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Towards a collaborative MRP for supply chain coordination

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Abstract- The necessity to increase collaboration in nowadays supply chains is emphasized both by academics and practitioners, but most of the supply chains are still managed through cascades of classical MRP/MRP2 systems. Interviews in the aeronautical sector have shown us the existence of many hidden practices aiming at satisfying local constraints which would be better addressed through collaborative processes. We suggest in this communication to define a "collaborative MRP" which would not only provide a better global performance than purely local planning, but take into account the autonomy of the involved partners which is not always respected by centralized approaches using APS (Advanced Planning Systems).

I. INTRODUCTION

Many recent studies on Supply Chain Management converge on the fact that information sharing, joint-planning, cooperation and strategic partnerships over the entire supply chain are conditions for building more efficient and reactive supply chains [1]. Such partnership, where trust replaces strict customer/supplier relationship and where many decisions are taken in common, is often summarized by the concept of "collaborative supply chain" [1]. As a consequence, several approaches have been suggested by both academics and practitioners in order to allow cooperative planning within supply chains, the most well known being for instance CPFR (Collaborative Planning, Forecasting and Replenishment), see for instance [2].

Nevertheless, it seems when looking at real supply chains that the projects launched (mainly by large companies) in order to increase the quality of partnership between supply chain members do not always result in increased trust and increased exchanges of information, especially when Small and Medium Enterprises are involved in the supply chain. Through interviews in companies working for the aeronautic sector in the South-West of France (see section II), we have seen that huge efforts were made by large companies for promoting the MRP2 (Manufacturing Resource Planning) method as the unique mean for planning production all along the supply chain (see section II. B).

We have also seen that most of the small and medium companies (SMEs) involved in these chains need to use local (but hidden) processes for coping with their local constraints, which they can hardly do within a strict application of the MRP method.

In section III, we suggest to include local processes performed by the SMEs in order to satisfy their internal constraints in a "collaborative MRP method" which could in our opinion provide a better balance between the local objectives of each supplier and the global objectives of the chain, usually represented by the final assembler, and as a consequence should lead to a better overall performance of the chain.

II. AN ANALYSIS OF INDUSTRIAL PRACTICES IN THE AERONAUTIC SECTOR

A. Context of the aeronautic sector

The aeronautic sector has been a domain of major changes in the next fifteen years since the necessity to decrease costs and cycle times has emerged rather recently in this rather protected domain. A specificity of the aeronautic sector (especially if compared to the automotive one) is that many SMEs are involved in the supply chains, since they are usually very reactive [3] and may have high and specific technical skills. Furthermore, companies do not usually need large capacity in this sector, since products like aircrafts, rockets or satellites are built in relatively low quantities. Even if they include many different components, the demand on each specific part is so relatively low and can be fulfilled by SMEs.

The involvement of SMEs in aeronautic supply chains have drastically changed through time. It was first dedicated to sub-contracting of manufacturing operations: the customer was sending raw materials or semi-finished components to the sub-contractor who was performing the operation, then was sending back the parts. The consequence was a high coordination effort from the customers, who decided through years to transfer to their suppliers the full responsibility on their own providers. This evolution required the SMEs to develop their competences on the management of more complex products (sub-systems described by bills of materials), but also to be able to manage their suppliers, including sending them forecasts and supply

plans. As a consequence, “supplier development” (term introduced in [4]) began to be a major issue in the sector. Supplier development summarizes the efforts made by a customer in order to increase the number of viable suppliers and improve supplier's performance or capability [5]. Lean manufacturing is a major constituent of supplier development programs [6-7] but is not enough for giving the capacity to control the suppliers: planning methods and especially MRP and MRP2 [8], supported by ERP (Enterprise Resource Planning) systems, are required to process information at each level of the supply chain. As a consequence, it is usually considered that SMEs must switch from simple financial plans to forecast based planning [9]. In that purpose, using an ERP system including an MRP module is now seen as mandatory if a SME wants to join a supply chain [10]. Nevertheless, for Arend and Wisner [11], SCM implementation can be negatively correlated with SME performance. Reasons can be that the requirements regarding business processes may be differently implemented in large and small companies. This point has been confirmed by interviews which are summarized in the next section.

B. Collaboration in the aeronautic industry

Analysis of the effects of the efforts of large companies for developing their small suppliers have been performed through two main projects:

- a "supplier development" project initiated by a large manufacturer of complex sub-systems for aircrafts. Ten small suppliers were selected and have been the object of an intensive development program mainly based on audits of their processes, training on the MRP method, then implementation of production management systems (or improvement of their use for some of them).

- an analysis of collaborative practices in the aeronautic industry, conducted with an Association of companies of the aeronautic sector and with a public body aiming at SMEs development. The objective of the project was to analyze the problems linked to the cooperation between partners of aeronautical supply chains on two main domains: collaborative design and product flow management. Twenty companies were visited in that purpose: 7 large ones and 13 of middle (around 200 employees) or low (less than 100 employees) size. If the relatively low number of visited companies does not allow to fully guarantee the generality of the identified problems and situations, we think that it nevertheless allows to show that some existing problems are not yet fully taken into account by existing practices.

1. Use of MRP as promoted by the large companies

Supply chains can be managed through centralized or decentralized approaches. Using a centralized approach, all the companies send their local information to an APS (Advanced Planning System) which optimizes the part flow management

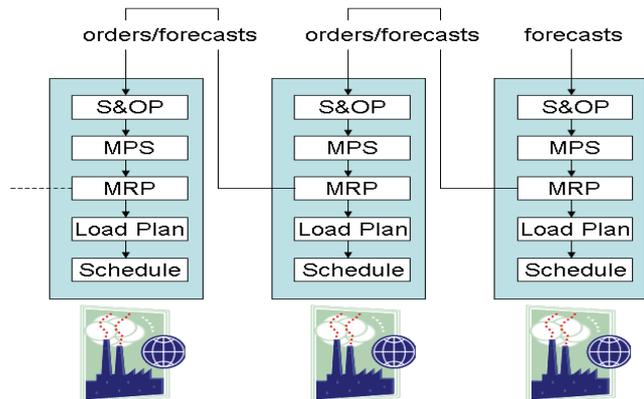


Fig. 1. Supply chain management through a cascade of MRP systems [13]

through all the supply chain [12] and communicates a local planning to each member. This method allows a global optimization, but requires to share information usually considered as confidential (concerning costs for instance), and is poorly adapted to the context of the coordination of autonomous entities, most of the time working for several supply chains. Therefore, it is mainly used inside industrial groups, in order to coordinate sites having a low level of autonomy.

Therefore, the usual solution which is promoted for coordinating the partners is through a cascade of local MRP2 (Manufacturing Resource Planning) systems [13] (see Figure 1). Forecasts based on the expected customer's demand are built by the focal company of the chain (usually the final assembler in the aeronautic sector) then processed using the MRP2 principles. After the MRP (Material requirement Planning) step, planned orders allow to build a supply plan (including forecasts) which is sent to the tier (n+1) partners.

In the aeronautic sector, the end-products are manufactured on the base of firm orders but also forecasted orders. Forecasts are usually built on a 1-3 years base and include a firm period (during which the orders cannot be changed), a flexible period (with allowed variations) and a free period, communicated for information only. Let us take an example for illustration (see Figure 2): the focal company A builds his sales forecasts based on firm orders and expected ones at long term. If the cycle time of its product (for instance an aircraft) is one year, the firm period of the forecasts should be at least one year (but preferably more). Let us suppose that this cycle time is the addition of an internal assembly process lasting for six months plus external supplies requiring six more months. Let us consider that these six months are divided into two months for the internal work of supplier B, and four months for the supply of the raw materials (supplier C). If the customer does not confirm a forecasted order expected on month 13, company A will have to cancel an internal load positioned on months 7 to 13, together with an order sent to B due on month 5. This order

was to be released on month 4 at supplier's B. As a consequence, B will have to cancel an order he planned to send to his raw material supplier next month (left part of Figure 2).

The lead time of the suppliers, so that the prices, are discussed during the RFQ (Request For Quotation) process. The contract concluded with the selected suppliers includes a decrease through years of both cycle times and prices. Indicators aiming at measuring the performance of the suppliers (mainly based on a service ratio) are also defined. All these parameters, cycle times and prices, but also firm period, characteristics of the flexible period etc., are included in the contract which may include penalties in case of late deliveries.

According to this "theoretical" framework, the key issue is to check that each partner of the supply chain (and especially the smallest ones) is able to process his forecasts and turn them into an internal load planning and an external supply planning using the MRP process. As it will be shown in next section, reality is somehow different and more complex.

2. Anomalies and additional local practices

The first issue identified during the interviews is that the parameters of the forecast horizons, but also the practices which result from these parameters, may be quite different from one large company to another. Reality appears to be often less consistent than the principles illustrated in Figure 2, since it is the market (and not always the focal company) which decides on the lead time acceptable by the customer. We have for instance seen the case of a company manufacturing small (and highly customized) aircrafts with a firm order horizon of 12 months, whereas their supply time for the motors was 14 months, the variant of the motor being chosen by the customer. This pressure set by the market is sometimes transmitted to the suppliers, e.g. for raw materials. During several years, a relative scarcity of some aeronautical alloys together with a lack of capacity of companies providing casting parts made that the supply time of raw materials increased up to 12 months in some cases... In spite of this, the firm period of the forecasts sent by the customers to their suppliers remained constant, around 3 months, forcing the suppliers to take the risk to order materials on the base of flexible forecasts, or to be sure to be late.

Some (rare) companies use the difference between the firm period received from their customers and the one sent to their suppliers as a way to protect their smallest suppliers. For instance, a large tier 1 company was mentioning that the importance of one his customers obliged him to accept that all orders (even firm ones) could be cancelled until it was received by the customer... Such a constraint can obviously not be transmitted to a SME. Therefore, the company did not set into question the firm horizon sent to his suppliers, but introduced high flexibility ratios ($\pm 50\%$) in the flexible zone. In order to make this acceptable, they decided that if the ordered quantities

decreased in this flexible zone, they would anyway buy the cancelled parts in the year.

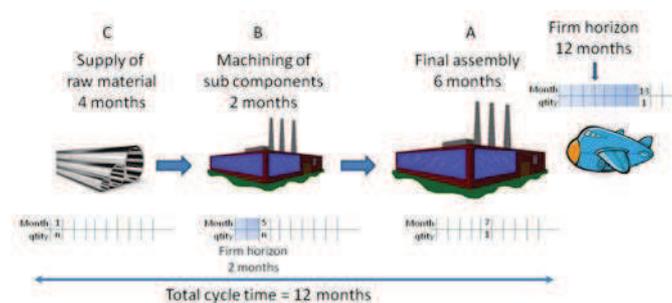


Fig. 2. Cycle time and firm horizon

The same company was sending the level of its inventories together with each order, in order to show his supplier what could be the consequence of a late order.

Many other problems were listed by the visited SMEs. Many of them for instance claimed that the parts described in an RFQ were in some cases impossible to manufacture because of overestimated tolerances. As a consequence, the suppliers had to commit themselves on delays and costs whereas they were sometimes conscious that they would not meet either of them in the future.

Many SMEs try to group orders in order to decrease their set-up times, and so increase their productivity and decrease their prices, as requested by their contracts with their customers. A problem is that many of them were unable to do it using their production management systems, which are often quite simple systems, often dedicated to SMEs¹. As a consequence, most of them solved the problem by exporting their production plan to Excel or Access, macros or dedicated programs being then used to group the similar parts. In several cases, the due dates were not exported, so not used as constraints in the grouping process, with the result of both late and early orders. Of course, the SMEs were conscious that they were not supposed to do this, so their customers were not informed and the SMEs tried to negotiate each tardiness when occurring.

Another SME, who have a strong position because of the scarcity of his competence (surface treatment), had a quite original approach to cycle times: he managed to impose to his customers that only three cycle times were possible (10 days, 15 days, 20 days), with decreasing prices. The consequence was the immediate decrease of the urgent orders...

Even if the generality of these practices cannot be demonstrated on few examples, we have verified through many

¹ For instance, some of them are strictly based on a MTO (Make-to-Order) logic, and do not allow to take into account forecasts. In that case, some SMEs were entering the whole forecasts as firm orders, making it impossible to distinguish between firm and flexible periods in the supply plans they were sending to their own suppliers

talks with consultants of the aeronautic sector that they were rather common. Therefore, we suggest in next section some ideas which are the base of an ongoing study aiming at formalizing these practices into a “collaborative MRP” approach.

III. TOWARDS A “COLLABORATIVE MRP” APPROACH

A. Candidate practices for a “collaborative MRP”

We have seen in section II that the exchanges of information between partners are mainly based on the MRP technique: lead times are discussed when the contract is established, then forecasts are sent and the orders are fulfilled at the short term level. We have also seen during the interviews that many practices are added to these basic principles, in an open way when they come from the customers, but in a more hidden way when they come from the suppliers.

On the customer's side, these practices can be summarized as:

- The use of the firm and flexible periods of the forecasts for protecting, or on the contrary, for putting some pressure on the suppliers. Sending a firm period longer than the received one means to protect the suppliers. Sending the same firm period than the received one means transmitting the pressure on the suppliers. Sending a firm period longer than the one received would mean to try to gain some slack time by urging the suppliers more than needed.
- The communication to the supplier of elements of information allowing him to assess the priority of the orders included in the forecasts, in addition to their due dates (e.g. the inventory level as seen above).

On the supplier's side, the main practices that we have considered are:

- The grouping of some orders, in order to decrease the set-up times by increasing of the lot-sizes.
- The use of an internal priority when all the orders cannot be fulfilled in time.
- The pre-order of some raw materials if the firm period of the forecasts is insufficient.
- The anticipation of the release of some orders, for smoothing the load.
- The possibility to link price and lead time, for instance in order to avoid losing money while processing urgent orders.

B. Suggested collaborative process

On this base, the collaborative process we suggest is summarized (see Figure 3); its main objective is to create loops of negotiation at different levels, in order to better address industrial practices which are nowadays not clearly formulated and may result into increased problems. As it will be seen, the main objective of this collaborative process is to negotiate

periodically the parameters of each MRP system (at the customer's and at the supplier's) instead of choosing these parameters only when the contracts are concluded.

This collaborative process aims at generalizing and making explicit some constraints which have to be fulfilled either on the customer or on the supplier side, the idea being that their fulfillment should be the result of a negotiation process, and not anymore the result of hidden practices, or the consequence of the power that a company has on his partner.

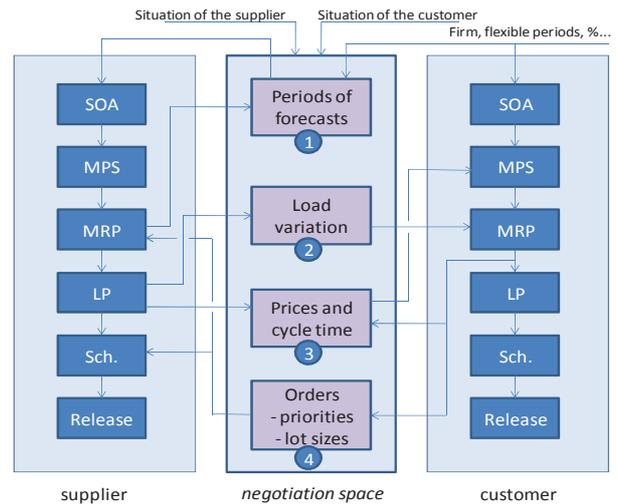


Fig. 3. Negotiation between two partners in a “Collaborative” MRP

The basic input of this "negotiation space" is the respective situation of the customer and supplier in terms vulnerability, the idea being that the stronger partner should protect the weakest one, for their mutual interest. It may appear as paradoxical that the stronger partner is the one who accepts to decrease the satisfaction of his local objectives. Many research works have emphasized the importance of power on the relationships along the supply chain [9, 14]. The power of a company over its partners makes it possible to impose his own objectives as the ones of the supply chain, but many studies emphasize that the exercise of power provokes a decreased trust, whereas trust is usually considered as bringing an increased performance [15]. In several cases, the interviews have shown that a strong partner taking care of a weaker one is a situation that may appear (even if seldom). For the four areas of negotiation considered here, the balance between the conflicting objectives of the partners should depend on their respective situation.

At level 1, the firm and flexible periods of the forecasts are adjusted for each supplier, together with the accepted possible variations within the flexible period. This will allow the customer to protect the weakest suppliers, and to take a part of their risks if the market forces the suppliers to send firm orders

on the base of the flexible period of their forecasts (see the case of the aeronautical alloys here above).

At level 2, the bearable load variation of the supplier will be taken into account by the customer in order to define a supply plan which does not destabilize the supplier. Like in the previous case, the result will inevitably be an increase of the inventories at the supplier's size. The cost of these increased inventories has so to be compared to the costs induced by the present erratic answer of many weak suppliers (especially SMEs) subject to a variable demand. Of course, taking into account the difficulty of the supplier to adjust his capacity is a short term issue, whereas middle/long term issues will allow to help him to better use the means to increase its capacity. In that case, it is also clear that an increased flexibility may have a cost that the customer should be ready to pay when the supplier answers an RFQ.

Negotiation at level 3 is based on the idea that the cycle time required by an order is not anymore fixed but may vary according to the situation. Processing an order quicker than defined in the contract could be acceptable, under condition that the over costs are paid by the customer. This is only the inverse situation of the universally accepted (even if seldom applied) practice of penalties for tardy deliveries.

Level 4 deals with problems which may impact the supplier's schedule (and not anymore the load planning like in the previous case). Especially, urgent orders coming from the customer can be negotiated. Two conditions seem to be necessary to process these orders without destabilizing the supplier:

- Scheduling urgent orders requires that the supplier has access to the real priority of the orders sent by his customers. Most of the time, the supplier guesses that his customer has kept some temporal margin (or security inventory, see interviews) but does not know on which orders and to what extent. If the customer accepts to share the information allowing his supplier to assess the real urgency of each order, the supplier reaction in case of urgency should possibly be less disturbing than when the supplier processes urgent orders by pushing blindly the work in progress.
- Of course, the customer should also accept to pay for the over cost generated by urgent orders.

C. Assessment and implementation of the negotiation processes

Studies are in progress in order to better identify the possible domains of interest of the previous negotiation areas. As a general statement, it is clear that this identification requires to identify:

- On one hand, the over cost induced by the negotiation,
- On the other hand, the cost of the present processes where the stronger partner imposes his solution, and

where the weaker partner tries to satisfy his local objectives in a hidden way.

Four negotiation areas have been suggested as examples but others may be considered. Anyway, a modular implementation of such a collaborative process is in our opinion possible, since it does not concern the internal processes of MRP2 but only the way some of the parameters of MRP are calculated (lot sizes, lead times, etc.). Therefore, we have begun tests aiming at developing prototypes of these modules using constraint propagation techniques.

IV. CONCLUSION

The literature clearly shows the interest of information sharing for increasing the performance of the supply chain [15-16]. On the base of interviews in large and small companies of aeronautical supply chains, we have seen that the real practices in these supply chains may set into question the efficiency of the planning process. In order to prevent the drawbacks of both power exertion from the mighty partners and hidden practices from the weak ones, we suggest to calculate dynamically some of the parameters of the MRP method on the base of a negotiation process. An ongoing study aims now at defining more precisely the conditions of negotiation and the prototyping of negotiation support systems using constraint propagation. Of course, sharing the information in order to allow negotiation increases the risk that the partner may have an opportunistic behavior, which is a known drawback of information sharing [17]. Trust is so a pre-requisite for such information sharing [18].

Accepting to take into account new constraints, mainly coming from the suppliers is uneasy for the large companies. Instead of considering that their practices are prohibited, it is in our opinion important to formalize them as a first step in a consistent collaborative process, even if improving the flexibility and reactivity of the suppliers may at long term provide another solution.

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