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A process map for the Demand Driven Adaptive Enterprise model: towards an explicit cartography

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Abstract. The DDMRP demand-driven model is being completed and has evolved towards Demand-Driven Adaptive Enterprise, a complete business set of rules, from the strategic level to the execution. But when looking for a standard way to understand and implement how the activities are coordinated a drastic lack of precision can be noticed. Through a series of experts' interviews and the study of existing literature on DDMRP, this paper proposes a cartography of the Demand Driven Adaptive Enterprise processes, aggregated in a map. The objective is to share a first knowledge basis to (i) allow for easier implementations and (ii) identify a precise research agenda on the demand-driven methodology.

Keywords: Demand-Driven Adaptive Enterprise, business process modelling, Demand-Driven Materials Requirement Planning, DDMRP

1. Introduction

If someone was to take time to assess today's complexity of Supply Chain Management, what would he see? If someone had a good enough bird's eye view, he would notice the sheer number of different manufactured products, from simple mass-produced appliances to make-to-order custom planes. He would also reckon that to deliver even the simplest product the flows may need to go through a complex network of supply chain actors. This is today's Supply Chain Management, and for several years, methodologies like MRP (Orlicky 1975) and Kanban (Sugimori et al. 1977) were able to deal with this complexity. But customers being human, needs for personalization, demand volatility and supply network complexity increased. Thus variability to be dealt with in production systems increased. So, how can complexity, uncertainty and the pressure of cost reduction be balanced?

One of the answers to this problem is using Demand Driven Materials Requirement Planning (Ptak et Smith 2011), or its most recent version, the Demand Driven Adaptive Enterprise (C. Smith, Ptak, et Ling 2017) which encompasses a higher level of decision, like Sales and Operations activities and strategic decisions. The Demand Driven method is a flow-centred pull method that has proved on certain cases (Romain Miclo 2016; Ihme et Stratton 2015; Klein 2015) to be able to increase On-Time Delivery and reduce stock levels on the long term. It has a more resilient and agile way to produce and distribute goods. Its main claims (Ptak et Smith 2011) are to use buffers as decoupling points, thus severing the connection between strategic parts of a Supply Chain. In turn, it makes the decoupled parts impervious to variabilities, and especially the bullwhip effect. The methodology then uses two different mechanisms to generate orders on a daily frequency: net flow equation comparison to limits within buffers, decoupled explosion inherited from material requirement planning for intermediate inventories.

Despite the various implementation cases of the Demand Driven methodology, very few publications explain how the tasks and processes are linked (C. Smith, Ptak, et Ling 2017). Moreover, the constant evolution of the DDMRP methodology generated vocabulary and definitions changes. The various feedbacks from previous implementations also state that, to that day, the Demand-Driven Institute training are not complete enough to allow supply chain managers to use fully use the demand-driven methodology.

This is the reason why we chose to bridge the gap by aggregating all existing piece of knowledge on the DDAE model onto a single process map. It would serve as a first step towards a complete view of the Demand-Driven methodology. However, this work is subject to some hypotheses, tied to the environment where it has been conducted. Hypotheses include, for example, using an information system, which is normally not included in the Demand Driven model. We hope that this work can serve as a foundation of a shared process. It would serve as (i) a support for supply chain managers and specialists when implementing the DDMRP methodology and (ii) it would help to define a research agenda by pinpointing exactly the perimeter of scientific and technical contributions in terms of functions.

2. An overview of the Demand Driven Adaptive Enterprise model

Historically, the Demand Driven model was made of only an operational stage. This stage was responsible for releasing orders according to the real demand. It would also adapt their operating model to the evolving nature of the demand and manage the orders. But as time passed and the professionals and researchers refined the model, more processes were added into the tactical and strategic ranges. In the end, it would cover the full spectrum of supply chain management activities.

The main objective of the methodology is to constantly adapt to an evolving demand. In order to achieve this, Ptak and Smith used a principle from early inventory management, the decoupling effect (Stratton et Warburton 2003). They then added dynamic management in order to respond to the changes. By succeeding in decoupling production activities from demand variation, they were able to propose a more resilient model. The second core principle that was added was to decide strategically what the most important references were. These always had to be in stock, and their stocks had to constantly follow the real demand. The two core principles were used in conjunction:

- Physical buffers—three-tiered stocks for certain references—are positioned in order to create a protected zone between them, where variation cannot be transferred
- The three zones in each physical buffer are regularly checked against the real demand to determine whether or not they need to be increased (higher demand) or decreased (lower demand)
- On a daily basis, the Net Flow Equation is calculated for each buffered reference, taking into account on-hand inventory, already existing manufacturing orders, real demand and qualified spikes that have been detected. The result of the NFE is transformed into orders.

Between two of these physical buffers, all other production steps are treated as being make-to-order steps, with intermediate stocks if necessary. The buffered references are sufficient to give the rhythm of the supply chain. Indeed, buffered references are generally end products, bought parts, references placed before the bill of materials forks between two possible ways, or simply raw materials.

On top of this initial stage, the DDMRP methodology evolved to integrate both tactical and strategic activities (C. Smith, Ptak, et Ling 2017). The Demand-Driven S&OP and Adaptive S&OP were added, but the operational step was also clearly divided to show what activities were under which responsibility, adding a demand-driven scheduling step and a demand-driven execution step. They are related as shown below in figure 1. The Demand Driven Adaptive Enterprise model was born.

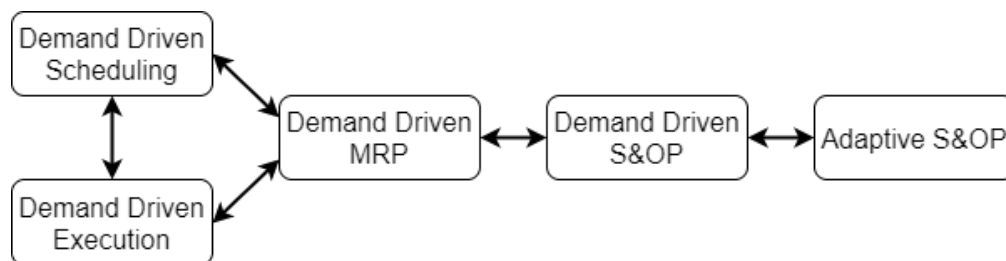


Figure 1 - Relation between DDAE bricks

3. The cartography: how to represent the complete Demand Driven Adaptive Enterprise?

While the view of the physical manufacturing system has been stable since 2011 (Ptak et Smith 2011), the tactical and strategical steps have become more complex. As a consequence, giving a structure to this complexity became a necessity; it was the first step towards finding the gaps and the discrepancies in the methodology.

In order to be exhaustive and collect all the existing information on this process, a methodology was designed to challenge all the tasks and flows. This was done in three phases: (i) the building of Demand Driven physical model, filled with « objects » that were used in the process view, (ii) challenging the accuracy of the model published by the Demand Driven Institute (C. Smith, Ptak, et Ling 2017) and the way the experts implemented the model, using a standard questionnaire, and (iii) the building of the final process view.

The ultimate goal of the questionnaire was to highlight any difference between the recommendations coming from the Demand Driven Institute and the real-life implementations. It also served to record any additional tool used to implement the methodology, such as KPIs of piece of software. The questionnaire was applied to both the existing planning literature and a series of experts' interviews of our industrial consultant partners (DDMRP specialists and certified trainers). The term "activity" used in the questions follows the definition given by the APICS dictionary (Cox et Blackstone 2002).

The questionnaire was filled for each identified planning activity and was organized on 5 main questions, each with a specific goal:

- What is the activity objective? The goal is to make sure inputs and outputs are known.
- What are the steps in this activity? Is it in reality a process or a macro-process? This question aims at finding any possible underlying task and making a specific activity.
- What are the relevant metrics for this activity? This question has been added so any pre-existing metric, relevant or not, was captured.
- What are the tools for this activity? The notion behind this question is to collect any tool-specific activity, such as using software or an information system. It was seen as a variation from the standard process and was tracked consequently.
- What are the problems for this activity? This gathered all hurdles and missing points, especially in the experts' interviews which, as they were based on implementation experience, were very valuable.

3.1. The physical system model

The physical view is depicted in Figure 2. It is based on a series of distinctions:

- Buffers from inventories: time buffers (for Make-To-Order products) or physical buffers (for Make-To-Stock) are distinguished from intermediate inventories. Buffers are defined as strategic stocks, divided into three zones (red, yellow and green). Each zone size is calculated on reference consumption, lead time and uncertainty factors. Intermediate stocks are stocks between buffers, inside a flow of steps. These stocks are not followed as closely as physical buffers and are generated by the "decoupled explosion" (Ptak et Smith 2011) of buffer orders.
- Lead time from decoupled lead time: decoupled lead time is used for generating alerts and zones associated to buffers. Lead times are used by "decoupled explosion" planning process.
- Machine from control point: Control points are strategic locations in the product, giving essential information about planning and flow. They are put on machines along the supply chain where specific constraints (nature of the operation, setup constraints) impact the scheduling of the flow: a basic FIFO rule is certainly not efficient.

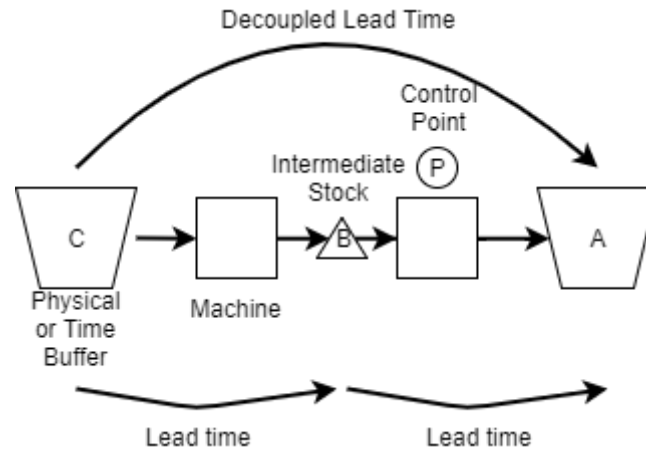


Figure 2 - Physical system model

3.2. Demand Driven planning reference model

The IDEF0 is selected in order to represent all the planning tasks and information. This representation enables to depict tasks in processes, actors, and information flow, from high-level macro-processes to low-level individual tasks. Moreover concepts inherited from the GRAI reference model (Doumeingts 1984) (Horizon, Frequency, granularity, information and decision) are included in order to precise the planning activities.

The concepts of our first version of the Demand Driven reference model are based on the GRAI philosophy (Doumeingts 1984) and are as follows:

- Function, is defined as being an encapsulating box regrouping several macro-processes and has a firm frontier, deciding what it is accountable for, on what horizon, what frequency and what granularity
- Horizon, is how far in time planning activities take existing data into account
- Frequency, is how often is an activity repeated
- Granularity, is the scope of goods manage by the function (specific reference, buffered reference, product family)
- Activities, are elementary tasks, often regrouped into processes or macro-processes for clarity
- Information/ Decisions are understood in the GRAI sense (Doumeingts 1984). Decisions are made against objectives, criteria, variables and constraints.

An example of the representation is given below in figure 2 to better understand how concepts interact with each other.

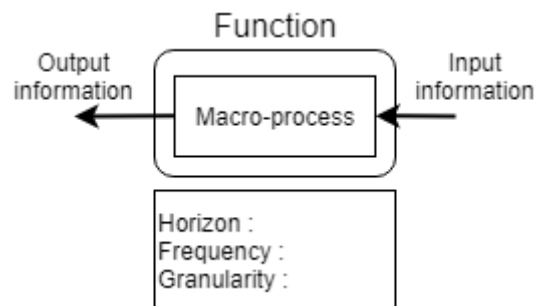


Figure 3 - Macro-process and function example

4. Reading the cartography: understanding the flow of activities

For an easier comprehension of the different processes involved in the Demand-Driven Adaptive Enterprise cartography, it has been divided into three parts. We will cover each of them in the next paragraphs. The parts are (i) the model definition process, which aims at constantly adapting the buffers to both forecasts and real received demand, (ii) the production process, which is tasked with releasing the daily necessary orders, scheduling and prioritizing them and (iii) the continuous improvement process, which gathers all variance sources and follows improvements.

4.1. The model definition process: transforming strategic goals and real-world constraints into buffers

The extracted process for model definition is given below in figure 3. The main goal for this process is to reconcile both the strategic expectations of the senior management, as defined in the Adaptive S&OP stage, and the uncertainty of daily demand, received here as “Improvements”.

The model definition process, in this version, asks for three different functions: the Adaptive S&OP team, usually composed of senior management, the Demand-Driven S&OP team, made from supply chain specialists and managers and the Information System, viewed here as storage.

The process works according to two cycles of decisions: a quarterly cycle for making and updating the business plan and a monthly cycle for integrating the forecasts and proposed improvements. The granularity also changes as we go through lower stages, from the complete portfolio of products to the strategic buffered references.

At first, the Adaptive S&OP team will reconcile all strategic objectives (products, finance, capabilities, supply and demand) into a coherent and measurable business plan. The business plan is then used by the DDS&OP team. They break down all the needs for the buffered references, leading to a specific demand plan. At this point in time, it might be necessary for the DDS&OP team to request exception forecasts from the higher stage to take into account promotion campaigns, unforeseen demand on references and so on. This demand plan gives guidelines that are correlated with the bill of material and lead times, but also with existing improvements from the last period. A model is then created (or updated in the case of pre-existing models) by setting buffer positions, buffer profiles (with uncertainty factors and specific management rules if need be) and buffer zone sizes. The model, named “configuration model” is the most important output of the process and is stored in the information system.

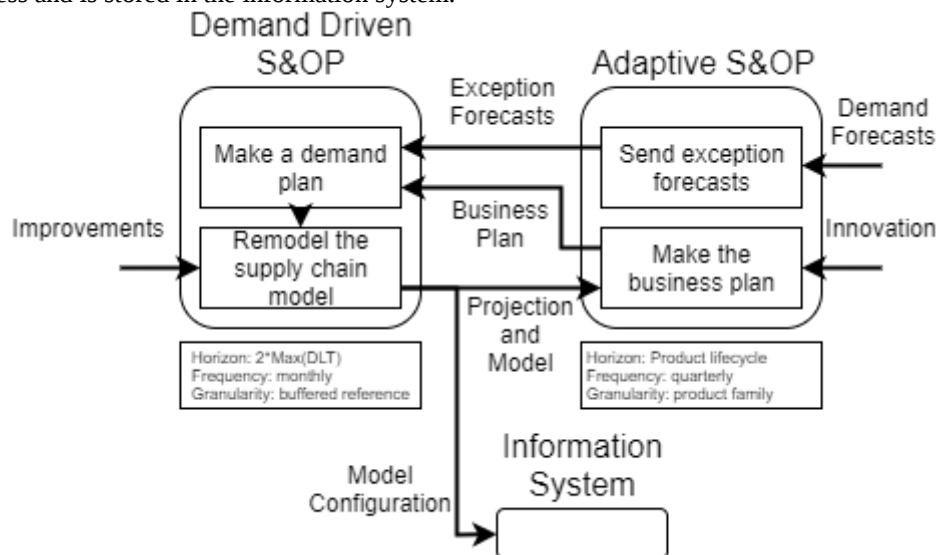


Figure 4 - Model definition process

4.2. The production process: adapting orders to real demand

The process is given below in figure 4. It calls for four different functions: (i) the information system, sued to make all the calculations and simple logic decisions, (ii) the DDMRP stage, where all complex decisions are taken and whose objective is to understand alerts and transform them into orders, (iii) the DD

Scheduling stage, which checks on the control points that the orders can be finished on time and with the right quantity and (iv) the Execution step, where all the prioritization and production is done.

Two cycles are considered here too: the daily decision cycle for the DDMRP stage and the information system, and the hourly decision cycle for Scheduling and Execution. The granularity in this step is split between two levels: buffered references only for releasing orders and all references between the buffers.

Two vital inputs can be identified at this stage, the model configuration coming from the previous step and the real demand received. These inputs are taken into account by the information system to run the Net Flow Equation (NFE, as described in the beginning of this paper), and compare qualified demand with predicted stock levels of buffered references. This NFE result is what ensures that all orders are as close as possible to the real demand, and is part of the reasons for adaptability. Alerts are then created according the NFE results and transmitted to the DDMRP stage.

The DDMRP stage reviews all alerts and makes a decision to release or not the corresponding orders, based on the recommendations given the demand-driven methodology and optional management rules, such as grouping or synchronization. Three types of orders can be created, each with a specific process. Purchase and stock transfer orders go directly to execution, while manufacturing orders have to go through scheduling first.

The scheduling step is focused on control point activities: checking for capacity, planning ahead, grouping orders if necessary. It is also tasked with following the progression of manufacturing orders in case one would be late. In this version, scheduling uses manufacturing orders with a quantity and request date, a method that is currently not present in the DDMRP methodology. The execution step receives all orders and has to decide which ones are a priority according to buffer penetration status, or how close they are from hitting the 0% level.

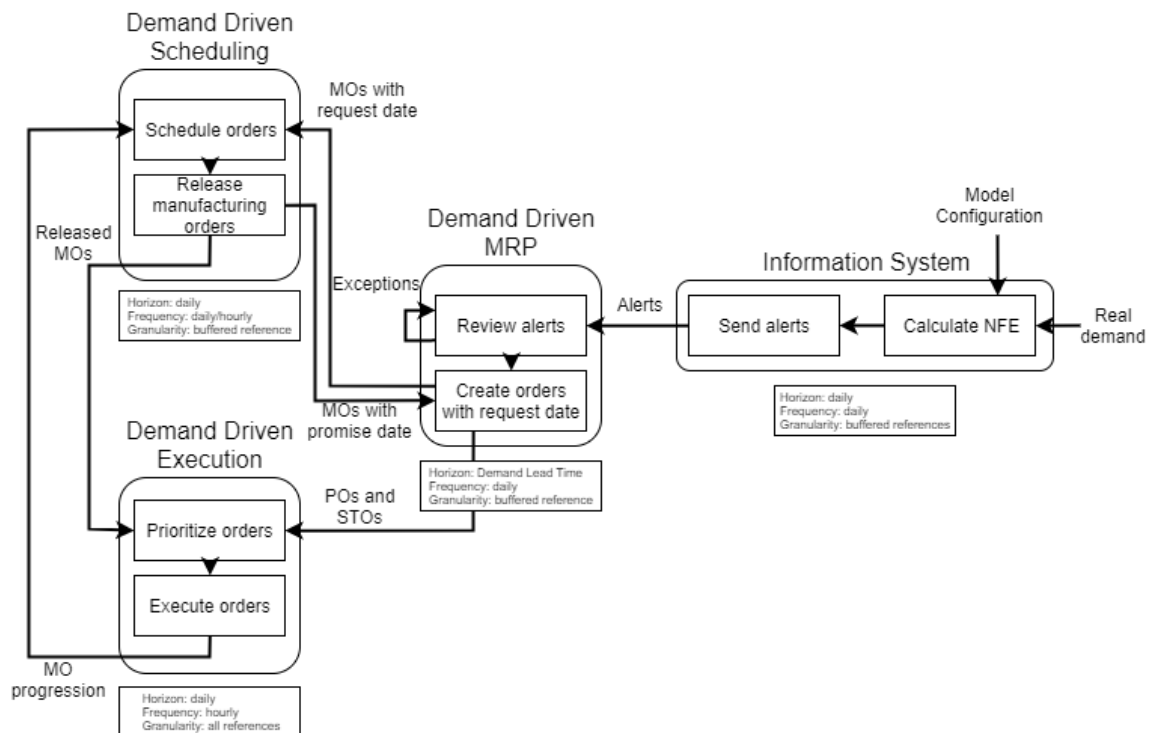


Figure 5 - Production process

4.3. The continuous improvement process: understanding variations

The process is given in the figure 5 below. It requires mainly a single function: the DDS&OP team. For better readability, the specific activities where the inputs come from have still been added. Two cycles are used: a daily cycle for collection and cycle as long as twice the maximum DLT of the buffered references, though this cycle can be adapted to how agile the process needs to be.

There are various outputs in the process but they all share a common nature, they are variance records from what was forecast. For example, they can be demand variance noticed by the DDMRP when daily demand

is received, scheduling variation if capacity or management rules allowed for more or less orders, or execution variance, with the simplest case being quality issues in the manufacturing. Three main activities at the DDMRP stage require focus: (i) the variance analysis activity, where all sources need to be aggregated and explained if necessary, (ii) the tactical exploitation, where improvement decisions are made and compared to the results they could bear and (iii) the steering of said improvements. As improvements can sometimes be modifications of the operating model, they are treated as an output of the process. The reason for this choice is a reflection of improvements such as uncertainty factor improvement, new buffer zone size recommendation, or lead time decrease that could impact the configuration model and the whole efficiency of the supply chain.

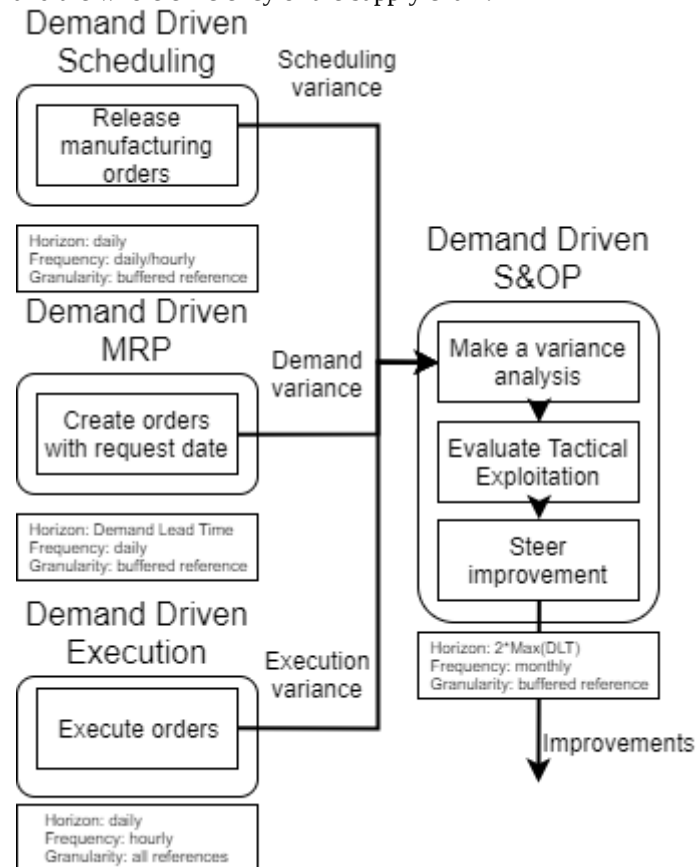


Figure 6 - Continuous improvement process

4.4. Complete cartography: a holistic view of the demand-driven methodology

We give below in figure 6 the final planning model, aggregated according to the model defined in the last chapter.

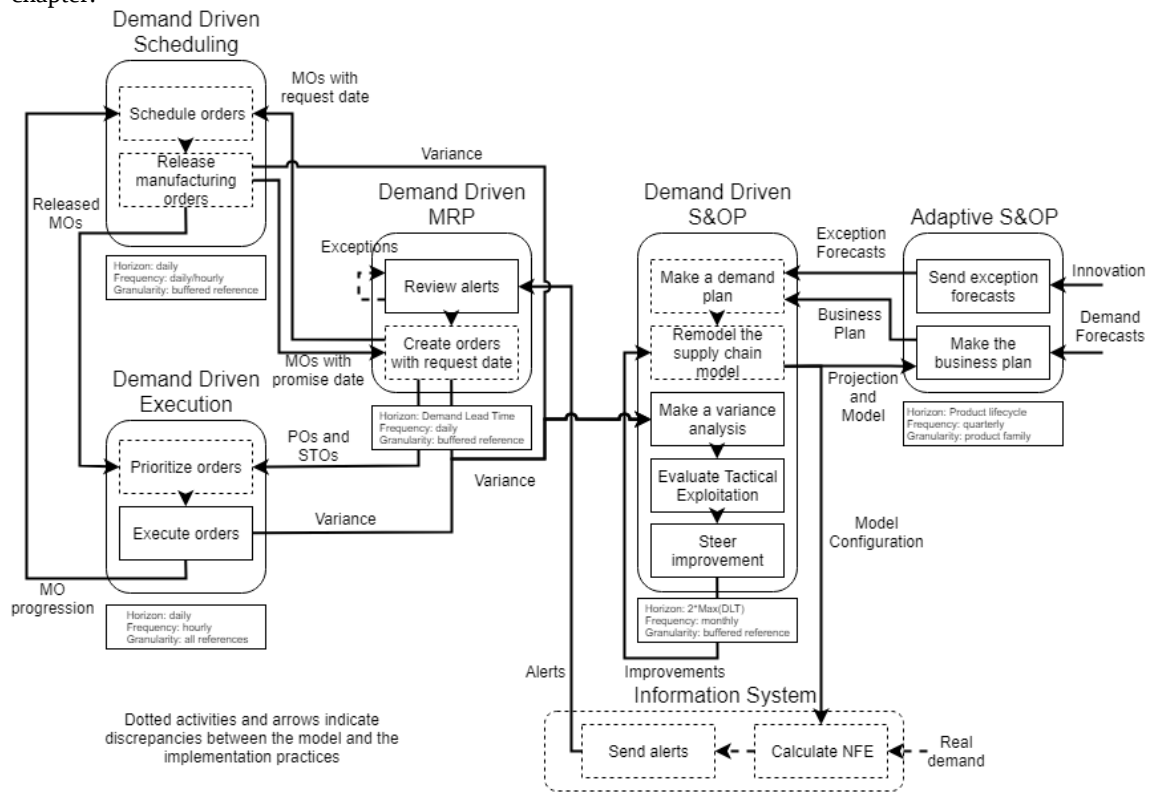


Figure 7 - Complete cartography

We can find the six functions mentioned earlier in his paper. These functions, as defined by the Demand-Driven Institute (C. Smith, Ptak, et Ling 2017), are as follows:

- Adaptive Sales and Operation, is tasked with defining the business plan for the whole supply chain, making all strategic decisions and supplying the other functions with strategic information
- Demand-Driven Sales and Operations, which aims to adapt the operating model of machines and buffers to the business plan on a specified frequency and steers the continuous improvement of the supply chain
- Demand-Driven MRP, which reviews real demand of the day and the alerts and production proposals that are recommended, in turn creating orders
- Demand Driven Scheduling, which validates or not manufacturing orders according to the state of control points
- Demand-Driven Execution, which is able, given the released orders and the priorities of the references to choose what will be produced.
- The information system is an added function, and represents the activities delegated to the machines. This is not represented in the material coming from the Demand-Driven Institute but is a reality of the deployments.

These functions (with the exception of information system) can be grouped under three horizon categories: strategic for the Adaptive S&OP stage, where long range decisions are made, tactical for the Demand Driven S&OP, as it requires a more agile steering at this stage and operational for the last three, where all the daily decisions are taken.

As written in figure 6, discrepancies between the implementation practices and the published methodology have been emphasized with dotted lines. We acknowledge five categories of differences, which are linked with the functions given previously.

At first, for the DDS&OP function, there is seldom a specific demand plan. Cases where the demand plan follows the Demand-Driven guidelines are even rarer. As a result, the “Make a demand plan” activity tends

to be separated between several actors. Next, the “Remodel the supply chain model” is often cumbersome when implemented, as it requires complex maintenance. The activity is rendered all the more difficult with a lot of references to manage.

We also noticed that the operational functions have to be adapted to each implantation case. The main difference comes with how orders are released, scheduled and prioritized. Indeed, according to the experts’ feedbacks, the physical organisation of the facilities, along with specific management and safety rules has a notable effect. There are various nuances to the adaptations of the methodology, some including higher than normal order quantities, high-frequency demand changes or complex grouping and assembly rules for scheduling orders. Lastly, despite the streamlined cases advertised, real-life implementations show that the exceptions and alerts still take time and attention from the planners.

5. Discussions and perspectives

With this cartography done, what are the limits and improvements for its future? If we take into account the objective we have of using the cartography as a support for establishing our research agenda, two concerns can be raised: (i) is the information given sufficient to build a complete research agenda and (ii) is the level of detail great enough so we could place precisely the research questions ?

As for question (i), the cartography has allowed us to share the beginning of a researched between all the teams involved on the topic, but also with the experts who have helped challenging the process. We have been able to identify which points had a higher priority and what type of returns we would obtain, be it short-term proof of concepts for tools or long-term strategic questions.

For question (ii), however, we were not completely able to define the precise perimeter of activities, input and outputs that would need to be challenged by each research work. The level of detail still is insufficient and needs to be refined by, for example, being able to have a more in-depth view of the activities. This is the reason why we chose to add a layer of Business Process Modelling Notation under the IDEF0 for our future work on the cartography. BPMN should allow us to challenge in detail the lower level activities and the relevance of inputs and outputs.

6. Conclusion

Even with all the aspects that could be challenged on our proposition, we have come to the conclusion that the process map still represents a solid basis for future discussion on the topic of demand-driven contributions. It will be easier, with the help of the process map, to share our research agenda with all interested stakeholders. There are a number of questions that still need to be addressed around the process map given in this paper, especially regarding the best way to model how activities work together and how all the data in the system is used. But these are the first steps towards a shared and easy to understand model of the Demand Driven Adaptive Enterprise for all the actors of the field.

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