International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 32 No. 2 Mar. 2021, pp. 240-248

http://www.ijias.issr-journals.org/

Production Planning under uncertainty in the aerospace companies in Morocco: State of the art

***Soumaya Idrissi Jazouli*[1], *Kenza Sahaf*[2], *and Said Rifai*[2]**

[1]Industrial Engineering, ENSEM School of Engineering, University Hassan II, Casablanca, Morocco

[2]LMPGI Research Laboratory, ESTC High school of Technology, University Hassan II, Casablanca, Morocco

ABSTRACT: Nowadays, manufacturing companies, especially aeronautical ones must be at the forefront of technology in terms of new products, flexibility and performance. Indeed, the key indicator logistic for any company wishing to remain competitive in the market is: the OTD (On Time delivery= Customer Service Rate).
This paper reviews some of the existing literature review of production planning, uncertainty and some solution approaches for the following production planning under uncertainty over the past decade.
The purpose of this article is to provide the reader with a starting point about production planning problems under uncertainties with some optimization methods existing through literature.

KEYWORDS: Production Planning, Uncertainty, DDMRP, Aerospace, Morocco, Flexible manufacturing System and Supply chain uncertainty.

1 INTRODUCTION

In today's unstable market environment, companies need to integrate demand uncertainty into their planning methods in order to better manage their resources and preserve their performance. Hence the need for planning tools to enable companies to overcome market fluctuations related to an uncertain and turbulent economic environment. Supply chains such as those in the aeronautics sector manufacture products to order, but also use standard components that are manufactured from stock (e.g. pitot probes, portholes, etc.) [1].

This paper seeks to provide a synthesis of the art of research that deals with the problems related to production planning under uncertainties, and mainly answers the following question: How is it possible to establish a production schedule under several unpredictable disruptions?

It is in this context that our research work aims to choose a well-adapted method of optimization to manage production within an aeronautical firm.

Section 2 of this article is devoted to production planning, these specific types and resolution approaches. In section 3, we discuss various facets of uncertainty and their sources; section 4 is devoted to Aerospace Industry in Morocco. And we conclude by presenting our conclusion and perspective.

2 MODELS FOR PRODUCTION PLANNING AND THEIR RESOLUTION APPROACHES

The industrial environment is undergoing a technological and organizational transformation under the era of the fourth industrial revolution, Industry 4.0.

This environment, particularly in the aerospace sector, is a source of increased competition, varied market demands, specific customer needs, a wide variety of products, high standards of delivery time, rising labor costs, and reduced manufacturing capacity. This has an impact on the manufacturing environment, which requires a planning system that balances customer satisfaction with efficient use of production resources, while taking corrective action in real time when deviations from initial plans occur. To do so, production planning systems adapted to the complex context must collect real-time data to monitor manufacturing processes and identify any significant disruptions [2].

Recent research has shown that manual solutions (such as Excel) and ERP (Enterprise Resource Planning) systems still form the basis of production planning activities in industrial contexts. Moreover, the use of traditional planning tools has multiple problems: [3]

- **From a technical point of view**: data interoperability, the evaluation of the solution is limited and takes a lot of time, it is possible that the data may become false without the planner's knowledge.
- **From a practical point of view**: these solutions do not respect all the constraints of the actual systems and the load and capacity are not balanced, which inevitably leads to stock-outs.

Anthony distinguished three levels of production planning according to the length of the planning horizon: long term (strategic planning), medium term (tactical planning) and short term (operational planning). The time dimension differs from one industry to another as shown in table 1 [4].

Table 1. Types of level's planning

Planning level	Example	Horizon
Long term (Strategic planning)	• Search for new industrial partners, • Selection of suppliers and sub-contractors, • Opening, closing or relocation of production sites, • Development of a new product, • Plant configuration,	From 1 to 5 years
Medium term (Tactical planning)	• Master production schedule • Resource load balancing	From 3 to 6 months
Short term (Operational planning)	• Scheduling, • Workshop monitoring, • Dispatching rules	From 1 to 6 weeks

2.1 Models Of Production Planning

From Wikipedia, Production planning is the planning of production and manufacturing modules in a company or industry. It utilizes the resource allocation of activities of employees, materials and production capacity, in order to serve different customers [5].

And different types of production planning can be applied:

2.1.1 Advanced Planning And Scheduling

The term Advanced Planning and Scheduling (APS) encompasses a wide variety of software tools and techniques, with many applications in manufacturing and logistics (including the service sector).

APS systems are decision support tools for planning and scheduling that use computer-based optimization.

For planners, APS systems quickly analyses the implications of alternative decisions, highlight consequences and problems, and generate optimal or near-optimal plans and schedules.

APS systems provide better information (and recommendations) on which planners and managers can base their decisions. Fast-moving environments with large numbers of items, orders, machines and people are difficult to plan effectively, as are environments with complex constraints. In such industries (High tech, CPG, third party logistics, and capacity constrained industries such as Process manufacturing) APS provides significant assistance [6].

2.1.2 Capacity Planning

In the context of manufacturing systems, Capacity planning is the goal of figuring out the realistic capacity of the shop floor to meet the demand for products within a certain period, to increase your profits and minimize your costs.

These plans can be developed for short- or long-term goals.

When you look at what is production capacity planning, you can think of it as something that's put together based on: [7]

- The number of workers on your shop floor;
- The skill of your workers;
- The number of machines;
- Wastage;
- Your scrap;
- Defects;
- Mistakes;
- Your productivity levels;
- Suppliers;
- Governmental regulations; and
- Predictive maintenance.

2.1.3 MASTER PRODUCTION SCHEDULE

According to **the business dictionary**, a master production schedule translates a business plan into a comprehensive product manufacturing schedule that covers what is to be assembled or made, when, with what materials acquired when, and the cash required. MPS is a key component of material requirements planning (MRP). It sets the quantity of each end item to be completed in each week of a short-range planning period. This period varies from a week to a month depending upon the industry.

It is more helpful for production, planning, purchasing and top management by giving them the information needed to plan and control manufacturing operation.

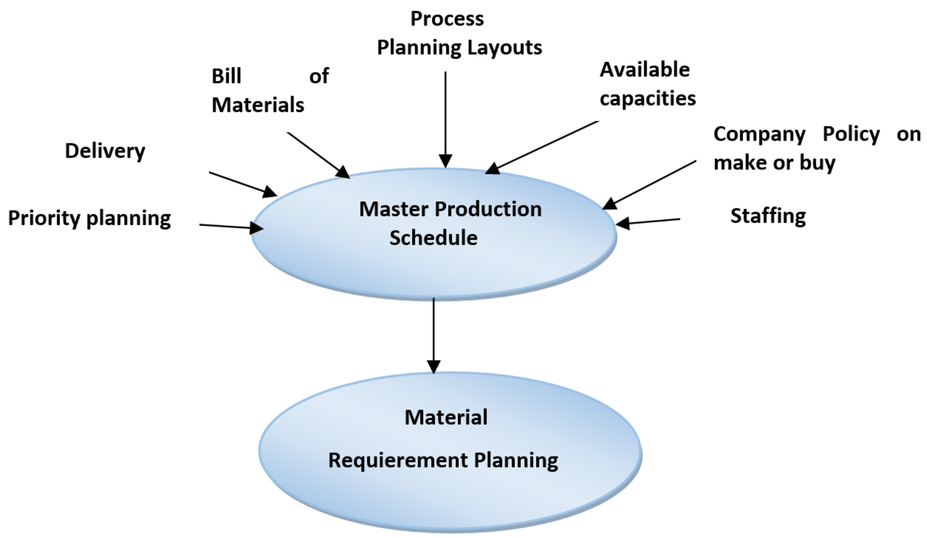

Fig. 1. Basic Input data for MPS, Master Production Schedule [8]

2.1.4 MATERIAL REQUIREMENT PLANNING

APICS (2016: pp. 110) defines MRP as "a set of techniques that uses BOM data, inventory data, and the Master Production Schedule (MPS) to calculate requirements for materials. It makes recommendations to release replenishment orders for material".

During the mid-1960s, many firms converted from Reorder Point system to MRP, thereby reducing inventory holding cost, improving customer service and streamlining operations with less need for shipments. Nonetheless, many authors have analyzed MRP and have concluded that it is not the best MPC system to deal with a volatile and variable world. In addition, MRP is fed by the forecast of the demand for the end-product, causing uncertainty and system nervousness. This leads to unacceptable inventory performance and service level, high shipping-related expenses and waste, and lack of visibility causing a bullwhip effect [9].

2.1.5 MANUFACTURING RESOURCE PLANNING

MRP II is a company-wide computer-aided system for managing all the resources of a manufacturing company. Manufacturing resource planning (MRP II) helps management to plan for all the resources required for production, including the equipment, manpower, finance, production planning and control requirements, standard costing, etc. It provides management with important details about the right time of when to order, or how much to order from suppliers, as well as the generation of new orders and rescheduling of orders, all of which are necessary to meet the ever-changing needs of customers and the entire manufacturing process. We can hence say that: [10]

Enterprise planning + Production planning + Inventory planning

leads to ➡ MRP I which leads to ➡ MRP II

2.1.6 SCHEDULING

Scheduling is the process of arranging, controlling and optimizing work and workloads in a production process.

Production scheduling is one of the most important activities of a company at the operational level for it to remain competitive in demanding consumer markets. Morton and Pentico argue that scheduling refers to the process of organizing, choosing and scheduling the resources to do all the activities necessary to meet customer demand. From this point of view, scheduling has a strategic role in the company, in contrast to many approaches that consider their importance restricted only to the shop floor [11].

2.1.7 WORKFLOW

Workflow is a generic term for the sequential movement of information or materials from one activity in a process or sub process to another in the same overall process. As applied in the CBOK, this is the aggregation of activity within a single Business Unit. Activity will be a combination of work from one or more processes. Organization of this work will be around efficiency.

The activities in the workflow will be shown as a flow that describes each activity's relationship with all the others performed in the Business Unit. Modeling will show this work as a flow that describes each activity's relationship with all the others performed in the Business Unit.

Workflows can be manual, automated, or more likely a combination of both. Workflow models often include both the diagram and the specific rules that define the flow of information from one activity to the next. When used in conjunction with the workflow system or engine, it usually refers to a software-based workflow system that will move information from a database to one computer or organization after the other [12].

Source: Guide to the Business Process Management Body of Knowledge – ABPMP BPM CBOK on Amazon.

2.2 RESOLUTION APPROACHES

The resolution approach is the last axis of that section; the categories for this axis have been established from the following methods of calculation used by the authors in literature. They have been grouped into the following approaches: [2], [4]

- Classical techniques such as MRP, MRPII, JIT and TOC
- Optimization methods
- Simulation models
- Artificial intelligence

2.2.1 CLASSICAL TECHNIQUES

Among the most classical industrial techniques of production planning and the most widespread are the Material Requirement Planning **(MRP)** technique introduced by Orlicky in 1975 which allows the calculation of the requirements for components without capacity and its evolution, and the Manufacturing Resource Planning **(MRPII)** technique developed by Wight in 1981 which integrates a system that adjusts capacity levels.

These techniques aim to generate production plans on the basis of orders which represent the input data. The main concept of the MRP method, in the generation of these plans, is to consider a fixed cycle time (or lead time) and an infinite capacity of machines.

In addition to the MRP technique and its evolutions, there are other classical techniques such as: Just in Time **(JIT)** method and the theory of constraints **(TOC)** [9].

- **The APICS Dictionary** defines **JIT** as: "A philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity. … The primary elements of **[JIT]** are to have only the required inventory when needed; to improve quality to zero defects; to reduce lead times by reducing setup times, queue lengths and lot sizes; to incrementally revise the operations themselves; and to accomplish these activities at minimum cost."

- **TOC** is a holistic management philosophy based on the principle that complex systems exhibit inherent simplicity. Every system has at least one constraint that limits the ability to generate more of the goal of the system **(APICS, 2016: pp. 187).**

2.2.2 Optimization Methods

Among the approaches to resolution by optimization, three groups were identified: the exact methods, metaheuristics and heuristics. The first group brings together the following techniques: constraint programming, linear programming and the separation algorithm and evaluation (branch and bound). Metaheuristic is a stochastic approach which aims to find an optimal solution through processes iterative. Strongly inspired by natural systems, these algorithms take as basis physical phenomena (algorithm of simulated annealing), genetics (genetic algorithm) and behavior animals (ant colony algorithm). This inspiration in natural phenomena is the main difference with the heuristics, which seeks to find feasible solutions, but not necessarily optimal or exact [2].

2.2.3 Simulation Methods

Simulation is a technique for evaluating the performance of a system based on the development of different scenarios based on a virtual model of this system. It can be considered as the emulation of the behavior of a real-world system over an interval of time. The process of simulation relies upon the generation of the history of a system and then analyzing that history to predict the outcome and improve the working of real systems.

Some of types of simulation were identified in the sample research: discrete-event simulation, discrete-event systems, and multi-agent and digital twin [2].

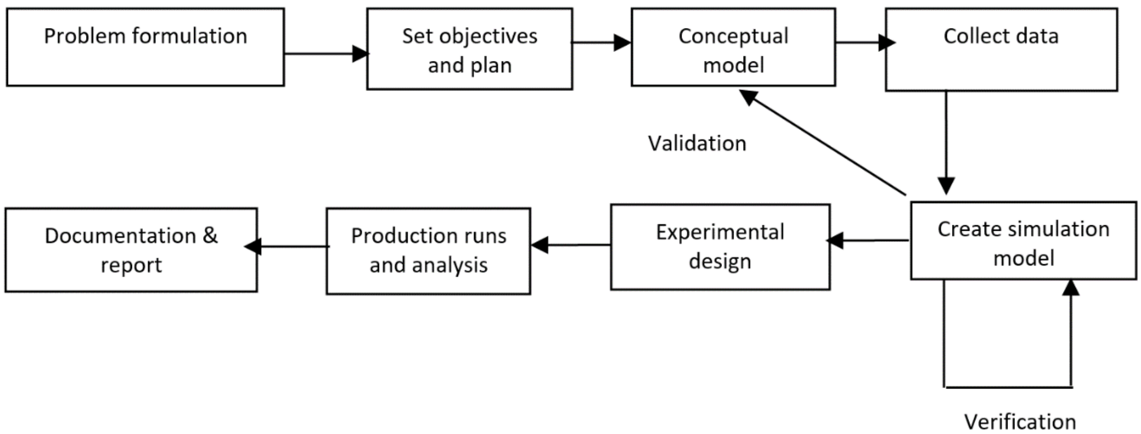

Fig. 2. Steps in a simulation study [13]

2.2.4 Artificial Intelligence

With the power of today's information technology, ever faster Internet connections and machine learning algorithms, the supply chain can rely on artificial intelligence (AI) to optimize its processes like: Planning production.

AI is a branch of computer science that is looking to program machines to solve problems, learn, plan, manipulate and move objects. It aims at generating output data based on the identification of trends by classification of the input data and numerical regressions.

Thus, the artificial intelligence has a possibility to anticipate, according to the many parameters (supply of raw materials, production speed, and time of year...) what will especially suggest according to these parameters, an optimal action plan for the production site and its various lines [2].

3 Facets Of Uncertainty And Their Sources

In this section we identify and discuss the major types of uncertainty that arise in manufacturing contexts and that can affect a production plan trough literature. Before, it is necessary first to define it;

Table 2. Definition of Uncertainty

Authors	Definition	Reference
Galbraith	Uncertainty as the difference between the amount of information required to perform a task and the amount of information already possessed. In the real world, there are many forms of uncertainty that affect production processes	[14]
Ho	Categorizes them into two groups: (i) environmental uncertainty and (ii) system uncertainty. Environmental uncertainty includes uncertainties beyond the production process, such as demand uncertainty and supply uncertainty. System uncertainty is related to uncertainties within the production process, such as operation yield uncertainty, production lead time uncertainty, quality uncertainty, failure of production system and changes to product structure, to mention some.	[14]

Through the literature, we find Three major types of uncertainty that arise in manufacturing contexts.

3.1 Types Of Uncertainty

3.1.1 Uncertainty In Demand Forecast

Nowadays, all production plans rely on a demand forecast as an input, this is usually the largest and significant source of uncertainty. In order to get more and better information about future demand, companies update their forecasts regularly (basically each week).

Forecasts are never perfect and may contain incorrect data; To address the uncertainty due to forecasts, we should characterize the forecast errors. Typically, we will view the forecast errors as random variables for which we will want to know (at least) the first two moments. It is important to recognize here that the forecast for a particular product is usually a vector of forecasts, which cover the planning horizon. That is, at any time t, for each product we have a forecast for future time periods **t+i, for i = 1**, … **H, where H is the planning horizon**. Thus, we have H forecasts; for instance, if we have weekly time periods, then we have a one-week forecast, a two-week forecast and so on. We then need to characterize the errors for each type of forecast, as each forecast has a different impact on the production plan [15], [16], [17].

3.1.2 Uncertainty In External Supply Process

A production plan cannot be achieved if we do not put in place orders on suppliers. Furthermore, the production plan has expectations on the fulfillment of these orders. For example, a plan might initiate an order for ten steel plates of a certain dimension and grade, and then expect that these plates will arrive and be available for processing according to a stated lead time of, say, eight weeks. Nevertheless, there can be uncertainty in the delivery date due to uncertainty and capacity constraints in the supplier's manufacturing and distribution processes; for instance, the order might not arrive until ten weeks due to a work stoppage or delays attributable to the weather. Otherwise, in some contexts the uncertainty can be related to the amount of delivery. For instance, a supplier might be permitted by 4 contracts to deliver plus or minus 10% of the amount ordered; in other contexts, the buyer might reject some portion of the delivery due to quality considerations. To model this uncertainty, one needs to characterize the uncertainty in the replenishment lead times and in the replenishment quantities [15], [16], [17].

3.1.3 Uncertainty In Internal Supply Process

As there is uncertainty associated with external supply process, there is also uncertainty associated with internal supply. Such as, job or work orders placed on the internal manufacturing, transportation and supply processes. For example, in the manufacture of semiconductors, that is, a plan might set the number of wafers starts into a semiconductor fabrication (fab) facility with expectations on both the yield from these wafers and the flow time or process duration for these wafers within the fab. Again, there is uncertainty on both accounts. the work-in-process in the shop, the equipment availability and the dispatch rules are the factors that impact completion time. the wafer yield is inherently random and depends on numerous process factors and conditions. Again, one needs to characterize the uncertainty in the flow or process lead times and in the yield quantities for each process step [15], [16], [17].

3.2 Sources Of Uncertainty

The following table provides a total of fourteen sources of uncertainty that have been identified.

Table 3. Sources of Uncertainty [17]

Factors / Variables	Description & Key Literature
Product Characteristics	Product life cycle, packaging, perishability, mix or specification Miller (1992), van der Vorst & Beulens (2002), Yang et al. (2004), van Donk and van der Vaart (2005)
Process/Manufacturing	Machine break downs, labour problems, process reliability, etc Miller (1992), Davis (1993), Mason-Jones & Towill (1998), van der Vorst & Beulens (2002), Christopher & Peck (2004), Sheffi & Rice (2005), Sawhney (2006), Lockamy-III et al. (2008)
Control/Chaos/Response Uncertainty	Uncertainty as a result of control systems in the supply chain e.g. inappropriate assumptions in an MRP system Mason-Jones & Towill (1998), Wilding (1998), Christopher & Peck (2004), Rodrigues et al. (2008), Lockamy-III et al. (2008)
Decision complexity	Uncertainty that arises because of multiple dimensions in decision making process e.g. multiple goals, constraints, long term plan etc Van der Vorst & Beulens (2002), Prater (2005), Xu & Beamon (2006)
Organisation structure & Human behaviour	E.g. organisation culture Miller (1992), van der Vorst & Beulens (2002), Sheffi & Rice (2005)
IT/IS Complexity	The realization of threats to IT use in the application level, organizational level and inter-organizational level e.g. computer viruses, technical failure, unauthorized physical access, misuse, etc Bandyopadhyay et al. (1999), van der Vorst & Beulens (2002), Deane et al. (2009)
End Customer Demand	Irregular purchases or irregular orders from final recipient of product or service Miller (1992), Davis (1993), Fisher (1997), Mason-Jones & Towill (1998), van der Vorst & Beulens (2002), Christopher & Peck (2004), Yang et al. (2004), Prater (2005), van Donk & van der Vaart (2005), Rodrigues et al. (2008), Lockamy-III et al. (2008)
Demand Amplification	Amplification of demand due to the bullwhip effect Davis (1993), Fisher (1997), Mason-Jones & Towill (1998), Wilding (1998), Yang et al. (2004), Prater (2005), van Donk & van der Vaart (2005), Lockamy-III et al. (2008)
Supplier	Supplier performance issues, such as quality problems, late delivery etc Miller (1992), Davis (1993), Mason-Jones & Towill (1998), van der Vorst & Beulens (2002), Christopher & Peck (2004), Yang et al. (2004), Prater (2005), Sawhney (2006), Lockamy-III et al. (2008); Neiger et al. (2009)
Parallel interaction	Parallel interaction refers to the situation where there is interaction between different channels of the supply chain in the same tier Wilding (1998), van der Vorst & Beulens (2002), Prater (2005)
Order forecast horizon / Lead-time gap	The longer the horizon, the larger the forecast errors and hence there is greater uncertainty in the demand forecasts van der Vorst & Beulens (2002), van Donk & van der Vaart (2005)
Chain infrastructure & facilities	E.g. number of parties involved, facilities used or location, etc Miller (1992), van der Vorst & Beulens (2002)
Environment	E.g. Political, government policy, macroeconomic and social issues; competitor behaviour Miller (1992), Christopher & Peck (2004), Yang et al. (2004), Rodrigues et al. (2008); Boyle et al. (2008)
Disruption/Natural Uncertainties	E.g. earthquake, tsunamis, non-deterministic chaos etc. Miller (1992), Christopher & Peck (2004), Kleindorfer & Saad (2005), Prater (2005), Tang (2006), Tomlin (2006)

Because of increasing uncertainty, supply chain management is challenging. Organizations are facing the increasing competition among supply chains and business ecosystems.

4 AEROSPACE INDUSTRY IN MOROCCO

The history of Moroccan aviation coincides with that of the Royal Armed Forces (FAR), the Royal Air Maroc (RAM) and Morocco Aviation (EADS). Established in 1957, RAM develops an industrial center of aircraft maintenance at Casablanca airport. The settlements of aerospace firms in 1990s favored labor pools around Casablanca, either integrated into the city nearest population areas or industrial areas. The focus was then is to move closer to the workforce. In 1999, SNECMA and RAM have created a joint venture, Snecma Morocco Engine Services (SMES) for the maintenance and repair of aircraft engines. SMES not only works for Airbus but also for global aircraft manufacturers such as Boeing, Embraer, Bombardier, Suiza, Messier Buggati, Dassault Facon. In 2001, SMES participated in a joint venture with Boeing and RAM to give birth to Matis Aerospace, specializing in The Development of Aerospace Sector in Morocco production of wiring harnesses for aircraft engines. Since then, the Safran group has attracted several of its subsidiaries to Morocco (Aircelle, Teuchos, Labinal Aerospace Morocco) and a number of subcontractors. Each of these subsidiaries in turn influenced the choice of location of its suppliers or subcontractors [18].

The Moroccan Aerospace industry is moving towards production (GIMAS, 2013). According to the Ministry of Industry, Trade and the Green and Digital Economy, there are currently more than 140 companies in the sector. These have created nearly 17,000 direct jobs and have achieved a turnover of 17.35 billion dirhams in 2018 [19].

5 Conclusion And Perspectives

Production planning practioners are usually very well aware of the problems they are facing. Nowadays, they also have extensive information processing equipment and vast amounts of data at their disposal. Their standard question, however, is how to exploit that advanced information processing technology at their disposal? Recently, companies, particularly those Aerospace industries, have been affected by a variety of fluctuations in demand of customers, cancellation of requirement and rescheduling the customer need…etc caused by Covid-19. So that causes progressively a larger fluctuation at the other stages of supply chain including Production Planning. This study contributes to have an overview on existing types of production planning and their resolution approaches, then the different sources of uncertainties that can impact the production planning within the manufacturing companies.

The perspective of our work is to measure the more significant uncertainty impacting the production planning in the Moroccan aerospace companies, and also to establish a production schedule under that the unpredictable disruption.

References

[1] “La gestion de l’incertitude dans une chaîne logistique globale: une étude de cas dans le secteur informatique | Cairn.info”, 11 octobre 2020, https://www.cairn.info/revue-management-et-avenir-2012-1-page-78.htm#.

[2] Estefania Tobón Valencia et al., « Production Planning in the Fourth Industrial Revolution: A Literature Review », IFAC-PapersOnLine 52, no 13 (2019): 2158-63, https://doi.org/10.1016/j.ifacol.2019.11.525.

[3] Valencia et al. Estefania Tobon Valencia, Samir Lamouri, Robert Pellerin, Pascal Forget, Alexandre Moeuf. Planification de la production et Industrie 4.0: Revue de la littérature. 13ème Conférence internationale CIGI QUALITA, Jun 2019, Montréal, Canada. ffhal-02475847f.

[4] Emna Mhiri, « Planification de la production à capacité finie dans un contexte à forte variabilité, application à l’industrie des semi-conducteurs”, s. d., 178.

[5] “Production Planning”, dans Wikipedia, 17 septembre 2020. https://en.wikipedia.org/w/index.php?title=Production_planning&oldid=978935628.

[6] “Advanced Planning and Scheduling | ORTEC”, 16 novembre 2020. https://ortec.com/fr/dictionnaire/advanced-planning-and-scheduling.

[7] “Rough Cut Capacity Planning: Is It Right for You?”, Rough Cut Capacity Planning: Is it right for you ?, consulté le 15 janvier 2021, https://katanamrp.com/blog/rough-cut-capacity-planning/.

[8] D.R. Kiran, « Master Production Schedules », dans Production Planning and Control (Elsevier, 2019), 331-44, https://doi.org/10.1016/B978-0-12-818364-9.00023-8.

[9] Alaitz Kortabarria et al., « Material Management without Forecasting: From MRP to Demand Driven MRP”, Journal of Industrial Engineering and Management 11, no 4 (27 septembre 2018): 632, https://doi.org/10.3926/jiem.2654.

[10] D.R. Kiran, « Manufacturing Resource Planning (MRP II) », dans Production Planning and Control (Elsevier, 2019), 441-55, https://doi.org/10.1016/B978-0-12-818364-9.00031-7.

[11] Helio Yochihiro Fuchigami et Socorro Rangel, « A Survey of Case Studies in Production Scheduling: Analysis and Perspectives”, Journal of Computational Science 25 (mars 2018): 425-36, https://doi.org/10.1016/j.jocs.2017.06.004.

[12] “What Is Workflow? Click to Read the Definition and Meaning”, HEFLO BPM (blog), consulté le 16 janvier 2021, https://www.heflo.com/definitions/what-is-workflow/.

[13] Prateek Sharma, « Discrete-Event Simulation » 4, no 04 (2015): 5.

[14] Josefa Mula et al., « Model for production planning under uncertainty: A review », International Journal of Production Economics 103 (1 septembre 2006): 271-85, https://doi.org/10.1016/j.ijpe.2005.09.001.

[15] Stephen Graves, « Uncertainty and Production Planning”, dans Planning Production and Inventories in the Extended Enterprise, vol. 151, 2011, 83-101, https://doi.org/10.1007/978-1-4419-6485-4_5.

[16] E. Simangunsong, L.C. Hendry, et M. Stevenson, « Supply-Chain Uncertainty: A Review and Theoretical Foundation for Future Research", International Journal of Production Research 50, no 16 (15 août 2012): 4493-4523. https://doi.org/10.1080/00207543.2011.613864.

[17] Brian Fynes, Seán de Búrca, et Donna Marshall, « Environmental Uncertainty, Supply Chain Relationship Quality and Performance », Journal of Purchasing and Supply Management 10, no 4-5 (juillet 2004): 179-90. https://doi.org/10.1016/j.pursup.2004.11.003.

[18] « The Development of Aerospace Sector in Morocco »:, dans Proceedings of the 3rd International Conference on Operations Research and Enterprise Systems (International Conference on Operations Research and Enterprise Systems, ESEO, Angers, Loire Valley, France: SCITEPRESS - Science and and Technology Publications, 2014), 264-70. https://doi.org/10.5220/0004861302640270.

[19] « AERONAUTIQUE | Ministère de l'Industrie, du Commerce et de l'Économie Verte et Numérique", consulté le 16 janvier 2021, http://intilaka.mcinet.gov.ma/fr/content/aeronautique.