

MRP-based negotiation in collaborative supply chains

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Abstract: Although collaboration between partners is now considered as a mean to increase the performance of the supply chains, most of them are still managed in a directive way through cascades of classical MRP/MRP2 systems, in which the constraints of the suppliers, especially the smallest ones, are poorly taken into account. We suggest in this article to assess the interest of the integration into collaborative processes of some practices based on MRP, identified after a study in aeronautical supply chains. Within these processes, classical parameters of MRP would be negotiated instead of being imposed by the large companies.

Key words: *collaborative supply chain, aeronautical industry, MRP2, negotiation.*

1. Introduction

Recent studies on Supply Chain Management consider that information sharing, joint-planning, cooperation and strategic partnerships over the entire supply chain are conditions for building more efficient and reactive supply chains (see for instance (Sahin and Powell Robinson, 2005)). Nevertheless, large industrial supply chains, like in the automotive or aeronautical sectors, still use classical production management methods, and especially MRP2 (Manufacturing Resource Planning), as the backbone of the exchanges between suppliers and customers (Van Donselaar *et al.*, 2000). When, as often, customers have more power on their suppliers than the opposite, the suppliers, especially if they are small companies, may be reluctant to express their local constraints to their customers. This difficulty is still increased when these constraints are poorly consistent with Supply Chain Management and Lean Manufacturing principles, now intensively promoted by large companies. The risk is then that these constraints turn into hidden practices, which may decrease the performance of the supply chain.

This article first aims at identifying such practices through interviews in companies of the aeronautic sector (section 2), then at “publishing” these constraints and including them in negotiation processes, even if the negotiation on the considered items may be considered as incompatible with nowadays habits (section 3).

Our purpose is to show that including some parameters of MRP into a negotiation process could lead in some cases to a “win-win” situation which could benefit to all the supply chain.

2. Analysis of real practices in the aeronautic sector

2.1. The context of aeronautical supply chains

The aeronautical industry has an oligopolistic market structure characterized by high technological, financial and market entry barriers (Tyson, 1992). To lower these barriers, the aircraft firms implement a production organization characterized by a pyramid-shaped hierarchic structure (convergent network)

with an assembly area at the top where the parts and components coming from three main sub-sectors (engines, equipment and avionics, and airframe) are assembled for obtaining the final product (Esposito and Passaro, 2009).

Three main production levels may be distinguished: at the first level, the leader firm, which directly operates in the airframe sub-sector, organizes the flow of parts, components, systems and information and coordinates the program and assembly of the final product. The firms of the second production level manufacture complex parts and components of the aircraft both for the sub-systems manufacturers and for the assembler (fuselage, wings, motors, land gears etc.). Generally, these large firms are leaders in their own program, and belong at the same time to the first and second level. The third production level includes Small and Medium Enterprises (SME), subcontracting firms who generally work for the second production level. From the second level firms, they receive the information on the production process, the manufacturing specifications, the technical service etc. When the manufacturing process is over, they transfer the ordered components and relevant information to the second-level customers. The suppliers in this level are approved by the leader firm, which checks if they are able to meet the quality standards required and if the production process is realized according to the procedures imposed in the program. In the last few years, suppliers have become increasingly involved in the production of parts with high added value, including the management of their upstream suppliers, but have also been invited to share the risks of the programs with the aircraft designer (Esposito and Passaro, 2009).

A major difference between this sector and the automotive industry is the higher diversity of the parts, aircrafts being produced in small series, but containing much more different parts (up to 1 million parts for a large aircraft), with long cycle times.

This results in three important constraints:

- Long term planning. Since the aircraft production cycle is much longer than for other products, it requires the involved partners (subcontractor, supplier) to have long terms procurement, manufacturing and transportation plans, including to monitor changes during a long period.
- High flexibility production. Manufacturing an aircraft is not a mass production process; each component is possibly different depending on the type of aircraft. This requires a high flexibility

and reactivity of each supply network member when performing his production processes.

- Efficient relationship. As an industry dealing with many diverse and expensive parts, inventories are to be kept at the minimum level while ensuring a good availability of each component, shortage having tremendous consequences. Thereby, the storage and delivery of raw materials, components, semi-finished products and sub-systems should be optimized, which highly depends on the coordination between supply network members.

Within aeronautical supply chains, the presence of many SMEs leads to specific advantages, but also to some constraints. Leaders of SMEs are usually very receptive to technological constraints but the planning process may be informal. Managers and operatives are more likely to be directly involved with the customers, two ways and face-to-face communication being the norm in SMEs (Ghobadian and Gallea, 1996). As a consequence, research shows that SMEs are more responsive to market needs, more adaptable to change, and more innovative in their ability to meet the customers' demand, but less oriented on information technology and management tools allowing long/middle term visibility (Appiah-Adu and Singh, 1998; Quayle, 2003). The traditional approaches and methodologies promoted by large companies (Lean Manufacturing, MRP...) are therefore considered by some authors as not suitable for SMEs, supposed to prefer logical reasoning approaches over systematic planning approaches, like aggregate production plans or production forecasts (Thakkar *et al.*, 2008).

2.2. Supply Chain Management in aeronautical Supply Chains

Supply chains (more exactly "supply networks", their structure being never linear) can be managed using two main techniques: centralized, or decentralized planning. Centralized planning can be performed using an APS (Advanced Planning System, (Stadtler and Kilger, 2007)), able to provide an optimal planning for all the members of a supply chain. In practice, this results in a poor autonomy of each company, which would be dedicated to a given supply chain, which is not the case in the aeronautical industry. On the other hand, decentralized planning can be performed using a point-to-point relationship, each partner receiving demands from his customers, that he translates into a supply plan for his own suppliers. This can be done using the MRP2 method

(Manufacturing Resource Planning) (see for instance (Adams and Cox, 1985)), which is the base of the production management modules of all the ERP (Enterprise Resource Planning) systems. Using MRP2, and for each partner of the supply chain, forecasts should be used as inputs for building a Sales and Operation Plan (SOP) with a 1-3 years horizon in the aeronautical sector (see Figure 1). A Master Production Schedule (MPS) can then be deduced at lower term. On the base of the obtained sequenced requirements on the final products, the bills of materials are used for generating on one side a Supply Plan, and on the other side a Production Plan (Material Requirement Planning step). The adequacy between the load generated by the Production Plan and the capacity of the company is checked (Load Planning), then the production is scheduled, with a typical horizon of 1-2 weeks.

Since adaptations of the initial production program may be necessary in order to react to unexpected events, the forecasts usually contain three zones: firm period, corresponding to confirmed orders (typically: 1 to 2 months); flexible period (typically: 3-6 months), in which the orders may vary within given ratios, e.g. +/-20%, and “free” period, only given for information. The total horizon of the forecasts is usually 2-3 years, in order to allow the suppliers to anticipate large variations of the demand.

Therefore, Supply Chain management is supposed to be implemented in this sector through a cascade of MRP systems, one in each company (see Figure 1), the supply plan of each company being used to create the forecasts sent to the suppliers. It is therefore mandatory that each partner uses consistent methods, and is able to efficiently perform his local

role for propagating information upstream the supply chain. As a consequence, it is usually considered that SMEs should switch from simple financial plans to forecast based planning (Thakkar *et al.*, 2008). In that purpose, the use of ERP systems including MRP modules, is more and more considered as a condition for SMEs to join Supply chains (Lenny Koh and Simpson, 2005). We shall see in next section that the use of these systems may in some cases be difficult.

3. From local practices to negotiation processes

3.1. Emergence of local practices in supply chains

During three projects launched by large companies aiming at analyzing the product flow in their supply chains (Ming, 2011), interviews have been performed in several tenths of both large and small companies. They showed that many local practices were added to the global process described in Figure 1 in order to cope with local objectives or constraints of the supply chain members. The performed analysis has mainly concerned four major operational processes: the answer to a “Request for Quotation”, having for result the creation of a middle/long term relationship between customer and supplier; the middle term order management; the orders fulfillment (short term) and the supplier development, through audit and transfer of various tools and techniques, among which MRP and Lean Manufacturing (this point will not be detailed here). Some findings of the study are summarized hereafter. In each case, we have tried to distinguish (even if it may be ambiguous in some cases), *cooperative* practices, i.e. practices aiming at helping the partner, from *selfish* practices, aiming at preserving local interests.

Customer’s side/Cooperative practices:

Attempts for protecting the small suppliers from variations of the demand have been noticed from several large companies, who try for instance, to smooth the demand between two periods when sending a supply plan to their small suppliers. Others try to increase the lot sizes of their commands in order to help their suppliers.

Some companies also noticed that sending precise due dates for all their orders was not always justified, since safety inventories were available for some parts. As a consequence, they decided to mention their level of inventory with each order, in order to

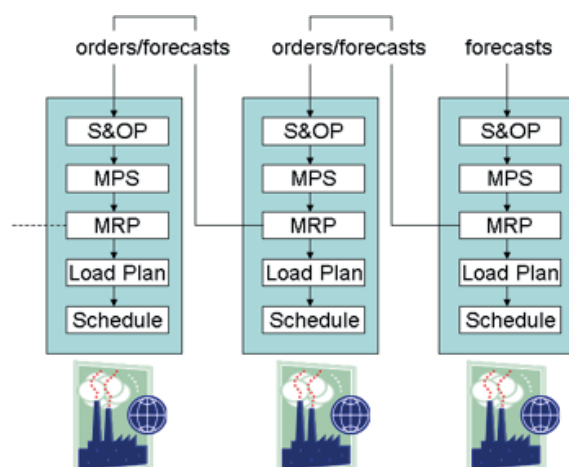


Figure 1. Supply chain management as a cascade of MRP systems (Grabot and Mayère, 2009)

allow their suppliers to assess themselves the criticality of the respect of the due date.

Customer's side/Selfish practices:

Most of the large companies admit that they choose suppliers for which they represent an important sale ratio (in order to have power over them), but not too much (in order to avoid any responsibility if they decide to decrease their orders).

Partnerships are usually signed for several years, all the contracts including a decrease of the price through time (up to 8% per year). The service ratio (percentage of parts delivered on time on a given period, often the month) is a very important indicator. When their ratio is not good, many companies turn the status of their order to "urgent" (which has a specific significance in the aeronautical industry) in order to be sure to be delivered on time, with the result of the destabilization of small suppliers having to cope with up to 30% of urgent parts. The Supply Network defines a "PERT-like" structure converging on the assembly of an aircraft, in which not all the orders (and suppliers) are on the critical path. Therefore, meeting the due dates does not have the same importance for all the parts and suppliers. Nevertheless, the logisticians, each of them managing a group of suppliers at the customer's, do not always know what are the "real" urgencies; therefore, they have no other choice than setting the same pressure on all the suppliers for all the parts, which may destabilize them in overloaded situations.

Supplier's side/Cooperative practices:

Even if the production program of each aircraft is relatively well known and stable, many hazards may occur during the manufacturing cycle, with the result of urgencies, or even changes in the definition of the parts. All the suppliers are used to these constraints, and do their best for dealing with them, even if it may be costly.

The scarcity of some raw materials (e.g. some aeronautical alloys and casted parts) has considerably increased the supply times in the recent years; some suppliers have now to order raw materials before the corresponding orders are confirmed... In that case, they take an important financial risk, to the benefit of the supply chain.

Supplier's side/Selfish practices:

Each supplier has "important" customers (usually those who generate a high cash flow) and less important ones. Therefore, when their capacity is insufficient, they privilege their important customers.

Nevertheless, it is not rare that all the customers work for the same final assembler. In that case, the supply chain is in a way "competing against itself", not always for its final benefit since the most important customer for a local supplier is not necessarily the critical one for the supply chain.

Some suppliers having a critical competence (for instance surface treatment, which is object of strict regulations and is therefore a scarce resource) may use this power for imposing to their customers a link between price and cycle time, which can hardly be taken into account in the classical MRP framework.

In many cases, having to decrease their prices through time leads the suppliers to questionable solutions. Many of them try for instance to increase their lot sizes, by grouping the demand on parts having similar characteristics. The result can sometimes be both early parts (creating inventories), and late ones.

These examples show a complex and sometimes paradoxical situation, where real attempts to help the partner cohabit with selfish behaviors, that often remain hidden. The usual way to address this problem is to promote standardized "best practices" supposed to improve the global performance of the supply chain to the final benefit of each partner. Nevertheless, some authors have shown that if the appropriate mechanisms are not in place, the supplier may not perceive the benefits associated with these investments and may reject the initiative to modify or improve their processes (Krause *et al.* 1998). For others, difficulties in developing "state of the art" capabilities in Management, technology or co-operation is inherent to relationships between large and small companies (Chen and Chen, 2002; Blomqvist, 2002).

In order to cope with this problem, a different research paradigm may be chosen. All behaviors have a justification for the companies adopting them, even if they can be considered as "positive" or "negative" according to usual criteria. Whatever their consequence can be, and even if they are not consistent with present habits, we have therefore chosen to consider some of the typical practices that we have observed, and try to include them in an open negotiation process, instead of keeping them hidden or informal. The practices we have chosen to test are described in next section.

3.2. A negotiation process for integrating hidden practices into collaborative processes

An explanation of the practices listed in previous section may be that many parameters usually defined in the contract between customer and supplier heavily depend on the context and on the situation of each partner. For instance, the price of the parts (including its evolution through time) is defined when the contract is concluded (even if it can be renegotiated in some cases). It is nevertheless clear that the production costs depend on a precise context: for instance, parts produced during extra-hours are more expensive than if produced during normal hours. On the other hand, since the price is an important criterion for choosing a partner, accepting that he may change it after the contract has been concluded is somehow inconsistent.

Similarly, the periods of the forecast (firm, flexible and free) should depend on the uncertainty of the final demand, and not on a local context. Nevertheless, we have decided here to assess what would happen if the identified local (and sometimes “hidden”) practices would be included in formal negotiation processes.

As an illustration, we have chosen to focus on four practices often mentioned during the interviews (directly or indirectly):

- the periods of the forecast. The difference between the length of the flexible period received by the customer and the one he sends to a supplier is a way to put pressure (shorter period) or to protect (longer period) the supplier. Similarly, sending to a supplier a firm period shorter than the supply cycle of his raw materials obliges the supplier to take risks. We suggest to generalize these behaviors by allowing a negotiation on the length of the periods of forecasts.
- the possible load variations during the flexible periods of the forecasts. These variations are usually defined in the contracts, and can be up to 50% in the aeronautical sector. Nevertheless, high variations may be acceptable by the supplier in some periods, while even low ones may be problematic in other periods, depending on the global load of the supplier. Therefore, we suggest to adjust a possible variation through negotiation.
- the prices and cycle times. Prices and cycle times are linked by the resources used, even if these two items are implicitly considered as independent. As a consequence, we suggest that the prices in a

given situation are adjusted according to the real costs induced by each situation.

- the order priority and lot sizes. Lot sizes are usually defined in the contracts, but their variation may allow to balance productivity and cycle time for a supplier. Similarly, suppliers have to sequence orders coming from their various customers without an objective view of their real criticality for each customer. We suggest that these two points could be discussed for a better mutual interest.

3.2.1. Negotiation on the periods of the forecasts

The real issue in the choice of the periods of forecast is risk sharing: risk taken by the supplier when he orders raw materials or releases production orders on the base of the flexible period of the forecasts he receives, and risk taken by the customer when he accepts to send to a supplier a firm period longer than the one he himself receives from his own customer. However, the interest of protective behaviors from the customer depends on the actual situations of the supplier. Therefore, we propose to put the periods of forecast into the middle term negotiation process, which would allow to make the length of the periods more flexible, being negotiated on the base of the real requirements and actual necessities of both customer and supplier.

The Business Process Diagram describing the conditions for releasing a negotiation on the periods of the forecasts is summarized in Figure 2, with the customer’s activities in the top and the supplier’s ones in the bottom on the figure. Using the MRP2 method, forecasts coming from customer’s customer are inputs of the customer’s SOP, and then used to generate the MPS (Master Production Schedule) (point ① in Figure 2). The MPS provides more detailed production requirements to the MRP (Material Requirement Planning) calculation (point ②). The supply plan (one of the outputs of MRP) is calculated using the BOM (Bill Of Materials), supply lead time, material inventory level, etc., according to the contractual horizons, including lengths of firm, flexible and free periods (point ③).

he supply plan is the base of the forecasts received by the supplier (point ④). The supplier makes then his own MRP calculation (point ⑤), resulting in a supply plan (not mentioned in Figure 2) and a load plan (point ⑥). Since he has taken into account his cycle time and the cycle time of his suppliers, the supplier is able to see whether this load planning is consistent or not, or in other terms whether he takes

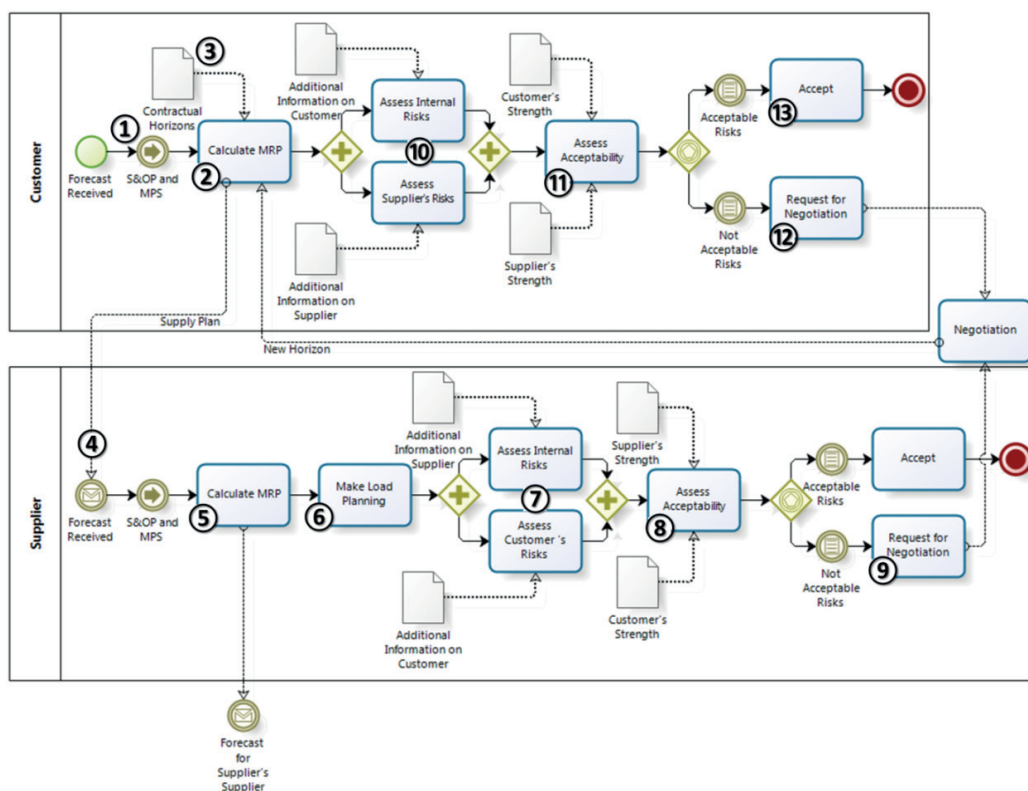


Figure 2. Negotiation of the periods of forecast.

too much risks (for instance by ordering parts on the base of the flexible period of forecasts, point ⑦). Depending on additional (and sometimes subjective) information on his customers and suppliers (e.g. Can they work faster? Do they have financial stability?), he decides whether these risks are acceptable or not (point ⑧). If he considers that he takes more risks than his partners (customers and suppliers), he may ask for negotiation (point ⑨).

The customer performs the same evaluation: he makes his assessment of both internal risks and risks he thinks the supplier takes (point ⑩). This assessment of course considers the horizon of the firm period received from his own customer, the horizon of the firm period he sends to his supplier, his internal cycle time, his supplier's cycle time, etc. It should also include his opinion on additional information, like the cycle time from supplier's suppliers, the real costs of his supplier, etc. It is clear that this information may be subjective or imprecise, since it is usually not provided by the supplier, who normally does not accept to communicate his real costs to his customer.

The risk taken by the customer can be different for each of his suppliers, since two different suppliers do not need the same protection, or in other terms do

not deserve that the customer takes the same risk. It is for instance acceptable to take risks for protecting a critical supplier, but not a "common" one. The assessment of the risk will so denote the customer's vision on the allocation of risks between him and his suppliers.

The next step is to decide on the acceptability of the risks he takes (point ⑪), by balancing the customer's own strength (precisely known) and its supplier's strength and weakness (supposed). This assessment is subjective, but is indeed implicitly done daily in real situations, within less formalized processes. If, from the customer's vision, his risks are not acceptable, he will ask for a negotiation process (point ⑫). Otherwise, the customer will accept the current plans (point ⑬). After the negotiation process, a new agreed horizon will be integrated into customer's MRP plan.

In all these cases, sharing real information instead of trying to guess the situation of the partner could facilitate to reach a consensus, but would certainly lead to other problems, especially linked to confidentiality and trust.

The exchanges of information between actors when negotiation is requested by the customer have been modeled using an UML Sequence Diagram (OMG,

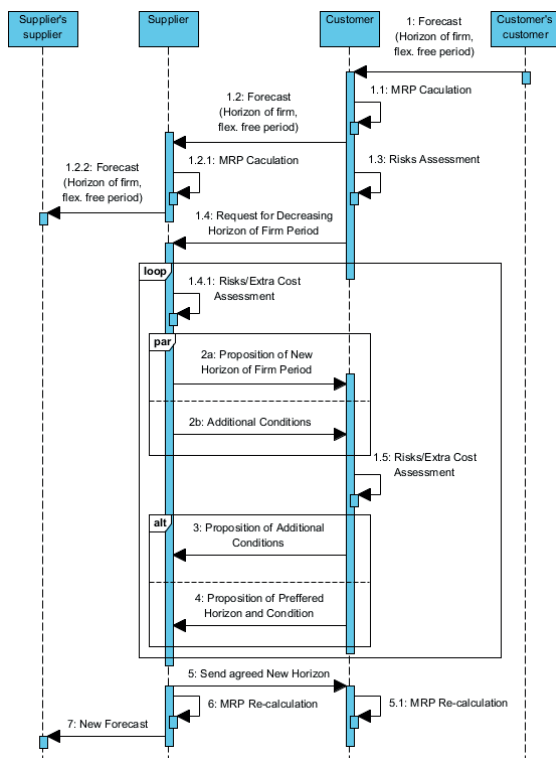


Figure 3. Sequence of activities for periods of forecast negotiation (customer requested).

2011) in Figure 3. The corresponding figures are not provided for the other negotiations, but bring quite similar information.

3.2.2. Negotiation on load variations

The second item we suggest to discuss, load variation, can generate problems at both customer and supplier's sides. The capacity of the suppliers is usually limited, especially because low prices are poorly consistent with extra capacity, but also because of the present increasing workload in the aeronautic sector. Therefore, it is certainly dangerous for the customer to send an irregular load to his suppliers if he is himself more likely able to cope with variations than his suppliers. We have seen in previous sections that some customers try to limit the load variation between two consecutive periods even if it would be allowed by their contractual agreement. Nevertheless, this protective attitude is perhaps not always necessary since the supplier can occasionally be able to cope with this variation, especially if the price paid by the customer covers his extra costs, linked to a temporary increase of its capacity or to sub-contracting. Therefore, instead of considering that the supplier HAS to answer to an overload if it is consistent with the contract, or CANNOT answer to an overload (in consistence with the contract

or not), overloads (but also lacks of loads) could also be negotiated, including setting into question the corresponding price paid by the customer.

On the customer's side, the negotiation on load variation is proposed after the MRP step has been performed (see the top part of Figure 4). After integrating the forecasts in the SOP, then processing the MPS, the customer begins the MRP calculation (point ① in Figure 4). The customer may then consider the supply plan for each of his suppliers in order to identify high load variations (by comparing the load on the current and previous periods) (point ②). For dealing with high load variation, the flexibility of the mid-term capacity of the supplier is essential. Therefore, the customer has to estimate the mid-term capacity on the supplier's side (point ③), as well as the costs to manage such capacity (point ④). As a consequence, additional information on the supplier's capacity, including internal regular and overtime capacity, externally accessible capacity (through subcontracting) (point ⑤), and additional information on related costs (point ⑥) are important inputs for this estimation. Again, depending on the closeness of the relationship, this information can be known or estimated.

Based on the estimated results, the customer needs to assess the feasibility of the load variation expected in the current period (point ⑦). From the customer's vision, if the supplier is capable to manage this load variation, the current plan is considered as feasible and the MRP result is accepted (point ⑧). Otherwise, the customer requests for a negotiation process, considering as doubtful the supplier's capability to perform on time delivery when facing the considered load variation (point ⑨).

On the supplier's side (bottom of Figure 4), the detection of capacity problems is not based on estimation, but on the actual capacity/load situation. According to the result of the load planning (point ⑩), the supplier identifies a possible capacity problem (point ⑪) and checks the feasibility (point ⑫) to address this problem (by extra hours or subcontracting in case of increase, by other solutions aiming at decreasing his capacity in the opposite case).

In that purpose, two important factors have to be taken into account:

- Price paid by customer (point ⑬)
- Cost for changing capacity (point ⑭).

From the supplier's vision, if the capacity change is considered as feasible, the current plans are accepted (point ⑮). Otherwise, the supplier will request a

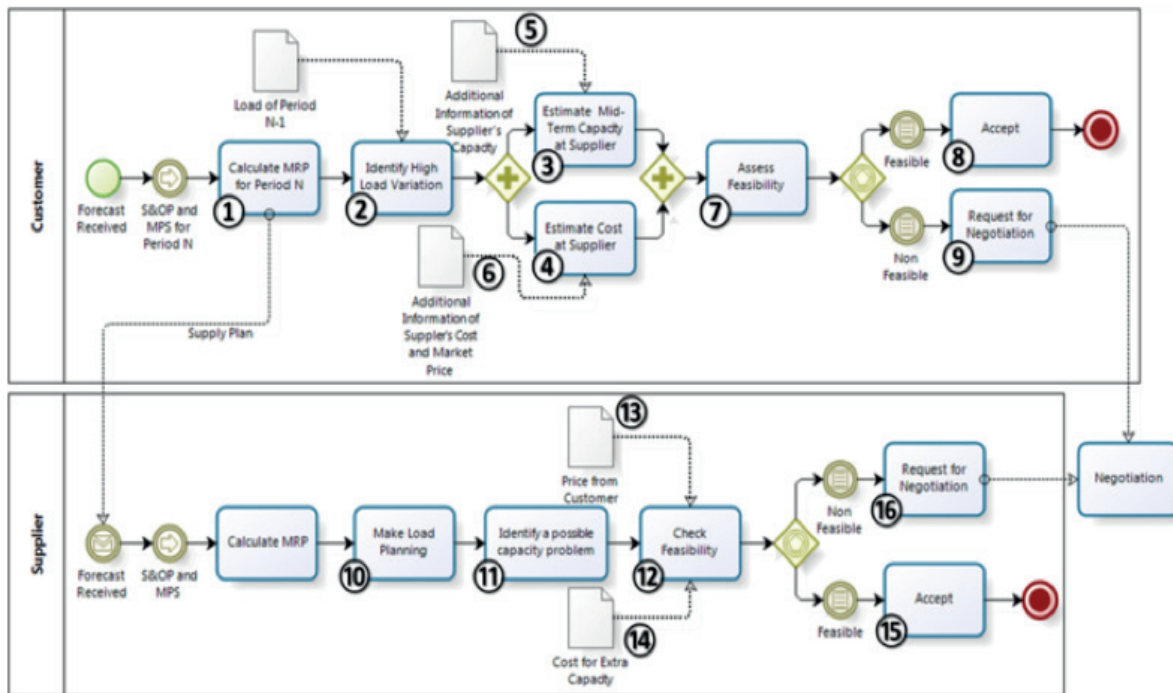


Figure 4. Negotiation on load variation.

negotiation process and communicate his capacity problems to the customer (point 16).

Again, the negotiation process will be triggered either by a customer request, a supplier request or a double request (not considered here). Of course, a problem detected by one of the partners should be validated by the other before negotiation. For instance, a customer may detect a high overload that may have no consequence for a supplier, if other customers of this supplier have decreased their orders during the same period.

3.2.3. Negotiation on prices vs. cycle times

As already mentioned, urgent orders are quite usual in the supply and demand process of the aeronautical industry, even if the demand is supposed to follow long term programs. We distinguish this point from the previous one in the sense that overloads can be detected quite early, in the flexible period of the forecasts for instance, whereas urgencies have to be handled at short term, often in the firm period. Urgencies are of course firstly detected at the customer's side, but the supplier is the one challenged through its flexibility and adjustment of capacity. Therefore, it can be considered as in Figure 5 that the problem of the cycle time for quick delivery is detected at the operational level of the supplier.

Usually, the urgencies are processed by the supplier depending on the influence of the customer over him, with the result of possible disturbances on the short term planning propagated to other customers. Two cooperative behaviors could help to mitigate these problems: the first one would deal with the price, allowing the supplier to find extra capacity for processing the urgent parts, whereas the second one would deal with a better negotiation on the priorities between the supplier and his customers (this point is addressed in next section).

Concerning the first point, we shall consider here that the cycle time of urgent orders is partially negotiable, as well as their cost. When an urgent demand occurs, the customer should pay for the cycle time he expects according to the situation of his supplier; for instance, no increase of price would be required if the supplier is in an under loaded period but in other cases, a negotiation process on price and cycle time is suggested to cope with the constraints due to the supplier capacity.

The negotiation on price and cycle time is considered here for a small number of urgent orders. At the customer's side, the MRP calculation is based on the SOP and MPS, also taking into account the urgent orders sent by the customer's customer (point 1 of Figure 5), at the level consistent with their

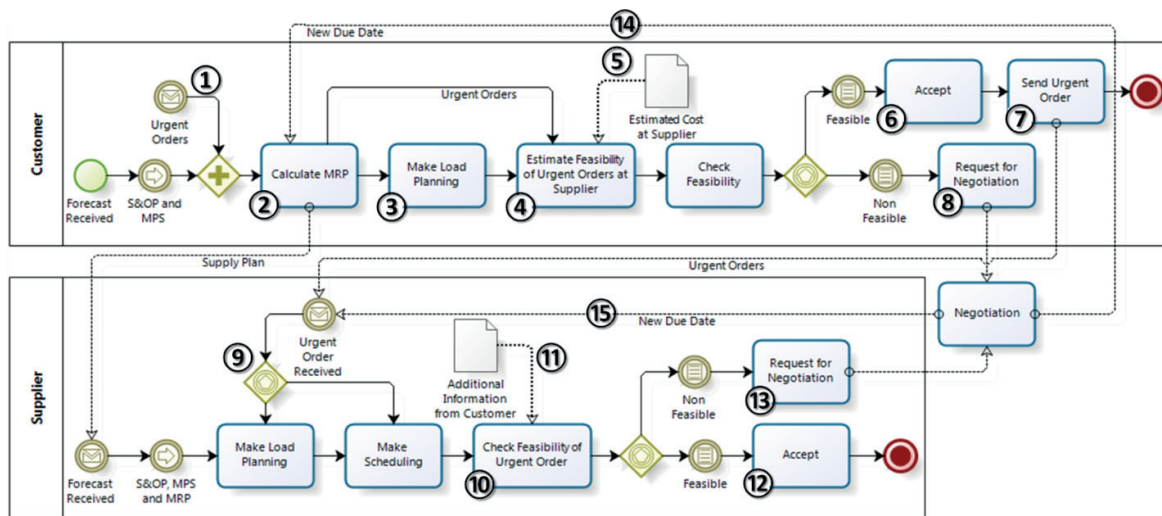


Figure 5. Negotiation on Prizes and Cycle times.

degree of anticipation. The results of the MRP step provide a clear view on the changes in the material requirements induced by these urgent orders for the supplier (point ②): they may have no effects on the current supply plan, or urgent material orders may be necessary. After the load planning, the required due dates of the materials are confirmed (point ③), then the customer needs to estimate the feasibility of urgent orders on supplier's side (point ④), as well as the possible extra cost for the supplier (point ⑤). According to customer's vision, if the urgent orders are considered as feasible, meaning that the supplier is supposed to be capable to deal with such urgency, the current plan is accepted (point ⑥) and the urgent orders are sent to the supplier (point ⑦). Otherwise, negotiation is requested (point ⑧).

At the supplier's side, the urgent orders are usually known at the load planning or detailed scheduling levels (point ⑨). Based on the allocation of load/capacity towards each customer, the supplier needs to check whether it is feasible to deliver the urgent order(s) (point ⑩) in the conditions required by the customer (including price) (point ⑪). If the actual situation allows the supplier to adjust his load/capacity for fulfilling the urgent orders, the current plan is acceptable and the production process is launched (point ⑫). Otherwise, the supplier sends a request for negotiation (point ⑬), and notifies his customer that delivery as required is questionable in the present situation.

After negotiation on the urgent orders, the new agreed due date will be integrated in both customer and supplier's plans (point ⑭, ⑮).

3.2.4. Negotiation on priority of orders and lot sizes

The final item that we suggest to put into the negotiation process groups two operational degrees of freedom, namely the orders priority and lot sizes. From the interviews, we have seen real cases where SMEs try to regroup orders having common characteristics, usually in order to decrease the set-up times by increasing the lot sizes (but other reasons may exist). Such regrouping, performed at the MRP level on the supplier's side, could possibly lead to early or delayed orders if not done properly.

If all the orders cannot be fulfilled in time, and without additional information from their customers, it is also common that the suppliers use an internal priority for scheduling the orders at the operational level. As a consequence, tardy orders for one or several customers may occur. Time margins or safety stocks may allow the customer to face delayed delivery on some of the orders, but this information is not always shared with the suppliers.

The negotiation on orders priority and lot sizes occurs at the operational levels, and is mainly related to constraints of capacity or cost (see Figure 6). At the customer's side, depending on the lot sizing policy, the lot size is either an input (for instance, if an economical lot size has been defined) (point ①) or a result (if a lot-for-lot policy is used) (point ②). The customer may in the last case need to check whether the supplier's constraints on lot sizes are consistent with his actual requirements (point ③). If, from the customer's point of view, there is no possible problem, the current MRP calculation is acceptable

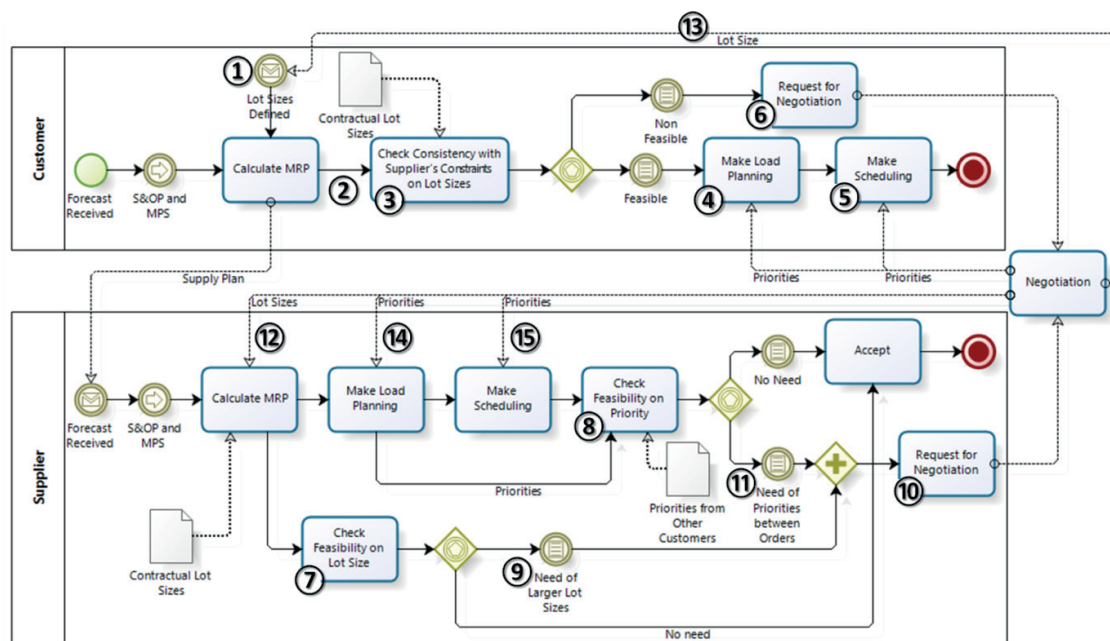


Figure 6. Negotiation on priority of orders and lot sizes.

and a load planning and detailed scheduling can be performed (point ④, ⑤). If the customer considers that the current lot size is not feasible, due to the constraints of the supplier, a request for negotiation on lot size will be sent (point ⑥).

At the supplier's side, there are two major tasks: one is to check the feasibility of lot sizes based on the results of the MRP calculation (point ⑦); the other is to check the respect of the due dates based on the load planning and detailed scheduling (point ⑧).

If the supplier considers that increasing the contractual lot size could possibly lead to some benefits (point ⑨), a request for negotiation on lot sizes can be sent to the customer (point ⑩). Similarly, if meeting all the due dates of the orders in process is not possible, and instead of defining internal priorities linked to the importance of each customer (point ⑪), the supplier can ask for a negotiation on the real priorities of the orders (point ⑩), which would allow him to define a schedule possibly acceptable by all the customers.

After the negotiation process, the new agreed lot sizes will be integrated into the MRP calculation of both customer and supplier (points ⑫, ⑬), and the order priorities will be entered into the load planning and scheduling (points ⑭, ⑮). It can be noticed that these two negotiations are quite different from the previous ones, since they may involve several customers at the same time, and would so be certainly more difficult to handle in practice.

We have suggested in this section several negotiation processes which can be added to a classical MRP2 process, aiming at discussing issues linked to local (but sometimes hidden) practices either by customers of suppliers of the aeronautical industry identified during our interviews. Because they turn some points included in the contracts into negotiable items, these practices can be considered as unrealistic. Nevertheless, we think that their possible interest should be assessed.

4. Conclusion

Despite the fact that our suggestions may seem to be inconsistent with common industrial habits (including e.g. continuous negotiation on prices and cycle times), the suggested negotiation processes are quite consistent with some practices identified during the industrial interviews. In any case, our goal is not to suggest a so-called "optimal" negotiation process, but to take some real empirical situations from case studies as examples, and try to include them into a consistent formal negotiation process, in order to check their real potential. In that purpose, numerical simulations are in progress in order to better identify the situations in which such negotiations would be pertinent.

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