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

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Abstract. Delay is a significant type of aerospace supply chain risk. The article tries explaining its aspects to reach a final strategy with regards to benchmarking through several related solutions of the risk mitigation. The strategy considers both lean and agile products of commercial airplane manufacturing.

Keywords: Supply chain risk, Aerospace industry, Risk of delay

1. INTRODUCTION

Supply chain risk has various sources and aspects. One of the industries in which it is most likely to suffer than others and of course more costly, due to impacts of delay, is aerospace industry.

Its importance came from complexity and abundance of suppliers across the process of manufacturing airplanes especially commercial ones. It is one of the main branches in the field of air transport, based on Kaps et al. (2012) who categorize aerospace industry into 1.Manufacturing air transport 2. Air transport as a whole 3. State air transport.

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, this difference would be argued.

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

The article is following with main approaches in aerospace supply chain and the concept of risk in the process.

2. LITERATURE REVIEW

2.1 Lean versus Agile Approaches

Almost all researchers pointed out that “lean is a systematic approach to identifying and eliminating waste through continuous improvement” (Nash et al. 2006, P.7) and 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.
Moreover, Porter (1998, p.11) suggested “three generic strategies for achieving above-average performance in an industry: cost leadership, differentiation, and focus strategies of which there are two variants, cost focus and differentiation focus” as figure 1 shows.

![Figure 1. Three Generic Strategies (Porter 1998, p. 12).](image)

“In a differentiation strategy, a firm seeks to be unique in its industry along some dimensions that are widely valued by buyers” (Porter 1998, p. 14) and “for firms pursuing a differentiation strategy, agile manufacturing is the choice” (Hallgren and Olhager 2009, p. 989). On the other hand, as Porter (1998, p. 12) noted, “a firm sets out to become the low-cost producer in its industry” when they adopt cost leadership strategy and Hallgren and Olhager (2009, p. 989) pointed out “firms with a cost-leadership strategy do not choose (and even avoid) agile operations characteristics. Instead, the choice is lean manufacturing”

Additionally, Mason-Jones et al. (2000) consider distinguished characteristics for both approach which are summarized in table 1.

### Table 1. Main Differences of Lean and Agile Products.

<table>
<thead>
<tr>
<th>Distinguished Characteristics</th>
<th>Lean Approach</th>
<th>Agile Approach</th>
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<tbody>
<tr>
<td><strong>Sample Products</strong></td>
<td>Commodity</td>
<td>Fashionable</td>
</tr>
<tr>
<td><strong>Market Demand</strong></td>
<td>Predictable</td>
<td>Volatile</td>
</tr>
<tr>
<td><strong>Variety</strong></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Life Cycle</strong></td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td><strong>Customer Motivation</strong></td>
<td>Price</td>
<td>Availability (of goods)</td>
</tr>
<tr>
<td><strong>Profit Margin</strong></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Main Cost</strong></td>
<td>Physical Cost</td>
<td>Marketing Cost</td>
</tr>
<tr>
<td><strong>Penalty (for shortages)</strong></td>
<td>Based on Contracts</td>
<td>Immediate and Volatile</td>
</tr>
<tr>
<td><strong>Purchasing Policy</strong></td>
<td>Buying Product (raw material)</td>
<td>Capacity Allocation</td>
</tr>
<tr>
<td><strong>Marketing Data Enrichment</strong></td>
<td>Helpful</td>
<td>Obligatory</td>
</tr>
<tr>
<td><strong>Market Forecasting Mechanism</strong></td>
<td>Consultation</td>
<td>Algorithmic</td>
</tr>
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These differences aid the managers to recognize the best final approach for each series of final components and raw material.
2.2 Supply Chain Risk
Among the researchers in the field, Juttner (2005) has a precise viewpoint to it. He categorized the main supply chain risk sources as:

1. External supply chain sources (e.g. political, natural, social)
2. Internal supply chain sources (e.g. strike, communication problems of IT systems)
3. Dependent sources (e.g. internal relations among firms within the process)

Additionally, Wallace (2012) points out 5 risk sources in aerospace supply chain (table 2). However, he originally postulated them for Boeing; then he generalized them for all airplane production companies.

Table 2. Risk Sources and Causes in Aerospace Supply Chain.

<table>
<thead>
<tr>
<th>Risk Source</th>
<th>Risk Causes</th>
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<tbody>
<tr>
<td>Technology</td>
<td>Utilizing new composite which did not used previously by any company. Presenting computer services for passengers which increases the risk of terrorist attacks through hacking the network systems.</td>
</tr>
<tr>
<td>Supply</td>
<td>First-tier suppliers outsource a part of their activities to those second-tier suppliers who suffer from lack of enough capability and knowledge to respond properly.</td>
</tr>
<tr>
<td>Process</td>
<td>Slowness of first-tier suppliers to fulfil the process.</td>
</tr>
<tr>
<td>Management</td>
<td>Unexperienced management team with insufficient knowledge about supply chain management.</td>
</tr>
<tr>
<td>Worker</td>
<td>Strike</td>
</tr>
</tbody>
</table>

All of the mentioned risk sources can impact on one of the most crucial supply chain risks, delay, as Chopra and Sodhi (2004) points out. The dimensions and impacts of follows.

3. RISK OF DELAY IN AN AEROSPACE SUPPLY CHAIN

The risk came from overproducing of production facilities or lack of flexibility across manufacturing process. Furthermore, low quality of suppliers’ components, causes reordering the components which prolongs the process and causes delay. From You and Grossmann’s (2008) point of view, the main reasons for delay in supply chain came from production and delivery long lead time.

Furthermore, as Lambert (2008) claims, utilizing inappropriate transport facilities derives frequent problems such as delay. It could be eventuated from climate or natural disaster like floods and earthquakes (Fuller, 2002).

Delay, is one of the central significant risks in aerospace industry. Boeing incur losses due to receiving components of Dreamliner 787 from its suppliers at improper time (Joseph & Asher, 2008). European Aeronautic, Defence & Space Co. (EADS) recognised minimum 271 million USD annually as the impacts of the risk and ranked it as the second financial roll-back factor of Boeing; however Boeing’s loss during 2000-2007 amounted to 6.1 billion USD.

There are distinctive reasons for the risk (Daily Telegraph, 2013):
1. Fastener Shortages (it occurred for both Airbus and Boeing (Michaels, 2012); 2. Software issues; 3. Strike; 4. Test program; 5. Engine; 6. Fuel Leaks; 7. Problem with wiring near the main batteries; and 8. Battery fire.

Additionally, Fouche (2014) mentions, problems for the wings of some Boeing’s products; not only increases the risk of delay; but only it was too time consuming for repairing. Another problem was the
differences between bodies of new Boeing’s airplanes with previous products in which aluminium was replaced by carbon fibre (Michaels, 2012). These changes could decrease airplanes fuel reduction by 20%. Furthermore, according to some problems during production of suppliers; more than 40 airplanes of Boeing released with 4-year delay which it affects more than 10 million USD to the company (Michaels, 2012).

Risk of delay for another known huge company of aerospace industry, Airbus, was significant as well. Airbus Chief Operating Officer Fabrice Bregier about the main reason of delay in the industry points out that they do not have any problem with first-tier suppliers who produce or assemble large components; although; the risk came from last-tiers suppliers who produce more complex parts than they have in the past. (Pearson, 2012).

Boeing came down with the problem; since its main suppliers work in Japan, Italy and USA (Kansas and South Carolina) while its second-and-upper-tiers suppliers commonly work in China and India and cannot up-to-date their production facilities based on new requirements (Ferrari, 2008).

All aforementioned issues, result in increasing the risk of delay in aerospace supply chain. Next is a solution for preventing and decreasing said risk.

4. THE SOLUTIONS TO MITIGATE RISK OF DELAY IN AN AEROSPACE SUPPLY CHAIN

4.1 Increase Capacity
According to a study by Kober and Heineckel (2013); average service rate of suppliers improved to 15% through increasing the capacity of them to 17%, and their delay for delivering the components decreased considerably. Furthermore, their average lead time declined from 14 weeks to 11 weeks (however statistics represents 6% decline of the suppliers’ capacity utilization).

The solution is applicable for only second or upper tier suppliers; since they produce small components some of which are common in many industries. While increasing capacity for first-tier suppliers due to costly facilities cannot be reached easily.

Boeing adopted this solution to avoid the risk for its required several main raw material and components. For instance, its composite is only produced by a Japanese company named Toray. Boeing through investment on Toray and increasing its capacity; has solved the risk. Since, it has received its composite on schedule (Stundza, 2007).

4.2 Increase Inventory
Safety stock, surplus production capacity and surplus supplier capacity; as Sodhi and Tang (2012) mention; are optimum methods to prevent the risk in supply chain (Sodhi & Tang, 2012).

The solution is relevant when the inventory cost surpasses volatility of currencies; however, as Sheffi (2005) claims, these kinds of solution increase the overall supply chain cost because of increment of inventory cost.

The producers also can through cooperation with Third Party Logistics (3PL) firms, outsource the risk of inventory to them. Accordingly, Airbus adopted the solution through outsourcing its pre-final assembly to one supplier. The supplier contracts with other suppliers and coordinate majority of the process across all suppliers, which the solution decreases the risk sharply for Airbus (Great Britain Parliament, 2007). However, it seems lack of perfect supervision on the process, brings forth obstacles (which did). In addition, warehousing a part of components as long as receiving other raw material, increases inventory cost that happened for Airbus.
4.3 Increase Flexibility
Increasing flexibility of suppliers is aid to improving responsiveness and delivering orders shortly which leads to decreasing the risk (Chopra & Sodhi, 2004). Producers have to study by details the capability of suppliers who let them control the flexibility of production line. In addition, since majority of problems happened from upper-tiers suppliers, their flexibility plays crucial role for the risk reduction.

4.4 Increase Capability
Lambert (2008) mentions lack of utilising appropriate transportation systems causes the risk of delay. He suggests expediting the process of receiving components and raw material as a solution for the risk. Thus, through scheduling for unplanned times of production and declining batch sizes within manufacturing; the solution decreases the risk.

For the most part, adopting adequate Master Production Schedule (MPS) not only decreases the risk which came from inappropriate vehicles; Blecker et al. (2013) mention that the calculation error within production provides the risk of delay as well. Moreover, the producers through adopting Just-in-Time (JIT) systems can decrease their delay in production and delivery remarkably. It is essential to recognize the principles of JIT systems to assess all-tiers suppliers, and then utilizing JIT delivery systems.

The system was invented by Ohno with the philosophy of delivery and production at right time with right quantity for right product (Ohno, 1982). Other researchers have explained new aspects of the system and typically consider it adjustable for lean approach (however as Trent (2008) points out, so many researchers have defined lean approach and JIT systems with the same meaning and procedure). Thus, it is necessary to be aware of the production capabilities of suppliers for utilizing JIT elements which include (Lai & Cheng, 2009):

- Cross-functional employee training
- Connected manufacturing cells
- Small batch production
- Reduce inventory investment
- Quick equipment changeover
- Close supplier partnerships
- Close customer partnerships
- Scheduled synchronized to demand
- Quality at the source
- Control production via Kanban
- Pull production
- Produce some of each product each day
- Continuous improvement
- Visual control
- Uniform production levels
- Pull product from suppliers.

The system seems so convenient for aerospace industry, while suppliers try sacrificing time to reach cost reduction that it causes those suppliers who adopt JIT system; heighten the risk of delay. Xu (2011) mentions adopting JIT production systems by suppliers of aerospace industry, escalates the risk (that it occurred for Boeing as well) and the producers need to be aware about the details of the production process as well as the company’s manufacturing philosophy to prevent the risk.

Furthermore, considering that the role of JIT delivery is significant to find the possibility of avoiding the risk. Cheng and Podolsky (1996) suggest the importance of lead-time reduction, waste elimination for delivery systems and continuous improvement as the main goal of the system. In addition, Aiello (2008) claims JIT delivery depends on JIT receiving and first-tier suppliers have to work with second-tier suppliers who adopt this system as well. Moreover, he thinks close supplier partnership and receiving small products for each order is essential. Orders could be delivered daily since there is a relation between frequency of deliveries and risk of delay. Because if any problem occurs within one delivery, it would be recouped by next delivery.

Accordingly, due to aforementioned issues, the main goal of JIT system should not be cost reduction; although these systems’ capabilities for lead-time decrement across suppliers and final producer is absolutely favourable to mitigate the risk.
5 FINAL STRATEGY TO MITIGATE RISK OF DELAY FOR LEAN AND AGILE APPROACHES

Risk of delivery often came from deficiencies of higher-tiers suppliers. It shows the significance of assessment the capabilities of all suppliers across the process to prevent the risk.

Increase capabilities through adopting JIT system is appropriate solutions for lean components and raw material. Inasmuch as the system is congruous for lean approach due to cost reduction potential. Once the producers find their lean-components suppliers; have to study their quality and experience for considered products to contract for a long-term cooperation with them.

On the contrary, producers have to study responsiveness and flexibility of suppliers who manufacture agile raw material. These two elements not only are crucial for fulfilment of agile production but also play essential role for risk of delay prevention and mitigation. In consideration of arising a problem within the final assembly process for a component; the suppliers can replenish it quickly (it is especially more significant for the products with shorter life-cycle like high-tech ones).

In addition, agile components have to be delivered by the most secure and quick methods since most of them are the core and critical ones for commercial airplane manufacturing. Accordingly, the producer has to identify suppliers who produce those series of lean components which would be sent by delay in order to expedite their hose are the products which are bought from low-experienced suppliers or those who work in countries with unfavorable climate that increase the risk of delay.

The final step is assembly lead time reduction by the main producer to prevent the risk. All aforementioned strategies for these components are summarized in table 3.

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<thead>
<tr>
<th></th>
<th>Lean Approach</th>
<th>Agile Approach</th>
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<tr>
<td></td>
<td>• Being aware of the capabilities of (second-and-upper-tiers) suppliers</td>
<td>• Cooperation with responsive and flexible suppliers.</td>
</tr>
<tr>
<td></td>
<td>• Considering quality and experience of suppliers as two significant criteria</td>
<td>• Considering highest quality of products for desired categories.</td>
</tr>
<tr>
<td></td>
<td>• Long-term contracts with suppliers.</td>
<td>• Expediting the process of delivery through secured channels.</td>
</tr>
<tr>
<td></td>
<td>• Receiving specific quantity of products at right time and right place.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Expediting the process of delivering products which are threatened by delays.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lead-time reduction.</td>
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6. CONCLUSION

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

REFERENCES