeholders (the transportation providers operating the trucks), and to organize the internal matters as a second step.

This sequential approach, however, might not be the best way to solve this problem, since truck scheduling and employee rostering are strongly intertwined. As noted by Van Belle et al. [6], “the scheduling of the trucks heavily influences the workload for the internal resources”. Taking staffing issues into account when creating the truck schedule might therefore lead to better solutions. Indeed, as noted by Maravelias and Sung [7]:

“To achieve globally optimal solutions, the interdependencies between the different planning functions should be taken into account, and planning decisions should be made simultaneously. In other words, planning problems should be integrated”.

However, the crossdock truck scheduling problem and the employee rostering problem are both complex. In cross-docking literature, resource constraints are not often taken into account (Ladier [8]), let alone detailed timetabling issues. However, the crossdock truck scheduling problem, that consists of scheduling the trucks only, is covered by many authors listed in the state-of-the art established by Van Belle et al. [6] – see e.g. Fazel Zarandi et al. [9]. On the other hand, the employee timetabling problem is widely developed for different fields of application (nurse rostering, crew scheduling...); but in the logistics field, that requires specific constraints regarding the workload variation and the very diverse employee qualifications, it is only covered by Günther and Nissen [10, 11] and Ladier et al. [12].

Integrating the two problems including all realistic business-oriented constraints would result in a model way too complex to solve. We therefore propose to use an iterative approach instead, that runs the two different models iteratively until a stable point is reached.

1 Rostering is “the placing, subject to constraints, of resources into slots in a pattern. One may seek to minimize some objective, or simply to obtain a feasible allocation. Often the resources will rotate through a roster”. Wren [5]
Vehicle Routing Problem with Time-Dependent Demand in Humanitarian Logistics

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Abstract—The Cumulative Capacitated Vehicle Routing Problem with Time-Dependent Demand (CCVRP-TDD) is a novel problem in humanitarian logistics where the demand is dynamic and the objective is to minimize the sum of arrival times at critical nodes due to the emergency of the situation. Critical nodes are the nodes closest to the source, from which people try to flee to seek first aid, food, etc. This mobilization of people through the affected territory generates an increase in the chaos already caused by the disaster. The vehicles must arrive at these nodes as soon as possible and after they must supply at farthest ones (non critical/safe points). This article presents a mixed integer linear program (MILP) and a two-phase heuristic method (TPHM) based on multi-start iterated local search (MS-ILS). The moves are evaluated in constant time. Both solutions methods are tested in small and medium instances. We show that the heuristic method finds the optimal solution on small instances.

I. INTRODUCTION

Humanitarian logistics is a set of activities that must be performed before, during and after a disaster minimizing its impact, according to Altay and Green in 2006[1]. Contrary to industrial logistics where the goal is to serve completely a set of demand points at minimum total cost, emergency considerations are more important than cost and it is in general impossible to satisfy all demands. The set of activities is divided in four phases. Mitigation phase refers to plans or mechanisms such as training to reduce people vulnerability, where the government and associations plays an important role. Preparation phase refers to operations or strategies that must be planned before a disaster occurs. This phase is crucial, because it incorporates past experiences in order to enhance the response to disasters. Response phase begins immediately after a disaster strikes, all the operations planned in previous phases must be carried on in order to reduce the casualties. Reconstruction phase refers to the rehabilitation process of infrastructure and the impact generated to the population [2]. In the last decade have occurred 4183 natural disasters (floods, earthquakes, volcanic eruptions, etc.) leaving more than 1.5 billion affected people around the world [3]. This has increased the interest in humanitarian logistics among researchers, because the disasters can happen anytime and human lives are involved. This work is focused on Response phase. When a disaster strikes a zone, it has a source (or epicenter) where it begins to spread throughout a territory and the people close to it have a higher probability than those that are farther to be affected. The victims tend to seek a safe place where they can find the first aids, food, etc. People fleeing from one point to another generate an increase in the chaos already caused by the disaster, and it increases the panic of people. The movement of people through the territory generates demand variations in the different points of it, safety points will face an increase in demand, while the points closest to the source will have a decrease.

In this paper, we present a Cumulative Capacitated Vehicle Routing Problem (CCVRP) for humanitarian logistics with time-dependent demand (CCVRP-TDD). Commonly, in VRPs the demand of each node (shelter, evacuation point, hospital, etc.) is known a priori and constant in time. Here we consider two types of nodes which the demand has a dynamic behavior: critical nodes and non-critical nodes. The former are the points closest to the source while the latter are the farthest ones. Critical nodes have a demand represented by a linear function \( f(t) = a - bt \), where \( a \) is the initial demand and \( b \) the number of people per time unit (demand variation) escaping from critical nodes to non-critical nodes. Non-critical nodes have an increasing continuous piecewise linear function. This linear function seeks to represent the mobilization of people trying to get away from critical nodes. Additionally, a cumulative objective function is used, the sum of arrival times at critical nodes. This is a service-based objective function due to the emergency of the situation. According to Campbell et al. [4], this kind of objective functions represent better the emergency in humanitarian logistics.

This paper is organized as follows: Section II shows the literature review. Section III presents the problem definition and mathematical model, then the TPHM is explained in Section IV. Computational results are presented in Section V and, followed by some conclusions in Section VI.

II. LITERATURE REVIEW

Humanitarian logistics is growing in literature. Zary et al. [5] present a survey of the studies in this field from 2001 to 2014, using bibliometric methods and techniques of social network analysis, while Zheng et al. [6] show the advances in evolutionary algorithms applied to humanitarian logistics between 1996 and 2014. There are different problems related to humanitarian logistics, such as location-allocation problems...
Insertion of new depot locations for the optimization of multi-vehicles Multi-Depots Pickup and Delivery Problems using Genetic Algorithm

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Abstract—The Pickup and Delivery Problems (PDP) represent an important class of Vehicle Routing Problems (VRP) in which goods must be collected and distributed. In this paper, we propose an approach which is based on the combination of Genetic Algorithm (GA) with the clustering algorithm for the optimization of multi-vehicles, multi-depots, pickup and delivery problem (m-MDPDP). The main contribution is to find new depot locations in order to obtain feasible solution (routes) for the m-MDPDPTW. These routes satisfy transportation requests without contravening any of the instance specific constraints.

Keywords—genetic algorithm; multi-depot; pickup and delivery problem; benchmark instances.

I. INTRODUCTION

In this paper, we study a variant of the Pickup and Delivery Problem (PDP) that is the Multi-vehicles, Multi-Depots, Pickup and Delivery Problem (m-MDPDP). The PDP is considered as one of the important research problems in logistics management. Many heuristic and metaheuristic techniques have been proposed to solve it and its variants. The PDP principal is to construct a set of routes satisfying the transportation requests. Each transportation request must be specifying the size of the load to be carried, the origin and the destination locations (pickup and delivery nodes) [1].

Extensive studies interested routing problems are special cases of the PDP. The Vehicle Routing Problem (VRP) is a PDP in which all origins or all destinations are located at the depot. In this particular case, all goods are transported between the depot and nodes. The type of problem is denoted Vehicle Routing with Pickup and Delivery (VRPPD). Vidal and all present in [2] two alternative hybrid metaheuristic algorithms for the Clustered VRP (CluVRP). The first algorithm is based on an Iterated Local Search algorithm, the second algorithm is a hybrid genetic search. In reference [3], Nagy and Salhi present a solution of the VRP and propose heuristics to make this possible solution. This later is able to solve simultaneous VRPPD for single and multiple depots. Liu et al. [4] proposed a Genetic Algorithm (GA) and a Tabu Search (TS) method to solve Vehicle Routing Problem with Simultaneous Pickup and Delivery problem with Time Windows (SVRPPDTW).

However, the well-known Dial A Ride Problem (DARP) can be considered as a PDP in which the loads to be transported represent people, and all load sizes are equal to one. Masson et al. [5] describe a tabu search algorithm for the DARP with transfers noted DARPT. A verification of the feasibility of the current solution is then tested.

Several researchers introduce a general framework to model a large collection of PDP [6, 7]. The authors in [8, 9] classify the methods of solving these problems to exact, heuristics, meta-heuristics and hybrid approaches. Andre et al. in [10] study the transport problem of meals, linen and medicines for internal and external hospitals. This problem is formulated as a PDPTW with resource constraints, and a combination of metaheuristics is proposed to solve it. A genetic algorithm is developed by Harbaoui Dridi in [11] treating the m-PDPTW while minimizing total travel distance and total transportation costs. This work is extended in [12] and proposes a new approach based on the use of Pareto dominance method to solve multi objective m-PDPTW problems. Numerous heuristics and metaheuristics have been developed for multi-depots problems. In the multi-depots vehicle routing problem (MDVRP) every location is visited by a vehicle based at one of several depots. In [13], a large classification of published papers with more than 70 references involving order-first split-second methods is proposed for MDVRP. In [14] Vidal and all present two meta-heuristics for MDVRP: an iterated local search and a
An environment friendly method to generate dynamic transportation routing in a distributed context

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Abstract—Due to the globalization, today’s manufacturing industry has to mobilize as many as resources in order to satisfy needs of every customer. At the same time, the production resources are more often geographically distributed. In this context, the necessary shifting of intermediate products as well as the final delivery requires transportation among different manufacturing sites, warehouses, consumers, etc. As the business of enterprises grows, transportation demands also grow with that, resulting problems of increasing transportation cost, environmental pollution and coordination between production and transportation operations. In order to address these problems, a possible solution is to better define the routing for transportation requests. This paper proposes an environment friendly method based on a reduced weighted graph with transportation resources competencies to generate dynamic routing between pickup and delivery locations according to shortest distance and time in order to facilitate consolidation and consequently cost and pollution reduction.

Keywords—Transportation routing; Multi-agent System; Transportation planning; Interoperability; Collaborative networks

I. INTRODUCTION

Nowadays, manufacturers have to deal with a variety of competitors, suppliers and customers coming from several markets in the world. With the help of Information Communication Technology (ICT), suppliers, manufacturers, distributors, and retailers can share information rapidly and precisely [1]. To deal with the complexity of business routines, people use some automatic mechanisms to handle the data and information during the operation in logistics and manufacturing activities. Indeed, firms around the world have been implementing Enterprise Resource Planning (ERP) systems since the 1990s in order to have a uniform information system in their respective organizations and to re-engineer their business processes [2]. However, it remains the lack of better coordination methods between production scheduling, logistics and warehousing, etc.

In most of the transportation approaches, routes of the vehicle come from an optimization scheduling process based on pick up and delivery dates of the considered set of transport orders. In our context, we consider that vehicle’s route is already defined by the transporter, on the basis of any criteria, for example future demand forecast. Example of this transportation is like train, bus or airplane routes whose circulation is predefined. Therefore, transportation planning assumed here has to optimally place transport orders in the vehicle’s route in efficient way and routing for finding optimal path for each transport order is the pre-step of the planning. This routing may determine route comprising of delivery of transport order by one or more vehicles in transshipment. Moreover, each transport order may request routing on the basis of several criteria (shortest distance, time, cost, early deliver or trade of between two or more of these criteria). The goal of the paper is to define the routing in an efficient way, which eventually focuses on both transport order’s priority criteria and efficient utilization of the transport resources in a collaborative context.

Driven by the requirement of dispatching distributed resources and high-performance collaboration between them, different multi-agent models have been proposed and applied trying to solve such scheduling tasks. Many researchers have proposed different active models to solve such distributed resource scheduling and planning problems. They proposed multi-agent system (MAS), which is a computerized system composed of multiple interacting intelligent agents within an environment [3]. It is designed to be competent to solve complex problems that are difficult or impossible for an individual agent or a monolithic system to solve by cooperation between several autonomous agents via collaborative networks.

In the context of transportation, whose objective is to support production, we consider transportation orders generating during the production process as well as for the final delivery. During a production process, one manufacturing site, usually a factory or workshop require delivery of intermediate products to the other sites for a next process. During the delivery, final products need to be shipped to warehouse or delivered to the customers. In both cases, a transport request arrives with basic information elements indicating starting location, delivery location, delivery time and etc. In order to plan those deliveries optimally, we need to find out the best path from the start to the destination. For the delivery of transport orders common constraint that arises is the limited transport resources (vehicles) usually operated by a single transporter service provider. In order to ensure the order’s delivery, transportation service providers need to cooperate
On the Evaluation of Arborescent Supply Chains with Inventory Errors

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Abstract—This paper addresses the impact of inventory errors on the performance of arborescent supply chains, characterized by the bullwhip effect. The inventory records inaccuracy is caused by a permanent shrinkage. Periodic inventory audits are used to control the consequences of the inventory records inaccuracy phenomenon. Different levels of shrinkage and different frequency of audits are considered in the analysis. The performance of the arborescent supply chain is compared with the performance of a classical serial supply chain in order to provide benchmarking. Data is obtained through multi-agent simulation. Results show that the impact of inventory records inaccuracy on the bullwhip effect is higher in the arborescent supply chain: (1) the arborescent supply chain is more vulnerable to inventory shrinkage than the serial supply chain, and (2) the adoption of periodic inventory audits is more beneficial in terms of bullwhip reduction in the arborescent supply chain than the serial supply chain.

Keywords—supply chain management; arborescent supply chain; inventory records inaccuracy; inventory audits; bullwhip effect; multi-agent simulation

I. INTRODUCTION

Inventory record inaccuracy (IRI) refers to the discrepancy between physical inventory held in stock and the information system of a firm [1]. This discrepancy can deeply affect the performance of firms [2] by generating lost sales, delay penalties, re-scheduling, suboptimal planning and increase in use of small transport vehicles, among others [3,4]. Such inefficiencies are a natural consequence of uncorrected order patterns generating by Supply Chain (SC) members affected by the inventory error occurrences. Essentially, it creates critical distortions in order placement, as almost every order policy uses information on current inventory level [5] and, if the recorded inventory quantity does not match the actual quantity on the shelf, the system will either order unnecessary items, or fall short on orders [6].

Several studies show IRI to be a significant problem in practice [7,8,9,10]. Reference [11] reports inventory accuracy was only 51% after a manual inventory verification of 500 stores of a global retailer. Reference [12] observed inaccuracies in 65% of the 369,567 inventory records collected from 37 leading retailers in USA. As example, in 2009, retailers in USA lost more than $33 billion due merely to shrinkage, one of the several root causes of IRI occurrences [13,14]. Therefore, understanding the impact of this phenomenon on SC performance is important for effective SC management [15,16]. For this reason, there is an increasing interest in investigating this issue [8,17].

Most of IRI analysis are merely performed for a single-stage SC [2], and, in particular, at retailer stage [18]. On the other hand, the few studies investigating the dynamic effect of IRI in multi-echelon SCs basically focus on the classical serial SC (i.e. SCs with only a single member in each echelon) [19]. The adoption of this multi-echelon model represents a common and powerful assumption for analyzing SC performance [20]. However, it is seldom verified in real SCs [21,22], since the relationships among firms in dynamic SCs are more complicated than simple one-to-one buyer-supplier connections [19,23]. The challenges imposed by the new generation of SCs [24,25,26,27] advocate for more realistic models to analyze the growing complexity of these structures. In the IRI context, it would be of benefit to assess the impact of errors in SCs characterized by more than one member in the same echelon of the chain, such as arborescent SCs [4,28].

Motivated by these considerations, in this paper we aim to address the impact of IRI on the dynamic performance on different SC configurations. These configurations are (1) a four-nodes serially-linked and (2) a twenty-two-nodes arborescent. To emulate the IRI scenarios, we model a gap between the physical inventory, (i.e. the units actually available in stock) and the inventory record, (i.e. the units that, according to the information system, are available in stock) of each member of SCs. To do this, we introduce in the inventory system a transaction-independent error, more specifically a shrinkage error [8]. Among all inventory inaccuracy sources, this type of error has the biggest impact on SC costs [1,4,17,29]. The shrinkage error is a permanent inventory loss, resulting in smaller actual inventory when compared to the record in the Information Technology (IT) system [30,31]. Therefore, it generates an overestimation of the actual stock: the system thinks it has inventory on hand (i.e., phantom inventory) and thus fails to order new inventory [7].

In order to provide a comprehensive data input, we use simulation approach and a full-factorial experimental design [32]. This approach is appropriate because: (1) it accommodates non-linearities essential to IRI research (e.g. frequencies in cycle counting and record corrections), and (2) it accounts for
Neighborhood Strategies for the Truck Dock Assignment Problem in Cross-Docks
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Abstract—In this paper, we are interested in the truck dock assignment problem in cross-docks with several constraints. A cross-dock is a warehouse with limited storage capacity. Arriving trucks are assigned to docks and have to deliver goods to a warehouse. These goods are sorted out and loaded into the outbound trucks immediately. The objective is to find an optimal dock assignment for each truck in order to minimize the cost of transferring shipments within the cross-dock while avoiding delivery problems. To solve this problem, we propose several meta-heuristics. The first one is a local search that is characterized by different neighboring operators. These operators are tested and compared one by one on various instances of the cross-docking problem. The second meta-heuristic is a Variable Neighborhood Search (VNS). According to the efficiency of the local search operators, we test the way they can be combined in a VNS structure. Our experimental study shows that VNS makes use of the operators depending on their properties.

Keywords—cross-dock; dock assignment; meta-heuristics; local search; variable neighborhood search; neighborhood operators

I. INTRODUCTION

Warehouse management is at the heart of supply chain of flows of companies. An important issue is to control these flows by optimizing the location and the organization of warehouses to improve their performance in terms of cost and time. We are interested in this problem and in particular in cross-dock management.

A cross-dock is a special type of warehouses. Arriving trucks are assigned to the docks and shipments must be unloaded. These shipments are immediately dispatched to other docks so they can be loaded into the departing trucks. An important property of a cross-dock is that it is a warehouse with small storage capacity. Goods cannot be stored, instead they must be loaded in the same day. This property limits the ability to sort and prepare the loading of trucks. However, the storage and the retrieval cost are the most expensive operations within warehousing. Hence, cross-docking is a logistic strategy often used to improve supply chain management, to reduce distribution costs and increase customer satisfaction [1].

In this report, a literature review is examined in section two. Afterwards a formal description of the problem is found in section three. A description of the meta-heuristics used to solve this problem is presented in section four and five. Finally we present the results of our experimental study.

II. LITERATURE REVIEW

The cross-docking problem was well studied in recent literature. Boysen and Fliedner provided a comprehensive overview of different variations for the cross-docking truck scheduling problem [2]. Van Belle et al. presented an extensive review of the existing literature about cross-docking and provided several characteristics. Until now, most of studies focused on dock assignment and truck scheduling problems separately, often using simplified cases with one receiving and one shipping door [8].

For the dock assignment problem, Cohen and Keren discussed the existing approaches. They suggested a new formulation and presented a heuristic algorithm that assigns docks to trucks [3]. For the truck scheduling problem, Vahdani and Zandieh applied five meta-heuristics algorithms to solve it. The results showed that VNS is the most efficient for this problem [7].

Miao et al. considered the truck scheduling problem where trucks are loaded or unloaded during a fixed time window interval [5]. Danloup et al. extended this approach and compared several heuristics with meta-heuristics. They showed that while heuristics are fast, meta-heuristics give better solutions for the cross-docking problem [4].

Our study belongs to the last class of problems described above. We consider a truck dock assignment problem with an operational time constraint in cross-dock. In addition, we consider the problem whenever the number of trucks exceeds the number of available docks. In this latter case, if no docks are free whenever a truck arrives, this truck isn’t treated. In this paper, we examine first the efficiency of several local search operators. Afterwards, some of them are included as VNS parameters and then we study the way they can be combined.
In this regular session we aim to highlight some different research areas with regards to the logistics problems.

Some topics developed in this session:

- Scheduling, optimization, supply chains;
- Vehicle routing problem, dynamic transportation routing;
- Neighborhood strategies, genetic algorithm.

Presented papers:

- Study of alternative operation strategies in railroad terminals using simulation
- Heuristic Approach for The Optimization of the Dynamic Multi-Vehicle Pickup and Delivery Problem with Time Windows
- A Sampling Approach to Solve the Vehicle Routing Problem with Time Windows and Stochastic Travel Times
- A Decision Framework for Outsourcing Logistics in the Pharmaceutical Supply Chain
- A comparison of intermodal transportation service network design models
- A Multi-objective approach based on Rank Ant System to Configure Logistics Networks
Study of alternative operation strategies in railroad terminals using simulation

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Abstract—In this work, a simulation tool has been developed for evaluating changes in the performances of railroad terminals. The tool is composed of two elements: an user interface that enables to define the terminal to study, and a simulation model that uses the information set in the user interface to automatically generate the simulation scenario. A wide range of configurations can be simulated by introducing changes on the terminal characteristics (specifications of the elements, layout, etc.), the operating rules (used to unload/load trains, store containers, etc.) and the demand for services (train timetable, truck arrival pattern, etc.). After simulating a scenario, the tool provides information of productivity, service level as well as resource and infrastructure use. To illustrate the use of the simulation tool, different operating rules have been evaluated to improve the service level of a specific railroad terminal.

Keywords—intermodal transport; combined transport; terminal simulation; railroad terminal

I. INTRODUCTION

Road transport has increased in the last decades, and has become the most common way of moving goods in Europe despite the problems it presents (accidents, noise, emission of harmful gases and particles into the atmosphere, etc.) [7].

In this situation, the European Commission is promoting some actions to reduce its dependency on road transport and thus, achieve a sustainable transportation system in the long term [8]. These actions include those which aim to encourage the use of rail transport versus road transport, so that rail is used in medium and long distances and road only for the first and last leg of the transport.

At this point, it would be interesting to analyze the current combined transport network to determine whether their terminals will be able to satisfy the new freight flows that will be transferred to rail transport with the implementation of the European actions.

II. OBJECTIVES AND METHODOLOGY

In a combined transport network, there are a wide variety of terminals that can be classified according to their location, functions, equipments, volume of transshipments, etc.

This work focuses on studying inland terminals that use containers as load unit, that exchange containers between trains and trucks using gantry cranes and reach stackers, and that use ground storage. These terminals are very common in Asia, Australia and North America, as well as in many European countries like Austria, Belgium, Bulgaria, Czech Republic, France, Germany, Italy, Netherlands, Poland, Romania, Spain, Sweden and Switzerland [11, 22].

The performance of these terminals is appropriate if there are no delays in train departures, if much of the trucks (at least 95%) are served in 20-30 minutes or less and if terminal resources and infrastructures are able to attend the current demand without generating bottlenecks or high percentages of idle capacity [2, 3].

An appropriate performance can be achieved through different strategies where several terminal characteristics may vary: number of cranes, work shifts, operating rules, etc.

In this context, a simulation tool able to automatically generate and evaluate a wide range of configurations from the information set by a decision-maker in an user interface is developed. This tool can be very useful in a redesign project of a combined transport network, given that it would make easier the study of several terminals and the evaluation of multiple alternative configurations to satisfy a train schedule.

The tool developed is able to represent alternative scenarios where a wide range of terminal characteristics may vary: specifications of terminal elements (number of cranes, operation times, number and length of tracks, etc.), layout, work shifts, operating rules (different procedures used to store containers, assign tasks to the reach stackers, unload/load trains, etc.) and demand. In the literature reviewed, there are other simulation tools that also may vary some terminal characteristics. However, none of them present the operating rules as an input datum, despite the strong impact that they have on the terminal performance.

In this work, it has been necessary to model some processes in detail in order to represent the different operating rules considered. This higher detail improves the simulation tool results to support decisions related to the redesign of simulated terminals (purchase of a new crane, extension of the working hours of an existing crane, change on the terminal operation, etc.).

In addition, the tool developed is able to represent two aspects that have not been considered in other simulation tools
Heuristic Approach for The Optimization of The Dynamic Multi-Vehicle Pickup and Delivery Problem with Time Windows

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Abstract— The PDPTW (Pickup and delivery problem with Time Windows) is an optimization vehicles routing problem which must meet requests for transport between suppliers and customers satisfying precedence, capacity and time constraints. In this paper, we present an approach based on genetic algorithm, aggregation method and minimum values for optimization of the dynamic multi-pickup and delivery problem with time windows. We propose in this sense a brief literature review of the PDPTW, present our approach to give a satisfying solution to the m-PDPTW, minimizing the compromise between the total travel cost and the total tardiness time.

Keywords— pickup and delivery, time windows, genetic algorithm, aggregation method

I. INTRODUCTION

The vehicle routing problem (VRP) is a class of combinatorial optimization. The goal is to serve a set of customers by minimizing one or more criteria related to the delivery cost.

We are interested in an important variant of VRP which is the PDPTW (Pickup and Delivery Problem with Time Windows) with time constraints and capacity constraints on vehicles.

In this paper we present a literature review of the VRP and the PDPTW followed our approach, minimizing the compromise between total travel cost and total tardiness time, based on genetic algorithms, aggregation method and minimum values, which treats the m-PDPTW dynamic. This latter must be able to integrate an unexpected while routing has been planned and that their operation has started.

II. LITERATURE REVIEW

A. Vehicle routing problem

The vehicle routing problem (VRP) lies at the heart of distribution management. It is faced each day by thousands of companies and organizations engaged in the delivery and collection of goods or people [1].

The VRP principle is: given a depot D and a set of customers orders C = (C1, ..., Cn), to build a package routing, for a finite number of vehicles, beginning and ending at a depot. In these routing, a customer must be served only once by a single vehicle and vehicle capacity transport for a routing should not be exceeded [2].

The Metaheuristics were also applied to solve the vehicle routing problem. Among these methods, we can include ant colony algorithms, a reactive tabu search and an extended great deluge which were used for the resolution of VRP [3][4].

B. The PDPTW: Pickup and Delivery Problem with Time Windows

The PDPTW is a variant of VRPTW where in addition to the existence of time constraints, this problem implies a set of customers and a set of suppliers geographically located. Every routing must also satisfy the precedence constraints to ensure that a customer should not be visited before his supplier.

A genetic algorithm was developed by Velasco, N and al to solve the 1-PDP bi-objective in which the total travel time must be minimized while satisfy in prioritise the most urgent requests. In this literature, the method proposed to resolve this problem is based on a No dominated Sorting Genetic Algorithm (NSGA-II) [5].

Kammarti, R and his coauthors deal the 1-PDPTW, minimizing the compromise between the total travel distance, total waiting time and total tardiness time, using an evolutionary algorithm with Special genetic operators, tabu search to provide a set of viable solutions [6][7].

Quan, L and his coauthors have presented a construction heuristic based on the integration principle with the objective function, minimizing the total cost, including the vehicles fixed costs and travel expenses that are proportional to the travel distance [8].

A new metaheuristic based on a tabu algorithm and a local search, was developed by Li, H and his coauthors to solve the m-PDPTW [9][10].

A genetic algorithm was developed by Harbaoui Dridi, I and his coauthors treating the m-PDPTW to minimize the total travel distance and the total transport cost [11]. This work has been extended, in proposing a new approach
A Sampling Approach to Solve the Vehicle Routing Problem with Time Windows and Stochastic Travel Times

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Abstract—In this paper, we discuss the vehicle routing problem with time windows (VRPTW) where stochastic travel times are assumed. In a first step, a variable neighborhood search (VNS) approach is proposed for the VRPTW where deterministic data is assumed. This approach is extended in a second step by adding a sampling approach to deal with the stochastic travel times. Problem instances are proposed that are based on the well-known Solomon instances from the literature. The resulting routes are executed in a stochastic environment to assess the performance of the proposed heuristic. Computational experiments demonstrate that it is reasonable to incorporate stochastic knowledge into VRPTW algorithms.

Keywords—Vehicle Routing, VNS, Stochastic Travel Times, Sampling, Computational Experiments

I. INTRODUCTION

Vehicle routing problems with time windows (VRPTW) are an important extension of the Capacitated VRP (CVRP) where the service at each customer has to start within a certain time interval, called time window [6]. There are hard and soft time windows. If hard time windows are assumed the vehicle has to wait until the customer is able to start service. Additional costs do not appear for waiting until the left boundary of the time window is reached. In the soft time window setting, each time window can be violated, but penalty costs occur in this situation. VRPTWs have many important real-world applications like in grocery delivery and urban newspaper distribution. The VRPTW is NP-hard since it contains the CVRP as a special case. Therefore, efficient metaheuristics are proposed to tackle large-size problem instances of the VRPTW in a reasonable amount of time [6].

One of the basic assumptions of VRPTW is that the travel times are deterministic and linearly correlated with the distance. Therefore, travel times can be associated with the distance. However, this is often not valid in real-world scenarios, for instance, due to traffic jams. While there are many heuristics available for the VRPTW with deterministic data, this is not the situation for problem settings where some of the data is stochastic (see [11] for a recent survey of stochastic VRPs). State-of-the-art application systems allow for using of large amounts of structured digital data for decision making. In recent years, the performance of hard- and software components has been dramatically increased. Efficient decision-making procedures combining heuristic and exact approaches are routinely developed. Hence, large-size real-world models based on data available in companies can be solved within a reasonable amount of time. The value of modeling uncertainty in next-generation decision support systems in logistics is also pointed out in [9], [17].

The VRPTW with soft time windows and stochastic travel times was studied for the first time by Li et al. [16]. In the present paper, we are interested in applying the Monte Carlo sampling approach proposed in [19] to the VRPTW. This paper is organized as follows. The problem is described in Section II. In addition, related work is discussed there. The proposed VNS scheme is presented in detail in Section III. In Section IV, the sampling method to incorporate stochastic travel times is discussed. The results of computational experiments are presented and analyzed in Section V.

II. PROBLEM DESCRIPTION

A. Problem

Following [6], the VRPTW is defined by a directed graph \( G = (V, A) \) where the depot is represented by the two vertices (nodes) \( 0 \) and \( n+1 \). These two vertices are called source and sink, respectively. The set of customer vertices is represented by \( N = V \setminus \{0, n+1\} \). The demand \( q_i \) of vertex \( i \) has to be delivered to customer \( i \in N \). The arc set is given by \( A = \{(i,j) \in V \times V \mid i \neq j\} \). The cost \( c_{ij} \) is associated with arc \( (i,j) \). Note that \( c_{ij} \) can be expressed by the travel time \( t_{ij} \) on arc \( (i,j) \). A route is a sequence \( r = (i_0, i_1, \ldots, i_{n+1}) \) where we have \( i_0 = 0 \) and \( i_{n+1} = n+1 \). The set of customers \( S(r) = \{i_1, \ldots, i_r\} \subseteq N \) is visited when route \( r \) is performed.
A Decision Framework for Outsourcing Logistics in the Pharmaceutical Supply Chain

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Abstract— With a constantly changing environment, organizations today are more than never required to optimize their supply chains while reducing costs and offering high levels of performance. Pharmaceutical firms in particular perform in a market that is characterized by highly fluctuating demands and are often asked to expand their capacity to meet their requirements. Having the choice of either investing in new human/infrastructure resources or outsourcing to an external logistics service provider, many firms consider logistics outsourcing (LO) with the expectation of lowering costs and/or attaining higher level of service performance. This study contributes to the literature by developing a theoretical framework to consider the option of outsourcing logistics in the pharmaceutical products supply chain (PPSC). The process of identification of relevant factors to consider and a logical flow diagram are described.

Keywords—Decision framework, Outsourcing, Logistics, Pharmaceutical supply chain

I. INTRODUCTION

Pharmaceutical products (PP) constitute a vital element in the functioning of the health system. The control of PP supply with respect to the needs of health services defines a safety stake for patients and control of costs from their storage, distribution to their expiry. In this past decade, a great deal of attention has been directed towards PPSC in the context of prioritizing health concerns internationally. Pharmaceutical firms have been challenged to produce larger quantities of PP to supply increasing number of patients’ demand. These companies are then pressured to optimize their SC while reducing costs to satisfy these fluctuating demands.

In order to counter these challenges, managers can either expand their resources or outsource functions to an external service provider. Organizations often opt for outsourcing functions such as logistics to an expert provider as it may be financially effective comparing to investing in new human and infrastructure resources. However, the decision for outsourcing requires an extensive study for determining the feasibility of this option. With limited standardized process frameworks, managers find themselves struggling with the planning process of LO. Outsourcing logistics in particular for the PPSC is a critical process since the SC entails specific complexity and high personalized characteristics [1].

The main idea of this paper is to provide a theoretical framework for investigating the feasibility of LO in PPSC taking into consideration specific factors and risks. The reminder of this communication is organized as follows. In the next section, a review of literature about the logistics outsourcing and PPSC is described. The main aim of this study was to present the latest in this field not as a collection of independent articles, but as a whole, in an integrated manner. We provide the relevant literature review of methods and approaches developed to understand various issues raised by the problem of outsourcing. Our intention is to cover the full spectrum of the outsourcing issues and provide a set of factors and risks which are to be considered in outsourcing decision. Based on the literature results, we describe our problem and the proposed approach of its resolution. Later sections deal with identifying factors and risks influencing LO in the PPSC. A logical flow diagram as a decision framework process is elaborated and described. Finally, a summary and presentation of possible extensions conclude the communication.

II. LITERATURE REVIEW

SCM is the management of multiple business processes starting from product planning and ending with delivery. It is defined as the integration of key business processes across the SC for the purpose of creating value for customers and stakeholders [2]. SCM is defined, according to [3], as planning and management of all activities involved in sourcing, procurement, conversion and all logistics activities. Supply chains in the pharmaceutical industry, one typical industry of products with a high added value per mass unit, comprise two manufacturing stages (primary manufacturing and secondary manufacturing), market warehouse/distribution centers, wholesales, retails/hospitals and patients [4]. Moreover, some unique characteristics such as high-regulated setting, the long development process, risky and high level of cost in research phase [5] distinguish the pharmaceutical industry from other industries. The PPSC is a rich example of information flows to many stakeholders. Product perishability is another critical issue in pharmaceutical/drug supply chains [6]. Apart from the
A comparison of intermodal transportation service
network design models

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Abstract—Intermodal transportation has known a great
development during last decades as consequence to the
development of container transportation services and supply
chain stakes. This development had required efforts and
researches to optimize the design and the configuration of
transportation network infrastructure and their service. The
design, configuration and the service network design of a system
performing intermodal transportation, obeys to the same
objectives as for a transportation and distribution network but
could differ because of either its specific structure, cost function
and/or specific constraints related to the actors points of view.
The purpose of this article is to compare and assess the existing
models for service network design in term of completeness of
embedded constraints, objective functions costing structure and
in term of compliance to upcoming schemas of distributions and
freight transportation networks.

Keywords—Intermodal Transportation; Service Network
Design; cost; model

I. INTRODUCTION

The optimization of distribution and transportation
networks is a complex field with a large number of operators
with divergent points of view and several phases of planning
(strategic, tactical and operational). Intermodal transportation
has experienced sustained growth in recent decades due to the
rise of containerization and challenges of the supply chain. The
development of gateways infrastructures (ports and airports),
intermodal terminals and dry ports, has significantly impacted
the development of activities and services of intermodal
carriers and freight forwarders. This development was also
accompanied by several research contributions for the
optimization of transport networks in terms of the service
design. The design and configuration of an intermodal
transportation network follows the same principles as per a
modal transportation or distribution network, but their
modeling may differ because of their specific structures (inter
modality), the objective function costing structure and
constraints related to the many actors involved and their points
of view.

The main objective of this article is to explore the state of
the art in modeling intermodal transport networks, and
especially service network design (SND) modeling. We
discussed the quality of the main models reviewed and their
completeness in terms of constraints and cost structure in the
objective function. Also we established an assessment of these
models using a set of criteria we considered compliant to
intermodal road-rail transport networks. This paper is
organized into four sections. Section II includes a literature
review of transport networks modeling contributions. Section
III contains and discuss the main models of intermodal
transportation service network design. Section IV establishes a
multi-criteria assessment positioning the main reviewed
models. The last section provides, in conclusion, perspectives
of our future research.

II. LITERATURE REVIEW ON THE OPTIMIZATION OF
TRANSPORTATION NETWORKS

The optimization of distribution and transportation
networks is a complex field with a large number of operators
with various points of view and several planning phases
(strategic, tactical and operational). Crainic and Laporte 1997
[1] identified the main issues of planning and transportation
operations for the three levels of decision. Crainic 2000 [2]
noted the increasing use of the Service Network Design (SND)
in the design and configuration of transportation network
services. Crainic and Kim 2006 [3] highlights the main issues
of intermodal transportation in the different levels of decision.
Desaulniers and Hickman 2007 [4] argue that public transit
problem can be divided into sub problems that are generally
solved sequentially at different levels of decision-making and
planning. They also made a review of the models and solving
approaches.

A. Network Design Problem (NDP)

NDP aim is the optimization of multi-objective
transportation network, providing alternatives (or choices) to
network users. The network is defined by a set of nodes and
arcs. Some nodes represent the origin of demand (of one or

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A Multi–objective approach based on Rank Ant System to Configure Logistics Networks

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Abstract—In this paper, we introduce the use of an Ant System called Rank-based Ant System (ASRB) to solve the problem of configuring the Supply Chain (SC), when the Production Cost (PC) and the Lead Time (LT) are minimised simultaneously. The SC is modelled as a graph in which nodes represent supply, manufacturing, and delivery stages. Each stage could be performed by more than two options. Thus the problem is to select the options that can minimise the PC and LT at the same time, given that a reduction in time increases the cost and vice versa.

We developed an algorithm to solve the SC configuration problem based on the (ASRB) in which ants, of different colonies, travel throughout the graph to configure the SC. Our algorithm is tested using a standard problem reported in the literature and we provide some metric of its performance.

I. INTRODUCTION

One major challenge that are facing global outsourcing, manufacturing and distribution organisations is how to effectively integrates, to coordinate, to control and hence to optimise their operations. One of these operations is the configuration of the SC, which plays an important role in SC management since SC network is the framework of the operations from the strategy to the operational level [1]. In this paper, the SC is divided into three kinds of stages (i): supply, manufacturing, and delivery stages. Supply stages represent the components necessary to assemble sub-assemblies or final product. Manufacturing stages represent the assembly facilities where sub-assemblies and final products are produced. Delivery stages represent the modes of transport used to deliver final products to customers. Every stage could be performed by more than one option (j), e.g. more than one supplier could supply the component represented by the supply stage. Thus, if i is a supply stage, then \( j = \{1, 2, \ldots, J \} \) represents the different supplier than can supply the component.

Every option is characterised by its direct cost (\( c_{ij} \)) and time (\( t_{ij} \)) that are added to the PC and LT, respectively. The SC configuration problem is solved when an option \( j \) has been selected to perform operation at stage \( i \). The problem can be optimised choosing a proper set of options so that to minimise the PC and LT at the same time where a reduction of the PC may increases the LT and vice versa. As the proposed problem has two objective functions, we use the weighted summation as the objective function.

The SC configuration problem, as stated above, is a classical problem of discrete optimisation [2] that is solved efficiently by Ant Colony Systems [3]. Real ants have the capacity of smelling and depositing chemical substances called pheromones (\( \tau \)) that allow them to communicate with each other. Ants move randomly when they leave the nest but when ants find a pheromone trail, they decide whether or not to follow it. If they decide to do so, they deposit their own pheromones over the trail. The probability that an ant selects one path over another is based on the quantity of \( \tau \) deposited over the path. With time, the amount of \( \tau \) on the path evaporates. Before the colony finds the shortest path between the nest and the food, ants use all the potential paths in equal number depositing pheromones as they travel. The ant that takes the shortest path will return to the nest in first place with the food. The shortest path will have the most \( \tau \) because the path has “fresh” pheromones, which have not evaporated yet, so the path will be more attractive to those ants that return to the food source. This natural behaviour is simulated in order to solve the SC design (SCD) problem but instead of looking for food, ants look for the final customer and they do not find the shortest route but the cheapest and fastest route from suppliers to customers. We developed an algorithm bases on ASRB to minimise PC and LT at same time. We tested our algorithm solving three instances used in literature [4], [5]. We solve the 24’272-solution instance in about 28 seconds, faster than the solution generated by standard operations of genetic algorithm. We show graphically that our algorithm finds solutions with lower weighted objective function than those solutions generated by the genetic algorithm.

II. LITERATURE REVIEW

Many techniques and approaches have been proposed to solve the SC design problem. These techniques include mathematical modelling, heuristics, and agent technology. Many mixed-integer programming (MIP) models have been proposed to solve the SCD. However, most of them both encompass just suppliers, manufacturers, and retailers and minimise costs such as cost of goods sold, transportation, facility location, and operation [6], [7], [8], [9]. These models are not able to cope with uncertainty and only minimise the cost objective because of simplicity of the models. Despite this, there are more complex models which not only include stochastic elements but also minimise two or more objective functions, e.g. [10] maximised the profits and demand satisfaction as well as minimised the the financial risk. [4]
Track - IESM2015

Regular session

Supply chain

Ana Paula Barbosa-Póvoa

Some aspects of research supply chains problems are proposed in this regular session.

Some topics developed in this session:

• Green supply chains;
• Management practices;
• Performance;
• Stochastic demand, cyclic demand;
• Location routing problem;
• Manufacturing strategies.

Presented papers

• Bullwhip effect metrics for multi-echelon systems under order batching policies with cyclic demand
• Adressing Environmental and Economic Impacts of changeover Operations through manufacturing strategies
• Integral Supply Chain Performance Management System Design and Implementation
• Analysis of The Influence of Organisational and Inter-Organisational Factors on the Implementation of Green Supply Chain Management Practices
• Supply Chain Management and Performance: a Bibliometric Analysis
• Performance Metrics for a Supply Chain Subject to Stochastic Demand
Bullwhip effect metrics for multi-echelon systems under order batching policies with cyclic demand

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Abstract—This paper analyzes how order batching policies impact on the bullwhip effect over a multi-echelon distribution supply chain facing cyclic demand. As a demand cycle is repeated over the time planning horizon, a wrapping around operator is considered and based on this a single cycle is required to represent the real problem. The problem consists on determining the optimal reordering plan, which minimizes the overall system operational costs while investigating which bullwhip measures are more adequate to control such type of systems. A mixed integer linear programming model is developed, which considers a multi-echelon inventory/distribution system formed by N-warehouses and M-retailers with lateral transshipments among warehouses and among retailers. A case study based on a real retailer distribution chain are presented and solved.

Keywords—supply chain management; order batching; bullwhip effect; inventory planning; wrap-around; mixed integer linear programming.

I. INTRODUCTION

In distribution chains products move from one echelon to another often in fixed lot sizes or batches. These batches can lead to large fluctuations in inventory levels leading to inventory levels rise up that will only be reduced when the reorder point is reached, point at which often a new batch may enter the inventory pipeline. The rapprochement of these conflicting objectives is a fundamental aim of the inventory management theory. Along the distribution chain, batching policies may affect the bullwhip effect and this influence is also an important topic to be addressed. Studies using simulations methods are the most common when bullwhip effects are analyzed [1]. Thus, selecting as modeling approach, mixed integer linear programming models to address this problem could represent an advance in bullwhip studies.

This paper explores these opportunities by introducing batching into an optimization distribution supply chain model while analyzing the bullwhip effect in terms of inventory instability and order amplification. The impact of different order batch sizes and the impact of different cyclic demands on bullwhip effect are studied.

The remainder of this paper is organized as follows. Section II includes a literature review on order batching and bullwhip effect and metrics for measuring the bullwhip effect. The problem definition is given in section III. Section IV describes the inventory planning mathematical model and the bullwhip effect metrics are defined in section V. A case study is solved and the results presented in section VI. Finally the conclusions are drawn in section VII.

II. LITERATURE REVIEW

The bullwhip effect related with batching is reviewed. Furthermore it is also addressed the quantification of the bullwhip effect through adequate metrics to assess its performance measurement. Relevant metrics may be used for further planning in order to reduce the impact of bullwhip in relevant decisions.

A. Order batching and bullwhip effect

The influence of the order lot sizing length on inventory instability throughout multi-echelon distribution supply chain is an identified problem that requires further research so as to support operations manager’s decisions when batching policies are used [2]. Some studies have however appearing dealing with such problem. Reference [3] studied the impact of order batching in a two-level distribution supply chain with a single supplier and many retailers. The study suggests that the bullwhip effect at the suppliers’ level can be reduced by balancing the orders of the retailers, considering longer orders interval time and smaller batch sizes. Reference [4] considered scenarios where orders are placed only in multiples of a fixed batch size, for both deterministic and stochastic demand rates. Using simulation the authors have shown the impact of changing batch size on bullwhip. Their results conclude that economies may be achieved through batching policies while minimizing the impact on bullwhip through the careful selection of the batch size.

More recently, [5] researched and reviewed the bullwhip effect in supply chains. They said, namely, that the analytical modelling uses a mathematical formalism to describe supply
Addressing environmental and economic impacts of changeover operations through manufacturing strategies

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Abstract—A Changeover is the set of operations required to switch from producing one product to another and quite frequently it includes both setup and cleaning operations. Changeovers are especially critical for multi-product environments where flexibility, time and quality are key requirements of the manufacturing system. A range of environmental and economic impacts occur during changeover operations and often the magnitude and extent of these are not fully captured by manufacturing companies. This paper investigates the implication of manufacturing strategies that are related to changeover operations such as LEAN, TQM, JIT and TPM on changeover operations and the direction they may drive changeover operations in the future. Current results from recent case studies suggest that a part of the environmental and economic impacts from changeovers is within the scope of these manufacturing philosophies and could have been mitigated through comprehensive and successful implementation. However, this has been countered by the lack of information that connects the changeover impacts to the manufacturing strategies. This paper aims to address this gap.

Keywords—Changeovers; eco-effective changeovers; setup operations; cleaning operations; sustainable manufacturing; industrial sustainability, manufacturing strategies; total productive maintenance; total quality management; lean manufacturing

I. INTRODUCTION

A Changeover is the set of operations required to switch from producing one product to another and quite often includes both setup and cleaning operations. It is especially important for factories dealing with a high product variety. In addition to that, there has been a movement towards a more customized, small volume and highly volatile market demands. This not only brings a challenge to companies to be more adaptive and more agile than ever but also encourages them to reconsider how they manage their changeover operations as one common factor of all these market changes is an increase on the number of changeovers.

For many years changeovers have been a problem for companies by causing significant losses of production time. Hence, the main area of interest have been achieving faster changeovers. One of the largest step changes have been through the introduction of Single-Minute-Exchange-of-Die (SMED) methodology by Shigeo Shingo. With the applications of SMED many companies have drastically reduced their changeover times. Whilst, this one dimensional approach has provided companies some benefits, both environmental and economic impacts started to stand out as the manufacturing companies are facing increased pressure to become more sustainable.

Changeovers are critical for a wide range of industries, however, the environmental and economic impacts as a result of changeover operations (after here will be mentioned as changeover impacts) have not been well understood yet. These operations can cause significant burdens through product and time losses, additional water and energy use, creation of wastewater and solid waste as well as chemical use. Environmental impacts could be described as the cost of these burdens to the nature and, while economic impacts represent the cost to the company. Without the proper attention, these impacts can drastically reduce the sustainability performance of the companies.

Academic literature covering the environmental and economic impacts of changeover operations has yet to be developed. Current literature streams are clustered around setup time reduction and cleaning operations separately. However, considering the complexity of the problem, in order to make balanced decisions all aspects of changeovers should be jointly
Integral Supply Chain Performance Management System Design and Implementation

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Abstract—“Supply chain versus supply chain” is the new mantra for contemporary competitive businesses. To reach the desired competitive advantage and sustainability, companies are acknowledging the importance of supply chain management (SCM) and the benefits of improving it by a performance management system (PMS). Since one cannot manage without measure, a performance measurement system (PMeS) is a basic requirement for any PMS. Combining SCM and PMS into a supply chain performance management system (SCPMS) should enable enterprise quest in becoming business differentiators. There is a large gap in literature when it comes to merging these two concepts into the SCPMS, so this research aims at bridging this gap, providing a case study within the high tech industry. A SCMPs framework is developed, together with a supply chain performance measurement system (SCPMeS) and the intent is to create awareness for further validation and development. This research is still in an exploratory level and will be followed by an implementation period in a high tech industry firm.

Keywords—supply chain management; supply chain performance; performance management system; performance measurement system; high tech industry.

1. INTRODUCTION

Globalization, new business models and an empowered customer and workforce have accelerated the pace of business beyond what seemed possible just five years ago. The Economist Intelligence Unit Limited, “The future of business: supply chains”. The Economist, 2014. Because accurate and appropriate performance evaluation is critical for judging the success or failure of a business, performance indicators that accurately reflect the competitiveness of a company must be carefully identified. Business to business (B2B) supply chains (SCs) are increasingly taking centre stage in the quest for greater profits and competitive The Economist Intelligence Unit Limited, “The future of business: supply chains”. The Economist, 2014. PwC Global Supply Chain Survey, “Next generation supply chains. Efficient, fast and tailored. PwC, 2013. concludes the following: companies that acknowledge SC as a strategic asset achieve 70% higher performance and the ones that beat the competition on supply chain (SC) performance also reach significantly better financial results. Henceforth, effective supply chain management (SCM) is treated as key to building a sustainable competitive edge through improved inter and intra-firm relationships A.E. Ellinger, “Improving marketing/logistics cross-functional collaboration in the supply chain” in Industrial Marketing Management Journal, vol. 29, no. 1, pp. 85-96, 2000..

Continuously improving SC performance has become a critical issue for most suppliers, manufacturers, and the related retailers to gain and maintain competitiveness J. Cai, X. Liu, Z. Xiao and J. Liu, “Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment” in Decision Support Systems, vol. 46, pp. 512-521, 2009. To carry out this constant performance development, one must always acknowledge the following two aspects of performance per se: performance management (PMe) and performance measurement (PMe). Accordingly, and bearing in mind the well-known quote by Peter Drucker “you can’t manage what you can’t measure”, PMe and PMe are not separable. They follow one another in an iterative process; management both precedes and follows measurement, and in doing so creates the context for its existence M.J. Lebas, “Performance measurement and performance management” in International Journal of Production Economics, vol. 41, pp. 23-35, 1995. In other words, performance management systems (PMSs) encompass performance measurement systems (PMeS), but not the other way around. M. Coveney, “Performance management vs. measurement performance” in FSN: Business Systems News and Analysis for Finance and IT Professionals, 2010.

Incorporating SCM and a PMS into a supply chain performance management system (SCPMS) should catapult enterprise revenue and contribute extensively towards a business differentiator. In view of this, one would expect interest in developing management systems for managing supply chain performance (SCP) to be escalating, however, and as acknowledged further in this research, current literature lacks an adequate framework for the design of SCPMSs and empirical cases of adoption experience are extremely limited in academic literature.

A suitable environment for a pragmatic case could be the high technology (high tech) industry since the nature of competition in this manufacturing industry has changed dramatically over the last two decades, and any of the traditional indicators of business performance are insufficient today F.M. Tseng, Y.J. Chiu and J.S. Chen, “Measuring business performance in the high tech manufacturing industry: a case study of Taiwan’s large-sized TFT-LCD panel companies” in International Journal of Management Science, vol. 37, pp. 686-697, 2007. Furthermore, in order to maintain their competitive edges in the market, high tech firms cannot
Analysis of The Influence of Organisational and Inter-Organisational Factors on the Implementation of Green Supply Chain Management Practices

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Abstract—Various drivers push companies to implement Green Supply Chain Management (GSCM) practices. However, implementing GSCM practices is always subject to a number of interacting factors (attributes, characteristics and practices) that characterize the company's organization and its relationships with other supply chain partners. This study contributes to understanding how such factors taken together interact as a system and influence the implementation of GSCM practices. We identify a set of 19 influential factors on the implementation of GSCM practices. Then, we build a model that exhibits and structures the influence relationships between these factors, using the Interpretative Structural Modeling (ISM) and the MICMAC analysis. The results of our study show that some organizational and inter-organizational factors have particularly high driving power and influence potential on the other factors that affect the implementation of GSCM practices by a company. Among these highly influential factors, we mention the relations with supply chain partners characterized by dependence, trust and/or long-term engagements, in addition to top management commitment and good management practices, such as the application of quality management and information and knowledge sharing.

I. INTRODUCTION

Green Supply Chain Management (GSCM) has been gaining in popularity among practitioners and researchers through the last two decades, and a large number of studies contributed to defining this approach to the management of the supply chain, and to clarifying the differences it has with the traditional approach to Supply Chain Management (SCM) [1]–[3]. In particular, previous research has identified a number of practices which could be considered as part of the implementation of a GSCM approach, and a number of drivers or pressures that push companies to adopt and implement such practices [2]. A number of empirical studies established direct relationships between the drivers that push the company to apply GSCM practices and the results or the performance level realized, according to environmental, economic and operational performance metrics [4]. Studies reported also that the success of a company in implementing GSCM practices is always subject to some factors (attributes of or characteristics and practices) that characterize the company’s organization and its relationships with other supply chain partners. However, there is still a need for more in depth and systematic approach to study these factors, considered together, in order to evaluate their potential impact and to understand how they interact between each other and influence the implementation of GSCM practices.

In this study, we intend to contribute to satisfying that need by using the well known Interpretive Structural Modeling (ISM) [5] method in analysing the influence and interactions of organizational and inter-organizational factors that affect the success of the company in implementing GSCM practices. We adopt the contingency theory approach that helps us identifying these factors and separating them from the drivers or pressures that push the company to adopt the GSCM practices, and from the practices themselves. Then, through an extensive literature review, we identify a set of 19 factors that are reported to be influential on the success of implementing GSCM practices. Then, we collect data necessary for the application of ISM methodology from 13 practitioners and experts in the field of SCM. Finally, we conduct an ISM and a MICMAC analysis [6] of the identified factors, present and discuss the findings and managerial implications of our research.

The remaining of this paper is organized as follows: Section II introduces GSCM, drivers and practices. Section III presents the results of our literature review aiming to identify the set of factors that affect the success of a company in implementing GSCM practices. Section IV introduces the ISM methodology, explains how we used it in this study and present the results we obtained. Section V discusses the results of our study and their managerial implications. Section VI concludes the study.

II. GSCM, PRACTICES AND DRIVERS

Supply Chain Management (SCM) has been traditionally defined by scholars as the coordination of business functions as well as material and informational flows within a particular company and between interdependent companies of a supply chain for the purpose of improving the performance of the individual companies and the supply chain as a whole [7]–[9]. It is commonly agreed that the scope of SCM encompasses all the activities and function areas of the company, that are engaged in providing a value and satisfying the customer needs, including marketing, research and development, forecasting,
Abstract—Supply Chain Management (SCM) has often been discussed and studied by academics and practitioners over the last two decades. One reason for the growing interest in SCM is that a company’s performance is no longer solely determined by the decisions it makes and actions it takes, but also by the contribution and performance of all the members along the supply chain. This study examines the academic literature on SCM. The aim is not to perform an exhaustive analysis. Rather, the goal is to carry out a representative work. This article interconnects two study areas: supply chain management and organizational performance. The analysis was based on 172 academic articles. This study helps to identify opportunities and weaknesses in the field of operations management and helps researchers to find trends that could support future studies in SCM.

Keywords—Supply Chain Management; Performance; Organization; Firm Performance

I. INTRODUCTION

Historically, the focus of operations management has been on continuously improving operational excellence through the development and implementation of strategies in order to obtain better organizational performance. Current economic conditions make it difficult for organizations to achieve a sustainable competitive advantage without a macro focus throughout the Supply Chain (SC), as well as the company’s integrated position within its SC. The company’s performance is therefore dependent on the intertwining of competitive strategies throughout the SC. The goal remains the implementation of strategies that strengthen SC links, forms of collaboration, and cooperation in a cohesive business model [11].

Supply Chain Management (SCM) has often been discussed and studied by academics and practitioners over the last two decades. One reason for the growing interest in SCM is that the performance of a company is not merely determined by the decisions it makes and actions it takes, but also by the contribution and performance of all the members within the supply chain. It is by collaborating that companies achieve the best results along the SC. According to [67], this is because the global competitive environment has changed from being between individual firms to a relationship between supply chains. Moreover, organizations are in constant pursuit of efficient supply chains and/or networks, which guarantee competitive advantages in the global economic market [43]. For these reasons, it is necessary for organizations to manage not only their own internal relations, but also their relationships with other organizations within the SC.

Another reason for the increasing interest in SCM is because it adds value and creates efficiencies that raise profitability, thereby increasing customer satisfaction [56]. Investigations show that other benefits are also able to justify the importance of SCM: lower costs as a result of decreasing redundancies, lower inventory levels, shorter waiting times and lower uncertainty in demand. Over time, effective SCM leads to the amelioration of product quality and customer service. It also leads to better market responsiveness, access to the target market, and hence improves organizational performance overall [e.g., 43, 52, 59].

Much of the previous research has been conducted with the aim to analyze the relationship between SCM and performance. The conclusions vary according to the practices analyzed: sample size, the countries chosen, and the variables studied. As for the results, some articles show that this relationship has a positive effect on performance [e.g., 12, 20, 55, 65] while others researchers found no evidence to support this statement [e.g., 28, 54].

In addition, measurements of “performance” vary considerably from survey to survey. Some authors use purely financial measures, some use only operational ones, while others choose to combine both. The contradictions in the results - as well as the different measurements - have motivated us to perform a systematic review and analysis regarding the current state of this field of research.

To fill this gap, this study examines the academic literature on SCM. The aim is not to perform an exhaustive analysis. Instead, the goal is to carry out a representative work. This article interconnects two study areas: supply chain management and organizational performance. 172 academic articles were analyzed, which are included in the database as Science Direct (Elsevier), Emerald Management Xtra, ABI Inform, SCOPUS. This study helps to identify opportunities and weaknesses in the field of operations management and helps researchers to find trends that could support future studies into SCM.

This paper is organized into eight sections. Section 2 describes the methodology used in this study. Section 3 categorizes the content of the investigation: identifying how, where, and when the papers analyzed in this review were published. Sections 4 and 5 respectively show the methodological approaches of the articles and the types of performances used in each line of research. Session 6 shows some evidence between the independent variables and performance. Finally, sections 7 and 8 summarize the main conclusions and some current challenges that could spark future research.

II. LITERATURE REVIEW AND RESEARCH APPROACH

The purpose of our review is to not to give a classic summary of what has already been published in SCM and its contribution to organizational performance. Rather, we want to contribute to theory building through a rigorous and systematic analysis of how a priori studies were conducted. Our study will facilitate trends and help researchers and managers.

The first step in the selection of journals was to use the Science Direct databases (Elsevier), Emerald Management Xtra, ABI Inform, Scopus, and Web of Knowledge ISO. We included specific journals of SCM and, Operations Management (OM),
Performance Metrics for a Supply Chain Subject to Stochastic Demand

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © t^2 e^2 2015

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Abstract—This work deals with characterization of the dynamic behavior of a single product supply chain (SC) composed by two levels. It is modeled by Industrial Dynamics concepts developed by Jay Forrester in the 60’s with the objective of determining the information and material flows using a discrete event system approach. There is a single inventory between assembly and distribution to attend a stochastic market demand. Using a replenishment policy with variable reorder point, two metrics are proposed to evaluate the SC performance under different demand. These metrics identify lead time and inventory intervals for which reduced disruption is observed.

Keywords - supply chain; discrete event simulation; performance metric; variable reorder point.

I. INTRODUCTION

Nowadays a great effort exists in reducing the delivery time of complex manufactured products to final customers while reducing inventories levels along the supply chain. This is particularly important when a product is a result of coordination among different entities in a supply chain (SC). An important issue in supply chains is orders definition to minimize intermediary inventories. A classical approach is to consider a predicted constant demand, which trigger a re-order when inventory decreases below a certain level with a constant optimal lot size [1][2][3]. However, when demand is stochastic, it is necessary to provide a different approach to avoid inventory disruption or costumer service level decrease. Such approaches are found in the literature by considering both variable re-order point and lot size. In [1] a new forecast-based dynamic inventory control was discussed focusing on a single-stage and single-item inventory system in discrete time. The forecast demand and uncertainties are known at each productive period. The policy of replenishment considers uncertain lead time and variable re-order point based in cumulative forecast demand. A cumulative forecast uncertainty was proposed, which differs from the classical policy that considers constant lead times and static re-order points. The proposed policy performance is assessed through empirical experimentation. The author ensures that empirical results demonstrate the benefits of using the proposed policy and identify the evolution of the new ideas into the proposed approach. In [2] another approach is proposed. A dynamic re-order point control policy is analyzed and its parameters are determined for a given target service level. An empirical investigation is conducted to evaluate the performance of the proposed policy and a comparison with the static re-order point policy is made. In both cases the order quantity is considered constant. The results indicate a similar performance of the two policies in terms of service level achieved. However, considerable inventory cost reductions are obtained when using the dynamic policy render its application preferable in real-world applications. The authors recommend to consider more elaborate models for representing the forecast uncertainty and also extend the analysis provided to other inventory control policies such as order-up-to-level.

In the present paper the recommendation made in [2] is explored. Performance aspects of a SC composed by two levels are considered. The SC is modeled by a discrete event simulation approach [4] and the dynamic behavior of the SC is analyzed considering inventory levels, and uncertainty in both demand and lead times. The propagation of demand variation on inventory, re-order point and lot size between SC levels is analyzed as well as its impacts on service level. The re-order point and lot size are characterized using performance metrics for demand and lead times. The obtained results appear as innovative when compared to other works presented in the literature [1][2][5][6][7][8][9].

The present paper is organized as follows. The problem description is presented in section II for a SC composed by two levels. The development of the proposed performance metrics are presented in section III and simulation results are discussed in section IV. Section V concludes the paper.

II. PROBLEM DESCRIPTION

As mentioned we consider in this paper a single product SC composed by two echelons (retailer/distribution and assembly/manufacturing) with retail inventory of finished goods. Inter arrival times between demands events are properly characterized by a probability distribution function (PDF) as well as the quantity of products demanded per event.
In this session we proposed the first group of student papers selected for the competition.

- Maryam Gallab: 
  *Model for Developing a Database for Risk Analysis*

- Borja Menéndez Moreno: 
  *An algorithm for batching, sequencing and picking operations in a warehouse*

- Abroon Qazi: 
  *Cost and Benefit Analysis of Supplier Risk Mitigation in an Aerospace Supply Chain*

- Manuel Dios: 
  *Constructive Heuristics Comparison in Hybrid Flow Shop Scheduling Environments with Missing Operations*

Final process for the student competition of IESM2015 Conference:

1. Selection of 16 papers from the reviewing process;
2. Selection of the best paper award after the presentation at Seville;
3. Announcement of the winner during the gala dinner.

All selected papers after the reviewing process should be presented by the student at Seville. The dimensions used for scoring papers in the student competition are the following:

- Observance of time limit in the oral presentation;
- Clarity of the presentation;
- Proper acknowledgment of previous research and a degree of knowledge in the field shown by the contestant;
- Level of contribution of the contestant in the work;
- Scientific relevance of the presented work;
- Practical relevance of the presented work;
- Potential for future work/publication of the presented results.
Model for Developing a Database for Risk Analysis

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Abstract—The aim of this paper is to propose a new systemic modelling approach in order to model a complex task of maintenance and analyses its risks. This model combines Emmanuel two different tools belonging to systemic approach: UML (Unified Model Language) and MOSAR (Method Organized for a Systemic Analysis of Risk). The objective of this new model is to identify and to model the mechanism of hazard between sources of hazard and targets in maintenance activity. In addition, this methodology allows to quantify the criticality of risks and to treat them on a hierarchical basis according to several risk factors (human, technical, organizational and environmental). The UML-MOSAR methodology allows creating a database as an information system for learning from accidents and provides a comprehensive view that facilitates the understanding of the organization of a maintenance activity and leads to more effective analysis of its safety.

Keywords—Systemic approach; maintenance; UML; MOSAR; risk analysis; interactions.

I. INTRODUCTION

Industry activities are very hazardous ones in which fatal and non-fatal occupational injuries occur most frequently. They presented many hazardous situations (hazardous equipments, poor working conditions, tough environments (e.g. noise, vibration, dust, handling of cargo and direct exposure to weather). Occupational injuries and illnesses impact not only the safety and health, but also economics, because of the high costs related to work injuries.

Maintenance activities are among the industry activities that are dangerous for operator's safety. A study of 900 accidents involving pipe-work failure in chemical plants found 38.7% have their origins in the maintenance phase [1]. Studies by the European Agency for Safety and Health at Work estimated that 15 to 20% of all accidents and 10 to 15% of all fatal accidents are related to maintenance [2]. A study by Hale on 294 accidents occurred in the chemical plants found out that 40% have their origins in the maintenance phase [3]. Other studies by the Occupational Safety and Health Administration (OSHA) of the accidents occurred in 1989 in the United States, showed that 122 fatalities were linked to maintenance activities [4] and [5].

In [6], the study revealed that maintenance workers were more vulnerable to occupational diseases than other workers. Other studies [7] [8] and [9] have discussed major accidents related to maintenance causes.

Maintenance work is potentially dangerous, during maintenance task (such as inspection and repair); work needs to be done in complex conditions that involve several interactions between operators and organization of maintenance activities [10] and [11]. These are the main reasons why accidents happen during maintenance [12] [13] [14] [15] and [16].

Therefore, safety related to maintenance must be one of the major challenges of any industrial activity. This is an opportunity to initiate a process of risk management in order to protect health and safety of operators. Risk analysis is the key activity to ensure the health and the safety of operators in this process of risk management.

Running a risk analysis process implies gathering information that contributes to a better knowledge of a particular (risk) situation. This information is usually plagued by complexity of maintenance task. A feedback on the accident analysis related to maintenance shows that these accidents are the results of a systemic conception where interactions between operators and equipments must be seen in light of the complex interactions between operators and organization of maintenance activities [10] [11] and [17]. This complexity often weakens the message from an analysis point of view [18] and [19].

The traditional risk analysis methods such as Hazard and Operability Study-HAZOP [20], Failure Mode Effect Analysis-FMEA [21], Fault Tree Analysis-FTA [22], Failure Mode Effect Criticality Analysis-FMECA [20], Preliminary Risks Analysis-PRA [20] and [21], focus on technical and human factors in risk analysis. They present an accident as a result of sequential events and don’t take into account the conjunction of technical, human and also organizational factors in the occurrence of the catastrophic events [23] [24] and [25]. Furthermore, in these traditional methods, lack of a database often weakens the feedback from a similar accident. Hence, ill-defined data prevent better
An algorithm for batching, sequencing and picking operations in a warehouse

(presented at the 6th IESM Conference, October 2015, Seville, Spain) c I e 2015

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Abstract—Order Batching is an optimization problem related to the picking process of orders in a warehouse. It consists in grouping the orders (each order is composed by a list of items to be collected) received in a warehouse in a set of batches of a maximum fixed capacity. Then, a route to collect the items in the same batch must be conformed. In this paper we tackle a variant of this problem known as Order Batching and Sequencing Problem where each order has a certain due date. This variant consists in grouping the orders into batches and then sequencing them, in such a way that the tardiness of each order (the extra time over the due date needed to collect it) is minimized. In this paper we propose a Variable Neighborhood Search algorithm to tackle the problem. Our approach outperforms previous attempts in the state of the art.

I. INTRODUCTION

Warehouse management systems have become an essential part of the supply chain strategy. They mainly focus on moving and storing materials within a warehouse by performing different transactions (including shipping, receiving, and picking). The success of warehouse management strongly depends on how customer orders (containing a set of goods or items) are retrieved. The picking process consists in collecting articles (items) in a specified quantity before shipment to satisfy the orders of the customers. This picking process may consume up to 60% of the total time of all labor activities in the warehouse (Drury, 1988), which can suppose more than half of the total operating costs.

Given a set of orders received in the warehouse, there are two basic order-picking strategies: strict-order picking and order batching. In the first one, each picker collects all the items included in one order. Once he/she finishes, the picker continues with the second order and so on. In the order batching strategy, several orders are put together into batches. Then, each batch is assigned to a picker, who can retrieve the items of any order grouped into the assigned batch, and satisfies a capacity constraint (fixed by a maximum weight).

As it is well documented in the literature, reducing travel time of picking operations improves order picking productivity. This is why batching strategies are used in warehouses. According to De Koster et al. (1999), if batching and routing are simultaneously considered, the associated benefits can be considerably increased, reducing travel times more than 35%. Although in this paper we focus on the batching and sequencing strategies to minimize the total tardiness, the objective function is evaluated by means of the routing algorithm.

In this paper we deal with an optimization problem which is a variant of the Order Batching Problem (OBP). The OBP consists in minimizing the total time needed to collect all the orders received in a warehouse, when the batching policy is considered. An order is composed of several items, and these items are placed at specific pick locations in the warehouse. A set of orders grouped together conform a batch. Batches have a maximum capacity fixed in advance. This capacity can not be exceeded by the weight of the items in the orders grouped in the same batch. This problem has been proven to be NP-hard for general instances, but it is solvable in polynomial time if each batch does not contain more than two orders (Gademann and Velde, 2005). Unfortunately, real warehouse instances do not usually fall into this category. Therefore, the OBP has been heuristically approached in the last few years. Among the most recent approaches to tackle the problem, Albareda-Sambola et al. (2009) proposed a Variable Neighborhood Descent (VND) algorithm that considered 6 different neighborhood structures. Henn et al. (2010) proposed two procedures, An Iterated Local Search (ILS) and a straightforward implementation of a Rank-Based Ant System. Later, Henn and Wäscher (2012) improved previous results by proposing two metaheuristic-based methods: a Tabu Search algorithm and an Attributed-Based Hill Climbing (ABHC) method with two genuine attribute sets. Oncan (2015) proposed several Mixed Integer Linear Programming (MILP) formulations, one for the batching problem and three for the routing problem. Additionally, this author also proposed an Iterated Local Search with a Tabu Thresholding method. As far as we know, the most recent approach to tackle the OBP is Menéndez et al. (2015), where the authors explored different Variable Neighborhood Search strategies to tackle the problem.

The addressed variant in this paper, known as Order Batching and Sequencing Problem (OBSP), involves not only grouping the orders into batches and retrieving the items in each order from their location, but also achieving the time requirements of customers. These requirements mean that each order has to be delivered before a determined due date. From this perspective, it turns out that if an order is not delivered on time, it has associated a tardiness. This tardiness is the extra time over the due date needed to collect an order. The aim of the OBSP is then to minimize the sum of the tardiness of all orders received in the warehouse. Then, from an optimization point of view, we can identify three different problems: how to group orders into batches (batching), how to determine the order to collect the conformed batches (sequencing) and how to design the corresponding routes to collect them (routing).
Cost and Benefit Analysis of Supplier Risk Mitigation in an Aerospace Supply Chain

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Abstract—Risk identification and risk estimation are important stages of any risk management process. Existing research in Supply chain risk management has mainly focused on these two stages whereas risk evaluation has not been fully explored which is an equally significant stage involving evaluation of different risk mitigation strategies. The main purpose of this paper is to propose a method of evaluating different mitigation strategies through cost and benefit analysis. The proposed method introduces a unique concept of integrating cost and relative impact of different combinations of mitigation strategies within a network setting of interconnected risk triggers, risk factors and risk mitigation strategies. We have applied our method on a case study that was conducted in an aerospace supply chain. Our approach is useful in identifying an optimal combination of mitigation strategies against a given budget constraint. Furthermore, the model can also be used for determining such strategies in relation to a given level of risk exposure. We have incorporated NoisyOR function within the Bayesian Network model in order to reduce the complexity involved in eliciting a huge number of conditional probability values.

Keywords—Supply chain risk management; risk evaluation; risk mitigation strategies; NoisyOR function

I. INTRODUCTION

Risk management is an established field in some areas of organizational life like finance but it is still a developing theme within the realm of supply chain management [1]. There is a consensus among researchers on treating risk management as a process comprising three stages of risk identification, risk estimation and risk evaluation [2].

Supply Chain Risk Management (SCRM) is defined as “the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity” [3]. Supply chain risks can be viewed with respect to three broad perspectives; a ‘butterfly’ concept that segregates the causes, risk events and the ultimate impact, the categorization of risks with respect to the resulting impact in terms of delays and disruptions and network based classification in terms of local-and-global causes and local-and-global effects [4].

It is important to realize that risk exists at various levels, inside the focal company and at the network level. Furthermore, risk evaluation depends on the stakeholder’s perspective and therefore, the subjective judgement of a particular stakeholder determines what constitutes a risk and what level of risk is acceptable [5].

Bayesian Belief Network (BBN) is a probabilistic graphical model that represents causal relationship between variables and captures uncertainty in dependency in terms of conditional probabilities [6, 7]. BBNs have been used in modelling supply chain risks and found to be an effective technique, however, the scope of such models has been limited to focused areas like supplier selection, risk profiling, etc. [8-10]. We make use of the BBNs in capturing interdependency between supply chain risks and modelling the interaction of mitigation strategies with associated risks taking into account the relative cost and benefit of such strategies. As the number of conditional probability values grows exponentially with the increase in number of causal factors for a risk, we utilize the concept of NoisyOR function in order to reduce the number of values from exponential to linear.

Research Problem and Contribution

Existing research in SCRM has mainly focused on the first two stages of risk management process; risk identification and risk estimation. In general, risk mitigation strategies have been described qualitatively and no study has investigated evaluation of risk mitigation strategies within a network setting of interconnected risks, triggers, consequences and mitigation strategies on the basis of cost and benefit analysis. This research paper is a first step towards bridging this major research gap. It attempts to propose a method that can help researchers and practitioners appreciate the importance of risk evaluation and develop better models for managing supply chain risks.

Outline

Literature review is briefly presented in Section II. BBNs and NoisyOR function are described in Section III. Section IV describes our proposed method of evaluating control strategies followed by its demonstration as a Case Study in Section V. Results and managerial implications are discussed in Section
Constructive Heuristics Comparison in Hybrid Flow Shop Scheduling Environments with Missing Operations

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © IEEE 2015

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Abstract—In this paper, we address the hybrid flowshop scheduling problem with makespan minisation as objective. This is a well-known problem with many practical applications that it has been tackled in the past. More specifically, we are interested in the special case where there are missing operations, i.e. not all jobs have to be processed in all stages, a condition inspired in a realistic problem in a plastic manufacturer. The main contribution of our paper is twofold. On the one hand we carry out a computational analysis to show that the hardness of the problem with missing operations is for most cases higher than that of the classical hybrid flowshop and flowshop scheduling problems. On the other hand, we propose a set of constructive heuristics that captures the special properties of the missing operations and compare these algorithms with already existing heuristics for the hybrid flowshop and for the flowshop. Computational results show that it is possible to reduce the makespan by interacting with the jobs containing missing operations, thus taking advantage of the special behaviour of missing operations for this kind of problems.

I. INTRODUCTION

Flowshop scheduling problems have been largely studied in literature during the last 50 years [1]. However, as a result of a rising demand of products[2], both in variety and quantity, it is commonplace that companies increase their capacity by adding new resources (both physical and human) to some stages in the manufacturing process in order to avoid clear bottlenecks. As a result, some processing stages are formed by several machines, and a flowshop layout turns into a hybrid flowshop, a manufacturing setting that is gaining importance nowadays [3].

For the hybrid flowshop problem, there are several variations: depending on the characteristics of the machines in every stage we may have identical machines (the processing time in all machines in the same stage is exactly the same), uniform machines (each machine in the stage has a speed parameter associated that decide the processing time), or unrelated machines (the processing time of the different machines in the stage is independent). In this paper we focus on the hybrid flowshop with identical parallel machines and with the possibility of missing operations, i.e. not every job has to go through all the machines, but it can skip some stages.

The problem of scheduling hybrid flowshops with missing operations has not been widely analysed in the literature. Most often, it has been addressed as an ordinary hybrid flowshop scheduling problem assuming that a missing operation is tantamount to an operation with processing time equal to zero. Nevertheless, since this assumption implies that every job has to be processed in every stage even with zero processing times, this approach [4], [5] results in an increase of the completion times of the jobs.

Regarding the objective function, according to [2], the main objectives used in literature can be classified into three related with the completion time of the jobs, with the delay of jobs, with multiple criteria or those with an specific problem-dependent criteria. In our case, as there are few contributions in literature related to missing operations, we focus on the maximum completion time (makespan) criterion since it is the most common objective among these works. This would enable us to compare and to discuss our results with existing contributions.

Another important issue to take into account is the solution approach. The hybrid flowshop scheduling problem for 2 stages where at least one of them has more than one machine and with the objective of makespan minimisation has been proven to be NP-hard [6], hence the k-stages hybrid flowshop scheduling problem with makespan criterion is also NP-hard (see e.g. [3]). Therefore, we focus on solving the problem by means of heuristic procedures. More specifically, we concentrate on constructive heuristics, first comparing the most efficient so-far ones, and developing a set of new efficient heuristics. The heuristics proposed exploit specific properties of missing operations in the hybrid flowshop setting and, in the subsequent computational experience, we show that they are efficient heuristics.

The paper is organized as follows: Section 2 contains a description of the problem under study and discusses existing contributions. In Section 3 we conduct a computational analysis of the empirical hardness that proves that our problem is at least as hard as the hybrid flowshop without missing operations. Section 4 describes the heuristics proposed and briefly explain the already existing heuristics that will be used.
In this session we proposed the first group of student papers selected for the competition.

- Wael Hafsa:
  *Prognostics of Health Status of Multi-component Systems With Degradation Interactions*

- Quentin Tonneau:
  *Multimodal multi-flow problem with transformation: application to waste supply chain*

- Margaux Nattaf:
  *A batch sizing and scheduling problem on parallel machines with different speeds maintenance operations, setup times and energy costs*

- Lazhar Tlili:
  *Availability optimization of periodically inspected production systems generating environmental damage*

- Victor Fernandez-Viagas:
  *Boundary lines between Flowshop Problems and Single Machine Problems*

Final process for the student competition of IESM2015 Conference:
1. Selection of 16 papers from the reviewing process;
2. Selection of the best paper award after the presentation at Seville;
3. Announcement of the winner during the gala dinner.

All selected papers after the reviewing process should be presented by the student at Seville. The dimensions used for scoring papers in the student competition are the following:

- Observance of time limit in the oral presentation;
- Clarity of the presentation;
- Proper acknowledgment of previous research and a degree of knowledge in the field shown by the contestant;
- Level of contribution of the contestant in the work;
- Scientific relevance of the presented work;
- Practical relevance of the presented work;
- Potential for future work/publication of the presented results.
Abstract—Many models and methodologies in order to predict the remaining useful life (RUL) of a critical component are investigated nowadays. However, estimating remaining useful life of multi-component systems is still an under explored area, especially when there are interdependencies among the components of these systems. Practically, prognostics can be quite complicated when there is absence of prior knowledge about these interactions. To optimize the availability and reliability of the system, it is required to embed a dependency model that implements component strength and the component’s health status. In this paper, a novel approach is proposed in order to emphasize the importance of interactions between complex system’s components in the RUL’s calculating. The effectiveness of the approach is judged by applying it to numerical studies in order to estimate system’s remaining useful life.

I. INTRODUCTION

Nowadays, the development of industrial systems is increasingly complex due to new technologies, and industrial manufacturing systems are becoming more complicated. Complex system may be defined as a coherent system composed of many interacting entities. Controlling, managing and keeping such a system in a good health status isn’t an easy task. This topic has received more attention from academic researchers and manufactures in the past decade. In fact, many research works have been developed on reliability of complex systems and their maintenance [11], [10], [1]-[2]. Prognostics is considered as a key process in maintenance strategies in order to predict the RUL (remaining useful life) and the performance of multi-component and networked systems, like aircraft, cars and mechanical machinery. Prognostics and Health Management (PHM) is an emerging discipline which links studies of failure mechanisms and life cycle management [3]. According to ISO:13381-1, prognostics is defined as the "estimation of time to failure and risk for one or more existing and future failure modes" [4]. The use of prognostics methods in maintenance in order to predict the RUL is receiving more attention over the past years. Many experts expect that effective prognostics will result (i) in reduced numbers and severity of failures, especially failures in the field, (ii) optimizing operational performance, (iii) extending the time between needed maintenance activities and reducing life-cycle costs. However, the use of these techniques in maintenance decision making and optimization in multi-component systems is still an under explored area due to the complexity of these systems which introduces additional interdependencies between components. In fact, complex systems are handled differently from single-component systems because we need a full understanding of interactions between components, and neglecting them leads to inefficient prognostics. Ancient approaches are reduced to consider the minimum of critical components RULs and to neglect interdependencies between components in order to avoid any possible system’s shutdown. Nevertheless, many researches have reported that the assumption of independence is impractical. In fact, Sun et al. [7] notice that this assumption leads frequently to errors in estimating the system’s RUL in real applications. Therefore, the decision making based on the resulting remaining useful life should be established in a predictive maintenance policy which highlights dependency between system components. Interdependencies between complex system components have been extensively studied in operations research literature for the past few decades. Murthy and Nguyen [5] indicate that the analysis of maintenance policies with failure interactions is an open problem. More recently, Nicolai and Dekker [6] have given a thorough overview of optimal maintenance policies for complex systems with dependency between components (i.e. stochastic, structural or economic dependence). However, no models that use prognostics or a prediction of Remaining Useful Life are mentioned. This paper focuses on stochastic dependence, where the degradation or the failure of one component influences the life time distribution of other components in the system, i.e. if a component degrades over time (due to wear, environmental variables or use conditions), it has an impact on the performance of other components by means of accelerating their degradation. In that context, Biau and Gebraeel focus on how degradation-based sensor signals associated with the components evolve over time, using stochastic models characterizing the natural degradation rates and the effects of interactions on the degradation rate [8]-[9]. Wu et al. [10] present a method to consider stochastic loading and strength degradation for computing the time-dependent reliability of a structural component. Besides, Van Horenbeek and Pintelon [11] present a dynamic predictive maintenance policy for complex systems that minimizes the long-term mean maintenance cost per unit time. This method is based on prognostics information while considering different component dependencies (i.e. economic, structural and stochastic). Moreover, Ribot [12]-[13] aims at improving classical approach to estimate the RUL of a complex system. Mainly, Ribot’s approach has an advantage of better system modeling, when there is absence of components dependency. Our work differs from the papers mentioned above in two folds, as shown in Fig. 1: i) Presenting a stochastic dependency model for degradation rate
Multimodal multi-flow problem with transformation: application to waste supply chain

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Abstract—This paper presents a new tactical optimization problem for non-hazardous waste and end-life product supply chain. Waste transport and recycling become crucial in our modern society, with a huge environmental and economic impact for industrials and communities. Operations on products during transport such as grinding or sorting allows companies to densify transports and reduce the overall supply cost. Integrating these new aspects, we introduce a new problem we term the multimodality, multi-flow problem with transformations and propose a linear mathematical model to solve it. With an application to a waste transport company and a performance benchmark on a linear solver, we show the pertinence of the model in a real case study and its scalability for more complex situations.

I. INTRODUCTION

Transformation of products in the supply chain is very common. A product’s life is composed of a large number of operations from its production (assembly of an industrial article, food industry) to its destruction (recycling, burying, energy transformation), often performed at different locations and transported in multiple ways. Numerous studies about logistics are dedicated to the production/distribution supply chain or reverse supply chain, whereas only few models are applicable to waste collection and recycling, mainly because of objective differences. A production supply chain must take into account delays and often deals with late penalties and satisfaction of customers, perishable supply chain must deliver products quickly to reduce losses. However, reprocessing supply chain objectives are cost and environmental impact reduction, regardless of delays and time to treat products.

The general problem of planning waste treatment supply chain operations can be decomposed into three major sub-problems, such as long-term strategic decisions (facility location, network expansion, introduction of new technologies), tactical decisions (management of products flow, reduction of global supply chain costs), and daily operational management (routing and inventory optimization, contingency management). In this paper, we focus on the tactical part of this problem, involving product flow management, transport mode selection and transformations performed within the supply chain. This problem can be considered as an extension of the existing Multi-commodity, Multi-Modal Flow Problem, which has already been studied in the literature.

With more than 2.5 billion tons of waste produced in Europe every year, collection and transportation of household and industrial waste results in a complex and large logistic chain. We can distinguish in this domain three particular cases which are door-to-door collection, industrial and municipal waste disposal collection and hazardous waste treatment. Hazardous waste involve very specific constraints, particularly in terms of security. If hazardous waste transportation is an important research field, there are only few publications about non-hazardous waste collection and recycling supply chain, despite its importance. Studies about door-to-door collection have already been done in major cities such as Brussels [1], but industrial (and municipal disposal) waste management characteristics have not been analyzed in real case studies. A recent survey [2] proposes to split supply chain decisions for solid waste into strategic and tactical issues. The first set of problems deals with facility location such as gathering point and recycling center, and the second set is dedicated to waste flow management (within an existing network).

Focusing on tactical decisions and characteristics, there are some studies and publications approaching the subject. Guelat et al. [3] treated a multi-product multi-modal network (graph) by considering all possible transport modes for each edge and executing an extended Dijkstra algorithm on it. This method is an efficient way to determine the best path in a multi-modal graph with imposed departure and destination nodes, but is not suitable for a flow problem where outlet selection is free (or with capacity constraints). Flow splitting and merging in nodes is another difference which limits the Dijkstra algorithm to perform this task. The intermodal transportation chapter from Crainic and Kim [4] is an interesting basis to our work, but their study was focused on rail and shipping and trying to solve problems about space and infrastructure organization of docks. More recently, Chang [5] studied the MMMFPPTTW (Multi Commodity MultiModal Multi Objective Flow Problem with Time Windows), which seems similar to our problem. How-
A batch sizing and scheduling problem on parallel machines with different speeds, maintenance operations, setup times and energy costs

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Abstract—This paper considers a production scheduling problem in a Chilean company from the metalworking industry. This company produces steel balls of different diameters on parallel production lines. There are different types of production lines and each production line may have a different speed for producing each diameter. Furthermore a setup time occurs when changing the diameter produced on each machine. Besides these production and setup operations, maintenance operations have to be scheduled. These electrical machines yield high energy demands. It is therefore crucial to minimize total energy consumption, which depends on batch/machine assignment, and maximum demand on peak hours. We consider the batch sizing and scheduling problem involving electricity costs in a non-uniform parallel machine context. Given a demand for each family of steel balls, the problem consists in splitting the demand in sublots (batches) that have to be assigned and scheduled on the parallel machines together with the required maintenance operations. The goal is to complete the schedule before a common deadline while minimizing electricity costs. We propose to tackle this problem through mixed integer linear programming. We propose a global formulation and a two-phase matheuristic. Computational results on realistic instances are provided.

I. INTRODUCTION

This paper considers a production scheduling problem in a Chilean company from the metalworking industry. The problem and the industrial context was described in [1]. This company produces steel balls on parallel production lines. The steel balls are obtained by roll forming or forging from a raw material consisting of metal bars. The steel balls are mainly used in the copper and gold mining industry for mineral grinding, i.e. for reducing the size of the mineral particles to a maximal granularity that permits to remove the major part of impurities from the mineral. There are several types of steel balls to produce, each corresponding to a different ball diameter. There are two types of production lines: roll formers for small diameters and forges for larger diameters (although medium diameter balls can be produced by both production line types). Each production line may have a different speed for producing each diameter. Furthermore a setup time occurs when changing the diameter produced on each machine. Besides these production and setup operations, maintenance operations have to be scheduled. These machines are electrical and the production process results in high energy demands. As mentioned in [1], up to 50% of the production cost in such a manufacturing process can be due to electricity consumption. In Chile, as in many other places, different electricity rates are applied for peak hours and off-peak hours. So it can be crucial for metalworking companies to control the electricity demand during peak hours. Planning the maintenance and setup operations during the peak hours can be intuitively a policy that favors electricity cost decrease.

In this paper we consider a batch sizing and scheduling problem involving electricity costs in a non-uniform parallel machine context. Given a demand for each family of steel balls, the problem consists in splitting the demand in sublots (batches) that have to be assigned and scheduled on the parallel machines together with the required maintenance operations. The goal is to complete the schedule before a common deadline while minimizing electricity costs. We propose to tackle this problem through a mixed integer linear programming approach.

Section II presents the batch sizing and scheduling problem. Section III is devoted to a brief presentation of the related work. Section IV gives the proposed mixed-integer linear programming (MILP) formulation. Section V gives a simplified MILP formulation that ignores the peak costs and that serves as a basis for a matheuristic. Section VI presents the considered realistic problem instances and the results obtained.
Availability optimization of periodically inspected production systems generating environmental damage

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Abstract—This paper deals with a condition-based maintenance policy for single-unit production systems which generate damage to environment as they degrade and get older. The system is submitted to periodic inspections to assess the generated environmental damage. In case an inspection reveals that the environmental degradation level has exceeded a critical level, the system is considered in a failed state and will have generated significant environmental damage. It is stopped during a certain time necessary to perform a corrective maintenance (CM) action and to eventually clean the environment. In order to prevent such an undesirable situation, a lower threshold level is considered to trigger a preventive maintenance (PM) action which takes less time than the corrective one. A mathematical model and a numerical procedure are developed to determine simultaneously the PM threshold level and the inspection period which maximize the stationary availability of the system. Numerical calculations are performed to illustrate the proposed model.

Keywords—condition-based maintenance, environmental degradation, periodic inspection, Wiener process, availability.

I. INTRODUCTION

The accumulation of deterioration of production systems may cause failure and/or damage to environment. For such systems which generate damage to environment as they degrade and get older, the most appropriate maintenance strategies rely on the monitoring of the quantity of environmental damage generated and taking the appropriate actions based on the assessment of the damage by comparing it to predefined threshold levels.

Two techniques are generally proposed to monitor the degradation: continuous monitoring \cite{1,2} and inspection \cite{3}. In many real situations, the continuous monitoring of the environmental damage generated by the system is costly and sometimes difficult to perform. Then, the sequential inspection can be more effective. Indeed, it is widely used by maintenance managers. Various works have been conducted to deal with the determination of the inspection (maintenance) sequence and critical thresholds that optimize a certain objective e.g. maintenance cost \cite{4,5}, system availability \cite{6,7}. Also, Stefanis et al. \cite{8} developed an approach for identifying the optimal preventive maintenance schedule that maximizes the profit of a given process while minimizing the environmental risk. They developed an optimization framework which takes into account the environmental risks and the operability characteristics at the early stage of process design. In the same context, Devarun G. \cite{9} presents an approach based on Multi-Criteria Decision-Making methodology (MCDM) for selecting the optimal mixture of maintenance strategies which maximize the profit. Radhoui et al. \cite{10} developed an optimization framework which takes into account, amongst others, the environmental penalty for multi-component systems. Vassiliadis and Pistikopoulos \cite{11} proposed an approach that aims at finding the preventive maintenance sequence that maximizes the profit taking into account the environmental damage cost with respect to the threshold amount of damage generated by each unit of a multi-component system.

In the present work, we consider a condition-based maintenance strategy with periodic inspections and two threshold levels related to the amount of environmental damage. A critical one, $U$, that is known, and a lower one, $L$, to be determined. In case an inspection reveals that the critical level $U$ has been exceeded, the system is stopped during a certain time necessary to perform a corrective maintenance (CM) action and to eventually clean the environment. A preventive maintenance (PM) action of a smaller duration is undertaken in case inspection reveals that the environmental damage is between $L$ and $U$. We propose a new modeling approach based on the fact that the degradation process is modeled by the Wiener process (discussed in section II). We develop a mathematical model and a numerical procedure in order to determine the threshold...
Boundary lines between Permutation Flowshop Problems and Single Machine Problems

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Abstract—The permutation flowshop scheduling and the single machine scheduling problems are two classical problems in the scheduling literature. Since the former is known to be NP-hard for more than two machines, hundreds of algorithms have been implemented in the last decades to solve it. Furthermore, several computational studies have found that the permutation flowshop problem can be easily solved, representing a great advance in the analysis of the PFSP. However, these studies do not consider the availability of all machines for processing jobs cannot be assumed. Our working hypothesis to explain this behaviour is that, under certain conditions of machine availability or structured processing times, only one stage in the flowshop layout determines the optimal sequence, approximately transforming the flowshop scheduling problem into a single machine scheduling problem. Since the single machine scheduling problem with makespan objective is a trivial problem where all feasible sequences are optimal, such transformation may explain why it is so easy to find good solutions for such flowshop scheduling problems. Therefore, the goal of this paper is to study under which assumptions a permutation flowshop scheduling problem can be reduced to a single machine scheduling problem. More specifically, we focus onto the two most common objectives in the literature (i.e. makespan and total flowtime). Our work is a combination of theoretical and computational analysis, therefore several properties are derived, together with an extensive computational evaluation.

1. INTRODUCTION

The Permutation Flowshop Scheduling Problem (denoted as PFSP) is one of the most studied problems in Operations Research (see e.g. [1], [2], [3], [4], [5] and [6]). This decision problem can be defined as follows: $n$ jobs have to be processed on each one of the $m$ machines of the shop following the same route. The problem consists in the determination of the processing sequence of the jobs in the shop, assuming that the same sequence is adopted for each machine. Among other assumptions (see e.g. [7] for a complete description), machines are always available since time zero as well as sequence-dependent set-up times are insignificant while sequence-independent set-up times are non-anticipatory and therefore, added to the processing times of the jobs. Although the problem has been solved for several objectives (see e.g. [8] and [9] for the homogeneity of the completion times; [10] and [11] for total tardiness; [12] and [13] for total tardiness and earliness; or [14] and [15] for several objectives), most of the research in the literature has focused in the minimisation of makespan and total flowtime (see e.g. the reviews by [1], [3] and [5]). Following the notation of [16], the PFSP to minimise makespan and total flowtime are $F_{\text{m}}|\text{prmu}|C_{\text{max}}$ and $F_{\text{m}}|\text{prmu}|\sum C_j$ respectively. Since the problem was shown to be NP-complete for makespan minimisation (for $m > 2$) and strongly NP-hard for total flowtime minimisation (for $m > 2$) by [17] and [18] respectively, hundreds of heuristic and meta-heuristics have been proposed in the literature to obtain good solutions in reasonable computation times (see e.g. [19], [20], [21] and [22]). Approximated algorithms have been tested and compared in several benchmarks ([23], [24], [25], [26], [27], [28] and recently in [29]). The input parameters of the PFSP and therefore, the output of these benchmark instances are the number of jobs, the number of machines, and the processing times of each job in each machine. Regarding the number of jobs and machines, several values have been tested in these benchmarks (from 20 to 800, and from 5 to 60 respectively). However, processing times have been traditionally generated by an uniform distribution (see e.g. the benchmarks of [27] and [23]) where exactly the same distribution is used for each processing time regardless the job or the machine. [26] analysed the $F_{\text{m}}|\text{prmu}|C_{\text{max}}$ problem when the processing times are structured and do not follow the same distribution for each job and each machine. Three types of correlations were generated (job, machine and mixed correlations) depending if the same distribution is used across jobs, across machines or both. Results show that most structured $F_{\text{m}}|\text{prmu}|C_{\text{max}}$ problems tend to be easily solvable in the sense that there are a lot of ‘good’ solutions in the solution space, therefore the probability to find a ‘good’ solution is very high.

On the other hand, the classical PFSP considers that the shop is initially empty and that each machine is available at time zero. However, this assumption can be only applied in real-world problems if it is the first time that jobs are to be scheduled in the shop, or a long period without processing jobs has occurred. Since these assumptions are not common in practice, [30] consider restrictions in the initial availability of the machines for the minimisation of the makespan. Results show how the initial availability assumption make the problem easier (again in the sense of increasing the probability of finding a ‘good’ solution), specially if structured processing times are considered. Thereby, both papers highlight that, under certain assumptions, some instances of the $F_{\text{m}}|\text{prmu}|C_{\text{max}}$ problem can be easily solvable, representing a great advance in the analysis of the PFSP. However, these studies do not
In this session we proposed the first group of student papers selected for the competition.

- Hossein Beheshti Fakher:
  Joint production-maintenance planning in an imperfect system with quality degradation

- Siham Lakri:
  Performance Measurement and Management Systems of Supply chains: A review of the challenges they raise

- Lorena Silva Belisário:
  Adaptive ConWIP: analyzing the impact of changing the number of cards

- Abroon Qazi:
  Modelling Project Complexity driven Risk Paths in New Product Development

Final process for the student competition of IESM2015 Conference:
1. Selection of 16 papers from the reviewing process;
2. Selection of the best paper award after the presentation at Seville;
3. Announcement of the winner during the gala dinner.

All selected papers after the reviewing process should be presented by the student at Seville. The dimensions used for scoring papers in the student competition are the following:

- Observance of time limit in the oral presentation;
- Clarity of the presentation;
- Proper acknowledgment of previous research and a degree of knowledge in the field shown by the contestant;
- Level of contribution of the contestant in the work;
- Scientific relevance of the presented work;
- Practical relevance of the presented work;
- Potential for future work/publication of the presented results.
Joint production-maintenance planning in an imperfect system with quality degradation

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Abstract— In this paper, lot sizing problem is integrated with preventive maintenance scheduling taking into account several aspects of the quality system. Integration of such highly dependent decisions in the same mathematical model results in an efficient decision structure, and it can reduce the costs. The significance of the savings resulted from joint models supports the competency of the organization. Age based imperfect maintenance with increasing hazard rate and its influences on production and quality systems is addressed, and related cost evaluations are developed. Length of quality inspection intervals is determined such that the integrated hazard rates over all segments of a period for a certain machine are equal. The optimum value of the integrated hazard depends on multiple factors, including reworking cost, backorder cost, production size, etc. The mathematical model is a nonlinear optimization problem and a genetic algorithm is used to solve it. A numerical example and extensive investigations are also conducted.

Keywords— Age based maintenance; Imperfect system; Lot scheduling; Quality; Integrated model

I. INTRODUCTION

Fulfillment of customer demands on time, with higher-quality levels, and affordable prices are the challenging issues in all production systems. Despite of strong interactions existing between production planning, maintenance scheduling, and design of quality systems, they have generally been treated separately. Provided that disjoint approaches cannot ensure the optimality of solutions, we integrate these key functions in the same model to handle their interferences. In deteriorating systems, performance or quality of machine diminishes by its age. For example, Yalaoui, Chaabi and Yalaoui [1] consider a deteriorating system in which the production capacities diminish with time. Another type of system deterioration corresponds to quality degradation. Colledani and Tolio [2] study the relationship between preventive maintenance (PM) and the production quality. Aghezzaf, Jamali and Ait-Kadi [3] study the integration of preventive maintenance and lot-sizing problem, and show that the two systems are coherent. Recently, several aspects of this problem have been addressed in the literature. Fitouhi and Nourelfath [4] integrate lot-sizing and non-cyclical preventive maintenance scheduling for a multi-state production system. They show that joint planning improves the total production and maintenance costs. Liu, Wang and Peng [5] propose that lot-sizing and determination of PM policies should be studied jointly since they influence on each other in terms of cost and profit. Siener and Aurich [6] address the problem of quality oriented maintenance scheduling to predict the influence of machines on final product quality. In most of real applications, maintenance does not bring the machine in its perfect state. Ouaret, Kenné, Gharbi and Polotski [7] propose the integrated model for the system in which the deterioration process increases the failure rate and decreases the quality.

Imperfect maintenance (Nakagawa [8], Pham and Wang [9]) suggests that the state of the machine after the PM is somewhere between as-good-as-new and as-bad-as-old conditions. Brown, Mahoney and Sivazlian [10] consider that maintenance can even rejuvenate a machine by further reducing its age. Nourelfath and Ben-Daya [11] deal with the integration of production, maintenance and quality in a multi-state production system in which the machines may randomly switch to a degraded state with lower quality level. In order to establish the link between maintenance and quality, Ben-Daya [12] consider the normal and degraded state of machine, in which, defective rate in out of control state is higher, and the time to shift (to a degraded state) is a random variable with increasing hazard rate. In factual production systems, there are more limitations on the feasibility of such integrated plans. For example, availability of maintenance teams or equipment can be subject to certain conditions. Time windows for maintenance operations in a joint model subject to shortage costs are investigated by Najid, Selsouli and Mohafid [13]. Chen [14] uses the idea of quality deterioration with two various degraded states and different defective rates. He assumes also that the reduction in the age of the machine is proportional to the cost of selected PM level. Several PM options as maintenance decisions are taken into account by several researchers. Do, Voisin, Levrat and Iung [15] consider
Performance Measurement and Management Systems of Supply chains: 
A Review of the Challenges they Raise
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Abstract—In the recent years, supply chain has been recognized as a key factor of companies’ success and particularly one of the best means by which companies can achieve a goal of paramount importance: enhance customer satisfaction. That is why performance measurement and management systems of supply chain (SC PMMS) became a crucial topic for enterprises and particularly for multinational corporations. This paper intended to provide a critical literature review on measurement and management of supply chain performance. To do so, relevant works appeared in the international journals from 2000 to 2015 are gathered and analysed. The purpose of this paper is to contribute to a more complete understanding of the current challenges related to SC PMMS, which should help future research works related to this topic. Findings reveal that supply chain performance management is clearly less broached in comparison with performance measurement of supply chain. The topic is still an open research area. In particular, the study highlights the lack of systems thinking to face current challenges of the field.

Keywords— Taxonomy, Performance measurement; Performance management, Supply chain

I. INTRODUCTION

Reduce supply chains (SC) exclusively to cost centres is nowadays obsolete. Todays’ SC are considered as critical growth levers of companies [1], [2]. They are recognized as one of the best means by which companies can achieve a goal of paramount importance: enhance customer satisfaction. It is equally outdated to represent SC using simple and linear flows. SC are complex multi-stage systems with temporal and causal interrelations, operating multi-input and multi-output production and services under utilization of fixed and variable resources [3]. In current competitive age, it is proven that many companies have not succeeded in maximizing their SC’s potential because they have often failed to develop the performance measures and metrics needed to fully integrate their SC to maximize effectiveness and efficiency [4]. Performance measurement and management systems (PMMS) of SC became a crucial topic for enterprises and particularly for multinational corporations. During the last two decades, important research works has been led on the topic and allowed the emergence of many frameworks as the well-known balanced scorecard [5] and SCOR model [6] among others. However, contributions of the majority of the existing performance measurement systems (PMS) in SC management context are discounted by the existence of too many limitations [7].

The principal purpose of the present paper is to conduct a critical literature review to identify the main challenges raised by PMMS in a SC context. Our undertaking is not only to review SC PMMS major stakes, but also to propose an analysis of this key set of challenges showing their features and contributing to reveal the opportunities they represent to fulfil the different roles of such systems. We do so by elaborating a matrix which crosses challenges and roles regarding SC performance systems. We also hope to encourage a greater level of clarity of SC PMMS and thus a diversification of methods and concepts used to broach SC PMMS issue.

This article is structured as follows. Section 2 describes the review methodology, Section 3 focuses on terminology by presenting a theoretical perspective of PMMS necessary to ensure clarity of the rest of the paper, Section 4 reviews the roles of SC PMMS, Section 5 highlights the main challenges related to SC PMMS based on the works reviewed, to finish Section 6 contains discussion presenting findings and Section 7 concludes suggesting future research directions.

II. REVIEW METHODOLOGY

Many papers have been published on the topic in the last few decades. We focus here on papers in line with the scope determined in the next section entitled “Terminology”. The
Adaptive ConWIP: analyzing the impact of changing the number of cards

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Abstract—In response to fast changing environments, adaptive ConWIP pull control systems have appeared as an efficient approach to reduce work in process while maintaining a good customer satisfaction. The number of cards is adjusted as a response to detected changes in the demand. However, in a real-life environment, adding and retrieving cards can have undesirable effects and disturb the manufacturing system. Our literature analysis underlines that, although numerous studies have investigated adaptive mechanisms, none of them seems to take into account the consequences of the numerous changes in the number of cards. In this article, we do not only consider the usual costs, but also the number of changes induced. A ConWIP example, often used in the literature, is studied using simulation optimization on the basis of these two considerations. Our results point out that the reduction of costs is achieved through a tremendous amount of changes, which can lead to system instability. They illustrate that, when implementing an adaptive ConWIP system, practitioners should carefully take into consideration the consequences of modifying the number of cards. Depending on the manufacturing system considered, we argue that several criteria should be used to better decide when changing this number is really necessary.

I. INTRODUCTION

Traditional Pull Control Systems (TPCS), which are based on a fixed number of cards (e.g., the classical kanban system), are known to be suitable in repetitive environments with constant processing times, smooth and stable market demand [1]. However, in an unstable environment with fluctuation of the demand, processing times instability, non-standardized operations, long setup times, great variety of items and raw material supply uncertainty, TPCS may not work satisfactorily and can be inadequate [2], [3]. Consequently, these systems can lead either to unnecessary work in process (WIP) or unwanted backorders. In this respect and in order to maximize the pull system performance, variations (or adaptations) of the system were created to adapt properly to companies specific reality. These systems modify their pull system parameters, particularly the number of authorization cards. Hence the concept of dynamically varying this number to suit the situation is given due consideration. In existing literature, numerous approaches have been suggested for achieving these goals.

One of the most frequently encountered system in industry is probably the ConWIP (CONstant Work In Process) control system [4]. Most authors use the term ConWIP to refer to systems maintaining constant the maximum amount of WIP. This is usually done by using cards. Each card is attached to a job when the later enters the system (see Fig. 1). When a job is processed in the last station, its corresponding card is released and sent back to the input of the system, where it is attached to the next job to be processed. No job can enter the system without a card. Production is allowed only upon the reception of authorization cards, which are used to control all the manufacturing process [5]. Such a system is consider to be more robust, flexible and easier to optimize than other pull systems [6] as it depends on a single parameter, namely the total number of production authorization cards. A ConWIP control system determines when to release raw parts at the input of the system in response to the actual customers’ demands for finished parts at the output of the system. Therefore, in its adaptive version, the number of cards is systematically manipulated to improve the system performance [7], [8], [9].

Since its introduction, the adaptive ConWIP system has received the attention of practitioners and researchers, being one of the numerous studied topics in the operations research literature [10], [11], [12]. The previous research on adaptive ConWIP system mainly focused on changing the number of production authorization cards in circulation to respond quickly to changes in the customers’ demand and achieve a given performance objective such as: reduce inventory, increase productivity and improve customer satisfaction [6]. Nevertheless, most researchers focus solely on one specific aspect of the adaptive ConWIP system, which is the optimization of the system performance, and seem not to take into account other practical considerations. It is clear that the optimization of WIP and customer satisfaction, for example, is a critical objective for a production system, since it represents saving of money in the product flow. However, in the adaptive ConWIP

![Fig. 1. ConWIP system](image-url)
Abstract—Project complexity has been extensively explored in the literature because of its major contribution towards the failure of major projects in terms of cost and time overruns. Researchers have identified important factors that contribute to the project complexity and validated their findings through case studies. Few studies have even focused on developing tools for evaluating the project complexity. However, existing research has not explored an important aspect of linking project complexity to different types of project and supply chain risks. We propose a framework for establishing risk paths across project complexity elements, project and supply chain risks, and resulting consequences. Project complexity elements are the knowns at the commencement stage of a project whereas project and supply chain risks are the uncertainties that might realize within the life cycle of the project. We demonstrate application of our proposed framework through a simple simulation example using Bayesian Belief Network. The method can be an important contribution to the literature and beneficial to the practitioners in terms of introducing a new perspective of investigating causal paths of interacting project complexity elements and risks.

Keywords—Project complexity; project and supply chain risks; risk paths; Bayesian Belief Network

I. INTRODUCTION

Long-term engineering development projects often result in major delays and cost overruns and therefore, keeping in view the complexity of such projects, it is extremely important to consider interdependency between risks and involve different stakeholders in identifying key risks [1]. Boeing adopted an unconventional supply chain and introduced loss-sharing partnership in the development project of 787 Dreamliner in order to reduce financial risks and development time, however, the project was delayed incurring major financial penalty because the project team did not realize the importance of assessing and managing supply chain risks before commencement of the project [2].

Complexity in projects relate to structural elements, dynamic elements and interaction of these elements across the broad categories of technical, organizational and environmental domains. Technical elements focus on the technical aspects of a project, organizational elements capture softer perspective while environmental elements influence the project and stakeholders from outside the project scope [3]. Analytical hierarchy process has been used to measure project complexity [4]. However, it is not only important to understand the complexity of a project but also to visualize the complex interaction between these complexity elements and risks in order to plan and implement appropriate risk mitigation strategies. Moreover, these risks must also be connected to the project objectives which in turn will influence the utility function of the decision maker.

Bayesian Belief Networks (BBNs) offer an effective modelling technique for capturing these complex interactions between risks [5, 6]. BBN is an acyclic directed graph representing uncertain variables as nodes and the causal relationship between variables as arcs. The strength of causal relationship is captured through conditional probability values. We make use of the BBNs in modelling the project complexity elements (knowns at the Project commencement stage) as deterministic nodes and risks and objectives as chance nodes. A utility node is also incorporated in our model for characterizing the utility function of a decision maker in relation to the project objectives.

Research Gap and Contribution

Major projects involving new product development often result in cost and time overruns. Project complexity elements pose vulnerabilities to the successful culmination of these projects. No existing study has focused on capturing the interaction between the knowns (complexity attributes) at the commencement stage of a project and the unknowns realizing within the life cycle of the project. We propose a new approach of modelling causal paths across project complexity elements, risks and consequences affecting the project objectives. The proposed approach will help researchers focus on an important theme of investigating causal paths within a setting of interconnected vulnerabilities, risks and consequences. Furthermore, the research is equally beneficial to practitioners in terms of helping them visualize the interaction of different causal paths and identify important risks for implementing mitigation strategies.

Outline

Literature review is briefly presented in Section II. Our proposed framework is described in Section III followed by its
Track - IESM2015
Regular session
Operations, Human Factor and Safety

Li-Ming Chen

In this regular session some different research areas are introduced with regards to the Operations, Human Factor and Safety problems.

Some topics developed in this session:

• Ergonomic parameters, cognitive process;
• Stochastic production systems;
• Neighborhood strategies, genetic algorithm.

Presented papers:

• Creating a Safe Working Environment Via Analyzing the Ergonomic Parameters of Workplaces on an Assembly Conveyor
• How Does a Responsible Supplier Control its Production under the Opportunity of Demand Expansion?
• Sustainability drivers, barriers and outcomes: Evidence from European High Performance Manufacturing companies.
• Towards an explicative model of human cognitive process in a hidden hazardous situation and a cognitive ergonomics intervention in railway environment
• A multiobjective simulation optimization approach to define teams of workers in stochastic production systems
Creating a Safe Working Environment Via Analyzing the Ergonomic Parameters of Workplaces on an Assembly Conveyor

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4e2 2015

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Abstract - Globalization places increasing requirements to quality and competitiveness of products in the automotive industry. This is forcing manufacturers to look for reserves to increase the safety and efficiency of production processes. In the past two decades many companies have used such advanced methods as simulation to identify the causes of inefficiency of technological processes, among them, analyzing of the process ergonomic parameters. Special software packages are based on applying the accurate three-dimensional models of the person for build virtual production. This approach is more economical than experimenting in real systems and significantly accelerates the analysis of ergonomic parameters because it can be done in parallel with technological preparation of a production but not after it has started. The paper demonstrates the capability of simulation models in optimizing and boosting the efficiency of a technological process, diminishing the work load on the staff in assembly area and risk of performance loops caused by job-related accidents and musculoskeletal disorders.

Keywords - automobile industry manufacture, simulation modeling, technological process, safety, ergonomic.

I. INTRODUCTION

The role of the automotive industry is known to be crucial in not only creating of high-tech products but also in contributing to shaping of other sectors, imparting mobility to population and transporting goods door-to-door. Moreover, almost all industries are employing various special equipment on automobile chassis. Nowadays, with huge output volumes, automobilization has reached a critical level. Competition is forcing the manufacturers to update both the design and the production technology. Meeting the keen competition can only be successful via continuous development and innovation.

The large companies should pay close attention to development of two main tendencies. The first thing is a global tendency of a sustainable development. It includes sustainable development of economy, environment and the social sphere. The second thing is a transition to “green” economy. This economy defined as low-carbon, resource-effective and social-inclusive economy. Only rational regulation of the physical, natural and human capital can develop these two tendencies. So, when developing new projects and technologies it is necessary to take social consequences of this development into account.

This is largely refers to high-tech industries, such as automotive industry. Being complicated and labor-intensive, the manufacture of vehicles requires investigating and improving of technological processes in order to diminish the physical exertion of operator, occupational injuries and the risk of occupational diseases. Potential economic effects of new machinery, and even entire production lines, can only materialize in the case of social efficiency and optimal interaction between man and technology.

As has been proved worldwide, the human factor should be considered when designing a production and creating of automated control systems. Failing to do so is reported to result in an up to 30% loss in operating performance compared to designed efficiency.

Moreover, with increasing complication of technical systems, which are becoming more intellectual, the probabilities of failure in such systems are increasingly dependent on erroneous human action. To minimize the likelihood of critical disruption, one needs to fully take into account the ergonomics requirements in the design, implementation of technical systems, and their subsequent operation.

II. RESEARCH METHODS

A. Lean production and features of its introduction

A widespread method of process improvement in high-tech industries is the “lean production” (LP) concept, which was developed for and first employed at automobile manufacturing companies.

However, analyses of the LP performance at major automotive manufacturers [1, 2, 3, 4] have revealed ambiguous and, in most cases, rather negative impacts. According to
How Does a Responsible Supplier Control its Production under the Opportunity of Demand Expansion?

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Abstract—Increasing supply chain players seek to run business in a responsible way. This work stands from a supplier’s point of view by considering a two-stage supply chain structure in which a responsible supplier produces a responsible component (or raw material, ingredient) through an entrepreneurial process and exploits the business opportunity (e.g., market expansion) to sell it to downstream buyers. Buyers’ market is classified by two: one for price-sensitive and one for responsible-conscious. We develop quantitative models to analyze a supplier’s production structure, interplaying with the magnitude to this business opportunity exploitation.

Keywords—Operations management, Dynamic programming, Responsible supply chain, Production

I. INTRODUCTION

Embedding the responsible behaviors into supply chain draws the interests of academic researchers and business practitioners. Many tragedies have proved that it is a necessity to pay attention to this issue. The collapse of a Bangladeshi garment factory in April 24, 2013, which killed over 1,100 workers, draws the public attentions of how apparels being manufactured unethically, from which labors are paid with low salaries and expose under poor working conditions. Consequently, the chain effect rapidly spreads to affect several well-known clothing makers who subcontract their products from this factory. They are labeled as sweat factories which rises people’s ethical consumerism on boycotting the purchase of apparels from them.

Since irresponsible/unethical behaviors have substantially negative impact on consumer’ purchase willingness and tarnish the whole supply chain [28], more chain players seek to run business in a responsible way by conducting the so-called responsible trading, meaning bilateral actions of downstream players referred as to buyers sourcing responsibly and upstream players referred as to suppliers producing responsible products, to satisfy consumers’ expectations. 2013 Fairtrade International Annual Report indicates that demand and supply of responsible/ethical products grows strongly that consumers spent 4.8 billion euros on Fairtrade certified products in 2012 and the number of Fairtrade producer organizations increases up to 1,149 with approximately 1.35 million farmers and workers in 70 countries, 16% more than that in 2011 [15]. To elaborate how responsible/ethical trade emerges as a popularity, we start from the consumers’ driving force. A growing number of consumers seriously make the purchase decision on the basis of how much a company contributes to behave responsibly, from which they are willing to pay a higher premium as reward [7]. Further, the social and environmental violations incur a series of consumers’ boycott and, through the flourishing social media, the negative effect proliferates worldwide to exacerbate buyers’ damage. Moreover, the higher profile a buyer possesses a greater change to be targeted by the publicity to scrutinize each activity under the microscope. The past experiences repeatedly remind us these phenomenon, such as Nike, Coca-Cola, HP, PVH, Wal-mart, and Primark being criticized for social and environmental violations [3][16][17]. Thus, increasing firms start to pay attention to the importance of sourcing responsibly, selecting their suppliers not based on price but rather based on suppliers’ responsible manners, to maintain a good reputation [22].

Followed by the consumers-driven need of responsible products and the consequent surge of buyer’s high demand of responsible sourcing, a supplier is stimulated to contribute to responsible supply which gives the edge of differentiating products from others competitors, pioneering to occupy this growing market. As [19] addressed, engaging in the corporate social responsibility as a product differentiation strategy assists a firm to create new demand. More than this, financially rewarding suppliers to offer quality assurance, ethical buyers pay a fair price or even more than a fair price (Over 80 million euros Fairtrade premium, on top of the selling price, is paid to producers [15]. Combining the increasing need and the incentive of being paid a fair price, a supplier is much willing to abnegate the conventional production mode and instead to devote to the production process in a responsible way that the environment is paid with respect and labors are treated with equality. Accordingly, a new business opportunity appears for news suppliers to provide a component in a responsible way.
Sustainability drivers, barriers and outcomes: Evidence from European High Performance Manufacturing companies

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Abstract— Implementing sustainability practices has become a requirement to be able to operate in several markets since the legal requirements are increasing and society (as well as customers) values sustainability behaviors more.

The aims of this paper are (1) to analyze the impact that drivers and barriers have on Environmental practices implemented in the high performance manufacturing industries, (2) to identify the relevant drivers and barriers for these environmental practices, and finally, (3) to study the influence that Environmental practices have on companies’ Financial Performance.

To carry out our research, we shall consider a European database of companies involved in the High Performance Manufacturing project. Partial Least Squares (PLS) will be used to test our hypotheses.

Keywords— Environmental Practices; Drivers; Barriers; Financial Performance; High Performance Manufacturing Industries.

I. INTRODUCTION

Companies are increasingly more concerned with being environment-friendly due to pressures from several stakeholders and society [1]. They argue that firms have responsibilities and they have to reduce their impact on the environment [2], so environmental management should become a core part of the business.

Although there are lots of laws and regulations in most of countries to protect the environment, nowadays for firms it is not sufficient to comply with the law [3]. For this reason, organizations have been forced to change their environmental engagement and commitment exceeding the legal requirements and making significant investments that enable them to be eco-efficient.

The aims of this paper are (a) to analyze the impact that drivers and barriers have on Environmental practices implemented in high performance manufacturing industries, (b) to identify the relevant drivers and barriers for these environmental practices, and finally, (c) to study the influence that Environmental practices have on companies’ Financial Performance.

Regarding first and second aims, the literature has made several efforts to try and identify sustainability barriers and drivers. Notwithstanding, there is not much research that quantifies the impacts of both on the sustainability practices implemented by companies.

Most of the literature on sustainability focuses on the outcomes, and mainly on their relationship with Financial Performance. However, the results are heterogeneous.

To carry out our research, we shall consider a European database of companies involved in the High Performance Manufacturing project. The Partial Least Squares technique will be used to test our hypotheses (PLS).

The remainder of the paper is organized as follows. In Section II, we focus on the debate around the drivers and barriers of environmental practices, and also Financial Performance. In Section III, we look more closely at the sample and variables used, as well as the methodology employed. Section IV presents the results of our study and the discussion. Finally, in Section V we present the main conclusions.

II. SUSTAINABILITY PRACTICES: DRIVERS, BARRIERS AND FINANCIAL PERFORMANCE

A. Drivers and Barriers

To identify the forces that are driving or blocking sustainability efforts in manufacturing plants is extremely important for being able to put appropriate policies in place. Notwithstanding, there is only limited research that quantifies the impacts of both of these on the sustainability practices implemented by companies.
Towards an explicative model of human cognitive process in a hidden hazardous situation and a cognitive ergonomics intervention in railway environment

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Abstract—Over the recent decades, situation awareness errors and human errors are always considered among primary factors contributing to railway incidents and accidents. Hence, the need to focus research efforts on approaches centered on human factors rather than absolute technical solutions is becoming greater.

In this paper, we firstly present the rail human factors context and cognitive ergonomics as a field of research in ergonomics. Then we state a brief overview of human errors contributing to rail accidents and that have major impact on railway safety. Secondly, we review models related to human cognitive behaviour in working environment. Then, we base our research on the Endesley model in order to propose an explicative model of cognitive processes involved in hidden hazardous situations. Through this model, we introduce the human cognitive processes with emphasis on situation awareness errors and complacency which are considered among causal factors of accidents including railway ones.

In relation to the proposed model, we will proceed to human behaviour analysis and a cognitive ergonomic intervention in railway environment. This latter will allow to understand human behaviour in hazardous or hidden hazardous situation, to design the human cognitive processes involved, and then to reduce the resulting accidents and incidents.

Keywords—cognitive process; cognitive ergonomics; situation awareness; model; railway hazard.

I. INTRODUCTION

Currently, railway security and safety are expected to play an increasingly pervasive and strategic role. They have now become a key element of railway services. Thus, researchers have long struggled to understand accidents and human factors associated with it.

Because many perception problems and complacency are source of human risk behaviours, the analysis of human cognitive behaviours may seem important. Moreover, if we can recognise the types of behaviours that result in errors, then we can plan to reduce their frequency and their consequences.

Thus, our contribution concerns the cognitive and behavioral analysis of human cognitive processes involved facing a hidden hazard or situation of insecurity. So, we try to present a first reflection on the research questions arising from that theme and the methodology to be adopted.

In this paper we briefly review the literature of rail human factors research which has grown rapidly over the past few years. Then, we try to model the human cognitive process involved in hidden hazardous situations. More precisely, we present a proposal of model which may explain the human cognitive process with emphasis on situation awareness errors. At the end, we suggest a methodology to experiment this model through an ergonomic intervention in railways environment.

II. RAIL HUMAN FACTORS AND COGNITIVE ERGONOMICS AS A FIELD OF RESEARCH

A. Rail human factors as a field of research

1) Human factors and ergonomics:

The human factors and ergonomics as discipline and research have widely grown. They aim to understand interactions with systems and among humans in order to:

- Enhance performance.
- Increase safety.
- Improve user satisfaction.

Human factors intend to study factors and develop tools that may allow reaching these goals [1].
A multiobjective simulation optimization approach to define teams of workers in stochastic production systems

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Abstract—In this paper, we address team configuration problems in manufacturing systems, which consist in defining the number of workers to be assigned to a production system, as well as the skills that each worker must have in order to meet several performance measures. This problem is studied in a stochastic production context. A multi-objective evolutionary algorithm is connected to a simulation model to deal with this problem. Two objectives are considered. The first one is the minimization of the expected manpower cost associated to manufacturing team and the second one is the minimization of the expected mean flow time of jobs. Machines redundancy and workers multi-functionality are considered, when defining workers skills, to cope with possible random events such as workers unavailability and bottlenecks. Since the way workers are assigned to work centers strongly impact the results, a recent adaptive assignment heuristic is embedded in the simulation model and its parameters are also optimized. The proposed multi-objective simulation optimization approach is applied to design manufacturing teams, of a job shop production system, using the Nondominated Sorting Genetic Algorithm II (NSGA-II) connected to a simulation model developed using Arena. The set of non dominated solutions is found, so that an additional multi-criteria analysis can be performed.

Keywords—worker teams configuration; workers assignment; multi-objective simulation optimization.

I. INTRODUCTION

A team of workers (TOW) can be defined as a group of workers assigned to a manufacturing system to perform various production tasks. Two main problems must be resolved when designing a TOW. The first one consists in defining the number of workers in the team. This number of workers depends on the production tasks that will have to be performed and the machines available. Indeed, each worker of the team can be assigned to one or several machines of the system to perform one or several tasks, according to the worker’s skills, which refer to the machines that he/she can use. If a worker can use only one type of machines, this worker is mono-skilled. However, if a worker can use several machines’ types, this worker is multi-skilled (also referred to as flexible). The number of machines’ types to which he/she may be assigned represents his/her level of flexibility also known as the level of multi-functionality. A worker may be fully skilled if he/she is skilled for all the machines of the system or partially skilled if his/her level of flexibility is less than the number of machines in the system. Moreover, the workers of the team may be homogeneous, if all workers have the same level of flexibility, or heterogeneous, if they can use different number of machines’ types [1, 2].

The second problem that must be resolved when designing a TOW is how to design the skill matrix which refers to the distribution of workers skills in the team (also known as worker-machine matrix or worker-task matrix). This distribution specifies which worker must be skilled for which machines and determines if the workers of the team should be mono or multi-skilled, fully or partially skilled and homogeneous or heterogeneous.

It is well known that the system performances are greatly affected by the TOW design. Indeed, a TOW characterized by a large number of workers (with respect to the need) and high level of flexibilities may achieve good performances on such criteria as the mean flow time (MFT) of jobs, the mean tardiness, etc. But the manpower cost induced may not be acceptable. On the other hand, a lower number of workers in the team with a lower flexibility level will reduce the manpower cost but may impact certain production objectives. As a consequence, both types of performance measures must be taken into account when designing teams of workers.

The TOW design depends on different types of considerations related to the system under study. Certain production systems are characterized by a deterministic behavior, i.e. predefined products mix, known demand, known arrivals time of orders, constant operating times, etc. The Team Of Workers Configuration Problems (TOWCPs) are known to be NP-hard in the deterministic context [3, 4]. Classical optimization methods, such as exact methods, heuristics and
In this regular session some different research areas are introduced with regards to the Operations, Human Factor and Safety problems.

Some topics developed in this session:

- Manufacturing systems;
- Control, robustness;
- Modeling, dependability;
- Robust Optimization;
- Industrial Processes.

Presented papers:

- *Support Vector Machine and Monte Carlo Simulation for Robust Optimization of Industrial Processes*
- *Robust LQR with actuator failure control strategies for 4DoF model of unmanned bicycle robot stabilised by inertial wheel*
- *The Dependability Control Analysis: Applied to centrifugal pumps in a oil petrochemical plant*
- *Modeling and Dependability Analysis of an Industrial Plant: Case Study*
- *A new Robustness index for machines selection in Reconfigurable Manufacturing System*
Support Vector Machine and Monte Carlo Simulation for Robust Optimization of Industrial Processes

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Abstract—Goods-producing industries continuously search to improve the quality of final products. The main approach is to identify a correlation between the process settings and the quality of the final product. In this work, a three steps robust approach is presented to improve an industrial process. The first step consists in using a Support Vector machines Regression (SVR) method to build a model of the considered process. It is based on the historic process data defined by an output (a criterion on the product quality) and multiple inputs (various production line settings). Then an optimization step based on an iterative descent method is done on the obtained model to identify interesting settings. Finally the set of settings found is validated by a Monte Carlo simulation approach used to simulate and test settings close to the one found on the optimization step. The proposed regression and optimization methods are compared to existing methods from the literature on a fluidized bed combustion boiler in the context of paper industry. The experiments confirm the efficiency of our approach.

Keywords— process control; support vector machines; Monte Carlo simulation; global optimization

I. INTRODUCTION

In the context of business globalization, the goods-producing industries (process industries) have to handle a growing competition. The competitiveness of a goods-producing industry is obviously linked to its performance but also to the quality of its products. Therefore, control and continuous improvement of their end products quality in order to better satisfy the end customer has become the major concern of goods-producing industries.

Improving the product quality in a manufacturing process involves optimization. Process control and monitoring enable collecting a large amount of data. These data allow constructing models of the processes via application of mathematical or statistical methods. Given this definition, such models are data-based. The goal is to build an empirical model from data collected by measurements. Then, the resulting model allows the estimation of one or more performance criteria. However if the structure of the model is not properly addressed, data-driven models can provide misleading results [1].

In this paper, we propose a three steps framework for process optimization. The first step uses a Support Vector machine Regression (SVR) method to estimate performance criteria of a given process related to the final product quality. This step takes as input industrial data provided by the continuous process monitoring. The second step is based on a global optimization method. Using regression models built in the first step, input process settings are optimized and, therefore, the process output quality is improved. However, various sources of uncertainty in process industry may lead to important negative effects on the operational performance (input parameters like raw materials, operating conditions and intermediate products quality). This aspect is addressed by a variety of (more conventional) approaches, such as stochastic programming, fuzzy programming and stochastic dynamic programming [2]. Yet, inclusion of uncertainties often leads to intractable pure mathematical modeling. Therefore, deterministic mathematical models are often used in practice. They are followed by various sensitivity analyses to evaluate the impact of several types of uncertainty on operational performance. Simulation is widely used since it can handle uncertainty in various system parameters. Thus the third step consists of a Monte Carlo-based approach to assert the use of settings obtained by the second step.

The paper is organized as follows: the problem under study is presented in the next section. Section III describes the proposed three steps framework for process optimization. The experiments results are reported Section IV, before concluding remarks.

II. PROBLEM DEFINITION AND ASSUMPTIONS

A. Problem definition

The problem consists in improving an industrial process using the historical data collected from the process. These data are usually collected by the monitoring system. The problem can be formalized as follows. Let \((x_1,y_1) \ldots (x_n,y_n)\) denote a dataset. For each \(i=1 \ldots n\), \(y_i\) is the value of a quality criterion to be improved and \(x_i\) is a set of inputs, i.e. process setting parameters. These parameters can be modified by the industrial process manager in order to set the quality criterion of the final product. Then, the problem consists in finding a unknown set of
Robust LQR with actuator failure control strategies for 4DoF model of unmanned bicycle robot stabilised by inertial wheel

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Abstract—The paper presents analysis of two control strategies, i.e. LQR and LQI, in application to control of continuous-time nonlinear system on the basis of its linearised discrete-time model, taking robustness approach into account. The applied control laws assure robustness subject to actuator failure what has been used to obtain better control quality (in the sense of selected performance indexes) in comparison to control laws that take no uncertainty into account. The uncertainty resembles here actuator failure or mismodeling case, whenever applied control signal results in different behaviour of the closed-loop system than desired, as in actuator failure case alone.

I. INTRODUCTION

The problem of robust control or stabilisation is widely discussed in the literature. There are papers related to measuring the performance as a quadratic cost for uncertain systems, as in [Chang et al (1972)] or [Petersen and McFarlane (1992)], in the case of continuous-time control systems. In the case of discrete-time control systems, the guaranteed-cost control has been addressed in [Xie and Soh (1995)].

Implementations of control algorithms are prone to failures, thus it is important to implement controllers that can tolerate the latter, to guarantee stability and certain performance level. The paper adopts the approach presented in [Yang et al (2000)] to apply LQR control strategies to stabilize bicycle robot model in an unstable equilibrium point, based on its linearised model. The actuator failure is used to mimic the uncertainty that originates from adopting linearised model to control nonlinear system, governed by nonlinear state-space equations.

The state-feedback control law is used to guarantee the cost in the case of actuator failure or, in other words, lack of consistency between linearised model and „true” model of the plant, projecting „robustness area” on the static characteristic of the nonlinearity present in the control system or unknown static characteristic of the nonlinear system.

The principle of inertial wheel stabilisation can be found in [Owczarkowski et al (2014)].

II. MATHEMATICAL MODEL OF THE BICYCLE ROBOT AND ITS LINEARISATION

The complete mathematical model of the robot is defined with non-linear differential equations (index (t) omitted for brevity) and is taken from [Owczarkowski et al (2014)]:

\[
\begin{align*}
\dot{x}_1 &= x_2, \\
\dot{x}_2 &= -\frac{1}{I_{mg}} \left[ b_x x_2 + \left( \frac{b_x x_4}{I_m + I_{mg}} - \frac{k_m}{I_m + I_{mg}} \right) (I_1 + I_{mg}) \right] + \frac{h_x m_x^2}{I_{mg}} + \frac{g h_x m_x \cos(\alpha) \sin(x_1)}{I_{mg}} + \frac{a c m_x^2 x_2 \sin^2(\lambda)}{I_{mg}}, \\
\dot{x}_3 &= x_4, \\
\dot{x}_4 &= \frac{k_m}{I_m + I_{mg}} - \frac{b y x_4}{I_1 + I_{mg}}, \\
\dot{x}_5 &= x_6, \\
\dot{x}_6 &= -\frac{b_u x_6}{m_r} + \frac{k_m}{m_r w} - g h_x m_x \sin(\alpha), \\
\dot{x}_7 &= x_8, \\
\dot{x}_8 &= -\frac{b_x x_8}{I_h^2} \frac{k_m}{I_h^2} - \frac{a c m_x^2 x_2 \sin^2(\lambda) + a c m_x^2 \cos(\alpha) \sin(\lambda)}{I_{mg}}.
\end{align*}
\]

with notation: \( \dot{x} \) – state vector, \( x_1 \) – deflection angle of the robot from the vertical axis, \( x_2 \) – angular velocity of the robot, \( x_3 \) – rotation angle of the reaction wheel, \( x_4 \) – angular velocity of the reaction wheel, \( x_5 \) – horizontal movement, \( x_6 \) – angular velocity, \( x_7 \) – rotation of the steering wheel, \( x_8 \) – angular velocity of the steering wheel, \( u \) – control vector, \( u_i \) – current of the \( i \)-th motor (\( i = 1, 2, 3 \)), \( m_r \) – weight of the robot, \( I_1 \) – moment of inertia of the reaction wheel, \( I_{mg} \) – moment of inertia of the rotor of the motor 1, \( I_{mg} \) – moment of inertia of the robot relative to the ground, \( h_r \) – moment of inertia of the handlebar, \( h_x \) – distance from the ground to the center of mass of the robot, \( r_w \) – radius of the wheel, \( g \) – gravity of the Earth, \( a \) – distance from a vertical line through the center of mass to \( P_1 \), \( b \) – wheel base, \( c \) – trail, \( \lambda \) – head angle, \( \alpha \) – inclination angle of the slope, \( R \) – bend radius, \( k_m \) – \( i \)-th motor constant, \( b_f \) – friction coefficient in the robot rotation, \( b_g \) – friction coefficient in the robot horizontal movement, \( b_f \) – friction coefficient in the rotation of the handlebar, \( b_r \) – friction coefficient in the rotation of the reaction wheel.

The system can be linearized by Jacobian matrix to the form: \( \dot{\mathbf{x}}(t) = A \mathbf{x}(t) + B \mathbf{u}(t) \). The result is given by
Abstract—In this paper, we highlight the issue of control and dependability of a preheating train of heat exchangers for a petrochemical industrial plant—unit 100 Topping of condensate RA2K (Skikda, Refinery Algeria). Our work includes both the risk analysis for the unit and for two centrifugal pumps used for pumping the condensate.

Two safety analysis methods are used which are FMECA (Failure Mode Effect) and HAZOP (Hazard and Operability study) along with a preliminary hazard analysis study (PHA) and FMA (jstudy. Our objective from the study is modeling the system operation to identify the major risks, determining the consequences in case where the overall system (safety system for unit 100) or the centrifugal pumps failed, and submit a performance monitoring architecture with a decision support tool that provides the necessary recommendations to ensure the performance and safety of the system.

To achieve these goals we start by introducing the detailed structure of the studied system followed by a detailed description and the principle for methods used, and finally the analysis and comparison between the results generated from different methods, the recommendations deduced and guidelines for future works are presented.

Keywords: safety control system analysis, complex system, Modelling, RMA, AHP, FMEAC, Hazop.

I. INTRODUCTION

Topping condensate RA2K plant is complex industrial plant this due to its size (it includes multiple units), its capacity of treatment [1], and the huge number of parameters to be adjusted and controlled. This system is used to treat 5 MM metric tons for a continuous period of 330 days of condensate. This plant is designed for the treatment of five different loads of condensate named as follows: OB1 Alrar, BEJAIA, RHOU D NOUSS, NEW OB1. The final products of the unit as butane, naphtha, kerosene, Light gas oil (LGO) and Heavy (HGO) are stored in intermediate storage tanks corresponding to an autonomy of operation approximately four-days, after that they are sent to Skikda refinery RA1K for commercial transactions. The complexity of the system requires adequate supervision and monitoring of all parameters (Temperature, pressure, asperation flow and refoulment flow) and instruments to ensure an optimal control parameters and safe operation (Figure 1).

To achieve this goal the following system structure is realised (Figure-2) such that the RAMS will receive the inputs and the parameters chosen to control the system, the outputs, and the desired parameters to accomplish complete analysis by taking into account the system dynamics. General recommendations are finally generated to ensure both the desired performances and system safety.

Fig. 1. Topping condensate RA2K.

Fig. 2. Safety control diagram of system
Modeling and Dependability Analysis of an Industrial Plant: Case Study

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Abstract—In this paper the dependability of an automatic detection and extinction system with Halon is presented. The risk control and analysis is done using three analysis methods, SADT (Structured Analysis and Design Technical), FMEA (Failure Mode Effect Analysis) and FTA (Fault Tree Analysis). The objective of our work is dependability planning optimization with the identification of the potential risks and these consequences on system. The optimal recommendations must be proposed. Decision tools used to improve production will be proposed. To achieve these objectives a detailed description of process structure and the main principles of both methods are given. We have applied these methods on the system with a comparative study between the results given by these methods. The obtained results will be presented with perspectives future work.

Keywords: Dependability, control system analysis, complex system, SADT, FMEA, FTA.

I. INTRODUCTION

A petroleum and petrochemical industries are considered as the main energy source and hence occupy an important place in the economy of many countries. However, these industries are characterized by their sensitivity toward risks, the fact that may cause damage to humans, property and the environment. The fires and explosions are potential initiators of major accidents for these kinds of industrial plants.

A storage and manufacturing of oil and gas products may be the origin of many dangerous explosions. These explosions cause damages for equipment, facilities for the plant itself as well as for neighboring units and the environment. In general and in the worst cases it may cause death of many persons as that happen in GL1K SKIKDA - Algeria (January, 19th, 2004). This accident caused a very bad consequences on material, humans and environment and their effects reaches SKIKDA city which is located 3 Km far from the plant. In order to avoid such problems, strict measures are taken in the plant and the storage tanks are equipped by an automatic system of detection and extinction by HALON.

However, the study of dependability is necessary at any time and is not dependent on the business or industry type. This study as to improve the dependability and security of the system. The desired parameters (ie. Level of counterweight at less of 30 cm, the nitrogen pressure \( P_N \geq 200 \text{ bars} \) and the halon pressure \( P_{Halon} \geq 20 \text{ bars} \)), the system inputs and control parameters are chosen to control the system and dependability analysis (RAMS). Recommendations are generated to improve the desired performances and system safety (Figure-1).

![Control diagram block system.](image)

We have chosen among different risks analysis methods existing in the literature, two different analysis methods and checking the recommendations resulted from each one. The first is FMEA analysis method (Failure Mode and Effect Analysis), and the second is FTA method (Fault Tree Analysis) [2][3].

II. DESCRIPTION OF THE SYSTEM

We consider in our study, the detection and extinguishing system by HALON (1211 BCF) (Figure 2). This system is composed of three main parts for: detection, extinguishing and alarming tools. The system is installed on the floating roof of the storage tanks. It allows an efficient and fast detection and overcoming of fire and this is due to automatic action of the detection system which followed by an audible and visual alarms.

The detection system is composed by fuses that are installed along the roof these fuses are connected in between by a Stainless steel cable. The rupture of the fuses under the fire temperature (90°C) will act on the nitrogen bottle through the counterweight hanging on the pulley. Installed on a support which will pull the cable and cause the opening...
A new Robustness index for machines selection in Reconfigurable Manufacturing System

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4e2 2015

Abstract—Responsiveness and high performance are key factors in today's world which is driven by economic globalization. Reconfigurable Manufacturing System (RMS) is one of the recent manufacturing paradigms driven by these factors. In such paradigm, system capacities and functionalities can be changed exactly when needed. Hence, the design of such systems is driven by the requirement of the production process, the specification of the needed product, and the capabilities offered by the reconfigurable machines. This paper considers the design problem in Reconfigurable Manufacturing System (RMS) and introduce a new index of system robustness. We present a new approach of RMS design to ensure the best process plans by selecting the best set of machines from a set of available (candidate) ones. The approach is based on an adapted non-dominated sorting genetic algorithm (NSGA-II) guided by the minimization of two objectives which are the total completion time and the perturbation caused by the unpredicted unavailability of selected machines (caused by failure, maintenance, human or technological errors...). The application of presented approach is illustrated through a numerical example and the discussion about the obtained results.

Keywords—Reconfigurable manufacturing systems; system design; robustness index; process plan; NSGA-II.

I. INTRODUCTION

The Reconfigurable Manufacturing System (RMS) is one of the recent manufacturing paradigms. This paradigm is the result of many factors facing today manufacturing environment like the rapid technological and social changes with unpredictable frequent market changes driven by the economic globalization. These factors make responsiveness in manufacturing enterprises crucial. Besides that, recent manufacturing paradigm shifts are driven by high performance and agility [1]. In RMS, to react rapidly to the changing requirement, machines components, machines or material handling units can be added, removed, modified or interchanged as needed [2].

Reconfigurable Manufacturing Systems are a very active research topic, nevertheless a complete reconfigurable system does not exist yet [1]. Currently, in manufacturing systems we can find two classes [4]. First, Dedicated Manufacturing Lines (DML). This kind of system is designed to produce a specific core product at high volume throughput, basing on inexpensive fixed automation. The second system is Flexible Manufacturing Systems (FMS). They are characterized by the ability to produce a changeable mix for a large variety of products. FMSs comprise programmable forms of automation and general-purpose Computer numerically controlled (CNC) machines.

TABLE I. COMPARISON OF SYSTEM FEATURES (DEDICATED VS. RMS VS. FMS) [4]

<table>
<thead>
<tr>
<th>Feature</th>
<th>Dedicated</th>
<th>RMS/RMT</th>
<th>FMS/CNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>System structure</td>
<td>Fixed</td>
<td>Adjustable</td>
<td>Adjustable</td>
</tr>
<tr>
<td>Machine structure</td>
<td>Fixed</td>
<td>Adjustable</td>
<td>Fixed</td>
</tr>
<tr>
<td>System focus</td>
<td>Part</td>
<td>Part family</td>
<td>Machine</td>
</tr>
<tr>
<td>Scalability</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Flexibility</td>
<td>No</td>
<td>Customized</td>
<td>General</td>
</tr>
<tr>
<td>Simultaneous operating tool</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Productivity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Lifetime cost</td>
<td>Low</td>
<td>Medium</td>
<td>Reasonable</td>
</tr>
</tbody>
</table>

Facing the challenges engendered by the new manufacturing environment, the two systems (i.e. DMLs and...
In this regular session many aspects of production problems are developed with regards to the following topics:

Some topics developed in this session:

- Inventory model;
- Manufacturing environments;
- Maintenance optimization;
- Fuzzy Hierarchical;
- Quality Management System;
- Dynamic lot-sizing;
- Optimization.

Presented papers:

- Buffer allocation, machine selection and preventive maintenance optimization in unreliable production lines
- Comparative Study of Fuzzy Hierarchical Hybrid Approaches for Control of Quality Management System
- A Fuzzy Hedging Point Policy for Sustainable Manufacturing System
- Dynamic lot-sizing-based working capital requirement minimization model with infinite capacity
- Local and global optimization in raw material processing
Buffer allocation, machine selection and preventive maintenance optimization in unreliable production lines

(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4e2 2015

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Abstract—In this paper, we consider a serial production line consisting of $n$ unreliable machines with $n-1$ buffers. The objective is to determine the optimal preventive maintenance policy, the optimal selection of machines and the optimal buffer allocation that will minimize the total system cost subject to a given system throughput level. We assume that the mean time between failures (MTBF) of all machines will be increased when performing periodic preventive maintenance. An analytical decomposition-type approximation is used to estimate the production line throughput. The optimal design problem is formulated as a combinatorial optimization one where the decision variables are buffer levels, types of machines and times between preventive maintenance. To solve this problem, a Genetic algorithm is proposed. A numerical example is presented to illustrate the model.

Keywords—Preventive maintenance; buffer allocation; production line; unreliable machines; machine selection; Genetic Algorithm

I. INTRODUCTION

A production line consists of machines connected in series and separated by buffers. A production line is called homogeneous (or balanced) if the processing times are equal at all machines. In a non-homogeneous (or non-balanced) line, machines may take different lengths of time performing operations on parts. The efficiency of a production line can be improved by providing optimally the sizes of the buffers between the machines, selecting high reliable machines or performing a good preventive maintenance plan. Preventive maintenance is used to increase the reliability of machines over the long term by scheduling planned maintenance actions aimed at the reduction of sudden breakdowns and failures [1]. In this paper, a preventive maintenance plan is integrated into the buffer allocation problem and the optimal machines selection problem.

There is a substantial literature on the buffer allocation problem (BAP). In 1967, Buzacott [2] solved this problem by using Markov chain models. So [3] studied the optimal allocation of buffer units by considering the objective of minimizing work-in-process in production lines. However, most of the studies were made on short reliable production lines (e.g. [4]). Recently, applications of metaheuristics have been proposed by some authors (e.g. [5], [6],[7]) to solve the buffer allocation problem. They proved the efficiency of these methods on large reliable and unreliable production lines. More recently, Can and Heavey [8], and Amiri and Mohtashami [9] propose simulation approach for solving the buffer allocation problem. Sabuncuoglu et al. [10] explored the experimental designs for evaluating the solutions to the buffer allocation problem. Demir et al. [11], present a classification of the research work in this domain. The goal of the majority of the existing works is to choose buffers sizes for a production line. They all assume that the only parameters to find are buffers sizes. The proposed approach to optimal design aims at optimizing buffers sizes, machine selection and PM plans.

A great number of studies on maintenance models for production-inventory systems have been published in recent years. In [12], the authors proposed a preventive maintenance policy, which is based on the information about the age of the installation and the content of the subsequent buffer of a deteriorating installation. Meller and Kim [13], the authors considered a system with two machines and a buffer between them. The objective is to determine the optimal buffer inventory level, that triggers preventive maintenance on the first machine. Yao et al. [14] studied joint preventive maintenance (PM) and production policies for an unreliable production-inventory system. In Rezg et al. [15] presented a joint optimal inventory control and preventive maintenance strategy for a randomly failing production unit which supplies an assembly line operating according to a just-in-time configuration. In Karamatsoukis and Kyriakidis [16], the authors studied a production-inventory system. The installation deteriorates in time and the problem of its optimal
Comparative Study of Fuzzy Hierarchical Hybrid Approaches for Control of Quality Management System

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Abstract— Nowadays, the control of Quality Management System (QMS) has become a major consideration in the businesses. Indeed, it has a large number of imprecise information and performance indicators inputs that must be managed. In this context, this paper proposes two approaches: Hierarchical Fuzzy Signature and Neuro-Fuzzy Hierarchical Hybrid able to control of QMS problem. These approaches has been validated on a real case and compared to Adaptive Neural Fuzzy Inference and Neuronal Network Systems in relation to learning phase.

Keywords— Fuzzy logic; quality management system; neuro-fuzzy hierarchical structure; fuzzy signature.

I. INTRODUCTION

For complex systems with imprecise information, several researchers have integrated the fuzzy concept in different areas such as: decision support [1], signal processing [2], etc. Many other studies have used fuzzy logic as a tool for decision support such as: the risk management [3], the defects classification [4], etc.

These practical applications have shown that fuzzy logic can only solve problems with simple structured data where the inputs number is well defined. However, when in the presence of high dimensional data, a new concept has invented by researchers in recent years, which is the concept of fuzzy signatures. This signature is widely applied for medical decision support [5].

Other researchers have applied the Neural Networks (NN) in several areas of decision support such as: the detection and classification of defects [6], fault diagnosis [7] and the classification ElectroEncephaloGram (EEG) of mental tasks [8]. Despite the advantages of self-learning and use in a variety of situations, the NN cannot, especially for problems of classification, associate digital data to linguistic data. To overcome these limitations and benefits of reasoning and learning these techniques, other researchers have proposed a hybrid structure combining both fuzzy logic and NN [9]. One of the strengths of these neuro-fuzzy systems is the treatment of both qualitative and quantitative variables.

The QMS have a large number of imprecise information and diverse qualitative and quantitative nature. In this context, we propose, in the second section, two approaches: Hierarchical Fuzzy Signature (HFS) and Neuro-Fuzzy Hierarchical Hybrid (NFHH), for control of QMS. These approaches are validated on a real company that will be the third section. Finally, a comparative study between NFHH, ANFIS (Adaptive Neural Fuzzy Inference Systems) and NN, is proposed to evaluate the performance of the proposed approach related learning phase.

II. FUZZY HIERARCHICAL HYBRID APPROACHES FOR CONTROL OF QMS

In general, the decomposition in hierarchical form has proved effective especially for solving complex problems with a fairly large number of variables. However, this hierarchical structure brought together two types of quantitative and qualitative variables. Facing the large number of variables and their diversity, several structures based on the integration of fuzzy set theory have been used in many fields.

For control of QMS having a fuzzy and diverse performance indicators inputs, the modeling in hierarchical form has been very effective for solving a classification problems similar to those of QMS. In this context, we propose two approaches: Hierarchical Fuzzy Signature (HFS) and Neuro-Fuzzy Hierarchical Hybrid (NFHH), able to control of QMS problem where the variables are fuzzy, large and diverse.

A. Hierarchical Fuzzy Signature (HFS)

The HFS aims handling complex information in a hierarchical fuzzy. This hierarchical structure makes it possible to expand the use of fuzzy set theory for many areas with complex and sometimes conflicting objectives. Thus, HFS concept can be one of the solutions for solving the decision making experts problem which is often based on comparisons of different data cases and/or missing elements. HFS is presented by fuzzy vectors where each vector can be composed by another fuzzy vector value (branch) or a single value (leaf). HFS is given by equation (1) [5].
A Fuzzy Hedging Point Policy for Sustainable Manufacturing System

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Abstract—This paper addresses a sustainable manufacturing system, i.e. a manufacturing system on which we try to minimize all economical costs while minimizing environmental impacts and improving workforce welfare. Indeed, on one hand, this system emits pollutants and greenhouse gases during its manufacturing process. On the other hand, the social dimension i.e. the human workforce and its working conditions are also discussed and considered because of the direct and indirect costs associated. A hedging point policy is then applied and adapted to this manufacturing system by using fuzzy logic to ensure sustainability. So, a fuzzy hedging point is defined to take into account pollutant emissions and human factors in order to minimize global costs.

Keywords— environmental impacts; economical costs; workforce welfare; hedging point policy; fuzzy logic

I. INTRODUCTION

Since the sustainable development has been defined [1], many countries have adopted strategies to strongly encourage individuals and companies to reduce their environmental impacts [2] and act ethically. Our work registers in this context and propose to define a production control policy which not only minimizes all production costs but also considers the pollution and greenhouse gases emitted and also the social dimension to obtain sustainability. Indeed, many studies and methodologies have been proposed to include environmental impacts (especially greenhouse gases emissions). We can cite for examples [3] and [4] which give good surveys on the subject. However, the social dimension is rarely considered [5].

In this paper, we try to consider at the same time the three pillars of sustainable development to define the production control policy. However, we limit our study to the social dimension and do not include the societal responsibility of the enterprise.

The representation of human factors in industry has been the subject of numerous studies conducted by different specialists (designers, engineers, ergonomists, occupational psychologists…) whose goal is generally to find the balance between operator’s capacities, whether physical, cognitive or moral, and the requirements of certain tasks [6]. Thus, the behavior of operator is defined by different factors such as external conditions, that is to say, the requirements and constraints imposed, or the nature of the task at hand, or line managers and also internal conditions (the characteristics of the individual) such as physiological, psychological and psychosocial factors such as motivation, satisfaction, confidence, fatigue, stress, and conflict [7]. More and more organizations are addressing the issue of psychological factor at work, because of the direct and indirect costs associated with this issue as higher absenteeism, lost productivity, the behavior of withdrawal, the tensions, ergonomics and musculoskeletal disorders etc. Our objective in this paper is not to clearly identify the human behavior and corresponding costs but only considering this social dimension in the definition of the proposed production policy.

The proposed production control policy is based on the well-known hedging point policy defined for the first time in [8]. In this policy, a nonnegative production surplus of particular types should be maintained at times of excess capacity in order to hedge against future capacity shortages caused by machine failures. For the case of failure-prone manufacturing system, this policy has been shown to be optimal (see for examples [9], [10] and [11]). The hedging point policy has been adapted in [12] to take into account the pollutant emissions during the production.

In this paper, based on the results obtained in [12], we redefine the hedging point policy to include at the same time the three pillars of sustainable development. For this, we propose to use fuzzy logic which is a very interesting tool for representing human factors [13]. Indeed, fuzzy logic defined by L. Zadeh in 1965 is well suited and powerful for vague or qualitative notions [14]. Then, we propose a fuzzy hedging point policy control based on a Mamdani model [15] and empirical data in order to easily change and adapt our fuzzy system with actual and real data.

This paper is organized as follows. Section 2 addresses the considered problem and presents the sustainable manufacturing system. In section 3, our fuzzy hedging point system is detailed and explained. Numerical results are given in section 4 and a discussion is proposed. We conclude the paper and give some perspectives to our work in section 5.

II. SUSTAINABLE MANUFACTURING SYSTEM

To simplify our study and the presentation, we consider a single-stage single-product manufacturing system composed...
Dynamic lot-sizing-based working capital requirement minimization model with infinite capacity

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Abstract—Tactical planning consists of developing production plans to fulfill client demands with a minimal logistic cost. However, plans generated by classical models for tactical planning do not consider a minimum financial need in terms of Working Capital Requirements (WCR) to maintain the activities related to the operating cycle. In this paper, we introduce a first link between tactical planning and the financial aspects of WCR. The concept of WCR is widely used in practice to assess the financial situation at any time. We propose a new generic WCR model which allows us to evaluate the company’s financial situation during the planning horizon. In addition, we develop a dynamic lot-sizing-based model with WCR modeling for single-site, single-level, single-product and infinite capacity cases. An exact algorithm is also presented with numerical tests in order to compare our approach with the traditional dynamic lot-sizing model.

I. INTRODUCTION

Serving the business strategy, efficient production and transportation management in the medium term (6-18 months) significantly improves the performance and enhances the competitiveness of companies. For these purposes, we are interested in all decisions related to production at the right time and lowest cost. A good production plan should facilitate the achievement of this objective. Such a plan should also include planning for the acquisition of resources, raw materials and all necessary production activities of intermediates and final products manufacturing. Grouping product manufacturing in lots is one of the most applied approaches in industry. It naturally implies a problem which is to determine the best lot sizes to meet demand at the lowest cost, known as the lot-sizing problem. In the literature, the Economic Lot-Sizing Problem (ELSP) is proposed for the problem with deterministic and constant demand over an infinite planning horizon by [1]. On the other hand, the Dynamic Lot-Sizing Problem (Dynamic LSP) tackles the case with time-varying demand in a finite horizon [2]. These problems have been widely studied in the past as presented in the literature review of [3]. In this paper, we focus on the Dynamic LSP problem. This problem aims at determining the timing and quantity of production lots with a total cost minimization objective. This total cost generally includes production, set-up and inventory costs. For several years, this problem has represented a new challenge in Supply Chain optimization, especially in multi-plant context as studied in [4]. It models the supply chain more realistically and aims at synchronizing production plans in factories and distribution plans, as well as plans of other actors in the same chain. Several recent models are discussed in [3]. Moreover, new trends recently appeared in the literature, as green supply chain planning [5] and production planning with carbon emissions considered in both ELSP [6] and dynamic LSP [7] cases.

Companies also need to cautiously manage their cash flow to ensure financial liquidity in the development phase or risk economic hardship. The working capital requirement (WCR) metric is known as a key indicator to monitor and control the financial situation of a company. Both operation and non-operation related requirements are considered in the real world. However, we consider only the operations-related working capital requirements (OWCR) in this work. The OWCR includes all financial needs generated in the operation cycle which roughly contains five steps: 1) order receiving, 2) procurement of raw materials, 3) manufacturing, 4) inventory and 5) final product distribution. In this operation cycle, essential operations can be categorized in acquisition of raw materials, machine configuration, production and inventory. According to [8], the OWCR is generated due to the fact that, in practice, there is a mismatch between the essential cost for production operations (i.e., accounts payable) and client payments (i.e., accounts receivable). Thus, positive OWCR represents the need
Local and global optimization in raw material processing

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Abstract—In this paper we are interested in the mine planning. The aims of this paper is to propose a new model of global optimization for bloc extraction and smelting furnace and then evaluate the advantage to use a global model rather than a set of local optimization. In fact, organizing a global optimization between mines extraction site and smelting furnace require a reorganization of the mines planning service and the smelting furnace planning service. Show the advantage of a global optimization approach is the first step of the process of a global optimization. The proposed model is capable of optimizing mining complexes and takes into account the possibility to produce different types of products thanks to production policies dictated by the processing plant.

I. INTRODUCTION

The bulk of the literature deals with two principal types of mining exploitation: underground mining [1] and open pit mining [2]. We are interested in open pit mining. Most research in planning and scheduling aims to resolve problems linked to the open pit mining. In the literature, the principal problems are: the determination of the ultimate open pit limit (the determination of the sequence of extracted bloc) [3][4][5][6], the management of the mining process [7] and the global optimization solving [8][9]. These different types of problems present different types of methods of resolution. These methods which are mostly: simplex, metaheuristics are dictated by the constraints, the decisions and objectives specific to each problem. To the best of our knowledge, the two principal types of models to represent these problems are: local models [4][5] and global models [8][9]. To resolve the problem related to the determination of the ultimate pit limit and the determination of the sequence of extracted bloc, several algorithm are developed based on metaheuristic, such as ant colony [3]. Godoy and Dimitrakopoulos (2004) applied simulated annealing method on the effective management of waste mining and orebody grade uncertainty. In [7], Dimitrakopoulos and Goodfellow (2013), combined two metaheuristics : simulated annealing and particle swarm optimization algorithm. Concerning, problem related to the mine planning there is a method to minimize perturbation during re-planning: [10] proposed three alternative formulations of the MIP (Mix Integer Programming) model.

All the products are the results of complexes processes. These processes are principally: raw material extraction, transport and transformation. These processes required actors. There are different types of actors and different kinds of interactions between these actors. The actors are classified in two principal categories : suppliers and customers. The interactions between these actors are: demand and supply.

This article focuses on the first steps of a generic chain production that is to say the steps where extraction, processing raw material and selling mining products, takes place. These activities of extraction and processing raw material are optimized to increase profit generated by the selling activity.

Consequently and as we said before, the principal steps in optimization are: first, defining the problem that we should resolve then developing a model to represent the problem and finally proposing methods and algorithm to resolve the problem.

However a main aspect of an optimization is gathering information [11]. Whittle in [11] presented the main actors and the principal informations that must be taking into account during an optimization process. Furthermore, communication between the actors is important that is to say every actors involved should be aware of the actions and results implemented in this endeavour. These different steps are complementary. Thus, in the literature, local models are used to represent local problems. These local models have a relatively low calculation time. However, we also find global models that aim to a global optimization of a mine complex. These global models closed to reality will give credibility to the associated optimization. However, some global models are simplified to avoid challenges associated with the global optimization(e.g. stockpile is not integrated to the model). Another aspect of the mine complex is the safety aspect: Tong Lei and Dou Yuanyuan,[12], proposed an approach by simulation to highlight the fact that investing in safety is benefic to the future. We understand that, preparing an accident will cost less expensive when it actually declare.

A common element of the different models that we have presented previously is the objective function. Indeed, the principal objective of the optimization of a mining process is to maximize profit. To optimize the activity of a mine complex, two approaches are possible : a global approach and a local approach. This paper aims to discuss the comparison between these two approaches. As a consequence, we have two local models and a global model. First, local models of extracting blocs, blending process and fusion process are proposed. The presentation of the different model and the implementation with generated data lead to several test. These test conduce to a comparison between profit generated by local and global approaches.
Abdelhakim Artiba

In this regular session many aspects of production problems are developed with regards to the following:

Some topics developed in this session:

- Inventory model;
- Manufacturing environments;
- Maintenance optimization;
- Fuzzy Hierarchical;
- Quality Management System;
- Dynamic lot-sizing;
- Optimization.

Presented papers:

- *Flow Line Balancing Problem: a survey*
- *MRP vs Demand-Driven MRP: Towards an Objective Comparison.*
- *A model for master production scheduling in automotive powertrain plants: A case study*
- *A Variable Neighborhood Search (VNS) metaheuristic for Multiprocessor Scheduling Problem with Communication Delays*
Flow Line Balancing Problem: a survey
(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4e2 2015

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Abstract— Flow lines are widely used in mechanical industry. They consist to a set of workstations through which parts are manufactured. Designing such a line is a very complex problem due to manufacturing and design constraints and to the large number of possible decisions. Usually, the design of this type of production lines involves the selection of the necessary operations (indivisible units of work) to machine a part, the configuration design, the line scheduling. In this paper we present a survey of flow lines balancing problem, their approach and formulation and some solutions to optimize them studied in the literature. A special attention is paid for the assembly lines balancing problems.

Keywords—Line balancing, line design, process planning, resource planning, line scheduling.

I. INTRODUCTION

A flow line consists of a sequence of workstations through which one or more products move one way in order to be processed. Originally, such a type of manufacturing organization was developed, and used to be employed, in order to enhance the performance and reduce the costs in the context of high-volume or mass production [1]. However, nowadays due to using advanced flexible equipment, it becomes available even for low volume production. Nevertheless, such manufacturing systems are still associated with high investment cost. This makes designing a flow line a long-term decision problem. It is a hard task that requires many crucial decisions affecting the manufacturing time and the cost of the product. Since, in practice, it is impossible to solve all these decision problems globally, by a unique optimization procedure or by a single person, the design process is split into several stages [2]. Each stage is characterized by the length of planning horizon and the data required for decision making process. Usually, they are considered iteratively, each previous stage provides the input data for the consequent one. Schematically, the design approach can be presented as follows [3]:

1) product design or product family constitution,
2) process selection,
3) line balancing,
4) line layout design,
5) production scheduling.

Despite the fact that often these stages are dealt with by different deciders, the common design objective trades off between cost, reliability, imbalance between stations, productivity and functionality [4]. To enhance the final line performance, it is necessary to consider several decision problems simultaneously. In this paper, we present an overview of flow lines balancing problems recently appeared in the literature which try to expand the core optimization problem dealing with assigning tasks to workstations by solving it jointly with another decision problems such as process planning or configuration design. In spite of the fact that previously the most attention was paid for the balancing problems concerning the assembly systems, the approaches and formulations of flow line balancing in machining environment are analysed as well.

II. LINE BALANCING

Under the term line balancing various decision problems have been presented in the literature. One of the first line balancing problems was introduced in an assembly environment by Salveson [5]. This formulation is used to be considered as a core line balancing problem, which deals with assigning the set of indivisible units of work (named tasks or operations) to a sequence of lineally ordered workstations. Each task is characterized by its processing time and the set of its predecessors (other operations that must be imperatively completed before). The given order relations among tasks must be respected while the assignment process, the constraints of this type are known as precedence constraints. The operations assigned to the same station are performed sequentially. The sum of their operation times (the workload of each station) cannot exceed a given value c referred to as cycle time.

This problem, referred to as Simple Assembly Line Balancing Problem (SALBP) since 1986 due to (Baybars [6] has been intensively studied in the literature. The objective is to minimize the line idle time by reducing the number of workstations (SALBP-1) or the line cycle time (SALBP-2) while meeting the precedence and cycle time constraints [7], [8].

As a result, many exact and heuristic methods were developed. Reviews of the approaches suggested for solving SALBP can be found, for example in [8], [9], [10], [11].

A solution for the basic line balancing problem indicates which tasks should be completed on which workstations. It
MRP vs. Demand-Driven MRP: Towards an Objective Comparison

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Abstract—The Demand-Driven MRP (DDMRP) is a recent method focusing on manufacturing and distribution flows that is supposed to manage uncertainties better than traditional Manufacturing Resources Planning (MRP). Nevertheless, this assertion has never been scientifically demonstrated. In this paper, a case study is investigated in order to objectively and quantitatively compare these two systems. A Discrete-Event Simulation (DES) approach is used to evaluate the impacts on systems behaviours regarding both management methods. The final goal of our work research is to objectivise the reality of the DDMRP benefits.

Keywords—Flow management; MRPII; Demand-Driven MRP; Discrete-Event Simulation.

I. Introduction and Research Statement

Satisfying customers is companies’ main purpose. In order to achieve this goal, they must perfectly manage their flows and deliver their products on time. In order to always deliver on time, lots of companies significantly raise their Work In Progress (WIP). However this WIP costs a lot of money. That is why the second goal is also to minimise the WIP amount all along the process. This second objective is even more relevant given the worldwide economic crisis.

To manage physical or economical flows lots of methods are known. Manufacturing Resource Planning (MRPII) is one of the well-known method [1] and the most followed in the world. Other methods, pull flow management (production depends on the real consumption, the real demand) are also widespread. The main pull flow policies are Kanban that is a subsystem of the Toyota Production System (TPS) [2] and ConWIP (Constraint Work In Progress) [3] that aims at managing the total amount of WIP in the process.

Another recent and promising method is Demand-Driven Material Requirements Planning (DDMRP) [4]. “DDMRP is a multi-echelon demand and supply planning and execution methodology.” It is developing since 2000 and is already set up in numerous companies in the United States. Furthermore it is spreading in Europe and Asia and generates an increasing interest of industrial managers. Its main originalities are in the strategic DDMRP buffer positioning, dimensioning and replenishment so that the different sources of variability (from supply, operational, demand and management) can be managed. Therefore, DDMRP is recognised as a right solution by combining best practices of MRPII [1], Lean [5], Theory Of Constraints (TOC) [6], Distribution Resource Planning [7], 6 sigma [8] and with some innovations. DDMRP highlights MRP and Lean deficiencies. It is a promising method but there is no scientific comparison to objectively demonstrate the differences between managing flow with DDMRP or MRPII and other pulling methods such as Kanban or ConWIP.

We can therefore formulate two research statements (RS) as follows:

RS1. What are the main DDMRP contributions compared with other management flow policy?

RS2. Are there underlying hypothesis for the implementation of DDMRP?

This paper focuses on the comparison with the classical MRPII and is organised as follows. A literature review is used to identify potential DDMRP contributions. Then, a case study is introduced to evaluate DDMRP compared to MRP.

II. Literature review

A. Manufacturing Resource Planning (MRPII)

Manufacturing Resource Planning (MRPII) is the most widespread planning method in the world. MRP and then MRPII were developed in the 1970s. It requires demand forecasts and plans all the manufacturing activities: it is a push flow method.

MRPII is “a method for the effective planning of all resources of a manufacturing company. Ideally it addresses...
A model for master production scheduling in automotive powertrain plants: a case study

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Abstract—Based on a case study in the automotive industry, this paper presents a mathematical model dedicated to support the master production scheduling process in powertrain plants. Powertrain plants produce engines, gearboxes, and chassis parts that supply the car assembly plants and spare parts centers. The proposed model helps to decide, every week, for each production line, on the quantities to be produced of each product over a planning horizon of several days. The weekly production planning process is called the master production scheduling process.

The aim of production planning is to decide about the quantity to be produced of each product, about the time at which such quantity have to be produced, and often about, the production facility on which the production must take place. According to Pochet and Wolsey [5], it is usually an operational to tactical planning problem (short to medium-term) where the usual objective is to meet forecast demand at minimum cost. In other words, the goal is to make planning decisions optimizing the tradeoff between economic objectives such as cost minimization or maximization of contribution to profit and the less tangible objective of customer satisfaction. Thus, production Planning is an important decision process for any manufacturing firm since it has direct implications on supply chain cost and customer satisfaction.

In the scientific literature, several studies have been made on production planning problems. A recent literature review done by Comelli and al. [6] gives an overview of mathematical models used to solve tactical planning problems. Based on more than seventy papers, this review classifies the models according to five parameters: mono or multi-level, mono or multi-objective, linear or integer programming, deterministic or stochastic model, and the problem of interest.
A Variable Neighborhood Search (VNS) metaheuristic for Multiprocessor Scheduling Problem with Communication Delays

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Abstract—The purpose of this paper is to present a Variable Neighborhood Search (VNS) metaheuristic for solving the Multiprocessor Scheduling Problem with Communication Delays (MSPCD). The MSPCD problem considers scheduling task graph on a multiprocessor system, taking into account communication delays. The task graph contains precedence relations as well as the amount of exchanged data between tasks. The multiprocessor architecture is composed by a set of identical processors connected in an arbitrary way. The communication is defined through two symmetric matrices containing, respectively, the communication rate and the access cost between each two processors. Unlike the proposed VNS in the literature, we use a different representation of the solutions that leads to the definition of two natural neighborhoods structures. Computational experience shows advantages of our approach.

Keywords: Multiprocessors, Task Scheduling, Communication delay, Variable Neighborhood Search, VNS, Metaheuristics.

I. INTRODUCTION

In this paper, we consider the Multiprocessors scheduling problem with communication delays (MSPCD) with the following characteristics. The dependency between tasks that should be executed are modelled as a directed acyclic graph, where the vertex set corresponds to tasks and the arcs set gives the logical precedence between tasks, where both the vertex and arcs are weighted. The weight of a vertex indicates the task processing time, while the weight of an arc corresponds to the amount of inter-task exchanged data. The computing network (network with processors) is assumed to be represented by a complete graph. We consider here homogeneous case, i.e., the computing units are identical. Thus, the vertices in the communication network represent computing units (processors) and the edges correspond to the communication medium between each two computing units. The communication depends on the exchanged data between task and the distance between computing units. The objective is to minimize the makespan, the maximum completion time, i.e., the end time of the last task to be processed.

The problem is then to map efficiently the tasks onto the processing network. We have to assign tasks to processing units such that each task respects the precedence and communication constraints to assure the semantics of the original program are preserved. Therefore, for each task, we need to decide a time at which its execution is started and a processing unit that is responsible for its execution. Each task must be processed and the whole graph should be planned on the available resources. The precedence and communication between the tasks executed must be respected. Note that a task can be executed on a given processor only when all data from its predecessors become available to that processor. There is no overlapping between tasks assigned to the same processing unit. Each processing unit could execute only one task at a time. The pre-emption is not allowed in our case.

The main contribution of this paper is a practical contribution, we adapt and apply the Variable Neighborhood Search (VNS) metaheuristic to the Multiprocessor Scheduling Problem with Communication Delays (MSPCD). We introduce a new GVNS with a new representation of the solution. The solution coding allows a definition of rich neighborhood structures that could lead a better exploration of all potential solution rapidly.

This paper is organized as follows. Section 2 gives a description of the problem. In the sections 3 we present our metaheuristic. Then we conclude this work in section 4.

II. RELATED WORKS

Rayward-Smith [21] was the first to address the communication delay case in solving MSP. He studied the case with a unit communication delay, prove that it is NP-hard and propose a generalized list schedule. Chrétienne and Picouleau [10] did a survey for the general case with communication delays. They present a list of existing variants on MSPCD, give an overview of their complexity and solution methods. For each class they describe the current knowledge regarding the edge between easy and difficult problems.

The majority of work deals with a metaheuristic based solution techniques, since the MSPCD problems are NP-hard (see e.g. [18], [14]). Moreover, the practical scheduling problems are even harder since they incorporate additional side constraints and / or optimize more than one objective. Hwang et al. [15] presents a comparison of algorithms for the case of identical processors with communication cost. Luo et al. [17] review 20 greedy algorithm for cases without communication.
In this regular session the management and services are developed with regards to many projects on the following topics:

Some topics developed in this session:

- Service systems;
- Strategy frameworks;
- Manufacturing services;
- Product service systems;
- Service Capacity.

Presented papers:

- Service Capacity Pooling in M/G/1 Service Systems
- Delays in construction projects - Causes and impacts
- Operations Strategy Frameworks in Manufacturing Services and Product-Service Systems
- Absorptive Capacity, Coopetition and Product Innovation: A comparative analysis between Italian and Portuguese Service Firms
Abstract—We study the cost-sharing problem among independent service providers in a service capacity pooling system. The effective improvement of such pooling system can be achieved by reducing the resource idleness in case of congestion. In this paper, we model both the service provider and the cooperative coalition as a single server queue. We attempt to answer the following questions: (i) which coalition strategy should be used; and (ii) which allocation rule should be selected in order to maintain the stability of the coalition? In particular, we consider the service pooling with a fixed service capacity for M/G/1 service systems. The benefit of the pooling system is due to the shortened waiting queue in the overall system. We develop the corresponding cooperative game with transferable utility, and analyze the core allocations. Although it is difficult to express a core allocation explicitly for the game, we prove the non-emptiness of the core. We give a reasonable expression of Equal Profit Method to distribute the cost for our game, and investigate a number of cost allocation rules under three typical situations to evaluate the gain of the service pooling strategy for each service provider. The numerical results show that the cost allocation rule proposed gives a reasonable cost-sharing result considering the contribution of each participant.

Key words: service pooling; queueing systems; cooperative game theory; core allocations; general service times

I. INTRODUCTION

Services play an important role in the world economy. Based on the report from the office of United States Trade Representative, four out of five jobs in US are proposed by service industry [1]. In France, service presents the biggest sector of the economy and accounts for 79% of total GDP according to statistical data from the World Bank. In the context of economic globalization, competition and cooperation in service industries are more and more popular in nowadays: price competition among fast food restaurant chains, operation combination of telecommunication companies, collaborative after-sell and maintenance services in electronic manufacturing industry etc. In this paper, we focus on the collaboration benefit between several independent service providers in terms of capacity sharing. In order to make service systems more efficient, there are several basic cooperative methods: queueing cooperation, e.g., scheduling among simultaneous arrival agencies or rerouting among different servers [2], [3]; service pooling, e.g., service rate pooling or staffing allocation [4]; cross-training [5]; collaboration with third-party service providers, e.g., service outsourcing [6], etc. In some cases, different methods can be combined to form a more profitable collaborative structure [7]. Under certain conditions, service providers could earn more revenue or reduce expenses by using the collaboration methods mentioned above.

All the previous methods can be classified broadly into three typical cooperation forms: vertical form, i.e., collaboration between customers and servers; horizontal form, i.e., collaboration among homogeneous servers; and external form, e.g., collaborative outsourcing. We focus in this study on horizontal service pooling among independent service providers. The obvious gain is the mitigated congestion in the cooperative system, owing to the disappearance of servers’ idleness with waiting customers in the queues. Altogether, the coalition service set is more efficient than individual ones. The pooling advantage for the whole system is apparent, but the collaborative gain of the entire alliance cannot be the incentive for each individual service provider to join the coalition. It is therefore important to address the following questions: which independent service providers should collaborate together; and how to share the cost of the pooling system among the participants to keep each individual staying in the coalition?

In this paper, we consider a set of independent single-server service providers, each of which faces its own incoming stream of customers/demand. Customer inter-arrival and service times are assumed to be random and distributed independently. We suppose that an individual incoming stream is strictly unrelated to those of other providers. This means that there is no competitive relationship among service providers in the set. The providers in the coalition could then join a profitable coalition by operating their service capacities in common. Alternatively, each provider could make his own decision independently to either join any coalition or not, based on his individual benefit. Once the coalitions is formed, the most important problem in the entire coalition for every independent provider returns to a cost-sharing problem under collaboration.

Cooperative game theory provides interesting concepts to find profitable coalition structures and solves the cost sharing problem among cooperative players. We assume that the total cost is a transferable utility, e.g., money in the general case. The corresponding cooperative game with transferable utility (TU-game) is defined among the set of independent service providers, and has a characteristic function defined by the total operating costs associated with each coalition for the cases of fixed system capacity. In order to make a profitable service pooling strategy, we prove that the system total cost could be minimized in the grand coalition. Therefore, as mentioned above, we focus on the cost-sharing problem to guarantee the stability of the grand coalition.

There exists a large literature focusing on the cooperative
Delays in construction projects - Causes and impacts
(presented at the 6th IESM Conference, October 2015, Seville, Spain) © IEEE 2015

Abstract—The main aim of this paper is to identify the main causes for the delays in the Portuguese construction industry and its impact, with the purpose of increasing knowledge on the causes and impacts of delays in construction projects. The Relative Importance Index was adopted to classify the importance of the 47 causes and six impacts identified causes of delays. Results show the main causes of delay are slow decision-making, changes to orders, unrealistic timescales and poor contract specifications, financial constraints on the contractor and the type of bidding and contract award process. The main impacts are time and cost overruns and disputes. Factor analysis revealed eight high-level causes that result in 26 of the original causes. Finally, Pearson correlation coefficients were calculated to find the relationship between the extracted factors (latent causes) and impacts, revealing that lack of commitment and sub-standard contracts are positively correlated with all impacts and poor consultant performance is negatively correlated with time overrun. These findings are expected to improve the scientific community's knowledge of construction management.

Keywords—construction industry; construction delays; relative importance index;

I. INTRODUCTION

Regardless the type and localization, delays in construction projects have always been an important issue. Assaf and Al-Hejji [1] define delay in construction as the time overrun either beyond the date the contract parties agree upon for delivery of a project, or beyond the completion date specified in the respective contract. A project is considered successful if it meets the requirements of 3 major indicators: time, cost and quality. However, the timely completion of a project was frequently seen as one of the major parameters for evaluating project success [2].

To overcome delays, projects are prolonged or speeded with additional costs. As project delays are so recurrent, it is common practice for a contingency cost to be considered in the contract, which is usually a fraction of the total contract price [3]. As a consequence of delays, a variety of problems can result, particularly financial problems, which frequently result in conflicts between the entities involved: contractors, consultants and developers. Notwithstanding all the efforts, the project design and construction complexity makes it often hard to find the causes of the delays, which often are interconnected [4]. The Portuguese scenario is no different and delays affect a large fraction of construction projects. Nevertheless, in recent years, the financial crisis has resulted in stagnation in the industry, forcing some firms to move abroad or declare bankruptcy. Consequently, the industry is becoming increasingly more competitive and improving the time and cost factors has become indispensable for contractors. Concerning this matter, a number of studies have been done but outside the Portuguese context. Thus, the aim of this research work is to identify the main causes and impacts of delays in the Portuguese construction industry and comprehend the links between them. It is also important to assess whether there are differences in perception between the entities involved in construction projects.

II. DELAYS IN THE CONSTRUCTION PROJECTS

In recent decades several researchers have studied the causes and impacts of delays in the construction industry. Mansfield et al. [5], using a questionnaire survey conducted with contractors, consultants and developers, found 16 major causes of delays and cost overruns in Nigerian construction projects, and they concluded that the main causes of delays had to do with finance and payment issues, poor contract management, shortage in materials, inaccurate estimates and price fluctuations.

Ogunlana et al. [6] led a study on causes of delays in Thailand, analyzing 12 skyscraper projects and they identified 26 causes and concluded that material shortages, especially cement, nonexistence of qualified workforce, change orders by the developers and lack of contractor experience were the most important ones. Chan and Kumaraswamy [3] conducted questionnaire survey in Hong Kong with contractors, consultants and developers with aim to classifying the relative importance of 83 causes of delays. The main causes of delay identified were poor site management and supervision, unforeseen ground conditions, low speed of decision making involving all project teams, developer initiated variations and necessary variations of work. Odeh and Battaineh [7] conducted a questionnaire survey in Jordan to evaluate the relative importance of 28 pre-selected causes of delays in traditional construction projects. They determined that the major causes of delays were inadequate contractor experience, developer interference, delay in progress payments by the developer, slow decision making by the developer, improper

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Operations Strategy Frameworks in Manufacturing, Services and Product-Service Systems

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Abstract— Many definitions for operations strategy appear in literature. Yet, after analysing some of these important definitions, there were some common denominators: planning and decision-making. It is through correct operations strategy planning and decisions that organizations achieve competitive edge, and for this reason, the subject is of major importance. In this paper we present a review on operations strategy (OS) in manufacturing, services and product-service organizations. Through the literature analysis we found several differences and fewer similarities between OS in manufacturing and services and also the positioning of product-service systems (PSS) OS, comparing to OS in manufacturing and in services. Our foremost contribution is providing a literature review and an analysis on the content of the OS frameworks.

Keywords— framework; manufacturing; operations strategy; product-service systems; services

I. INTRODUCTION

Skinner [1] introduced for the first time the concept of an operations strategy (OS). Since then, several definitions for OS appeared in literature. A few examples include the definition by Lowson (2001) [2], Slack and Lewis [3], Van Mieghem [4], or Reid and Sanders [5]. Despite being different, all share common characteristics. There is always the conversion of objectives into action plans, a decision pattern involved in the concept, and all the decisions are medium to long term. Briefly, the purpose of OS is that organizations properly use their competencies, processes and resources to achieve a strong competitive advantage [6], and successfully create value for customers and stakeholders [7]. However, considering Porter’s work [8], Enders et al. [9] agree that creating superior value for customers is not sufficient to insure profits; the company must succeed in capturing value. Strategy should be a nonstop learning process as markets are now global and their settings are always changing. It is crucial to have skills to learn to cope with changes [10, 11] and even revise the first strategic plan [12]. Thus, all members in an organization have the duty to bind themselves to a continuous learning process and strategy formation [10, 13], being communication a key asset [14]. Constant knowledge building is a competitive advantage [15].

Inside an organization, each division’s performance - operations management (OM), technology selection, product development, human resources, among others - is affected by OS [16-19]. Given the impact of OS in organizations, some specialize in specific tasks, while others have to be outsourced. This is a means for higher efficiency and cost reduction [20]. It is important that companies tie strategic objectives to operational capabilities, and understand their limits [21, 22].

There are two elements in OS, as stated by Martín-Peña et al. [23]: competitive priorities (CPs) and operations decisions. The first refers to aims the organization pursues and identifies the areas where operations should be outstanding to offer competitive advantage; the second relates to decisions that aid in achieving the operations and corporate goals and can be split into structural and infrastructural. This division was first proposed by Hayes and Wheelwright in 1984 [24].

Van Mieghem [4] proposed a conceptual framework for OS with three crucial components: competencies, resources and processes, as in Fig.1. The framework can build on the market view to define the competencies that operations should develop through proper selection of resources and processes. This refers to a customer driven organization. Indeed, the same framework can be seen from a different perspective, the resource and processes perspective. Here, the resources and products are the strategic building blocks; therefore, it is possible to insure that the value proposition offered to customers will be properly delivered. The second view is resource driven.

The strategy can also be seen as directed or emergent. The first allows the senior management in an organization to build a correct planning for the organization of the internal resources, considering the external environment, and the stakeholders’ demands. The second focuses on developing, organizing and using resources to attain operational excellence, competitive advantage, market share and good performance [25].

There has been evolution in the concept of OS due to change in market demands. The OS appeared to respond to highly variable demands from customers [26, 27]. With variety in the OS implementation, companies are challenged to

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Fig. 1. Operations Strategy Framework (adapted from [4]).
Absorptive Capacity, Coopetition and Product Innovation: A comparative analysis between Italian and Portuguese Service Firms

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Abstract—This paper focuses on the effects of absorptive capacity and coopetition on the generation of product innovation, by making use of service firms, both Knowledge intensive (KIS) and Less Knowledge intensive service (LKIS) firms, from Italy and Portugal. For this purpose, we use two datasets of 8647 Italian service firms and 2500 Portuguese service firms that participated in the European Community Innovation Survey (CIS), 2010. A logit analysis is conducted for ‘KIS’ and ‘LKIS’ firms and, the results reveal that for both KIS and LKIS service firms in Italy, absorptive capacity enablers, such as external R&D, internal R&D and employees expertise have a positive and significant effect on the generation of product innovation. In addition, the establishment of coopetition relationships with Italian concurrent firms denotes a positive and significant effect on the generation of product innovation. Furthermore, for the LKIS service Italian firms, the coopetition relations with rival firms located in China and India also denotes a positive and significant impact on product innovation. For the Portuguese KIS firms, we find out that the internal R&D activities and acquisition of external R&D have a positive and significant effect on the generation of product innovation. In addition, the set of coopetition relationships with concurrent European firms also presents a positive and significant effect on the generation of product innovation. For the LKIS firms, the internal R&D and the external R&D also impact positively and in a significant way on the generation of innovation. Moreover, for this sub-sample, the coopetition schemes with rival companies inside the country also denote a significant and positive effect on the firms’ product innovation.

Keywords—Absorptive Capacity; Coopetition; Innovation; Knowledge intensive (KIS) and Less Knowledge intensive service (LKIS) firms.

I. INTRODUCTION

The concept of absorptive capacity is based in an individual cognitive structure that deals with problem solving and learning cumulative processes. The individual level comes into the organizational level, with memory and application capacities, for associating and connecting ideas that generate new knowledge (Cohen and Levinthal, 1989, 1990).

The firm’s search for external sources of new knowledge spillovers embraces a set of problem solving activities, involving the creation of innovations and the recombination of technological ideas to generate new knowledge and innovation.

Absorptive capacity is the ability of firms to recognize and exploit knowledge flows and can act as a competitive advantage.

As so, absorptive capacity depends on the firm’s enablers, namely the knowledge stock embedded in its processes, people and products and it is determined by cumulative learning and subsequent learning performance, depending on the knowledge held by individuals (Cohen and Levinthal, 1989, 1990). This previous knowledge stock enables the individual to assimilate better external flows and to use them for creating new settings (King and Lakhani, 2011).

Authors like Camisón and Forés (2010) and García Morales et al. (2007, 2012) argue that the firm’s absorptive capacity makes employees more innovation oriented, by using technological skills and by being involved in a learning context making the firm achieve a more complex knowledge structure.

This use of knowledge spillovers by means of the firm’s absorptive capacity, fosters firm’s internal innovation and develops its markets (Chesbrough et al., 2006), being coopetition a sort of knowledge inflows.

Coopetition is an inter-organizational relationship, making a combination between cooperation and competition (Bengtsson and Kock, 2000; Bouncken et al., 2015).

Several benefits and risks can arise from coopetition relationships. In terms of benefits, we can point the creation of greater value, and the improvement of economic performance (Rusko, 2011), sharing risks, costs and expertise (Chesbrough, 2003; Huston and Sakkab, 2006; Enkel et al., 2009; Gasemann et al., 2010), achieving synergetic effects, getting economies of scale and sharing activities (Luo, 2007; Chin et al., 2008; Ginyawati and Park, 2009, 2011), pooling R&D activities and having access to external knowledge and resources that the
In this regular session the management and services are developed with regards to many projects on the following topics:

Some topics developed in this session:

- PROMETHEE;
- Supply Chain Risks;
- Network modeling;
- Risk management.

Presented papers:

- *An ANP-PROMETHEE model for supplier selection and a case study*
- *Evaluation of Control Strategies for Managing Supply Chain Risks using Bayesian Belief Networks*
- *IP/MPLS network modeling using Bayesian networks to improve double failure recovery*
- *Risk management in the modern retail supply chain: Lessons from a case study and literature review*
- *Analytic Network Process Approach for Automatic Teller Machines Deployment Problem*
- *Towards a Model of Integration between Risk Management and Lesson Learned for Project Management*
An ANP-PROMETHEE model for supplier selection and a case study

(Presented at the 6th IESM Conference, October 2015, Seville, Spain) © IEEE 2015

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Abstract—The supplier selection problem is one of the strategic decisions that have a significant impact on the performance of the supply chain. In this study, supplier selection problem of a well-known refining company in Africa is investigated and an integrated ANP-PROMETHEE methodology is used to select the best supplier providing the most customer satisfaction for the criteria determined. After the main criteria and sub-criteria for supplier selection are defined to construct the ANP model, the weights of criteria are calculated using Analytic network process approach and then PROMETHEE method is used for optimal ranking of the alternatives. The effectiveness of this methodology for the selection of the best supplier among three alternatives for process chemicals used for refining processes has been demonstrated.

Keywords—Supplier Selection; ANP; PROMETHEE; refining company;

I. INTRODUCTION

Since 1960s, supplier selection criteria have been a focal point for many researchers. Supplier selection is nowadays one of the critical topics in supply chain management. The performance of potential suppliers is evaluated against multiple criteria rather than considering a single factor-cost, there are many criteria for evaluation and selection of the best supplier. In the literature, several empirical and exploratory studies on the problem of selection and evaluation of suppliers have emerged to show the strategic importance of this problem. Dickson [1] identified 23 criteria for supplier selection, the study showed that supplier selection is a multi-criteria decision problem which involves the simultaneous consideration of various criteria such as price, delivery time and quality, and it is extremely difficult to find a perfect supplier.

Weber and Ellram [2] analyzed 74 articles published between 1966 and 1990 dealing with this problem. Zhang and Lei [3] compare Dickson and Weber study, and summarized new supplier selection criteria from the study of 49 articles from 1992 to 2003. Extensive multi-criteria decision making approaches have been proposed for supplier selection, such as the analytic hierarchy process (AHP), Analytic Network Process (ANP), Case-Based Reasoning (CBR), mathematical programming, Data Envelopment Analysis (DEA), Genetic Algorithm (GA)...
The AHP [4] is one of the most widely used MCDM methods which decomposes a problem into several levels that make up a hierarchy in which each decision element is supposed to be independent. AHP can only be employed in hierarchical decision models, however, many decision problems cannot be structured hierarchically and real world problems usually consist of dependence or feedback between elements. Analytic Network Process (ANP) [5] is a generalization of the (AHP), it considers the dependence between the elements of the hierarchy. Saaty applied ANP to handle dependence among criteria and alternatives without assuming independent decision criteria. The ANP feedback approach replaces hierarchies with networks, and emphasizes interdependent relationships among various decision-making [6], also interdependencies among the decision criteria and permit more systematic analysis. ANP is used very often in combination with other methods. ANP is used in combination with goal programming approach [7], and DEMATEL (Decision- Making Trial and Evaluation Laboratory) approach [8], [9]. Lin, Chen and Ting [10] used ANP and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) to establish real-time purchasing environment. ANP and TOPSIS are used to calculate weight of criteria and rank suppliers. Demirtas and Usturn [11] applied ANP and multi-objective programming to a refrigerator-manufacturing unit.

The preference ranking organization method for enrichment evaluations (PROMETHEE) has received wide attention and has been applied in diverse areas. For instance, Cavallaro [12] utilized PROMETHEE II for selecting renewable energy installations from a number of alternatives that are operating in the area of Messina in Sicily. Mavrotas, Diakoulaki, and Caloghirou [13] utilized PROMETHEE V method which is combined with an integer programming formulation for Selection of firms for financial support. Araz and Ozkarahan [14] utilized PROMETHEE for Supplier evaluation and management.

The combination of two methods provides pleasant results, helps to reduce complexity, and increase the correctness, accuracy, and easiness of obtained results. So as to find the best
Evaluation of Control Strategies for Managing Supply Chain Risks using Bayesian Belief Networks

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Abstract—Supply chains have become complex and vulnerable and therefore, researchers are developing effective techniques in order to capture the complex structure of the supply network and interdependency between supply chain risks. Researchers have recently started using Bayesian Belief Networks for modelling supply chain risks. However, these models are still focused on limited domains of supply chain risk management like supplier selection, supplier performance evaluation and ranking. We have developed a comprehensive risk management process using Bayesian networks that captures all three stages of risk management including risk identification, risk assessment and risk evaluation. Our proposed new risk measures and evaluation scheme of different combinations of control strategies are considered as an important contribution to the literature. We have modelled supply network as a Bayesian Belief Network incorporating the supply network configuration, probabilistic interdependency between risks, resulting losses, risk mitigation control strategies and associated costs. An illustrative example is presented and three different models are solved corresponding to different risk attitudes of the decision maker. Based on our results, it is not always viable to implement control strategy at the most important risk factor because of the consideration of mitigation cost, relative loss and probabilistic interdependency between connected risk factors.

Keywords—supply chain risks; Bayesian Belief Networks; control strategies; risk measures

I. INTRODUCTION

Supply chains have become complex because of the globalization and outsourcing in manufacturing industries. Supply chain risk management (SCRM) is an active area of research that deals with the overall management of the risk events ranging across the entire spectrum of the supply chain including external risk factors. Supply chain risk is characterized by both the probability of an event and its severity given that an event occurs [1]. Following three components are found in all conceptualizations of risk [2]:

- Probability (likelihood) of the occurrence of an event that leads to realization of the risk
- Potential losses in case of realization of risk
- Significance of the consequences of losses

Bayesian Belief Networks (BBNs) have started gaining the interest of researchers in modelling supply chain risks [3]. BBNs offer a unique feature of modelling risks combining both the statistical data and subjective judgment in case of non-availability of data [4-6]. Researchers have used BBNs to model specific domains of supply chain risks and validated these models through case studies. BBN is a graphical representation of causal relationships between variables and associated uncertainty in the dependency in terms of conditional probabilities [4]. The variables are represented by nodes while an arc (directed between two nodes) represents direct causal relationship.

Research Gap and Contribution

Existing research in SCRM has not addressed a very important issue of evaluating different combinations of mitigation strategies in a setting of interconnected network of supply chain actors, corresponding risks, resulting losses, and costs and benefits associated with potential strategies. We utilize BBNs in bridging this major research gap and evaluate different combinations of mitigation strategies. Furthermore, we also introduce new risk measures for evaluating risk exposure of the supply network and incorporate risk attitude of the decision maker in our model using the feature of utility function.

Outline

Literature review including discussion on limitations of the existing BBN based models is briefly presented in Section II. We propose new risk measures and modelling approach in Section III. An illustrative example of a supply network including the modelling parameters is presented in Section IV. Results are presented and discussed in Section V followed by the conclusion and future research presented in Section VI.

II. LITERATURE REVIEW

Supply Chain Risk Management

“SCRM is the management of supply chain risks through coordination or collaboration amongst the supply chain partners so as to ensure profitability and continuity” [7]. “SCRM aims to identify the potential sources of supply chain risk and implement appropriate actions to avoid or contain
IP/MPLS network modeling using Bayesian networks to improve double failure recovery
(presented at the 6th IESM Conference, October 2015, Seville, Spain) © ¹e² 2015

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Abstract— Protocols engineering of IP/MPLS networks are constantly improving with new separated features and new resilience mechanisms. In the transportation of audiovisual signals domain we must compose with multicast protocols which are designed from other scientific developments. This audiovisual traffic due to his non springy nature presents a very huge sensitivity to network recovery after a failure and these effects can be amplified by end devices (encoding, decoding and MPEG IP encapsulation). In this way when we choose between engineering solutions the unique criterion of availability is not enough, we must complete by an impact analysis on the service made by the network resilience techniques. In this paper, we propose a first approach to analyze the behavior of different protocols engineering to improve selection. We propose using Bayesian networks to compare performance on different criteria and we will illustrate with two engineering models. The results focus on a real improvement of availability by choosing the adapted engineering solution.

Keywords — Protocol Modeling, Network Survivability, Bayesian Network, Engineering Choice, Availability, Dependability, Multicast Transport.

I. INTRODUCTION

A network service can be implemented using different ways considering topological and architectural views of the network, considering protocols accumulation and obviously considering client requirements on the quality of service. In the multicast transportation domain the protocols unified under the “multicast VPN” term have proved their fullness and are now available with different variants. Otherwise, the client requirements are rising while we are observing a clear fall of the performance about our transmission links which constitute the network infrastructure and especially on the availability point of view. Then we must strengthen the mesh of our network and improve our engineering solutions to use this entire new infrastructure for all point of service.

Networks specialized in audiovisual broadcasting possess particularities which are not a prerequisite for an efficient telecommunication network. Then a traditional network could be with a medium performance and could accept frequent rerouting or congestion on the contrary of an audiovisual network.

The goal of all networks is to be the more stable and the more resilient. In this context where we are talking about network survivability [1-2], the problems concerning failure resistance or cyber-attack are primordial. There are also other solutions as those based on autonomic networks [3-4] which consist to limit human interactions with the network. But these technics are not natively implemented in routers because of the long convergence time to a new steady state of autonomic systems. In addition we want that all recovery decisions of the network are totally automatic to react as fast as possible to a failure. Most of the time, engineers have different choices of implementation for the solution.

For the same physical structure, parts manufacturers allow to separate data for each client using network services related to a client. This possibility enables for each client to use his own resources and his own protocol engineering correctly adapted to his requirements.

Network services are implemented for each client and it is possible to adapt all the protocols for each client demand. In this context the customer is the final receiver on TV and clients are TV stations which pay for a broadcasting service.

Because of the innovation of technologies and all limitations, engineers are encourage to evolve engineering existing solutions to new innovative solutions which are bringing better performance. The choice of evolution and the comparison between two engineering solutions is most of the time conditioned by the experience of systems architects and with all the technical data given by parts manufacturers or by realizing prototype. The aim of this paper is to propose a decision support for the development of an engineering solution specialized in the multicast stream transportation guarantying all the above criteria. Although we could focus on every aspect of RAMS frameworks [5], only the customer availability will be considered. The first part will expose the modeling problematic and the target of this study. The second will explain the two engineering solutions, then the last part will present on simple cases how to apply this modeling solution and will show us on a real case the contribution of each solution to conclude this study.

II. PROTOCOL MODELING

Availability study for a client’s service is based on the physical infrastructure analysis but it is especially based on
Risk management in the modern retail supply chain: Lessons from a case study and literature review

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Abstract — In today’s increasingly risky and uncertain business and industrial environments, supply chains need to be more flexible and more robust to improve their performance. During the last decade supply chain risk management has emerged as a challenge on the strategic and operational supply chain issues. A deeply analysis of a case study has revealed that modern retail industry needs decision support tools to manage supply chain risks. These tools should cope with emerging practices and integrate many categories of risks. Of course, it has to be understood that risks can differ from one sector to another and from one supply chain to another and one country to another. In this paper we present preliminary research concepts and findings concerning the identification, the analysis and the modeling of risks in the modern retail supply chains. We propose a new framework for categorizing the risks in order to assess the overall impact on the performance of the retail supply chain. These risks were selected based on the literature review and on a case study of a leading retail company in Tunisia. Review of the literature on supply chain risk modeling techniques are presented and discussed. The paper concludes with numerical analysis of supply risk and comments on opportunities for further research on the area of supply chain risk and performance trade-off.

Keywords — Supply Chain Risk Management (SCRM); Modern retail supply chain; Risk categories, Risk modeling, Risk-performance trade-off.

I. INTRODUCTION

The vulnerability of modern retail supply chains increases with increasing supply chains exposure to risk and uncertainty. It’s recognized today that “a breakdown of any one element in a supply chain potentially causes disruptions for all partnering companies upstream and downstream” [1]. In the field of supply chain risk, there is confusion between terms such as vulnerability, disruption, risks and uncertainties. According to [2] risk is the expected outcome of an uncertain event, that we call “risk events”. Supply chain risk may result from many unexpected risk events as demand variability, product quality, production or storage capacities, supply reliability, or even economic crisis or natural disasters [3] [4].

Beside supply chain performance, managing supply chain risk is becoming one of the most critical responsibilities of supply chain managers. Supply chain risk management (SCRM) is defined as “the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity” [5]. Within the SCRM literature, the most commonly discussed dimensions of risk are probability and impact of losses. Therefore, there is a need of effective strategies to reduce the probability of risks and mitigate the impact of risks on the supply chain performance. It’s recognized today that the biggest challenge that companies face is managing supply chain risks for a better supply chain performance achievement.

It has to be understood that the retailing industry can differ from one country to another. Our partner, a leading company in the modern retail industry in Tunisia has expressed a growing need for decision support tools that reflect emerging practices of supply chain management and incorporate dimensions of risks in order to optimize its supply chain and improve its performance. The development of robust strategies for managing risk depends on first understanding the sources of risk, their interaction and their quantification and aggregation. The main objectives of our research are to identify the risks involved in the retail industry supply chains based on a case study; and to determine the interactions among identified risks and the supply chain performance outcome.

The paper is organized as follows: Section 2 surveys the literature on supply chain risks. The risks categories and the risks modeling techniques are than classified and discussed. Section 3 provides an overview of the company, case study, and presents the proposed categories of risks in the modern retail industry. In section 4, we share some of our computational results and analysis about supply risk and fill rate performance; and finally we conclude in section 5 with a discussion on perspectives about future work.
Analytic Network Process Approach for Automatic Teller Machines Deployment Problem
(presented at the 6th IESM Conference, October 2015, Seville, Spain) © IEEE 2015
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Abstract—Deciding facility location is a hard and sophisticated problem for decision makers as there are many criteria some of which are conflicting and subjective. Determining the location of an automatic teller machine (ATM) for deployment is also a challenging decision for banks which has not been addressed adequately in the literature up to now. Where to locate the automatic teller machines is a strategic and long-term decision therefore making the right decision is important for the banks. In this paper, both qualitative and quantitative criteria that should be considered are defined for ATM deployment problem. The criteria are categorized into main clusters in accordance with their similar characteristics and the interdependencies between them are explained. Analytic Network Process (ANP) methodology is preferred to evaluate the importance levels of these criteria. This study intends to build up a generic framework that can be used afterwards to determine the best locations for off-site ATMs of a bank which cover all customer demand and keep costs at a minimum level in ATM deployment problem. The study also covers the banks which have ATMs or do not have any ATMs and searching for the best locations in order to deploy new ATMs.

Keywords—automatic teller machines; location selection; multi-criteria decision making; analytic network process

I. INTRODUCTION

Nowadays, companies compete with each other in many service industries for maximizing customer satisfaction and minimizing their overall costs. Therefore, making service ready when customer needs, is the critical key factor of customer satisfaction and achieving this with the minimum cost becomes really important for companies to survive in these harsh economic conditions. Banks also take their sides in this economic battle and try to keep their costs at minimum level while making their customers satisfied with the provided service.

Automatic teller machines (ATMs) management is one of the crucial management problems for the banks to ensure sustainable profitability and customer satisfaction in today’s competitive environment. On the other hand, management of ATMs is a very complex issue for the banks as the process is related with a great deal of agents and variables. Different departments of the headquarters, branches, outsource companies, and customers are involved in the ATM Management process. Moreover, ATM management process involves several sub-processes such as deployment, cash management, security management, remote monitoring, and maintenance. Here, we choose to deal with deployment management issues as we think it is one of the most important ATM management problems.

Over the past two decades, service operations have been given a significant amount of attention in the literature. However, financial services have not been discussed as much as other service industries such as transportation, health care, entertainment, and hospitality [1].

Moreover, when we look into the literature related with banking although there are quite a few researches about operations management, marketing and sales processes such as; product design and offerings, campaign management, client relationship management, general cash management, lending operations, technology management, operational risk management, call centre management, and branch management, the scarcity of the studies about Automatic Teller Machines’ (ATMs) management problems can be easily seen. In the literature ATMs are also referred as “Automated Teller Machines” or “Auto Teller Machines”.

There are many components that have effect on ATM site selection decision. Some of these components can be measured whilst some of them can be expressed by subjective evaluations. Additionally, there are inherent factors which conflict with each other and influence the judgment positively or negatively. Moreover, the number of criteria that are need to be taken into account while deciding locations for ATMs, increases the problem complexity in addition to problem size.

From the bank perspective; ATMs are required to sustain their profitability and operability for an extended period of time after they start to operate. As a result of wrong decisions, moving or redeploying the machines may be perceived by the customers as there are problems with the bank and this may cause loss of reputation. The additional incurred costs due to moving or redeploying ATMs makes the problem more considerable.

In the study; we try to define and determine all the criteria that affect the location selection decision. Analytic Network Process (ANP) which is a multi-criteria decision making technique that takes all kinds of dependence and feedback into account in the decision problem is proposed to solve this complex multiple criteria real world problem.
Abstract—Lesson Learning is a process aiming to create knowledge through selection, analysis and reuse of past success and failures (experiences). This paper presents an approach to integrate a Lesson Learning System and a Risk Management Process in order to improve Project Management performance.

An integrated methodology is proposed, summarized in five activities, as well as decision support tools based on experience capitalization and risk-related knowledge creation. The created knowledge can then be applied to new analysis, mitigation of risk and increased project efficiency.

The proposed methodology offers a way to characterize and exploit past experiences in order to improve Project Risk Management.

I. INTRODUCTION

Project Management contributes to create a strategic value chain enabling companies to gain a competitive edge over rivals and in markets [1]. To carry out projects, managers must take into account a large number of contextual parameters (economic, environmental, social, security) and often, a large number of stakeholders. They should study the potential positive and negative consequences of their decisions and evaluate the risks as precisely as possible.

Increased complexity in projects means increased inherent risks [2]. Thus, Risk Management is now an integral part of Project Management. Risk Management (RM) can be defined as the systematic process of identifying, analyzing and responding to project risks [3]. A major objective of RM is to maximize the probability and consequences of positive events and to minimize the probability and consequences of events adverse to project performance. To improve risk analysis and to be efficient, project managers should reuse experiences and practices learned during past projects.

Unfortunately, capitalization of such experiences is traditionally a static stage at the project closeout; and therefore, it just enables the capture of few events memorized by the experts involved. In addition, the capitalized information is difficult to directly reuse in new risk analysis.

The objective of this paper is to present a model to improve Project Risk Management by integrating a dynamic Lesson Learning System. This paper is organized as follows: section II presents a literature review on existing approaches combining Project Management, Risk Management and a Lesson Learning System. Section III details the proposed integrated model for Project Risk Management. Finally, section IV concludes on the interests and limits of the proposed approach.

II. LITERATURE REVIEW

A. Project management

There are various standard approaches for managing projects, including, but not necessarily limited to, ISO 21500:2012, GAPPs, PMBOK Guide, and PRINCE2.

Fig. 1 presents the current model of Project Management (PM) described in the PMBOK. This methodology includes five processes: Initiating, Planning, Executing, Monitoring / Controlling and Closing that "guarantee" the effective progress of the project throughout its life cycle, along with a control system focused on the correct execution of the project to reach the expected objectives.

![Figure 1. Project Management processes](image_url)

Our goal is not to explain this methodology in detail, but the reader can consult the reference [3] for more information about
In this regular session the management and services are developed with regards to many projects on the following topics:

Some topics developed in this session:

• Dynamic modeling;
• Product Service Systems;
• Risk management;
• Market complexity.

Presented papers:

• A dynamic model for the redesign of a product and its upstream supply chain integrating PLM(Product Lifecycle Management) approach
• Analysis of time to market complexity: A case study of application of Bayesian networks as a forecasting tool
• Critical Success Factors for Effective Risk Management in New product Development
• Towards a Requirements Traceability Reference Model for Product Service Systems
• Why Product Service Systems Development is Special
A dynamic model for the redesign of a product and its upstream supply chain integrating PLM (Product Lifecycle Management) approach

Presented at the 6th IESM Conference, October 2015, Seville, Spain © I4e2 2015

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Abstract—This paper deals with a recent approach that tackles the product and the supply chain design issues at the same time. The simultaneous design of a product and its supply chain is relevant. In fact, supply chain decisions incorporated during the early phases of the product design enhance its performance. Therefore, collaboration among all supply chain partners is very important, especially at the product design phase. In this paper, we investigate the role of the PLM (Product Life Cycle Management) as a key to integrating product and supply chain optimization.

We study the case of an existing product’s redesign. The design change affects either the components or the process of the product or both of them at once. First, we present an UML model for designing the product and its supply chain integrating PLM. Then, we propose a mixed integer linear programming (MILP) formulation to determine simultaneously the optimal redesign alternative accompanied with its optimal upstream supply chain configuration. Being at a strategic design, time periods in the mathematical model are considered to be product life cycle phases. This consideration gave a dynamic aspect to the model. Finally a numerical example is given to illustrate the application of the model.

Keywords—Product Lifecycle Management (PLM); supply chain integration; product redesign; supply chain optimization; unified modeling language (UML).

I. INTRODUCTION
Today, customer’s needs are rapidly changing over the time. As a consequence, product lifecycle is becoming very shorter. To meet different segments of customer’s demands and to face high competitiveness, companies must innovate and diversify their products by introducing constantly new products to the market.

New product design implies, certainly, the configuration of its corresponding supply chain. A better performance is achieved only if the designed product meets customer’s needs on one hand and optimizes supply chain functions on the other hand. Research studies showed that 85% of logistics costs are driven by design choices [1] and over 70% of product cost is determined by decisions during this phase of development [2]. Therefore, more efficiency is achieved when supply chain integration is done early in product lifecycle particularly in product development process.

Thus, collaborative and distributed product development has become a trend in manufacturing industry. Such cooperation requires product information exchange between all supply chain partners. This has led to the emergence of methods and systems to manage the technical data of the engineering process. It is in this context that the concept of PLM (Product Lifecycle Management) was born. We show in this paper the role of PLM as a key element for integrating product and supply chain optimization, especially at the product design phase.

In our previous work, we showed that the optimization of supply chain costs should be conducted according to the characteristics of the designed product [3]. In other words, if the designed product is a functional product known in the market, it would be better to prioritize the optimization of production costs to reach efficiency. Also, it would be better to optimize transport costs when the designed product have a short lead time.

In this paper, we consider that we are in the case of redesigning an existing product. The design change affects either the components or the process of the product or both of them at once. Therefore, we prioritize the optimization of supplying and production costs. Design team, supported by PLM solutions, proposes several alternatives to redesign the product. The aim of this study is to select from
Analysis of time to market complexity: a case study of application of Bayesian networks as a forecasting tool

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Abstract— This study is dedicated to the research of the main critical factors that exist during the product concept phase and the influence of these factors have on defining time to market. The main factors were identified by a survey involving experts from different segments of the industry. The validation of the main factors was done by the simulation applying Bayesian network inside the New Product Development Area (NPD) of the one company leader of market in Brazil. The results show that two common factors contribute heavily to the delay in the launch of new products in this sector. The factors identified include the introduction of non-dominated technologies into new products and the competence of the project leader. The empirical application of artificial intelligence using the Bayesian networks as a statistical tool is analyzed as an alternative to the statistical methods commonly employed for the study of project performance.

Keywords— Bayesian networks, time to market, fuzzy-front-end

1. INTRODUCTION

The time of delivery of a new product to the market or time-to-market (TtM), is the length of time it takes from a product being conceived until its being available for sale. The time-to-market (TtM) is defined as the total time for the development of a new product. It is obtained by the sum of the time of conception of the new product (Tcet) with the time of conversion (completion of designs/prototypes/tests) plus the execution time (making of molds and tools of the product). For Mascitelli (2006) TtM was less important than cost and innovation in new products in the past but in the last decade speed and efficiency (to achieve time to market for a new product) have been considered at the same priority level as price and cost targets for a new product have been considered at the same priority level as price and cost. According to the author, many companies have clearly defined the difference between the total profit generated on providing a product that is available before or after its market competitors (first-to-launch). While many organizations adopt the strategy of quick copy (fast-follower) of a product already launched on the market, it should be noted that having a great TtM typically earns profit gains by having a differentiated product before their competitors.

In seeking to reduce TtM this work focuses on the conceptualization phase of a new product, since according to authors Smith and Reinertsen (1997), Kerzner (2003) and Kahn et al (2006) this is the phase where there are more questions and uncertainties in the development of a project. The figure 1 shows, using the C2C model (Whirlpool, 2008), the IST tollgates or Idea Selection Tollgate where the new project idea is approved, the CSM or Concept Selection Milestone where the final concept is selected, CET or Concept Evaluation Tollgate where the product concept is defined and frozen, the BET or Business Evaluation Tollgate where investments in tools and molds are defined and finally the LCT or Launching Tollgate where the production and commercialization of new products is approved. Also Figure 1 defined by Barros (2013) shows the project team’s uncertainty levels during the project’s development phases.

Conversion and Execution phases will be considered in this study as dependent on the Conceptualization phase and more predictable. In other words, it’s understood that the expected results for these two phases depend more on the excellence of its execution and standardization of procedures. Departing from the principle that the critical factors are inherent in the early phases of Conceptualization, since this is the phase where there is a greater lack of accurate information to the project team, this phase becomes critical for meeting TtM.

According to studies by Basele et al (2012) for several products (i.e. refrigerators, freezers, washer machine, hermetic compressors) the time to market is considered standard if developed between 15 and 22 months. In this study, TtM is considered good when the development and launch of a new product are realized within 15 months or 450 days. The same
Critical Success Factors for Effective Risk Management in New Product Development

(Presented at the 6th IESM conference, October 2015, Seville, Spain) © I4e2 2015
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Abstract—In order for risk management (RM) to continue to provide strategic and operational value to improve NPD project performance, the process of RM has to be supported by certain critical success factors that ensure its success. Although there is a well-developed body of knowledge about RM tools and methods, the literature lacks any effort in providing guiding research on the critical success factors. By using systematic review methodology, this paper aims to fill in this significant gap and contribute to NPD literature in two ways. First, we identify and classify the various critical success factors from NPD literature. Next, these critical success factors will map the literature and offer a unifying framework that aggregates and structure these success factors in a parsimonious way.

Keywords—Risk (NPD),

INTRODUCTION

Intense global competition, highly turbulent environments and globalization require firms to continually invest in NPD (Somer et al., 2008) to sustain competitive advantage in the market (Mu et al., 2009). Although, NPD creates value for firms, risks are inherited in NPD projects in all industries (Keizer et al., 2005).

There is evidence in the literature that shows how inherited risks in NPD projects result in overall failures of project. For example, the US department of defense faced massive cost and schedule overrun for more than 96 defense related projects. According to the report released by the US government accountability office (GAO), due to the extensive amount of testing of aircraft concepts and alteration of manufacturing processes for F-35 jet, an additional $289 million dollars were allocated for the project which require another couple of years to complete its first production. GAO further noted that "managing an extensive, still-maturing global network of suppliers adds another layer of complexity to producing aircraft efficiently and on-time" (GAO, 2011, p. 74).

Given the high cost of failures, firms cannot continue to carry NPD projects which are prone to risks. As firms continue to develop new products, a primary area of concern is to minimize NPD project failures.

The use of risk management (RM) is a key mechanism when it comes to minimizing NPD project related failures (Nidumolu, 1995; 1996). It is also considered as an important tool for increasing the likelihood of success of NPD projects (Bassler, 2011; Mu et al., 2009; Jiang and Klein, 1999; 2000 and Jiang et al., 2001). For example, Mu et al. (2002) conducted empirical research in Chinese sector and found that risk management strategies aimed at technological, organizational, and marketing risk factors contribute both individually and interactively to the performance of NPD projects. Despite this, there is growing evidence that risk management is often ineffective (Kutsch et al., 2014). Such ineffectiveness can be attributed to the fact that RM does not work simply by identifying and managing risks with the help of RM methods and tools only. It rather has to be supported by certain critical success factors that ensure its success. For example, lack of knowledge or inadequate integration of stakeholders into RM activities (e.g. Nelson, 2007; Kutsch et al., 2014).

The general management literature defines critical success factors (CSFs) as “those limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where things must go right for the business to flourish (Rochart, 1979). It is also defined as those few things that must go right for a particular process to flourish. Through these factors, key areas that are essential for management success of particular task are made explicit (Boynton and Zmud, 1984). CSFs may also be used as guidelines or philosophies which govern management behavior. In the context of the NPD project, these CSFs may drive or govern the RM process (ISO, 2009). They may also improve the effectiveness of RM by drawing the attention of management to key activities and tasks. Furthermore, besides driving the RM process, we posit that they also establish the values and philosophy of the process. Finally, CSFs also link a RM framework and practices to the strategic goals of the firm and help align RM to corporate activities (ISO, 2009).

While there is a well-developed body of knowledge about RM tools and methods, with a few exceptions (Oehmen et al., 2014; Kutsch et al., 2014), past research has not provided much guidance on why RM in NPD project is ineffective. This paper aims to fill in this significant gap in the literature by using systematic review methodology to identify the various successful characteristics which are currently scattered across the literature and develop a comprehensive framework. This framework will provide a rigorous and structured conceptualization of these characteristics and map the NPD literature according to these characteristics.

The section is structured as follows. The next section outlines briefly the systematic review methodology adopted in this.
Towards a Requirements Traceability Reference Model for Product Service Systems

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Abstract—Differentiation opportunities for providers of traditional products and services are declining due to increasing global competition. As a result, companies are transforming into solution providers offering integrated bundles of products and services, so called Product Service Systems (PSS). The development of PSS requires intense collaboration of different disciplines (e.g. mechanical, software or service engineering) to produce a solution that fits the customers’ needs. However, each discipline relies on specific engineering models, produces heterogeneous artifacts and uses different languages to describe them. For successful integration of the different PSS components, developers need a joint system model that allows understanding interdependencies and tracing the evolution of artifacts. In this context traceability is of utmost importance since requirements of other disciplines in order to guarantee full integration and cooperation between the different disciplines a highly specialized to the respective discipline, making specific models [1]. Existing theory on development processes does not take place in practice. The development of products and service is carried out in separate processes using discipline-specific models [1]. Existing theory on development processes is highly specialized to the respective discipline, making integration and cooperation between the different disciplines a difficult task [5]. In the development of PSS modifications to the product eventually lead to modifications to the service bundle. Vice versa, service related changes may lead to drastic changes to the product. However, the controllability of these interdependencies is absolutely essential. Therefore, a multidisciplinary approach for PSS development is required [6]. In practice, however, the development of products and services is often carried out independently, which leads to an inadequate consideration of the mutual influences of product and service components. For successful development of a PSS it is not enough to understand the characteristics of these three disciplines, it is also necessary to address interfaces and interdependencies between the disciplines [7].

In conclusion, to design a seamlessly integrated PSS developers require an integrative traceability model uniting the different disciplines and their requirement and design artifacts. Artifacts of one discipline thus need to be linked to the artifacts of other disciplines in order to guarantee full integration and traceability. An important building block in this context is a traceability reference model for PSS. Reference models are an

According to Baines et al. [2], a PSS combines tangible product and intangible service components. The trend towards PSS is mainly customer-driven. There is a growing customer demand for complete solutions to individual problems and needs, instead of solely buying goods or services [3]. A PSS therefore strives to deliver a solution that specifically targets the customer’s needs. To achieve this objective the components of a PSS need to be adapted to individual customer needs which includes intense collaborations and integration of the customer in the design and development process. Additionally, the design of PSS includes various disciplines, such as product, software and service engineering [4].

Further, the different components are likely to have different life cycles, facing companies with the challenge of managing inherent dependencies between the different components. Yet, cross-disciplinary integration does usually not take place in practice. The development of products and service is carried out in separate processes using discipline-specific models [1]. Existing theory on development processes is highly specialized to the respective discipline, making integration and cooperation between the different disciplines a difficult task [5]. In the development of PSS modifications to the product eventually lead to modifications to the service bundle. Vice versa, service related changes may lead to drastic changes to the product. However, the controllability of these interdependencies is absolutely essential. Therefore, a multidisciplinary approach for PSS development is required [6]. In practice, however, the development of products and services is often carried out independently, which leads to an inadequate consideration of the mutual influences of product and service components. For successful development of a PSS it is not enough to understand the characteristics of these three disciplines, it is also necessary to address interfaces and interdependencies between the disciplines [7].

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Why Product Service Systems Development is Special

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Abstract— The design and development of product service systems (PSS) is a complex process that brings together product, software and service engineering. A fully integrated PSS calls for significant collaboration among the different engineering disciplines along the entire design and development process which can pose several challenges to the development team. Therefore, when developing a PSS, companies should take into account the special characteristics and complexities that are relevant in the context of PSS. However, in practice companies often follow their traditional development processes and simply design a service around their existing products. This way, many PSS offerings do not live up to their full potential. In order to overcome this issue practitioners need to know what makes PSS development special. By reviewing existing literature on PSS development, this paper identifies and describes the special characteristics of PSS development in contrast to traditional products or services.

Keywords— Product Service System; Development; Characteristics; Literature Review

I. INTRODUCTION

In an increasingly globalized world, companies, especially manufacturing companies, find themselves confronted with fierce competition in which it is hard to differentiate oneself just on the basis of their products. In most of the cases there are a large number of competitors that are capable of delivering a product of comparable quality. This often leads to ruinous price wars causing margins to collapse [1]. Therefore, manufacturing companies across various industry sectors increasingly realize that they can realize additional profits and tighten their customer relationships by offering services that complement and enhance their original product portfolio. In doing so, they create bundles of products and services that form a specialized solution for a certain problem or need of the customer. These bundles are often described as so called product service systems (PSS), i.e. integrated customer solutions consisting of product and service components that generate value in use [2].

In general, mainly three types of PSS can be differentiated: (1) product-oriented PSS, (2) use-oriented PSS and (3) result-oriented PSS [3]. In product-oriented PSS, the main focus is still on the selling and vending of products and only few services such as maintenance and repair are added. Product-oriented PSS can be further classified into product-related services as well as advice and consultancy. Product-related services refer to additional services which are needed during the use phase of the product [3] e.g. maintenance or financing schemes. In contrast, advice and consultancy are services that guide the efficient and effective use of the product sold. For instance, training and demonstrations are examples of advice and consultancy services.

Use-oriented PSS refer to the use or consumption of a particular product, and the services associated with such use-oriented solutions. Use-oriented PSS can be differentiated into product lease, product renting/sharing and product pooling. Here the product itself stays in the ownership of the provider, but is made available to and shared by numerous users [3]. While the user has unlimited access to the leased product e.g. a car, this is not the case for product renting/sharing where the product is used by a number of different customers in succession. In contrast, the PSS business model of product pooling enables simultaneous use of the product by a certain number of users, e.g. sharing of a car for a ride to work so that several consumers use the car at once.

Result-oriented PSS focus on the service component of the PSS. The provider and the customer agree on a pre-specified result, which is later delivered by the provider [3]. Examples for result-oriented services are the delivery or outsourcing of activities such as cleaning, catering or hosting, support and maintenance of IT infrastructure.

While PSS provide manufacturing companies with an opportunity to gain competitive and strategic benefit, they also pose significant challenges and complexities in terms of designing such systems. Companies are faced with the need to shift from a product orientation to a service orientation, and manage the inherent interdependencies between the product and service components, more so since each of these components are likely to be designed and developed by different business organizations. Developing a PSS incorporates the integration of components from multiple engineering disciplines such as mechanical engineering, software engineering and service engineering. In this regard it does not make sense to separate the development into domain-specific processes. Instead the development of those systems is
In this regular session the management and services are developed with regards to many projects on the following topics:

Some topics developed in this session:

- Reverse logistic;
- Manufacturing process;
- Industrial performance;
- Maintenance.

Presented papers:

- Information System Design for Reverse logistics Management using UML
- Improving interoperability of clinical documents: a case study of LOINC mapping in analysis laboratories
- Value Analysis approach in the resources pre-selection of agile/virtual enterprises: domain of applicability and selection time
- Measuring product semantic similarity by exploiting a manufacturing process ontology
- An advisory tool for sustainability-driven maintenance. A real case in mould and die industry
Information System Design for Reverse Logistics Management using UML

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Abstract—The work presented in this paper is the modeling of an information system supporting all activities of the reverse logistics (RL). In order to gather knowledge about the current state of the art on this topic, a literature review is established for the available research works which are classified using a suitable criteria. Based on this review, our work consist of developing an information system (IS) design for reverse logistics (RL) management. The proposed modeling is based on an object-oriented analysis approach. The results announced at the analysis step includes the use case diagrams which modeling the dynamic aspect of the system with the actors interacting processes and a class diagram that models the key concepts of information managed in the system. This modeling is generic for a company which takes into account good practices in RL.

I. INTRODUCTION

A few years ago, reverse logistics (RL) was practically unknown by the industry and the world of research. Today, it is a concept which expands due to the environmental requirements and profits potentially achievable. Environmental regulations and government policies, encourage organizations to be creative and innovative in developing their products and services by integrating the principle of sustainability. Then, a sustainable development policy needs to master the management of the supply chain in order to develop the activities of RL. The main objective of RL is to achieve the return of products or materials from the customer to the manufacturer. It includes many activities such as collecting, sorting, processing, repackaging, landfilling, incineration, etc.

According to the literature, several authors including Giuntini and Andel [1], Rogers and Tibben-Lembke [2], and Schwartz [3], propose a generic process for RL. This process defines a process mapping which aims to integrate the activities of RL to the classical supply chain. The adopted mapping suggests four main stages for reverse logistics: gatekeeping (entry point), collection, sorting, and treatment. The integration of RL to a supply chain adds material, information and financial flows. The exchange of materials and information must be supported and synchronized by information system (IS) adapted to the diversity of products. Hence, another important aspect is the integration of the mentioned four stages in an IS for the RL activities. This aspect is proposed by Lambert et al [4] and [5] in his approach which adds two related elements in order to develop a generic system for reverse logistics management: an integrated information system and a shipping system. This approach allows to identify all the required information to the monitoring of processes and products throughout the life cycle.

For the organizations, integrating or not RL, only some of them have succeeded to integrate or adapt some functionalities to their current informational supports. These functionalities consist of monitoring and controlling some procedures managing the return and the treatment process of recovered products. Then, the major problem of lacking an information system and decision-making tools designed specially for managing the returns are considered as a significant barriers to the success of the integration of RL activities [2]. The complexity of developing such information system for returns management is due to the level of uncertainty encountered during the return product process. Moreover, the management of returns associates various departments from the same organization and sometimes other external agents. These extended Borders add a further complexity to the problem. In addition, RL is not a priority for integrated information system specialists. Several companies are choosing to use their own solution, but they must deal with integration problems with the other business systems. Otherwise, companies can choose a commercial software, which often only covers return management, without taking into account the other activities or elements of reverse logistics.

In order to support RL, the IS should be able to deal with the information relevant to each of the required activities, such as return management, inventory management, production planning, and product improvement. However, this is quite difficult, because there is still not many software applications specifically designed for RL, since such software requires us to do a lot of customization or modifications. Another important goal of reverse logistics information system is to ensure a good traceability for monitoring of the returns at all the stages of the reverse logistics system. Indeed, the activities of reverse logistics system are still, in many cases, structured, organized, planned and inadequately supported making information that might be cumulative inaccessible or unusable. For a more efficient and effective returns management and processing of the recovered products is not only the informational system that needs to be reviewed but also the flow of material and information that must be properly defined. This makes good
Improving interoperability of clinical documents: a case study of LOINC mapping in analysis laboratories

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Abstract— Health care organizations are increasing their efforts towards administrative and clinical-process informatization. In this field, the electronic health record (EHR) can be usefully employed to improve the patient care process, as it allows the health care operator to chronologically gather care events. In achieving such a goal, the possibility of storing care events issuing from different sources is the main challenge to be faced, as it involves the possibility of rendering interoperable different proprietary systems that use customized encoding systems. System interoperability requires the exchange of standardized information and documents, using specialized document templates and encoding systems. This is the case of the Health Level 7/Clinical Document Architecture (HL7/CDA2), which requires the Logical Observation Identifiers Names and Codes (LOINC®) system for encoding clinical documents. This paper presents a case study of an interoperability system aimed at producing HL7/CDA2 documents to be sent to a centralized EHR. The case study deals with the standardization of an analysis laboratory encoding system based on LOINC, focusing on a software tool for semi-automatic mapping of internal analysis laboratory codes into LOINC codes. It was carried out at the University of Pittsburgh Medical Center, Italy (UPMC Italy) within the Smart Health 2.0 (Pon04a2_C) project, and aimed at realizing an advanced EHR that enables the collection of structured documents produced by different health care organizations in the region of Sicily, and facilitates data retrieval and longitudinal or cross-sectional analysis.

Keywords— HL7/CDA, interoperability, LOINC, mapping

I. INTRODUCTION

It is well known that electronic health records (EHRs) are now increasingly perceived as tools that allow for the fast retrieval of chronologically organized information. Until now, however, implementation of EHRs in Italy is viewed as a collection of unstructured documents (e.g., pdf), which does not enable time-series analysis of patient data or longitudinal or cross-sectional analysis of specific diseases that affect the general population. On the other hand, such an analysis could contribute to exploiting the Value of Information in the health care field. In fact, it could allow reduction of the time spent on data retrieval, and determine the trend of specific data (retrieved from different files, and even produced by different health care structures), thus improving medical knowledge of each patient’s diseases, and accelerating the decision-making process. In order to achieve this goal, it is necessary to organize EHR data into structured documents, allowing for the fast retrieval of single types of data for a given patient. Moreover, in order to support the interoperability of systems, as required by guidelines for the implementation of the EHR in Italy, data should be structured into standard formats, e.g., those that rely on an XML-based mark-up standard, such as the Health Level 7/Clinical Document Architecture, Version 2 (HL7/CDA2). This standard “specifies the structure and semantics of clinical documents for the purpose of exchange between healthcare providers and patients” [1]. The HL7/CDA2 standard has been transposed in Italy by means of the national Board of Electronic Health (Tavolo di Sanità Elettronica). It provides a framework for exchange of documents, and recommends the use of clinical document codes from LOINC® (Logical Observation Identifiers Names and Codes) to specify the particular kind of document (e.g., laboratory tests, discharge summary, progress note) that is being transmitted [2, 3]. Unfortunately, a common problem is that public and private laboratories, instead of adopting standard encoding systems such as the LOINC, make use of proprietary coding systems, or those suggested by the regional nomenclature system (as experienced in Italy by the authors). In this case study, we deal with the realization of an interoperability system for the automatic and real-time supplying of an advanced EHR with different document types, such as laboratory tests, discharge summaries, X-ray reports. It was specifically designed and developed to allow integration of laboratory documents with the EHR, avoiding large investments or organizational changes in laboratory management systems. It consists of a tool for the automatic...
Value Analysis approach in the resources pre-selection of agile/virtual enterprises: domain of applicability and selection time

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Abstract— For the project of an Agile/Virtual Enterprise (A/V E) the resources selection is a key factor. The resources systems (output of the selection process) should be prepared to guarantee quality, efficiency and cost-attractiveness, in order to ensure the agility and integrability of the A/V E. This is a difficult matter because it can be a combinatorial and multi-criteria problem. Despite the potential of Value Analysis (VA), none of the resources selection models found in the literature incorporates the evaluation of the resources value. They approach mainly the factors cost and/or time. So, our model constitutes an innovative approach because it gives the highest importance to the value of the resources systems, through the incorporation of VA. The main objective is to quantify the selection process performance with VA integrated into the pre-selection of resources in accordance with the developed model. The paper contribution is the positive confirmation, through the simulation results analysis, of the benefits of VA integration in the resources selection process: greater applicability domain for candidate resources and number of tasks; and reduction of the selection time. In conclusion, the increased efficiency and the superior applicability domain of the model are demonstrated.

Keywords— agile/virtual enterprises; value analysis; resources pre-selection; resources selection; model applicability domain; selection time

I. INTRODUCTION

It was the work of Drucker which gave rise to the concept of virtual enterprise associated with the concept of creating dynamic networks of companies [1]. There is a lot of work done in the context of virtual enterprises [2, 3, 4] but the resources selection problem remains a critical issue, namely the integrability of the resources in the configuration process of A/V E.

Our model of A/V E involves the creation of a temporary network of various physical organizations (or resources) with the intent of developing and producing one or more products/services, in the desired quantities and quality, in response to the market request [5]. In our model, the problem consists of selecting a system of resources (partners) with enough value to ensure the integrability of the resources systems which minimizes the total production time and/or cost (processing and transport) for the elaboration of a single product, independent of quantity, for which there are several candidate resources to process.

The main objective is to quantify the selection performance time using VA according to the model developed. Such a model intends also to identify the applicability domain of the VA integration model. Several methods (ex: AHP, game theory, linear/goal/multi-objective programming, Fuzzy, etc) were proposed to overcome the problem, but does not exist a consensus about this question. The incorporation of VA contributes with additional support for the A/V E configuration process. These factors are related to the nature of partners, trust, integrity, dynamic reconfiguration and organizational integration of A/V E.

VA is a well known structured method to increase value and support the selection of the most valuable solution [6]. Throughout recent decades, VA has proven able to reduce costs and ensure quality, while also contributing to the improvement of decision-making and other important organizational tasks. It is our belief that the application of VA into the paradigms of A/V E will bring the same contributions to A/V E performance as it has so far done in conventional systems [7, 8, 9]. The development and optimization of A/V E involve additional issues than those traditionally taken into consideration in conventional companies. The tool has proven its potential to solve problems, not only regarding cost reduction and quality improvement, but also in process optimization and as a support for decision-making [10, 11]. The results validate that the VA integration brings quality and quantity benefits to the process of resources selection, demonstrating the benefits of VA integration: 1) greater applicability domain; 2) reduction of the selection time.

This paper contains five sections including this Introduction which begin with a discussion on the relevance and the actuality of the theme as well as their implications for the organizations. Section Two defines the resources pre-selection model with value analysis. Section Three presents a brief
Measuring product semantic similarity by exploiting a manufacturing process ontology
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Abstract—The retrieval of manufacturing knowledge in companies is critical because product and process knowledge was not actually managed but only documented. Particularly, the identification of similarities between new and past products relied almost exclusively on the memory and the experience of people, and thus it is a time-consuming task. In this paper, a method to allow the automatic identification of past similar products is proposed, so that they can be used to speed up the design of manufacturing of the new product. The similarity is computed by using a semantic model in the form of ontology, which constitutes the hierarchical structure of concepts. A new similarity index is defined based on the portion of overlapping subgraph of concepts existing between two products. The different weight of each node is also considered because more descendants the node has, less specific its semantics information content is. The computation of the similarity measurement will allow the discovery of knowledge from stored data, thus supporting the engineers in searching for past products having similar characteristics with the new one. The potentiality of the proposed index is shown in a motivating example.

Keywords—Information retrieval; knowledge modelling; manufacturing systems; semantic similarity; ontology.

I. INTRODUCTION

The problem of storing and reusing the manufacturing knowledge available in companies is crucial and many enterprises admit that they are unaware of the actual extent of the manufacturing knowledge existing in their organizations [1][2]. It is also indicative that 20% of a designer’s time is dedicated to searching and analysing the available information [3], and that 40% of the required information is identified through personally stored information [4]. People who worked in an enterprise may have very valuable knowledge, and when they leave their knowledge is taken away. Also the documents they leave behind are difficult to be interpreted and used by other employees [5]. It has been estimated that around 50% of the available knowledge is not stored in information systems [6]. Moreover, information retrieval and reuse are not efficient in most systems, and product and process knowledge was not actually managed but only documented[7][8].

The advent of the semantic technology has led to the development of knowledge management systems, both to help the company in organizing their data and to allow the easy finding of information and its reuse [9][10][11]. In fact, ontologies make it possible to integrate information from different abstraction levels, and they improve knowledge capture and reuse [12]. Despite the improvements in the state of the art literature, knowledge management dealing with the classification of past projects lacks in companies, especially SMEs [13]. Similarity identification between new and past projects relied almost exclusively on the memory and the experience of experts, thus being a time-consuming process.

The proposed approach aims at designing a supporting tool that facilitates the automatic identification of past similar products, so that they can be used to speed up the design of manufacturing of the new product. Despite the existence of a great number of similarity measures, they present the limitation of being applicable only to numerical attributes [13][14] or to compute string similarity based on edit-distance functions without taking into account the meaning of the words [15]. Since here the aim is to compute a semantic similarity, an approach widely used in bioinformatics is adopted, which computes the functional similarity between genes in the Gene Ontology context [16]. Particularly, the similarity is computed by using a semantic manufacturing model in the form of ontology, which constitute the reference knowledge hierarchy of concepts. A new similarity index is defined based on the portion of overlapping subgraph of concepts existing between two products. The different weight of each node is also considered because more descendants the node has, less specific the semantics is.

The rest of the paper is organized as follows. Section 2 describes the manufacturing process ontology at the basis of the framework to compute the semantic similarity between products. Section 3 describes the architecture of the proposed framework and its main building blocks. Section 4 gives details on the semantic similarity computation performed by the proposed framework. Finally, Section 5 draws conclusions and states future works.
BCVR: A Methodological Framework for Industrial Performance Management and Decision-Support

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Abstract—The necessity to simultaneously satisfy different stakeholders’ objectives in an industrial project or in a process requires efficient performance management for decision-making. With the characteristics of multi-dimensions and dynamic nature of performance and the proliferation of evaluation criteria, the design and construction of performance measurement and management systems are facing new challenges. However, none of the existing methodologies and tools can globally satisfy this expectation. In this context, a new methodological framework, named BCVR, has been developed to help decision-makers in performance management and decision-making processes on the basis of four assessment dimensions, namely: benefit, cost, value and risk. In this paper, the basic concepts and the main mechanisms of the proposed framework are presented with an illustration about supplier selection risk assessment in a typical supply chain process.

Keywords—performance management; decision-support; methodology; benefit; cost; value; risk

1. INTRODUCTION

Performance measurement and management pose serious challenges to practitioners and researchers in industrial engineering and management sciences in terms of simultaneous achievement of multiple stakeholders’ objectives. Furthermore, this problem is even more complicated because different objectives can be contradictory while the time to develop and distribute a product or a service becomes much shorter. The difficulties increase in the case of corporate networks, supply chains and value networks. With the growing proliferation of various types of indicators, building performance measurement and management systems is facing a three-fold difficulty. First, it is necessary to build an efficient system which only provides relevant information for decision-makers. Second, it should be clear how to transform and aggregate the basic measurements into global decision-making indicators. Third, the system should be built within the deadline and at a reasonable cost.

Nowadays, the methods for performance measurement and management focus mainly on the elaboration of an evaluation based on companies’ precise objectives. To create value for the different stakeholders, companies design and implement activities to meet their requirements. However, the creation of value is subject to uncertainties and events that may have negative impacts on the activities of value creation. In addition, these activities consume necessary resources during the process of value creation. Hopefully, the realization of these activities provides some potential advantages for the stakeholders.

Indeed, for all projects or systems of importance in a company, the management wants to know what will be the expected benefits for the company, the overall cost of the project or of the solution to the problem, the value it will bring to the company or its clients and the implied risk for the company. In this case, the performance of an industrial system can be globally measured and managed in terms of the following four dimensions: benefit, cost, value and risk (BCVR) [1].

If we know how to decompose the global BCVR indicators into elementary measures, how to aggregate the basic measurements, and how to quantify the global results of the overall cost, value and risk for the company at a moment, we can apply a BCVR analysis and represent the project trajectory over time in a cost-value-risk space to assist decision-makers in their work. One could even simulate various decision scenarios of the trajectory from an initial point to predict effect of alternative action plans.

This work, based on the PhD thesis of Shah [2], proposes an operational methodology for the BCVR framework. The aim is to guide the evaluators/analysts in industrial performance management in solving various types of decision problems.

The first part of the paper presents the basic concepts of the proposed BCVR framework by indicating its application area. The second part presents the structure of the methodological approach and its main steps. The final part presents the proposed mechanism for decomposing and aggregating the basic measures and indicators into global indicators with an illustration about risk assessment in a supplier selection process.

2. BASIC CONCEPTS

Performance measurement and management systems are used to evaluate and manage projects, systems or business processes of a company. So, companies should develop and implement a tool for performance measurement and management in order to assess achievement of their objectives as well as stakeholders’ requirements and expectations. To be a useful for the decision-makers, such a tool must be efficient
An advisory tool for sustainability-driven maintenance. A real case in mould and die industry

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Abstract— Maintenance impacts on environmental, economical and social performances of a product are often overlooked or underestimated. Especially for durable goods, maintenance should positively influence the product sustainability profile extending its lifespan, but, negatively, it also adds operations and materials usage. Available sustainability (mostly environmental) assessment tools either do not consider maintenance impacts, or compute them just for already produced products, this extremely limiting (or even inhibiting) the capability to improve the sustainability profile of under-design products. The here presented tool, based on a Naïve Bayes Classifier, real-time computes the sustainability performances of under-design moulds, thus advising the mould designer towards better performing design choices. The paper presents the tool development process and achieved results, exploiting the advantages of the selected target product: a long-lasting, frequently maintained capital good.

Keywords— Sustainability assessment; maintenance; mould and die; Naïve Bayes Classifier.

I. INTRODUCTION

The concept of sustainability is used (and sometimes misused) in heterogeneous contexts and, especially in manufacturing industry, its translation into actual applications is still not standardized. The adoption of strategies in manufacturing contexts necessarily passes through measurement. The same happens for sustainability: appropriate metrics need to be recognized and made available (using proper tools) with the final goals to create awareness and measuring the current (and envisaged) performances of the pondered target. Unfortunately, even if many tools are currently available for assessing the sustainability performances of products, most of them are intended to be applied after the design phase, when all the design decisions have already been made. On the contrary, assessing (expected) sustainability impacts during the design phase would provide designers with valuable information they can use to modify the product characteristics in order to improve its sustainability (environmental, economic and social) profile. Still, the calculation of sustainability indicators before manufacturing the product is a challenging task since reliable estimations are needed for all the product lifecycle steps (in accordance to LCA dictates). Such estimations have thus to be forecasted relying on data gathered from previous products or product versions. Unfortunately, for some lifecycle phases, there’s a definite shortage of real-life information (this happens, for example, for the maintenance tasks), and appropriate methodologies are needed to gather the required knowledge from such few samples. This paper is meant to present an advisory tool intended to support the designer of a mould in estimating the sustainability impacts of maintenance tasks it will undergo during its lifecycle. A statistical approach based on the Naïve Bayes Classifier (NBC) has been used to amplify the statistical dataset correlating the morphological characteristics of 250 moulds and their maintenance needs. The data has been actually collected by the mould&die department of Interroll SA, a Swiss company producing components for material handling systems.

The developed tool allows to forecast the number of maintenance interventions to be performed during the lifecycle of the mould using as inputs a selection of the mould characteristics (identified as highly correlated with its maintenance effort). After forecasting the number of interventions, the tool is also able to calculate environmental, economical and social indicators concerning the maintenance operations. This is performed in real time, immediately providing the designer with reliable indications concerning the impacts generated by its design decisions. Through the immediate calculation of the sustainability indexes, the designer is able to modify the mould design and rapidly ponder the obtained effects in terms of sustainability profile.

After the introduction of the problem illustrated in this section, the paper is structured into four other parts. Section II presents the state of the art analysis that presents the
In this regular session the operations and lean problems are discussed with regards to many projects on the following topics:

Some topics developed in this session:

• Lean, Cognitive Ergonomics;
• Operation Management System;
• Flexibility, Scheduling problem;
• Performance, Production strategy.

Presented papers:

• *Determinants of the outcomes of services outsourcing: an empirical study of transport services*
• *Modeling the complexity of the relationship (Lean, Company, Employee and Cognitive Ergonomics) Case of Moroccan SMEs*
• *Implementation of an Operations Management System in eight Spanish SMEs*
• *Considering the effect of demand diversity on the performance of different production strategies for the economic lot scheduling problem*
• *A preliminary study on integrating operation flexibility within semi-heterarchical FMS control*
Abstract— The purpose of our study is to examine whether the design and management of the interfaces and interaction processes between customer and provider in services outsourcing are determinants of the results achieved by the outsourcing company. Following the conceptual framework initiated in the study by Wynstra et al. [11], this study focuses on transport services and hypothesized relationships are tested using the Partial Least Squares (PLS) statistical technique. The primary data used was obtained from a survey in three different countries (Germany, Japan and Spain), and from manufacturing companies in the electronics, automotive and machinery sectors. Among other things, the results show that both the structural dimensions of interaction (the organization's resources that it must commit) and the process dimensions of interaction (that consider the dynamic nature of the relationships), are important for obtaining adequate performance from transport services outsourcing.

Keywords— Outsourcing services, logistics, transport.

I. INTRODUCTION

Outsourcing any activities generates relationships between the buying and selling companies that need to be well managed to ensure that a positive effect comes from said relationship [1]. In the particular case of logistics activity there are many companies that forge long term links with specialized suppliers (Logistics services providers, LSPs). The success of the relationship and, by extension, of the outsourcing of the logistics activity can become important for achieving a competitive advantage [2]. Unfortunately, the difficulty of managing relationships between the customer company and the logistics services provider has been recognized and this difficulty is considered to be at the root of the wide differences found in the results of logistics outsourcing [3], as can be observed in a range of studies (e.g. [4-6]). Accordingly, it seems that it is essential for special attention to be given to the design and management of the interfaces of the interaction that determines the logistics outsourcing buyer-service provider relationship. A variety of authors state in relation to this that

the design and management of the interfaces and interaction processes are two major determinants of the results that come from customer-provider relationships (e.g. [7-8]) and that it is essential to know what the aspects of management and design are that impact positively the results of outsourcing [9]. Despite the importance of the topic, empirical research in the field is limited [10].

With respect to the above, Wynstra et al. [11] suggest that there are two groups of dimensions (or determinants) to take into account: Structural dimensions of interaction (related to the organization's resources that should be committed to the interaction) and Interaction process dimensions (which take into consideration the dynamic nature of the relationships). In addition, they state that the configuration of these dimensions is influenced by the key objective pursued in the interaction, which depends on how the buying company uses the outsourced service in its business process. Using this criterion they distinguish four outsourced services types: consumption, instrumental, semi-manufactured and component. Each requires a different configuration of these dimensions resulting in ideal interaction patterns for each type of service. According to van der Valk et al. [12-13] these patterns are what determine the services outsourcing outcome.

The same authors that propose these patterns state the need for them to be tested empirically for specific services. It seems that it can be deduced from the examination of the bibliography undertaken for the present study that, despite the stated importance for logistics services outsourcing (an instrumental service type), no research has been published that has focused on this field. This is the reason why this study will focus on said services and, more specifically, on transport services, as this is the part of logistics with the highest rate of outsourcing. Thus this study's main objective is to establish whether complying with the interaction patterns proposed in the prior literature and adapted to our specific case has a positive impact on the success of transport services outsourcing. In addition, the study seeks to determine whether the risk level associated
Modeling the complexity of the relationship (Lean, Company, Employee and Cognitive Ergonomics) 
Case of Moroccan SMEs

Abstract—The feedback on the implementation of Lean confirms a gap between the “real work” and “prescribed work” and a negative impact of Lean on employees in terms of stress. These results allow considering in practice, ergonomic interventions to ensure the effective functioning of Lean while preserving the mental health and safety of operators.

In this paper, we propose a model to explain the complexity of the relationship "Lean, Company, Employee, & Cognitive Ergonomics." Through this model, we will address, first, the Lean as an organization which has positive impacts on humans but also generates stress. Then we analyze the effect of the Lean on the company as an organization that improves the performance but we stress in the same sense the complexity of the relationship "stress & performance" knowing that Lean generates stress. Finally, we present, through this model, the role of cognitive ergonomics in improving both company's performance and the interaction of the Lean with Human cognitive space by the use of cognitive aids.

At the end of this paper, we present the results concerning the model pre-measurement in the case of a Moroccan SMEs in the food sector.

Keywords—Lean; performance; stress; cognitive ergonomics; cognitive aids

I. INTRODUCTION

In the current economic environment, companies have to face every day a global competition and growing performance requirements. Thus, companies must implement essential growth levers and have agility and adaptation evidence to gain competitive advantage. Lean organization is, in this sense, a way forward to improve the competitiveness of the company, reduce the additional costs and increase profitability.

In addition to the implementation of a set of techniques and tools, Lean is a management style based on the human factor and suggests that staff works with a mindset oriented towards reducing losses and waste. The motivation and behavior of employees are necessary conditions for successful integration.

If the benefits of Lean on company performance have been demonstrated, its effects on employees are not provided, and several studies have shown that Lean organization generates stress. In this sense, the intervention of cognitive ergonomics for its design and its implementation seems important to better manage this stress by improving employee interaction with a Lean environment.

In this article, we first, illustrate the impact of Lean on improving the company performance. We approach then the effects of Lean on employees with a specific focus on the stress generated by the Lean and we also analyze the relationship Stress - Performance. Finally, we present the role of cognitive ergonomics in improving company performance and ensuring better match between Lean environment and cognitive space of employee through cognitive aids. At the end of this bibliographic analysis we model the complexity of the relationship "Lean, Company, Employee & Cognitive Ergonomics" and we present the principles of the questionnaire used to experiment the proposed model. To conclude, we present the results concerning the model pre-measurement in the case of a Moroccan SMEs in the food sector.

II. THE RELATIONSHIP LEAN-COMPANY : EMERGENCE OF PERFORMANCE

Studies confirming the positive impact of Lean on the company's performance are numerous (see for example: [1], [2] and [3]). Alarcón and al. [4] analyzed in their article some of the main impacts and some of the lessons learned from implementations of ‘Lean construction practices and tools' observed in construction projects. In their article, the authors examine the challenges and obstacles for the implementation, improvements in productivity, variability reduction and effectiveness of implementation strategies.

Several companies have had difficulty in accurately measuring the performance; however, in almost all observed projects there were many perceived benefits through the application of Lean. Qualitative measurements were obtained from surveys and questionnaires answered by members of project teams involved in the implementation.
Implementation of an Operations Management System in eight Spanish SMEs

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Abstract— Innovation on the base of technologies in the operation management function is key for the competitiveness of the SMEs. This paper analyzes the learnt lessons related to the implementation of an “Operation Management System” (OMS) in a group of eight Spanish SMEs and provides guides to make it more efficient. We applied Lean Manufacturing techniques in the pre-implementation phase. Then, we reflect on specific and practical issues with the objective to ensure a successful implementation and encourage SMEs to adopt this type of technological tool. We describe the main occurred incidents and the corresponding contingency actions as well as the best practices identified in the participating SMEs. We highlight the relevance of tackling with the resistance to change through the communication and training. Regular meetings with managers are considered key for the success of the project.

Keywords— operation management systems; SME; lean; ERP; reengineering

I. INTRODUCTION

The Operations Management (OM) is the management function responsible for the production of the physical goods and the services that a company offers in the market. Its goal is to achieve simultaneously the objectives of quality, flexibility, costs and deadlines. Between other activities, OM includes procurement (inbound logistics), operations that transforms inputs in outputs, quality assurance and distribution (outbound logistics).

If a production company is capable to manage its operations with effectiveness and efficiency, it will get and keep some relevant competitive advantages. That is because in this type of companies, the OM is responsible for about the 80% of the added-value, 80% of the assets and 60% of the staff [1].

In the framework of the modern OM, it is essential to incorporate new technologies and use information systems to increase the productivity. It is almost impossible to comply with company strategy (and the corresponding operations strategy) if there is not an appropriate monitoring and control system adapted to the company.

Reference [2] shows a very interesting discussion about the main factors that form the basis for the new OM strategies, techniques, tools and technologies. Authors consider that one of the main focus of the productivity and competitive strategies should be on leveraging information technologies and systems (IT/IS) and mention the Enterprise Resource Planning (ERP) as one of the major factors related to two of the four dimensions identified for the emerging OM function: “Productivity and competitive strategies” and “Production planning and control”. Regarding the other two dimensions (Physical inflow and outflow of materials) they highlight the e-procurement, e-logistics and the RFID technologies especially.

ERP has come to mean many things over the last several decades. In fact, the fundamental benefits of ERP systems do not come from their inherent “planning” capabilities but rather from their abilities to process transactions efficiently and to provide organized record keeping structures for such transactions. Planning and decision support applications represent optional additions to the basic transaction processing, query and report capabilities included in a typical system [3].

Reference [4] emphasizes that the ERP systems should not be looked at simply as tools that have a fixed and measurable output, but rather as a technological infrastructure designed to support the capability of all other tools and processes used by a firm.

A similar view is taken by the reference [5]. The design of this architecture (the system itself) should therefore be based on an understanding of the actual firm’s processes and should allow for the eased introduction of future processes that the firm believes may offer competitive value. Object-oriented approaches to ERP system designs have become the standard for excellence towards implementing these objectives [6], [7].

Along the same lines, any reengineering of a business process that the system is intended to support should not be handled with the intent of accommodating the system. Rather, reengineering should involve the implementation of best practices, specifically supported by the system that improves the performance of the company as a whole. All in all, researchers generally agree that this task requires a mix of cross-functional strategic planning and enterprise-wide corporate diplomacy [8]. The concept of ERP is fundamentally tied to the integration, standardization, extension and assurance of future flexibility for corporate processes, whereas the ERP system represents the technical manifestation of these goals and the changes required to attain and maintain them [9].
Considering the effect of demand diversity on the performance of different production strategies for the economic lot scheduling problem

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I. INTRODUCTION

Since the economic order quantity (EOQ) inventory model was presented by Harris [1], inventory management has been an area of intensive research. A particular area of research in this field is the economic lot scheduling problem (ELSP), which focuses on accommodating cyclical production patterns of several items on a single facility. The solution to the ELSP involves two critical decisions. On the one hand, the lot sizing decision must be approached, that is, determine the quantity of each item to be produced to minimize total costs. On the other hand, the scheduling decision has to be approached, that is, decide when the items have to be produced.

The simplest approach to solve the ELSP lot sizing decision is the Independent Solution (IS), which in fact uses the economic order quantity defined in [1] to determine the lot-size for each product. The IS approach ignores any condition for feasibility, and therefore it is common to find situations in which the optimal solution of this approach is not feasible. Other relevant methods in the literature to approach the lot sizing decision are: Common Cycle (CC) [2], Basic Period (BP) [3], Extended Basic Period (EBP) [4] and Lot sizing Variation [5].

Regarding the ELSP scheduling decision, one of the first rules of scheduling was contributed by Delporte and Thomas [6], who set a series of heuristics to establish the order in which items are to be manufactured. Some of the most significant contributions to the scheduling part of the problem are [7], [8], [9], [10]. Some other scheduling policies presented recently in the literature are [11], [12] and [13]. In [14], an interesting scheduling policy is presented and described with a simple and small numerical example. We have deepened in the study of this scheduling policy by considering it in our simulation study.

Regarding the demand type, the classical ELSP as defined in [3] assumes constant demand rates. In [15] the authors refer to the problem where demand is assumed to be time varying as stochastic economic lot scheduling problem (SELSP), and present a complete literature review. Another interesting and up-to-date SELSP review is presented in [16]. We agree with the conclusions of this work, affirming that most papers focus on the evaluation of a single class of policies, and that research should pay more attention to the comparison between different policies.

As far as simulation is concerned, there are several studies in the literature considering stochastic demand e.g.[7], [8], [17], [18]. In [7], different production strategies based on the consideration of the inventory levels of all the individual products are analyzed. In [17], the authors perform a simulation study to determine if a deterministic model can be used in a practical situation where the demand rate is stochastic. In [18] the simulation study compares scheduling policies in a hybrid production system where make-to-order and make-to-stock products are considered.
A preliminary study on integrating operation flexibility within semi-heterarchical FMS control

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Abstract—This study aims to analyze the integration of operation flexibility (OF) within a semi-heterarchical flexible manufacturing system (SHFMS) control architecture. This architecture is composed of two types of decisional entities, global and local, and it exists three different modes in which those two types of entities can interact. In this paper, various ways in which OF can be integrated in the SHFMS architecture are presented and analyzed. Two of these options were implemented and tested using a theoretical flexible manufacturing system benchmark. The promising results confirm the significant contribution OF can provide, not only in terms of Just-In-Time (JIT) global performance but also in terms of the capacity to react to perturbations.

Keywords—Operation flexibility; Semi-heterarchical control; Flexible manufacturing Systems; Reactivity; Genetic algorithm.

I. INTRODUCTION

In the current industrial context, manufacturing flexibility is seen as a key competitive factor for surviving in markets [1]. Flexibility in manufacturing is the ability to respond in a cost-effective manner to changes in volume and product-mix requirements, machine status and processing capabilities [2]. Although the importance of flexibility has been widely recognized, it is rather frequent to find industrial situations where Flexible manufacturing systems (FMS) have unsatisfactory performance [3], available flexibility remains unused [4], or the management perceives flexibility more as an undesirable complication than a potential advantage for competitiveness [5]. Recent studies concluded that the actual positive effects of flexibility are only attained if flexibility is properly utilized by the FMS control [6]. However, flexibility combined with the heterogeneity of FMS components and their interrelationships impose more complexity into FMS control [7]. Consequently, flexibility and FMS control are inseparable and obviously major elements necessary for providing a good FMS performance [6]. Particularly, operation flexibility offers potential benefits in terms of flow time, work-in-progress and inventory reduction [8]. OF refers to the ability of producing a product in different ways and it is inherent to the product structure and design [4]. Then, OF may provide a more cost-effective solution for improving FMS performance [9]. Given that FMS control can be hardly constrained under hierarchical control architectures, heterarchical-based control architectures seem to be more suitable to take advantage of OF based on their low-complexity, local reactivity and adaptability in the presence of internal and external perturbations [10]. Particularly, semi-heterarchical architectures are of our interest because they achieve to merge the benefits of hierarchy in terms of global performance and heterarchy[11]. Therefore, this study aims to propose an implementation of OF within a semi-heterarchical architecture focused on reactivity, hence on the way in which OF could be used to deal with different kinds of internal and external perturbations. This paper is organized as follows. Section II provides the FMS formalization problem. Section III presents a state of the art considering OF within FMS control and semi-heterarchical architectures. Section IV is dedicated to description of the chosen semi-heterarchical architecture (SHFMS). In Section V, a description of the possible configurations to integrate OF within the SHFMS are presented. Then, section VI describes two instantiations of the SHFMS architecture using two interaction modes: the coercive and limitary. Section VII deal with implementation of these two instantiations. Section VIII reports an experimental study and results analysis. Some conclusions and further research topics are listed in the last section.

II. THE FMS PROBLEM

FMS control deals with scheduling, dispatching and on-line monitoring. The FMS decision-making problem can be modeled as a flexible job-shop problem (FJS). The FJS problem deals with the allocation of a sequence of operations, corresponding to a set of n different products \( P = \{1, 2, \ldots, j, \ldots, n\} \), into a set of \( r \) equivalent machines, possibly with different processing characteristics. Hence, there exist different machine sequences for the same type of product. It is thus assumed that a machine can process one operation at a time and one operation is performed by only one machine.
In this regular session, many projects present the manufacturing aspects based on the following topics:

Some topics developed in this session:

- Metaheuristic, Bee colony;
- Lot sizing problem;
- Optimization, Simulation;
- Quality-Maintenance policy.

Presented papers:

- Reduced simulation model for flow analysis in a sawmill internal supply chain
- Metaheuristic based optimization for capacitated disassembly lot sizing problem with lost sales
- Integrated Quality-Maintenance policy with Reworking Activity
- An Artificial Bee Colony with Aging Leader in the Elite Group Approach for Intercell Scheduling Considering Transportation Capacity
- A multi-level capacitated lot-sizing problem with energy consideration
Reduced simulation model for flow analysis in a sawmill internal supply chain
(presented at the 6th IESM Conference, October 2015, Seville, Spain) © I4e2 2015

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Abstract—Accurate and simple simulation flow model is useful to make decision at the right time to manage supply chain or workshop. To do that, different reduction model complexity approaches have been proposed. One of them is to associate discrete event model of bottlenecks and continuous model of other work centers according to the theory of constraints. The continuous approximation is used only to determine how the bottlenecks are fed. Different continuous model have been proposed in the past. This paper focuses on the association of regression trees and neural networks in order to benefit of the advantages of each other. This approach is used for the modeling of a sawmill workshop and the results are compared with those obtained previously by using only CART model or neural network model.

Keywords—Decision tree; CART; reduced model; neural network; simulation; supply chain; learning

I. INTRODUCTION

The decision making process in internal/external supply chains (SC) domain needs to evaluate planning or scheduling strategy. Part 3 is devoted to the considered industrial application case, when part 4 presents the results before to conclude.

This “predictive scheduling” may be called into question when significant events occur on the shop floor. This fact implies to perform a “reactive scheduling” by using information on these events collected by the real time systems [6]. The main difficulty is to exploit this information quickly in order to take decision [12, 13]. The goal is to manage critical resource capacity which are mainly bottlenecks [20]. The theory of Constraints (ToC) consists in managing all the SC by bottlenecks control [4]. In this case, the evaluation of material flow by discrete events simulation model is useful [14]. However, the building of such models is a very complex task and lead to problem of scale [11] that is why different approaches of reduced/aggregated simulation modelling has been proposed [2, 3, 19]. Among these different approaches, the using of continuous flow models to approximate discrete manufacturing environments is one of the more investigated [19]. The authors have proposed and compared different types of continuous models including neural networks (NN) [19] or classification and regression trees (CART) [17]. These two tools are able to extract models directly from dataset. The main advantage of CART is that the resulting model is a sequential model which logically combines a sequence of simple tests. This fact allows to extract knowledge from the model.

This paper investigates the association of NN and CART models in order to improve the continuous approximation of the reduced part of the simulation model. The main idea is to compare the structures of different CART models of the same system constructed with different datasets. The common part of these models is preserved when the divergent parts are discarded and replaced by NN models. This approach is tested and compared with the results obtained by using only NN or CART models on sawmill internal SC case.

The next section presents the reduced model building strategy. Part 3 is devoted to the considered industrial application case, when part 4 presents the results before to conclude.

II. THE REDUCED MODEL

A. The algorithm

The main idea of the approach is to determine which part (work centers) of the system is essential to model and which one is less important. This is performed according to the ToC concept [4] with the goal to reduce the number of elements, connections and model calculation in order to reduce complexity [22]. A literature review of reduction model approach can be found in [19]. The reduction model approach proposed here is based on the one proposed by Thomas and Thomas [18] where discrete event models and continuous models are associated to design the simulation model. The essential works centers of the model are described by using discrete event model when continuous model is used to determine how the essential work center are fed. The main
Metaheuristic based optimization for capacitated disassembly lot sizing problem with lost sales

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ABSTRACT—Disassembly operations are required for most of manufactured products at the end of their life cycle. As economic activities and environmental pressures increase, the volume of product reverse flows are more and more important and costly. In this context, we propose an optimization method to minimize cost in disassembly planning with lot sizing and lost sales. Comparing to others lot sizing problems with lost sales, this problem has some specificities that required original optimization methods. To this end, we proposed a metaheuristic based on genetic algorithm scheme that integrates some neighborhoods dedicated to this problem. The quality of the solutions is compared with those obtained from a mathematical programming solver for small instances and different configurations of the algorithm are compared. The metaheuristic allows finding good solutions in a reasonable computational time for this tactical problem for all instance sizes.

KEYWORDS—Disassembly; Reverse logistic; lot sizing; Mixed integer programming; metaheuristic

I. INTRODUCTION

Nowadays, manufacturing enterprise are responsive for the products they produce until the end of their life cycle. Reverse logistic aims at recovering end-of-life products to supply recycling, remanufacturing or repair process or to dispose them in an environmentally conscious way. To this end, most of manufactured products have to be disassembled in order to separate their materials and theirs components which have to be assigned to different process. With current increasing environmental pressures, disassembly activities are caused to develop and planning decisions are becoming more difficult.

In this paper, a disassembly planning defines how many end-of-life products to disassemble knowing the demands of their components in each period of a finite and discrete planning horizon. The objective is to satisfy customer demands while minimizing several costs. In disassembly lot sizing, inventory costs and disassembly costs are considered. As in single item production lot sizing, disassembly (production) quantities of several periods are grouped into a single one to decrease disassembly costs (particularly fixed set-up cost) while increasing inventory costs. Optimization methods are used to find solutions with minimum costs [1]. However, disassembly lot sizing problems have some specificities and need dedicated models and optimizations methods [2].

One of the main specificity of disassembly lot sizing problems compared to others lot sizing problems is that with one product several component demands have to be satisfied. Due to the yields (number of each component contained in one product) and the demands between components that are not necessarily well balanced, high inventory surplus can be generated throughout the planning horizon [3]. Disassembly lot sizing models with lost sales or (component) outsourcing are thus interested to apply when it is possible in real industrial cases.

In this paper we consider multi-product disassembly lot sizing problem with two-level product structures, setup and inventory cost, lost sales costs and limited capacity. Part commonalities between products are not considered. To our knowledge, this problem has not been studied in literature. In section II, a literature review is proposed on disassembly planning (without lost sales) and on production lost sizing with lost sales. In section III, a mixed integer program (MIP) model is presented. The MIP solver CPLEX do not give solutions in a reasonable amount of time for large instances of the problem. Our contribution is presented in section IV which is a metaheuristic based approach with use several dedicated neighborhoods. An experimental study is also proposed in section IV.

II. LITERATURE REVIEW

The disassembly planning problem for a single product without explicit cost function can be treated by a reversed Material Requirement Planning (MRP) approach [4]. This problem was further extended in [5] to include parts commonality for multiple product disassembly. The capacitated problem can be modeled with an integer programming model as in [6] for the case of single product type. When set up costs and inventory costs are considered in the objective function, lost sizing decision have to be made. In this case, several lot sizing heuristic are studied in [7] to improve solutions obtained from reverse MRP algorithm. MIP models can be used for the problem with part commonalities and relaxation based heuristic gives good solutions in reasonable time [8] [9]. The capacitated problem is solved in [10] without part commonalities with a Lagrangian relaxation that gives good lower and upper bounds. The approach also integrates random demands and backorders. The relaxed problem is solved by using dynamic program based on the zero inventory property traditionally used in lot sizing [11]. This property is not valid for the case with lost sales and the previous approach cannot be used.
Joint Integrated Maintenance-Quality Policy with reworking activity

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Abstract—This paper investigates integrated models joining Non Quality effect and preventive maintenance (PM) policy. We consider a single machine subject to random failure rate and producing progressive deteriorating products. A preventive maintenance (PM) strategy with minimal repair is applied with non negligible durations of maintenance tasks. This study consists in developing analytical models in order to determine the optimal integrated maintenance plan taking into account the impact of non-conforming products. Two strategies are developed. The first strategy consists on selling products at a discount price due to the loss of quality caused by the machine degradation. The aim of this strategy is to determine the optimal number of batches produced $N^*$ after applying each preventive maintenance action maximizing the total profit ($P_{NT}$) per time unit. For the second approach, we propose a rework activity for deteriorated products in order to improve their quality condition to be sold at the best price $P_{max}$. For this second strategy, our objective is to determine the number of batches sold after a reworking task $N_1$ and the number of batches sold at a discount price $N_2$. A mathematical model is developed to find simultaneously the optimal value of the two decision variables $N_1^*$ and $N_2^*$ which maximize the total net profit ($P_{NT}$) per time unit for a finite horizon $H$ taking into account rework and setup costs. The preventive maintenance action will be undertaking after each $N_1+N_2$ batches. Numerical examples are presented in order to illustrate proposed models and a sensitivity study is used to evaluate the influence of model parameters.

Keywords: Integrated maintenance strategy, quality deterioration, degradation, Optimization, rework cost, setup cost

I. INTRODUCTION

In todays highly dynamic and rapidly changing environment, manufacturing companies that want to survive must manage several functional areas successfully such as maintenance, quality, production and marketing. The increased global competition call farms to ensure an efficient coordination between them. Consequently, managers and decision makers have to consider new management approaches integrating the interaction between parts or all of those functions. Maintenance and quality are among important components in any industrial process and they have been widely studied separately during decades. In fact, the earliest work on maintenance policies was elaborated by Barlow [1] and since that researchers has allocated considerable efforts on developing and optimizing preventive maintenance models which contributed to a good understanding of the properties and effectiveness of preventive maintenance policies under various conditions. During the last decade companies have realized that strategies dissociating maintenance and quality were imperfect and ineffective and it is commonly argued that preventive maintenance (PM) policies can contribute significantly in increasing equipment reliability as well as product quality. In this perspectives, the need for developing new integrated maintenance-quality strategies became evident and the simultaneous consideration of maintenance policies and quality deterioration has recently become an important research area. We intend in this study to develop new models joining maintenance and quality simultaneously for a manufacturing system composed of a single machine producing a single product. The machine is subject to progressive degradation according to an increased random failure rate which affects the product quality. We consider a PM strategy with minimal repair. The preventive and corrective actions have non-negligible durations. The aim is to find a compromise between the quality deterioration and the preventive maintenance action under different strategies.

The main contribution of this work consist on applying preventive maintenance action after a number of batches produced contrarily to existing literature in which the preventive maintenance action is related to time. In addition, the majority of research treated the problem in term of reliability and equipment state. In our study, we focus on the economic effect of quality deterioration by maximizing the total profit under some conditions. Moreover, we study the optimization for a finite horizon with the possibility of reworking task and taking into account the setup cost.

The reminder of this paper is organized as follow: next section gives an overview of works that study maintenance policies and the integrated maintenance strategies. Section 3 introduced the problem statement and the notation used. In section 4, we present two mathematical models each for giving strategy. Section 5 is dedicated to present numerical examples to illustrate our models and results obtained and in the last section we present a sensitivity study to show the impact of the variation of some parameters.

Motivation

Practitioners and academicians recognize that there is a strong relationship between product quality and equipment
Abstract—Intercell transfers make the idea of creating independent cells in cellular manufacturing systems impossible, but are essential for enterprises to reduce the costs. Because intercell transportation in the equipment manufacturing industry cannot be neglected, the problem of intercell scheduling with a limited transportation capacity constraint, which is essentially the integration of part scheduling and transportation, is addressed in this paper. An artificial bee colony (ABC) with aging leader in the elite group (ALEG) approach is proposed. Different from the basic ABC algorithm, a leading mechanism, namely ALEG is used in the onlooker bee phase, which provides the colony with more opportunities to search in promising regions. Aiming at minimizing the total weighted tardiness, the experiment is conducted by applying two leading mechanisms, i.e., ALEG and the one proposed in the previous study, to ABC, respectively. Computational results show that the proposed approach is better than the latter one.

Keywords—intercell scheduling; limited transportation capacity; artificial bee colony; aging leader in the elite group

I. INTRODUCTION

Cellular manufacturing (CM) is an implementation of group technology (GT), in which parts or part families requiring similar production processes are grouped into distinct manufacturing cells. Ideally, all machines required for producing a part can be allocated to a cell.

However, in real production, parts are becoming more and more complex, and some parts assigned to one cell may require a particular machine in another one. Although purchasing additional machines is one resolution to the above difficulty, it may not be economical to achieve such cell independence. The parts requiring processing on machines in two or more cells are termed exceptional parts in this paper. Additionally, there exist some special machines which are put together in a specific cell owing to their high prices and large volumes. Because manufacturing resources are both valuable and rare, they are about to process various parts from different cells. These machines are called exceptional machines. Therefore, to transport parts between two or more cells is inevitable. Intercell transfers are defined as the movement caused by an exceptional part or an exceptional machine [1], which disrupt the philosophy of creating independent cells in CM but are essential for enterprises to reduce production costs.

Our survey of the equipment manufacturing industry in China indicates that, for some complex products like synthetic transmission devices, intercell transfers occur in the processing routes of more than 51% of parts, and more than 47% of tardy parts are caused by inefficient intercell cooperation. Therefore, it is needed that scheduling is studied in the context of multiple cells with intercell transfers.

It was reported that 72.9% of manufacturing firms with more than 100 employees had adopted manufacturing cells [2], the median level of intercell flow was 10% (with a mean of approximately 20%) and only 10% of the surveyed shops processed parts completely within cells [1]. According to Garza and Smunt [1], the effects of intercell transfers have on manufacturing systems should be quantitatively analyzed for intercell transfers were unavoidable. However, compared with cell design (which includes cell formation and cell layout [3], [4]) and cell operation (which deals with planning and scheduling in CMS [5], [6]), little research on scheduling problems considering intercell transfers has been found.

Some researchers focused on intercell scheduling problems of flow shop cells with intercell transfers. Yang and Liao [7] proposed a branch-and-bound approach for a scheduling problem in a CMS, in which there were two cells and the maximum number of operations each part had within each cell is less than two. However, the fact is that there are usually multiple cells in a CMS, and each part might have more than one operation in a cell. Solimanpur et al. [8] developed a two-stage heuristic approach in which the sequence of parts within a cell was determined in the first stage followed by the sequence of cells. In their study, it was assumed that intercell transfers could not happen until destination cells had completed processing all parts originally assigned to them. However, intercell transfers may occur at any time in practice. Tavakkoli-Moghaddam et al. [9] proposed a multi-criteria scatter search algorithm by simultaneously considering makespan, intracell

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A multi-level capacitated lot-sizing problem with energy consideration

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Abstract—This paper reports on a new Multi-Level Capacitated Lot-Sizing Problem (MLCLSP) taking into account the energetic aspect. A linear mixed integer programming model is proposed to solve this problem. Since the MLCLSP is NP-hard ([10]), two heuristics, that provide solutions in a reasonable computational time, are developed. In this study, the horizon is split into $T$ periods where each one is characterized by a duration, an electricity cost, a maximum peak power and a demand. To evaluate the performance of the model and the heuristics, computational experiments are presented and numerical results are discussed.

I. INTRODUCTION

The lot-sizing problem has as objective to determine the quantity of products to be produced at each period to satisfy the demand while minimizing total costs. This problem is considered to manage the production planning in manufacturing systems.

The rise in energy price and the intensification of the global warming provide motivation for the manufacturers to minimize their energy consumption and green house gas emissions. Generally, a quick literature review about production planning and scheduling shows that the main objectives for the production decision model are cost, time and quality. Decreasing energy consumption in industrial systems is not widely developed, but recently, there has been growing interest in research treating this aspect.

Reference [19] presents a mathematical model to minimize total tardiness of jobs and total energy consumption in a single machine. Another research study deals with a generalized case with a set of machines [13]. While respecting the peak power's demand for the manufacturing system, the authors of [6] proposed a mixed-integer programming problem that aims to minimize total tardiness and makespan. A reduction of the power demand for a scheduling problem in a hybrid flow-shop system is considered in [26]. The minimization of total electricity consumption and total electricity cost without affecting the throughput are proposed in [25]. To reduce the power demand during peak periods, the authors of [21] introduced a "just for peak" buffer inventory model. Minimizing the makespan, peak power consumption and carbon footprint are the objectives of [8] for the flow-shop scheduling system. The variation of the electricity price according to periods is considered in [4] and [14].

Minimizing the makespan and energy consumption in manufacturing systems are the objectives of the proposed model of flexible flow-shop scheduling [7]. For lot-sizing problem taking into account the ecological aspect, the reference [1] introduced periodic, cumulative, global and rolling carbon emission constraint in the single item lot-sizing problem. Carbon emission, power usage and water consumption are integrated in lot-size study [12]. The limitation of green house gas emission in manufacturing systems for lot-sizing problems is also considered [29]. For the energy consumption and $CO_2$ reduction, the reference [20] looks as example a steel industry.

In this paper, we will focus on lot-sizing problems in flow-shop systems. For this type of problem, several research studies can be cited. Ramezanian et al., were looking for minimizing the production, holding and sequence-dependent setup costs while respecting availability constraints in [21]. Another study proposed a multi-level and multi-period capacitated lot-sizing and scheduling problem with setup carry over, backlogging and sequence-dependent setups [2]. A mixed-integer model for lot-sizing problem in flow-shop systems was developed in [17] where the objective is to minimize production, storage and makespan costs. To minimize setup, holding and over time cost, a mixed-integer model for multi-level capacitated lot-sizing problem is presented in [22]. The research study of [16], dealing with this type of problem, aims to minimize sequence-dependent setup, holding and production costs.

So, neither energy nor environmental impacts have been yet taken into account for this type of problem.

In this paper, a multi-level capacitated lot sizing problem with energy consideration is presented, first introduced in [15]. The variation of the electricity price is taken into account. Two types of demand response programs are exposed in [11] : price driven and event driven. The price of electricity varies according to periods, "off-peak" and "on-peak". The price during the off-peak period is lower than the on-period's one. To minimize the cost of electricity, the manufacturers manage their production planning in a way to produce mainly during off-peak periods. For this category, Time Of Use (TOU), Critical Peak Pricing (CPP) and Real-Time Pricing are some examples. For the second category, in response to specific triggering events as weather condition and systems economics, rewards will be allocated to customers who reduce their electricity consumption.

The outline of this paper is organized as follows. In section 2, the problem description and assumptions are presented. Section 3 presents an illustrative example. Section 4 reports the heuristics description. The numerical examples are presented in section 5 and the last section presents the conclusions and future researches.
In this regular session we aim to highlight some different research areas with regards to the logistics problems.

Some topics developed in this session:

- Supply chains, manufacturing systems;
- Cross-docking;
- Location routing problem;
- Determining;
- Metaheuristic methods

Presented papers:

- Determining the optimal routes in the multi-product multi-site joint delivery problem
- Integrated strategic and tactical optimization of animal-waste sourced biopower supply chains
- A hybrid metaheuristic approach for the Capacitated Vehicle Routing Problem with Container Loading Constraints
- A model and a metaheuristic method for the Hub Location Routing Problem and application to postal services
- A comparison of different cross-docking organizations in a JIT manufacturing system; application in the automotive industry
Determining the optimal routes in the multi-product multi-site joint delivery problem
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Abstract—When planning the delivery in a supply chain, it is necessary to prepare a schedule of deliveries for different products at different sites during the planning horizon while satisfying demand and respecting material and financial resources constraints. In addition, to manage a supply chain, we need to solve problems such as the JRP (Joint Replenishment Problem) taking into account the problem of organizing delivery tours as in the IRP (Inventory Routing Problem) model. In this study, the conventional assumption of periodic deliveries for each pair (product, website) was lifted to better utilize the degrees of freedom in the delivery program over a common cycle used in the optimization as a planning horizon. Assuming that the planning horizon was previously determined, the proposed formulation for the joint delivery model (JDP) takes the form of a multi-site version of the classical multi-product IRP problem, but with major and minor set-up costs and with consideration of an indirect grouping strategy for deliveries for each product. This is a mixed integer linear programming problem (MILP) having real variables and binary variables. As such, it is known as a NP-hard problem.

Keywords—Joint Replenishment Problem; Inventory Routing Problem; Lot Sizing Problem

I. INTRODUCTION

In the general context of multi-product and multi-site supply networks, two generic mathematical problems are the joint replenishment problem (JRP) and the Inventory Routing Problem (IRP) as studied in [1]. The study of the JRP problem in a multi-actor framework can lead to the analysis of the joint replenishment game, an approach that may be strategic, cooperative or dynamic. This problem can be analyzed from the perspective of the provider that manages inventory of its customers, using an integrated approach of the VMI type (Vendor Managed Inventory), which became very common in the last decade [2], or a cooperative approach where buyers cooperate by pooling their orders, as in [3]. The basic JRP model [4, 5] addresses the problem of how to group commands optimally among the products and / or buyers. These models are nonlinear because they assume unknown the elementary supply period and aim at optimizing it. Moreover, since they do not take into account explicitly the organization and planning of delivery rounds, they admit periodic solutions for each product and / or each center since consumption rates are assumed to be constant.

This paper presents and analyzes the coordination and organization of supplies by integrating the transport of products to various distribution sites. Typically, the model combines the JRP inventory problem with transport problems. It can therefore be also regarded as a multi-site extension of the Inventory Routing Problem (IRP) applied to supply chains [6]. The IRP introduced by Bell et al. [7] intends to couple the decisions of delivery and routing. It is a planning problem that takes into account inventory capacity at each site and the distributor delivery capability from the common warehouse when planning delivery rounds. Its objective is to satisfy the customers’ needs at minimum cost over the planning horizon. Its extreme complexity comes from the fact that the routing decisions are usually optimized for each tour [8]. The approach we propose is based on the assumptions that travel costs do not vary in time and the number of sites is not very large (up to 10). It is then possible to solve a priori all the traveling salesman problems (TSP) associated with all sites subsets. In the simplest case, the TSP problem can be solved by enumeration. But there are also high-performance exact methods for solving deterministic TSP, as the “Concorde” method proposed by D. Applegate et al. [9].
Integrated strategic and tactical optimization of animal-waste sourced biopower supply chains

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Abstract—Many models have been recently developed for the optimization of biomass related supply chains. However, models for biopower supply chains powered by animal waste have not received much attention yet. In this paper, we propose a mixed integer linear programming model for supplier selection and procurement planning for a biopower plant. The model integrates time window constraints for the collection of animal waste as well as inventory constraints. We show that the model is intractable with a state-of-the art commercial solver and propose a heuristic approach based on the Adaptive Large Neighbourhood Search (ALNS) framework. We show the efficiency of this approach on a case study in central France.

I. INTRODUCTION

The declining reserves of fossil fuels and an ever-increasing demand for energy has forced many economies to gradually shift their dependency for energy derived from non-renewable to renewable sources. The shift can be seen from the fact that between 2003 and 2012, the gross energy consumption of energy derived from renewable sources in France has increased from 12.1% to 15.6% [1].

Among the various sources of renewable energy produced in France, biomass holds a major share with 52% [2]. Owing to a large agricultural area and immense resources of animal waste, the production of energy from biomass holds a lot of potential in France [3]. Moreover, the potential of biomass to produce energy in different forms - as biofuel (bioethanol) and, biopower (electricity), is really beneficial as well. At present, there exist more than 230 active biomass processing plants worth an installed capacity of 110MWe and these figures are expected to triple by the year 2020 [4]. This boost in the number of biomass processing plants is due to the increased feed-in tariffs and subsidies provided to the producers.

However, despite the abundance and ease of availability of biomass (agricultural and animal waste), producing energy from biomass is costlier than other sources [5]. In particular, transportation cost of animal waste is an issue because of its high water content [6].

Thus, it is imperative to produce energy at the lowest possible costs for biomass to remain an attractive source of energy in the future.

Biomass collected from agricultural farms can be broadly divided into two categories waste coming from plants (agricultural biomass) and animal waste. Agricultural waste is generally produced during the harvesting season in high quantities. While on the other hand, animal waste is characterized by irregular production, and in small quantities. This imposes time-windows on the collection of animal waste, and thus differentiates it with the agricultural waste. In this paper, we consider the strategic selection of animal waste suppliers for a biopower plant and the tactical optimization of the collection schedule at suppliers. In must be noted here that the biomass considered in this study is restricted to animal waste, due to its characteristics which make it different from other biomass supply chains. In section II, we review the related literature to better position our work in the corresponding field of research. In section III, we propose a mixed integer linear programming (MILP) formulation. The MILP model minimizes the total costs, by taking into account the transportation costs incurred while procuring the biomass. We take into account the time-windows (minimum and maximum gap between consecutive deliveries) to align this problem closer to practice. The model also takes into account several practical constraints such as the collection of a minimum percentage of biomass from a selected supplier. This constraint does not exist in all situations, but is still common in many real-life situations. In section IV, we present a case study in central France and show that the CPLEX solver cannot solve it within acceptable computation time. In section V, we propose an Adaptive Large Neighborhood Search (ALNS) [7], [8] meta-heuristic for the problem. We also run scenarios with different plant capacities and time discretizations. Section VI concludes this paper, and maps issues for further research.

II. LITERATURE SURVEY

Extensive literature reviews on the biomass supply chains have been proposed by [9], [10] and [11] and can be referred for the current state of the art of the problem. In their literature review, Eskandarpour et al. [12] identify biomass to bioenergy supply chains as the leading application area of sustainable supply chain network design.

Studies have been made to reduce costs by the optimization of the biomass to bioethanol supply chains which
A hybrid metaheuristic approach for the Capacitated Vehicle Routing Problem with Container Loading Constraints

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Abstract—In this work, we introduce a hybrid metaheuristic approach for the 3L-CVRP. The proposed approach uses an initial solution obtained by a modified Clark & Wright algorithm considering the packing constraints by a GRASP scheme. Then, a Granular Tabu Search (GTS) algorithm is employed to improve the initial solution, meanwhile the GRASP approach validates the packing constraints during the search process. The proposed algorithm has been compared with the most effective algorithms proposed for the 3L-CVRP. Computational results show the effectiveness of the proposed approach.

I. INTRODUCTION

The research problem related to the decisions of determining routes and the best place to carry on the products within a container for a given route, is a prominent research area. Both decisions are challenging combinatorial problems and considered as classics NP-hard. Currently, the combined problem of routing and packing have increased the interest of the industry and practitioners of the applied research on combinatorial optimization problems. The main motivation of this research study is to integrate the Container Loading Problem (CLP) with the classical Vehicle Routing Problem (VRP).

The CLP seeks to find the best position of the boxes to be delivered to a set of customers. The main objective of the CLP is to maximize the utilization of the space and the allocation of products with patterns that do not need relocation of the load when a customer is visited by a vehicle in a performed route. In addition, the VRP tries to minimize the distance traveled by the performed routes. The combination of the VRP and the CLP together produces a problem called the Capacitated Vehicle Routing Problem with Three Dimensional Loading Constraint (3L-CVRP). The 3L-CVRP considers a set of homogeneous fleet.

In this work, we introduce a hybrid metaheuristic approach for the 3L-CVRP. The proposed approach uses an initial solution $S_0$ obtained by a modified Clark & Wright algorithm by considering the packing constraints which are controlled by a GRASP scheme. Then, a Granular Tabu Search (GTS) algorithm is applied to improve $S_0$, meanwhile the GRASP approach validates the three dimensional loading constraints during the search process.

The paper is structured as follows. A formal description of the problem 3L-CVRP is presented in Section II. The literature associated to the 3L-CVRP is presented in Section III. Section IV presents a detailed description of the framework used by the proposed algorithm. A computational comparative study on a subset of benchmark instances from the literature is provided in Section V. Finally, Section VI contains concluding remarks and future research.

II. DESCRIPTION OF THE PROBLEM

The Capacitated Vehicle Routing Problem with Loading Constraints (3L-CVRP) considers the combination of two well-known NP-hard problems: Capacitated Vehicle Routing Problem (CVRP) and Three Dimensional Loading Problem (3L). In the 3L-CVRP, $n_i$ is the number of 3-dimensional items demanded for each customer $i$ (where, $(i = 1, 2, \ldots, n)$) and $c_i$ is the total weight of the demand ordered by each
A model and a metaheuristic method for the Hub Location Routing Problem and application to postal services

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1. Introduction

Among freight transportation companies, some are specialized in Less Than Truckload (LTL) shipments, consisting in the transportation of small freight, collected from various shippers and distributed to various clients. To achieve economical performance, they need a special organization, based on hub terminals to consolidate flows. The freight collections can be operated in a straight-and-back way or through a multiple stop tours, depending on the quantities shipped. After collection, freight in sorted and consolidated within the hub, either for additional line-hauls to another hub or for shipment to the destination, directly or through delivery tours. Applications of such a system, can be found in the express freight industry or for postal systems and this problem is known as the Hub Location Routing Problem (HLRP).

In this paper, we focus on postal service systems, presenting some specific characteristics. In this application, each node location represent a post code district which has both collection and delivery flows to handle. These flows correspond to parcels or mail volumes and can be exchanged between any two node locations of the network. The hub nodes play not only a consolidation role but offer also a sorting function. Indeed in this hub location-routing network of postal systems, instead of direct connection between two nodes, the parcels are consolidated, sorted and grouped at hub facilities and then are sent to the different destinations. In order to reduce the number of vehicles used in the system and increase the efficiency, local tours are operated between non-hub nodes to collect and deliver the parcels or mail instead of through direct links between non-hub and hubs nodes. In postal service systems, mail collected in the area of a non-hub node may be redistributed within the same area or elsewhere. This indicates that flow may be sent to a hub node where it is sorted and then be returned to the same post district (same node). In such a system, collection and delivery processes are handled simultaneously in the same route. Therefore, each non-hub node location is be visited once through a single vehicle route.

Based on the above description, the network of HLRP in postal service systems can be represented in Fig. 1 where the squares and circles represent the established hub nodes and non-hub nodes, respectively. The bold lines are inter-hub arcs while dotted lines denote local tour arcs. So in order to optimize the design of a hub location-routing network for a postal service system, one needs to determine the location of hub nodes, the allocation of non-hub nodes, as well as the local tours visiting each node location for collection and deliveries.

The goal of this paper is to present and discuss the HLRP and propose a mathematical model for it with specific assumptions and an efficient metaheuristics in order to solve realistic instances. In the next section we present a state of art of this problem and review previous works. A mathematical formulation is proposed in section III and a memetic algorithm is developed in section IV. The generation of instance sets is described in section V, as well as our computational experiments and results. Section VI contains our conclusions.
A comparison of different cross-docking organizations in a JIT manufacturing system; application in the automotive industry
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Abstract—Cross-docking is a logistics strategy used to accelerate the flows and to reduce inventory levels. In this paper, we consider the case of cross-docking centers applied in JIT manufacturing systems. We make a comparison between different cross-docking positioning policies: per supplier, per time slot, per mixed small/big time slots and per mixed supplier/time slot. We intend to shed light on the impact of different characteristics of the system like the supplier arrival frequency and the capacity of cross-docks on the performance of each cross-docking policy. The case study of Faurecia, an automotive parts suppliers, is used to consolidate the insights of our paper. We find that it is better to use the mixed cross-docking because it permits to minimize the used surface and to facilitate the realized movements.

Keywords—cross-docking; JIT plant; warehousing; picking; supplier

I. INTRODUCTION

Cross-docking is a warehousing strategy used in distribution and manufacturing systems to improve the responsiveness of the supply chain. There are many definitions of cross-docking in literature, Van Belle et al (2012) define it as the process of consolidating freight with the same destination (but coming from several origins), with minimal handling and with little or no storage between unloading and loading of the goods. Different companies from different sectors use cross-docking in their supply chains like Walmart and Toyota. In fact, cross-docking has many advantages: it permits to reduce the warehousing costs, the labor costs and the storage space.

Generally, cross-docking center is an independent facility used in the distribution part of the supply chain (see Figure 1). It links between the final destination (retailers, customers) and different sources (suppliers, vendors, distribution warehouses…). In our study, we consider a different form of cross-docking used in manufacturing systems (see figure 2) where the final destination is the picking zone of the manufacturer and the sources represent the suppliers. In fact, our model is based on the case of Faurecia, a supplier of automotive parts. They work on four areas of business: automotive seating, interior systems, automotive exteriors and emissions control technologies. Faurecia uses JIT manufacturing systems. Their plants are composed of a cross-docking zone, a picking zone and assembly lines. The model used in this paper can be generalized to all companies that use JIT manufacturing systems.

Fig. 1. Classic cross-docking center

Fig. 2. Cross-docking in JIT plant

A classic cross-docking center consists of inbound and outbound doors where the trucks load or unload the freight. The cross-docking center contains also a storage space where the goods are stored. Generally, the goods stay less than 24 hours in the center, unless, the center is considered as a traditional warehouse. The storage space consists of lanes called the cross-docks (see figure 3). The lanes can take many forms like I, U, L… In this paper, we assume that the cross-docks have an I-shape called also “narrow rectangles”. When the truck arrives to the center, the operator knows exactly the
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