Design of a Supply Chain Quality Logistics Model

Based on the production system of Airbus Deutschland GmbH
MSc Thesis of Twan Duivenvoorden

By what means can Airbus improve cooperation with its suppliers regarding supply chain delivery efforts? While working on my final thesis at the Airbus site in Hamburg, this has been the basic question. New assembly proceedings are designed according to the principles of lean manufacturing. Lean manufacturing stresses the responsibility of the organizations in the supply chain. Especially with the start of the A380 series production, as well as the coming A400M and A350 projects, a high number of newly delivered parts have to be organized and controlled. In my thesis, the Kraljic-matrix was used to select a strategy in determining when to perform which quality and planning assuring efforts, and when to delegate to or collaborate with suppliers.

By Twan Duivenvoorden, TU Delft, Aerospace Management & Organisation

The lean manufacturing principles of the Toyota Production System (TPS) have conquered the world of manufacturing processes and have taken the first steps in supply chain organisation. Through the success stories of many automobile manufacturers, it has set challenges for the aerospace industry as well. The question arises whether or not these techniques are suitable for the highly complex and customized characteristics of aircraft and spacecraft products. The recent and current switches in production organization of civil airplane assemblers, like Airbus Industries and the Boeing Company, changing to the principle of flow in the assembly lines, seem to acknowledge a positive outcome. This can only succeed if the supply chain is organized in the same lean way, oriented at the flow of only the right materials. Suppliers' deliveries need to be synchronized with the new demands of the assembly lines.

Supply chain and means of delivery

The supply chain consists of many suppliers and one final integrator, who mainly assembles the parts into the final product and delivers it to the customer, the airliner. The final integrator holds the certificate to build an airplane and is therefore responsible for the total design, production and assembly of all parts. The integrator can decide what parts suppliers produce, and, if the suppliers are responsible for the design and development as well, see figure 1. This is called 'build to print' and 'design and build' respectively.

Outsourcing to or buying parts from supplier's requests an order and delivery process. To control the means of delivery from the different suppliers, three classical delivery phases have been organized, mostly done in a distribution centre (DC). These phases are a quality inspection, storage and commission effort. This way, the final integrator can guarantee the quality level, the on-time delivery and the right commission of parts to the assembly lines. The commission effort

Author in FAL A320. *source: Airbus*

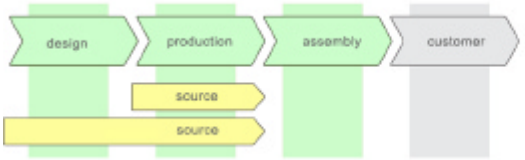

Figure 1: Sourcing possibilities for the final integrator
Source Twan Duivenvoorden

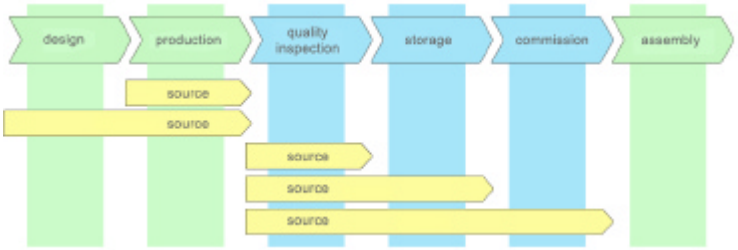

Figure 2: Sourcing possibilities for final integrator in the delivery process
Source Twan Duivenvoorden

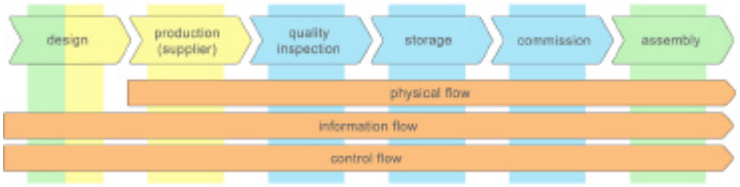

Figure 3: The delivery process can be divided into three flows
Source Twan Duivenvoorden

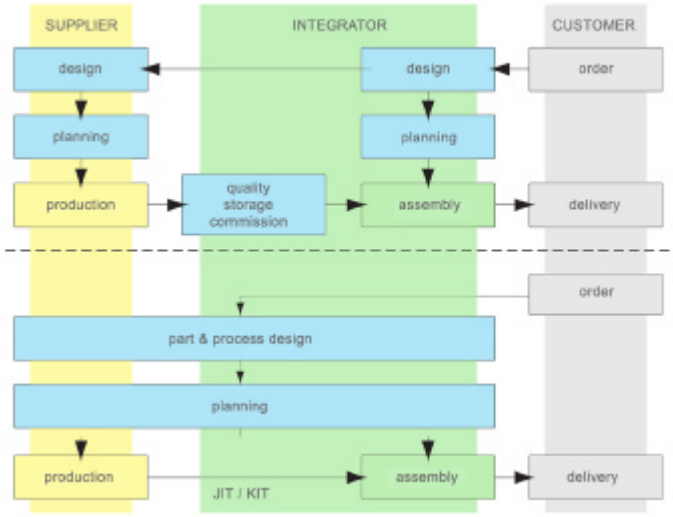

Figure 4: Integration of part & process design and planning supersede actions at the integrator's site, and causes a faster and better response to a customer order
Source Twan Duivenvoorden

is done to supply the assembly line exactly with the needed parts for an assembly assignment together on one wagon. This way, the worker spends no time walking and searching for parts. For the three delivery phases, the final integrator once again has the opportunity to outsource them to the suppliers, see figure 2. A quality agreement lets the supplier deliver straight into the storage. When a supplier is capable of a Just-In-Time (JIT) delivery, the parts will be sent into the assembly line right away. The final stage can be outsourced if a supplier is responsible for an entire system, and delivers it in a pre-commissioned box, called a kit. Outsourcing the three phases mostly comes in the discussed order. For example, when parts in a kit need to go through a quality inspection, it creates a big effort to unpack, inspect and repack them.

A lean manufacturing approach gives a new dimension to the delivery process, calling for a more accurate response to downstream demands and a high quality level, since failures will have more impact.

Supply chain integration and sharing of information

To organize and to control the outsourced phases, different means of collaboration with the supplier are possible. The basics lie in sharing knowledge and information. Therefore, three flows are identified through the supply chain, see figure 3. The physical flow is the actual part (or module) itself. The information flow consists of part drawings, part history and possible production concessions, being the quality status of the part. The control flow tells the current location of a part and can be used to confirm forecasts and possible storage levels. The flows can be treated independently and therefore create independent moves of part and information. For example, the information flow can identify quality problems of a part in an early stage. The final integrator can therefore give a rework order before the part is even shipped. And, in case of a damage part during the assembly line, the control flow can show the first possible replacement part upstream and activate the recovery process.

Perhaps the most intensive way of supplier collaboration is integration of the part & process design phases, and the planning phase, see figure 4. When suppliers are already involved at an early stage of defining product characteristics, customized products in particular will have a shorter reaction time to a customer order. Additionally, working together on the design and process characteristics supersedes the quality inspection at delivery of the parts. When a planning interface is organized as well, like sharing forecasts, production proceedings and storage levels, a JIT delivery is possible. Combined with the customer order specifications, delivery in a kit will be the highest form of supplier collaboration.

Kraljic-matrix

To determine which delivery phases should be outsourced, and how to collaborate with suppliers, a strategy has to be formed. This strategy is dependent on part and supplier characteristics. A supplier of a large and critical system will need more controlling than for example a small fasteners supplier. Therefore, Peter Kraljic designed the 'Kraljic-matrix' in 1983, combining profit impact with supply risk into one

graph, see figure 5. The matrix identifies four types of products: non-critical, leverage, bottleneck and strategic.

The profit impact can be expressed by the yearly turnover a supplier delivers to the final integrator. The supply risk is a more complex dimension. In this thesis, the focus was on the operative supply risk, rather than on market factors such as the number of possible suppliers:
- Operative supply risk
- Part uniqueness or customization level;
- Failure probability, discoverability, reactivity & criticality.
- Quality level parts
- Transparency of supply chain
- Replacement lead time
- Criticality to continuity of assembly line

The combination of the operative aspects is hard to express in a single value. The result of one aspect can cause a strategy decision on another one. For example, for a very unique part, the lead time needs to be kept low, or the supply chain transparency should be high. This is why, in this thesis, the uniqueness or customization level is used as the dimension for the supply risk and thereon allocates the means of delivery to the quadrants. These characteristics will then request a certain level of failure probability, discoverability, reactivity and criticality. Together they form the supplier strategy.

The uniqueness or customization level of a part is dependent on how often it is installed. The customization level can be expressed in the way a part is standard or not. For example, the fly-by-wire system must be installed in every aircraft in the same way, whereas the electrical system is dependent on the kind and location of the galleys. The difficulty with these systems is that a single supplier delivers both fly-by-wire and electrical cables in a single harness, making it a fully-customized delivery.
The failure probability can be seen as the quality level of a part, in other words: the chance for it to break down or not to fulfil the task it was designed for. The discoverability means how this possible failure would then be discovered. Will a system show a red light, or does it first appear in the flight test (which is rather late)? The reactivity states how fast such a failure can be solved, for example by using a replacement part. Finally, the criticality shows how much influence the failure has on the assembly line. Does it cause the line to halt or will rework in the next assembly station solve the problem?
The failure probability, discoverability, reactivity and criticality are very difficult to express in a single value. What can be stated are the influences of these aspects on the supply risk, so tools can be developed to decrease these risks.

Supplier strategies

For non-critical parts, Airbus must perform all three delivery phases, because of the low risk and turnover of the suppliers. Suppliers of leverage products will deliver JIT due to the high financial volume. An additional commission effort will happen in the DC. Strategic suppliers will deliver JIT as well. The high customization level additionally suits delivery in a kit. The same holds for bottleneck part suppliers. The high customization level tends to a kit-delivery, so a quality agreement and JIT delivery would be suitable.
As already mentioned, these delivery strategies cause controlling efforts. The high customization level in the airplane industry locates most parts on the right hand side of the matrix. Especially these strategic and bottleneck parts cause a high level of collaboration or supplier development, to secure the supply risk. The problem with these measures, such as a quality agreement or warehouse interface, is that they cost money. These non-recurring costs will not always be price-efficient for bottleneck suppliers. As the name of the quadrant already tells us, these suppliers should be avoided. This is possible through, for example, system integration, see figure 6. Sourcing more parts to a single supplier lets it move towards the strategic quadrant, where supplier development will be effective. Figure 7 shows the strategies for all quadrants.

Improvements for Airbus

Due to new programmes like the A380, A400M and A350, an increasing number of parts will have to go through the quality and logistics organization of Airbus. Additionally, the new means of lean manufacturing demand a more accurate response of the supply chain in quality and timing. The increased supply risk needs to be assured trough more intensive, but selective supplier collaboration and development. Especially in the level of quality agreements lies an opportunity to improve Airbus' supplier strategy. Around 70% of the high turnover and critical suppliers have an agreement, which should be further increased. Around 25% of the low turnover and less critical suppliers have an agreement, which obviously must be decreased. Recommendations on the level of JIT and kit deliveries require further study, since these definitions can also be categorized. For example, JIT can vary from an hour up till several days before assembly start. A subassembly can be seen as a kit, but all these parts delivered, unassembled in a box, can also be considered a kit.
'Airbus Procurement and Supply Chain Quality' has confirmed to use several aspects of this thesis to improve the supplier strategy on quality assurance and delivery logistics.

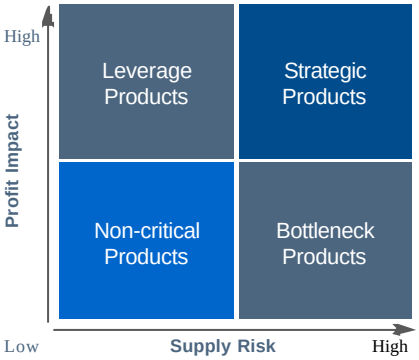

Figure 5: The Kraljic-matrix

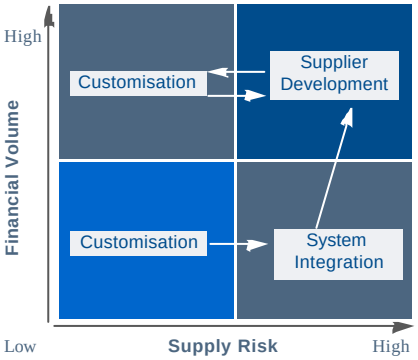

Figure 6: Moving suppliers out of the bottleneck quadrant via system integration

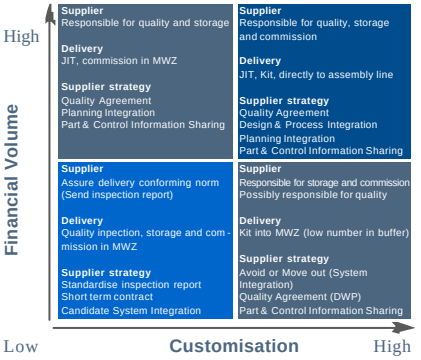

Figure 7: Supplier strategies per quadrant