A Framework to Mitigate the Risk of Inventory in an Aerospace Supply Chain

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ABSTRACT

Inventory is one of the most crucial types of aerospace supply chain risk. The articles tries clarifying all aspects of it with related mitigation solutions. As the last step, a final strategy through benchmarking the solutions would be studied for both series of lean and agile products of commercial airplane manufacturing.

Keywords: Supply Chain Risk; Aerospace Industry; Risk of Inventory.

1. INTRODUCTION

Inventory has consistently remained a main concern for supply chain managers. Since some researchers like Dooley (2005), define inventory management the same as supply chain management and regard it as its most indispensable facet, accordingly, the effects of its risk on nearly all production industries are highly significant, especially on aerospace.

Aerospace industry has 7 major components, from the viewpoint of Wolfe and NewMeyer (1985), including: 1. Aviation manufacturing; 2. Major/National airlines 3. Commuter/Regional airlines 4. Airports 5. Fixed base operators; 6. Corporate flight departments 7. Airmen. Aviation manufacturing is also categorized as: 1. Defense; 2. Space; 3. Commercial. This article tries to illuminate the effects of inventory risk on manufacturing commercial planes as well as presenting some applicable solutions to reach a final strategy through benchmarking the proposed resolutions. Additionally, owing to the fact that adopting different paradigms (either lean or agile) for different categories of products is of noticeable importance, as the final approach, arguments for this difference is brought fourth.

This research utilizes the documentation method as one of the principal branches of observation in qualitative research methodology to scrutinize both various aspects of this risk and the applicability of the presented solutions, in detail. Furthermore, for each part of the article, we will provide some examples related to the first two airplane producing companies, Boeing and Airbus, to clarify the risk and potential solutions in the best manner.

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2. LITERATURE REVIEW

2.1 Components of Airplanes and Main Approaches

As the first step, it is imperative for the main categories of the products offered by the industry to be apprised in order to recognize the related paradigms for each series.

Airbus categorizes its commercial airplanes’ components in to 6 commodities departments, which are (Airbus Procurement, 2010):

1. Aerostructure (Fuselage, Fairing & Boxes, Airframe, Wings)
2. Materials (Aluminum, Titanium, Composite, Standard parts)
4. Systems (Engines, Nacelles)
5. Cabin (Customer guidance and cabin configuration, Monuments and Floor to Floor, Seats and cabin lighting, In-Flight Entertainment (IFE) systems)

In addition, there is a consensus among most researchers in the field of supply chain to introduce two main paradigms for this field of management: lean and agile. Each one of them has its own characteristics to guide companies to adopt diverse strategies.
Almost all researchers have pointed out that “lean is a systematic approach to identifying and eliminating waste through a continuous improvement” (Nash et al. 2006, P.7), and it is about doing more with less (Christopher 2011). On the other hand, Slack et al. (2010, P. 47) argued “agility means responding to market requirements by producing new and existing products and services fast and flexibly”. In fact, speed and flexibility are two main characteristics of the agile paradigm.

Additionally, Christopher (2011) distinguished between lean and agile based on differences in variability and volume per variant (figure 1) and supply and demand characteristics (figure 2).

Figure 1: Agile and Lean Paradigms based on Variability and Volume per variant (Christopher 2011, p.100)

Figure 2: Generic Paradigms of Supply Chain Management (Christopher 2011, p. 101)

However, there has been no business practice or industry to clearly and separately implement these paradigms. Managers try to reduce the costs and simultaneously improve the speed and flexibility of their business, but by doing so they are merely prioritizing only one approach across the fulfillment of the process. Therefore, for aerospace industry, due to the influential differences among products, the appropriate paradigm should be adopted for each category.

2.2 Supply Chain Risk

Zsidisin et al. (2001) define supply chain risk as: “the potential occurrence of an incident or failure to seize opportunities with inbound supply in which its outcome results in a financial loss for the [purchasing] firm.”

On the other hand, Tang (2006) points out two hierarchical and dynamic characteristics of the risk and also defines some risks as the source of other risks. The main sources of risk from his standpoint are demand, supply and natural disasters in 3 categories of: operational events, operational disasters and strategic uncertainty. Furthermore, Chopra and Sodhi (2004) cite 9 main supply chain risk sources among which inventory is one of the most influential origins. They argue the risk of inventory’s drivers as: “Rate of product obsolescence, inventory holding cost, product value, demand and supply uncertainty.”
Thus, it is necessary to find the sources of the risk in the aerospace industry to recognize related solutions for it. Also, the 4-step risk mitigation methodology of Kleindorfer and Saad (2005), which is utilized by The Wharton Risk Center as well (table 1), will be employed here to recognize and plan for reducing the risk’s effects.

<table>
<thead>
<tr>
<th>Establish Voluntary Security Standard</th>
<th>Classification of Assets/Processes</th>
<th>Ranking and Prioritization</th>
<th>Iterate for Continuous Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Design a voluntary standard in Security Management that will allow private firms to achieve optimal “internal levels” of security. 2. Standard should define a process, along the lines of ISO 9000.</td>
<td>1. For each sector determine main assets/processes. 2. Assess vulnerability of each asset/process jointly with private industry using Red-Teaming. 3. Categorize according to vulnerability profiles. 4. Assess likelihood of intentional tempering and relate causally to supply chain metrics 5. Determine synergies with reduction in theft and losses.</td>
<td>1. Develop and validate models for assessing costs and benefits of security-related interventions. 2. Value potential impacts from a security branch for each asset class. 3. Construct prioritization criteria such as Cost of Security Breach to Likelihood ratio (CBL). 4. Prioritize efforts in various sectors and asset classes e.g., according to CBL ratio.</td>
<td>1. Analyze alternative strategies for DHS to reduce consequence of security breaches by direct action. 2. Evaluate direct and indirect costs of best available private actions. 3. Analyze alternative to re-align public and private interests. 4. Evaluate costs and benefits of private public partnership. 5. Design audit system to monitor effectiveness and compliance.</td>
</tr>
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</table>

### 3. RISK OF INVENTORY IN AVIATION MANUFACTURING

Principally, risk is studied based on the cost of warehousing and the probable value reduction of inventory. As Kimmel et al. (2010) mention, there are 3 types of inventory: Raw Material (RM), Work in Process (WIP) and Finished Good (FG). Thus, it is necessary to consider all these three types of inventory for the risk assessment.

Harris (2003) thinks that there are two kinds of inventory risk: 1. Diversifiable inventory risk 2. Adverse selection risk.

“First risks are due to events that cause price changes no one can predict and dealers can minimize their total inventory risk by dealing in many instruments. While dealers face adverse selection risk when they trade with informed traders” (Harris 2003, p. 286)

Since main components of airplanes are made from high-tech units and their life cycle is short, the value of components usually decreases. Additionally, in order to calculate the inventory cost of the products, producers not only have to forecast the future value of them, but also need to consider their salvage value.

Generally speaking, as Coyle et al. (2009) mention, it is important to recognize the cost of packaging, workers, space, insurance, taxes, obsolescence and depreciation to find out the total cost of inventory.

The risk of inventory in aerospace industry is crucial, since so many components must be received from so many suppliers (as a result of the complex web of numerous component suppliers). Its importance comes from 5 issues: 1. Abundance of components; 2. Differences among each category of components; 3. Huge size; 4. High-security required; and 5. Unbalanced time for receiving components from different suppliers. Additionally, if any event occurs to a component during assembling, it is necessary to replenish the warehouse which increases the risk due to the fact that all other components and raw materials must be stored until new components are received.

These issues of inventory provide a number of risks for the supply chain. Such risks are more complex for aerospace supply chain due to the abundance of components in a final airplane. Thus, some applicable solutions to the inventory risk mitigation of the industry are as follows. These solutions have some related costs regarding the examples of Boeing and/or Airbus to clarify their capabilities.

### 4. MAIN SOLUTIONS TO MITIGATE RISK OF INVENTORY

#### 4.1 Increase Capacity
High capacity of suppliers to produce customized and right components; decreases the need of warehousing of them for final producer (assembler); because the producers could be assured about receiving their ordered components at right amount, right time and right place.

Producers usually expect their suppliers to store specified amount of products in their warehouses to enable quick delivery, when orders are placed. It means each producer outsources the risk of inventory to its first-tier supplier. Consequently the highest risk of inventory threatens the last-tier suppliers of this process. On the other hand, studies show that this tier of suppliers, are source of most risks of aerospace supply chain. Thus, it is so important to assess the capacity of last-tier suppliers to decrease the risk; since there is a direct relation between their capacity and risk of inventory for this supply chain as a whole. It could be reached through balancing and coordinating the activities of suppliers and final producer in this procedure.

Xu (2011) argues that it not only decreases the risk of inventory; prevents it as well. He takes an example from Boeing; the company due to multiplicity of suppliers could not coordinate this process well during 1990’s. From the beginning of the next decade, a new department to coordinate the activities of suppliers was established. It led to a sharp decline and prevention of the risk of inventory through gaining access to the inventory data of all suppliers and gaining adequate control.

4.2 Get redundant suppliers

The solution is recommended by many researchers. Aribjorn et al. (2010) point out that companies can keep their inventory low through working with redundant suppliers and get their considered components from many suppliers. In addition, Benyoucef and Xie (2011) argue that this solution has many benefits such as competition of quality and price among suppliers and possibility of replenishing an item by different suppliers; all of which causes inventory cost and risk reduction.

Boeing adopted this solution for some crucial components. For instance, it works simultaneously with both Rolls-Royce and General Electric (GE) for airplanes’ engines. While Rolls-Royce was its sole supplier until several years ago (Wall, 2014).

4.3 Increase Flexibility

LaMacchia (2014) claims that increasing flexibility of suppliers can reduce the risk of inventory considerably. He claims that suppliers play vital role for risk reduction through delivering the products in low-quantity, periodically.

In this situation, producers probably miss “Economic Order Quantity (EOQ)” and the cost of order (and consequently the whole cost of system) will be increased. Another aspect of this solution is about increasing the flexibility of suppliers’ production systems. Berman (2002) mentions that it is possible to reach risk reduction through improving customization of production and distribution by fulfillment of modular product design and postponement of assembly to last assembly stage.

Fredriksson and Gadde (2005) point out the principle of modularity in three dimensions:

1. Modular product architecture: implying that a product is designed to consist of independent modules that can quickly be assembled into different product variants.
2. Modular process architecture: implying that manufacturing processes are designed to consist of independent activities that can be rearranged.
3. Modular logistics and supplier configurations: implying the capability of taking individual customer orders as the starting point for the operations.

From their point of view, building this modular process helps increasing the flexibility of suppliers and consequently decreasing the need of inventory which causes its risk as well. Thus the capabilities of suppliers for modular production, adopted engineering systems (that the most appropriate one is make-to-order) and the flexibility of suppliers (across all tiers) should be studied clearly.

As Kleinford and Wind (2009) say, Boeing adopts this solution for its all three types of inventory (especially WIP) through working with more flexible suppliers and postponing the process to final assembly stage.

4.4 Increase Responsiveness

Producers in this industry usually try increasing responsiveness through increasing inventory. Since it has costs, they prefer to outsource both inventory and its risk to higher-tier suppliers. While it is not a win-win attitude and if one of the suppliers cannot handle its inventory well, it damages the whole process.

Tyan et al. (2003) in order to solve this problem, suggest Third-Party Logistics (3PL). These firms “may be defined as an external supplier that performs or manages the performance of all or part of a company’s logistics function” (Coyle, et al., 2009). Bozarth and Handfield (2013) argue that working with these firms causes improving the service level factor and lets them concentrate on production systems instead of too many aspects some of which do not add value to this process.

This approach is adopted by some firms in aerospace industry as well. For instance, Boeing has increased outsourcing of its main components to 70%, that 3PL firms play a crucial role for a major percentage of its outsourcing (Chopra & Sodhi, 2004). Airbus adopted this strategy as well and outsource more than 50% of

4.5 Increase Source Capability

Increasing source capability for the risk reduction has different ways and methods in aerospace industry. Most of these methods are based on lean approach of supply chain and some of them are appropriate for agile.

Experience shows that the companies in the industry, through adopting Just-In-Time (JIT) system, can reach inventory reduction and its related risks. Wakchaure et al. (2006) point out that risk and delay reduction as two main functions of the system for all three types of inventory. Because, as Lussier (2012) claims, suppliers through utilizing this system can deliver more components with higher speed and lower quantity that it causes inventory reduction. Consequently, companies need to store fewer components and decrease their WIP inventory as well. Thus each tier of suppliers across this supply chain, can deliver components and raw material to next segment with minimum inventory.

Furthermore, Boeing for reducing its risk of inventory, increases its source capability through improving Material Requirement Planning (MRP). Plunkett et al. (2007) point out: they implement this process through concentration and following all several million components instead of only final airplane. Since the ordered airplanes from airlines were different, Boeing needed to store many components for its unpredictable orders. It imposed significant inventory cost to the company. Recently, its inventory department, has categorized the components and raw material to three different categories based on their level of importance. While they previously consider each component separately and it was too time consuming.

Accordingly, Boeing through utilizing Oracle database, gather and sort the information of more than 200 suppliers who produce tens of thousands components in 40 categories, based on their 10-year requirements. It aids the company to forecast its required components based on following projects and order required components on specific times to avoid any kind of shortages. The company implements it for first-to-fifth-tier suppliers (Harrison, et al., 2004).

5. MAIN STRATEGY TO MITIGATE RISK OF INVENTORY

One of the main risks of aerospace supply chain is inventory which has destructive and costly impacts on the process whole. Some of mentioned solutions could prevent or avoid these risks. Thus, it is necessary to adopt a final strategy that not only decrease this risk, but also prevent increasing the other kinds of supply chain risk as well.

For lean products, producers miss economies of scale through adopting redundant-supplier solution. If the final cost surpasses holding inventory cost, thus this approach is meaningful; if not, it could be better for producers to adopt sole-supplier strategy. In addition, working with redundant suppliers, often gives the opportunity of replenishing products in a shorter time which eventuates inventory risk reduction.

Another solution for lean components is utilizing the capable functions of JIT delivery. Since it lets producers receive the right quantity of components at specified times. In order to implement it, it is always necessary to compare the order cost with holding cost.

The final solution for this series of components (lean); is appropriate for reducing risk of WIP inventory which could be achieved through fulfilment of adequate and detailed Master Production Schedule (MPS) during final assembly.

On the other hand, exploiting customization based on increasing flexibility solution, could reduce the risk for agile components. This solution prevents the need for storing the components and change on the products before final assembly. The producers can through working with suppliers who work based on make-to-order system and follow the principles of modularity for their production; receive their components in final format with no requirement to further changes.

Additionally, like lean components, producers should minimize the quantity of their orders to receive them quickly, before final assembly.

Finally, for both series of components, working with 3PL firms in order to reduce the risk for both suppliers and producer is recommended. However, it depends on the flexibility of supplier to work with them as well.

The mentioned strategies for lean and agile products are summarized in table 2.
Table2 : Risk of Inventory Mitigation Strategies for Lean and Agile Products

<table>
<thead>
<tr>
<th>Lean Approach</th>
<th>Agile Approach</th>
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<tbody>
<tr>
<td>• Adopting redundant-supplier if the producer can keep economies of scale.</td>
<td>• Receiving components and raw material from the suppliers who adopted modular design and make-to-order system for their production.</td>
</tr>
<tr>
<td>• Regular delivering of components from suppliers if the order cost surpasses holding cost.</td>
<td>• Receiving components in low quantity and quick delivery from those suppliers who are responsive enough.</td>
</tr>
<tr>
<td>• WIP inventory risk reduction during final assembly.</td>
<td>• Cooperation with 3pl firms to outsource risk of inventory for both suppliers and producer.</td>
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6. CONCLUSION

Inventory risk is one of the main kinds of risk in aerospace supply chain. This article points out the most influential aspects of it with presenting some experienced and applicable solutions.

These solutions summarize a final strategy for both main approaches of supply chain. It is hoped that it could be instrumental and practical for all managers and researchers concerned with this field for considering and realizing their various objectives.

REFERENCES


