A Survey of Disruptions in Aviation and Aerospace Supply Chains and Recommendations for Increasing Resilience

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Summary

Current developments in the aviation and aerospace industries have transformed the risk landscape, making supply chains vulnerable to disruptions. We present a survey identifying the major causes of supply chain disruptions in aviation and aerospace supply chains. The survey suggests that a supply chain risk management system is the most powerful tool to increase supply chain resilience. Hence we delineate a generic supply chain risk management system for the aviation and aerospace industry and present recommendations for a successful implementation.

Aviation and aerospace supply chains move eastwards

Aircraft fleets are becoming larger and at the same time airlines need to replace aged equipment. The expansion is particularly noticeable in Asia, where a steady and rapid increase of the global share of aircraft in service is expected [Airbus 2013/Boeing 2013]. The enormous demand for large commercial aircraft (LCA) provides remunerative business opportunities to the two traditional OEMs (Airbus and Boeing), as well as to Bombardier and Embraer that expand out of the regional jet segment. The trend spills over to after-sales services. Today the Asia-Pacific region accounts for more than 20% of the global maintenance, repair, and overhaul (MRO) market [Michaels 2011]. This share will inevitably grow due to necessary market proximity to the steadily growing number of operated aircraft as well as low labor cost for MRO services in this region.

Rapidly growing markets outside the domestic regions in combination with local content requirements forced Airbus and Boeing to globalize their production network in the past decade. The global networks benefit from more immediate access to raw materials and engineering capacities, but also lower labor cost, and the possibility of natural hedging. Especially important to Airbus, natural hedging enables the manufacturer to accomplish the value creation in local currency and limits the exposure to foreign exchange rate fluctuations [Richter/Advani 2011].

Today the large commercial aircraft OEMs face the challenge of performing an unprecedented production ramp-up for next-generation wide body aircraft simultaneously to updating their single-aisle models. Meanwhile, airlines and MRO providers need to create capabilities to operate this new generation of aircraft. However, this capability creation is obstructed by risk-sharing models that distribute knowledge across numerous actors in the OEMs' supply chains. When introducing their new generation aircraft (A350 XWB and B787, respectively) Airbus and Boeing aimed to achieve a shorter time-to-market and to share the high costs of product development with their suppliers. To this end they outsourced substantial work packages in the engineering and manufacturing processes to major Tier-1 risk-sharing-partners [Wagner/Hoegl 2006]. The introduction of carbon composites fuselages and the transformation of former manufacturing plants into independent companies further boosted complexity [Wagner 2012]. Despite these positive effects, this

Today's aviation and aerospace industry supply chains are global, highly complex and more vulnerable than ever.

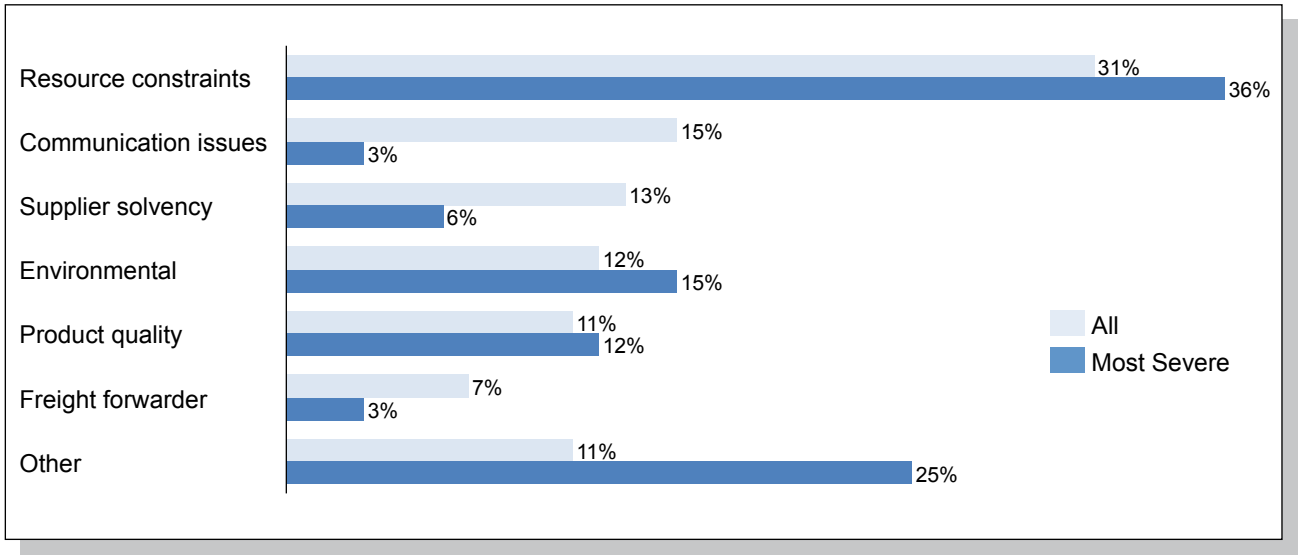

Figure 1: Root cause of disruption

approach generated several pitfalls for the ramp-up phase. In 2006 Airbus experienced issues with the A380 harnesses, caused by an insufficient coordination between the internal engineering departments and the respective suppliers. For its part, Boeing stumbled over non-conforming fasteners in its B787 program in 2007. These events not only slowed the delivery schedules and impaired the EBIT, but they also destroyed shareholder value.

The main culprits of supply chain disruptions are resource constraints, communication and quality issues, followed by suppliers' insolvency and environmental events.

Moreover, customers eagerly waiting for their new generation aircraft to arrive, were forced to operate outdated fleets resulting in higher fuel consumption and unplanned and unbudgeted maintenance checks. These delays are not the only challenges to airline operations. Aircraft on ground (AOG) situations or delays in MRO operations disrupt flight schedules and have a tremendous financial impact.

Supply chain disruptions are prevalent root causes of operational delays. They can result from natural disasters (e.g. earthquakes, volcano eruptions, floods) and subsequent logistical challenges as well as from man-made risks. Financially distressed suppliers, resource constraints and socio-political reasons (e.g. strikes, political unrest) can likewise halt a production line.

Risk landscape in aviation and aerospace supply chains

The previously outlined changes in the OEM value creation process imply a transformed risk landscape in the underlying aviation and aerospace supply chains. To assess the root causes and magnitude of risks that supply chains in aviation and aerospace are facing today, we invited 273 aviation and aerospace industry professionals to participate in a survey.

We obtained 52 completed surveys. The above-average response rate of 19% confirms the high relevance of supply chain risk management (SCRM) to practitioners. The respondents represent the breadth of the industry well: on average the respondents' companies employ 20,000 people with a median of 3,700 employees. The headquarters of the sample companies are located mostly in Europe and North America, 29% offer MRO services, 25% represent OEMs, and 17% are commercial airlines; the remainder consists of suppliers of different tier levels, interior aircraft outfitting specialists and spare part distributors. The respondents' functions indicate a high level of expertise: 52% of our participants hold positions in senior and executive management, 30% in middle management and 18% represent specialists from different fields. Most of them work in supply chain management departments (52%), and sales/business development (25%), followed by quality (7%), general management (6%) and others (10%).

The respondents highlight that resource constraints (e.g. regarding manpower, machines or material) are the major root causes of encountered supply chain disruptions, especially for those disruptions with high impact. We summarize our findings in Figure 1. Twelve percent of the disruptions are triggered by environmental issues – disruption sources completely outside of firms' control. Figure 2 shows that 91% of all disruptions occur upstream in the supply chain and again outside the direct control of the focal company.

On average the disruptions reported caused significant financial and reputational harm to the firms: the schedules were affected for an average of 4.8 weeks

with a maximum of over 20 weeks until operations were back to normal – a long time in the fast-moving aviation and aerospace world. These delays cost an average of US$2.9 m for the most severe disruptions only. Not surprisingly, firms that apply make-to-order strategies are more prone to be hit by a supply chain disruption.

When firm size is taken into account, small firms suffer more from the effects of supply chain disruptions and complex supply chains intensify the consequences of severe disruptions.

Our findings suggest that SCRM largely contains the negative effects of supply chain risks. Figure 3 shows that firms with SCRM systems in place had an average number of 14 vs. 91 supply chain disruptions with a shorter duration of 4.5 compared to 5.2 weeks. The most severe disruption created an average financial effect of only US$0.4 m for firms with a implemented SCRM system compared to US$3.5 m for firms without one. Motivated by our findings that a SCRM system is key to achieving supply chain resilience, we present the backbone of an aviation and aerospace SCRM system that was developed based on the findings of the survey.

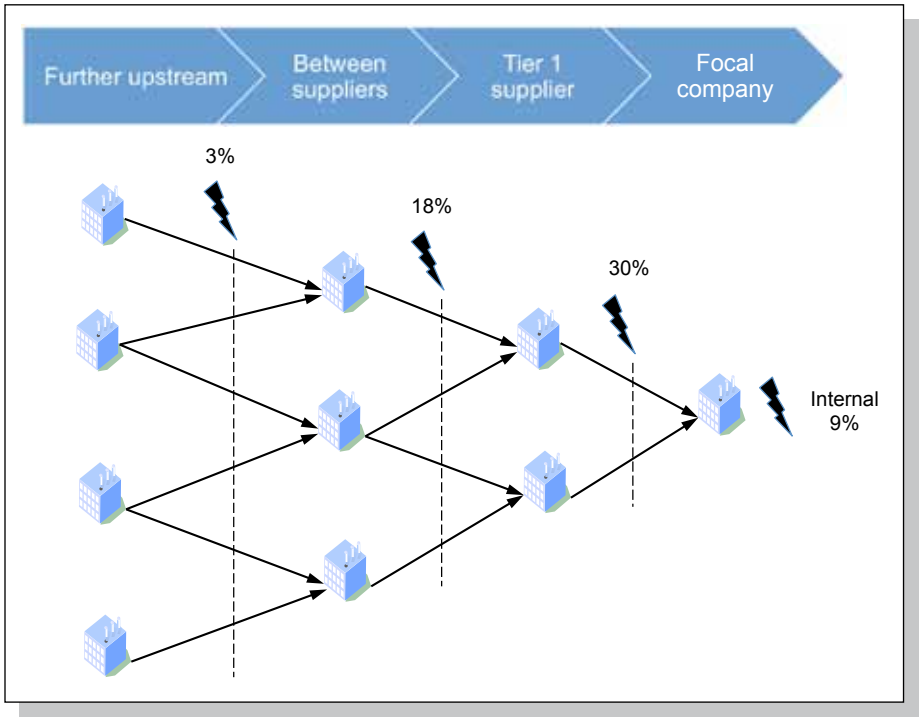

Figure 2: Disruption location

Implementing an aviation and aerospace supply chain risk management system

The main objective of applying a SCRM framework in practice is to coordinate activities to direct and control a company's end-to-end supply chain with regard to risk [ISO 2009]. SCRM reduces the overall risk exposure of a company's supply chain and increases the supply chain's resilience. In this context, companies have to identify and assess their potential risk landscape under criteria of likelihood and consequence by creating a supply chain risk map.

As the implementation and daily operation of such a SCRM system come at a significant cost, certain prerequisites and conditions need to be fulfilled right from the beginning: the company's leadership must offer full support (with money and resources) and lead the SCRM initiative. The established SCRM organization should consist of cross-functional specialists from operations (including procurement, engineering, manufacturing, quality, logistics, supplier management), support (including legal, trade compliance), as well as general management (including corporate governance, finance). Procedures have to incorporate the SCRM framework including meeting structures with defined attendees and deliverables.

When the company has no risk management structure, it is recommended to request professional support from specialized consultancies throughout the concept

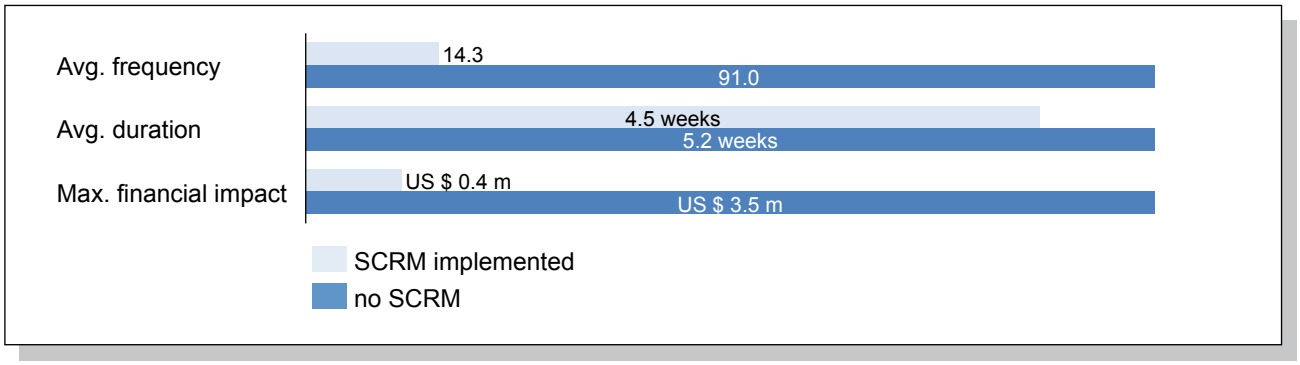

Figure 3: Impact of supply chain risk management

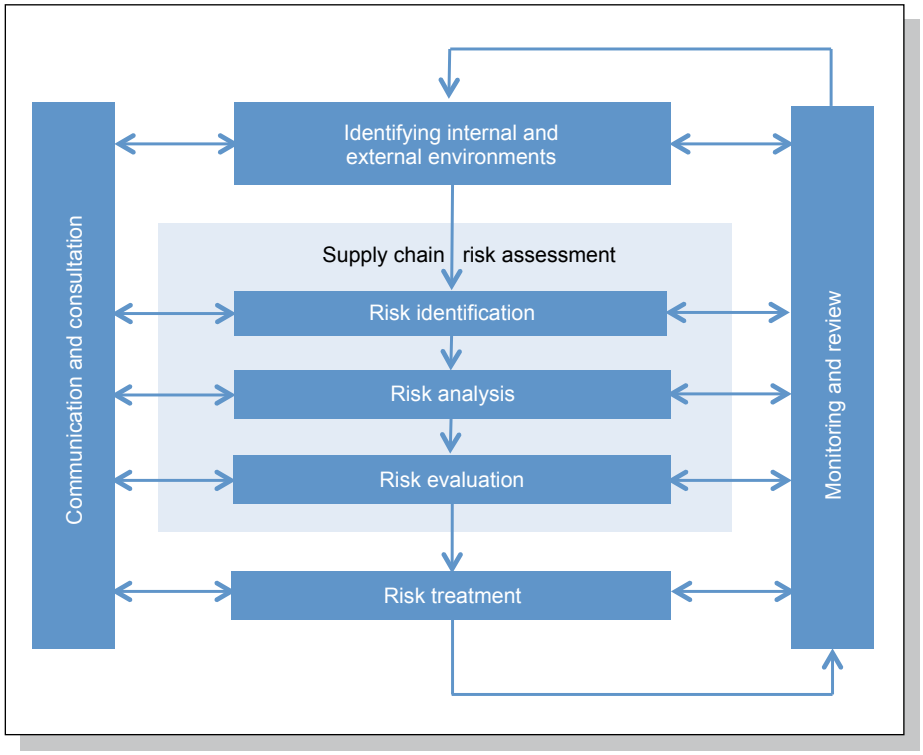

Figure 4: Supply chain risk management process

and implementation phases to ensure implementation of an efficient and effective SCRM process as well as the mobilization of all relevant stakeholders.

As shown in Figure 4, the generic aviation and aerospace SCRM process, is inspired by the Supply Chain Risk Leadership Council [SCRLC 2011], and provides the key elements of identification of the internal and external environments, risk assessment, treatment, communication and consultation as well as monitoring and review.

Identifying Internal and External Environments

This initial step creates an understanding of the internal and external environments that constrain a company in its SCRM activities. It sets the stage for the subsequent analysis and supports the development of risk criteria by defining the areas under investigation.

Supply Chain Risk Assessment: Risk Identification, Analysis and Evaluation

Most effort is required in the initial risk identification, analysis and evaluation phases. The extensive input of resources in this stage is well invested, as it represents the basis of the entire SCRM system and all subsequently developed predefined risk treatment measures and monitoring activities. Based on their individual risk propensity, stakeholders are biased in their risk judgments. Many factors influence individual risk propensities; among them are different experiences, and cultural backgrounds. Thus it is essential to perform the entire analysis in a multi-functional team.

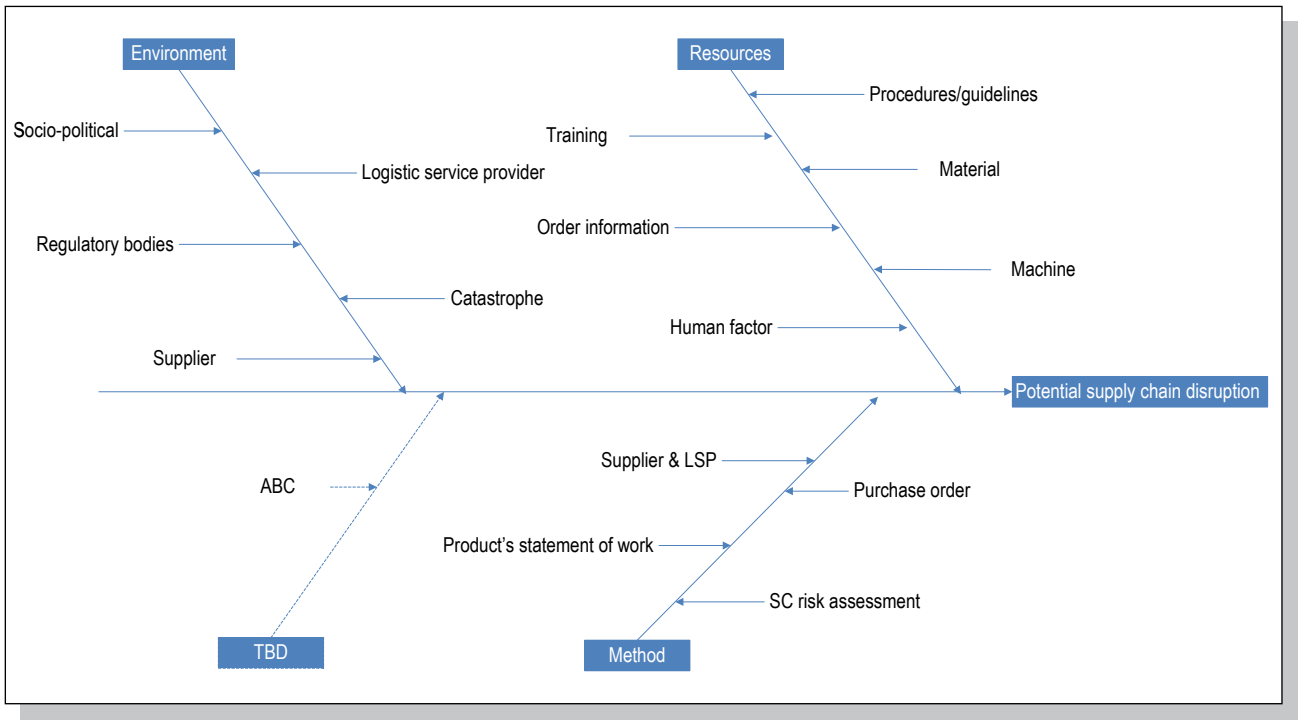

Figure 5: Ishikawa diagram of potential supply chain risks

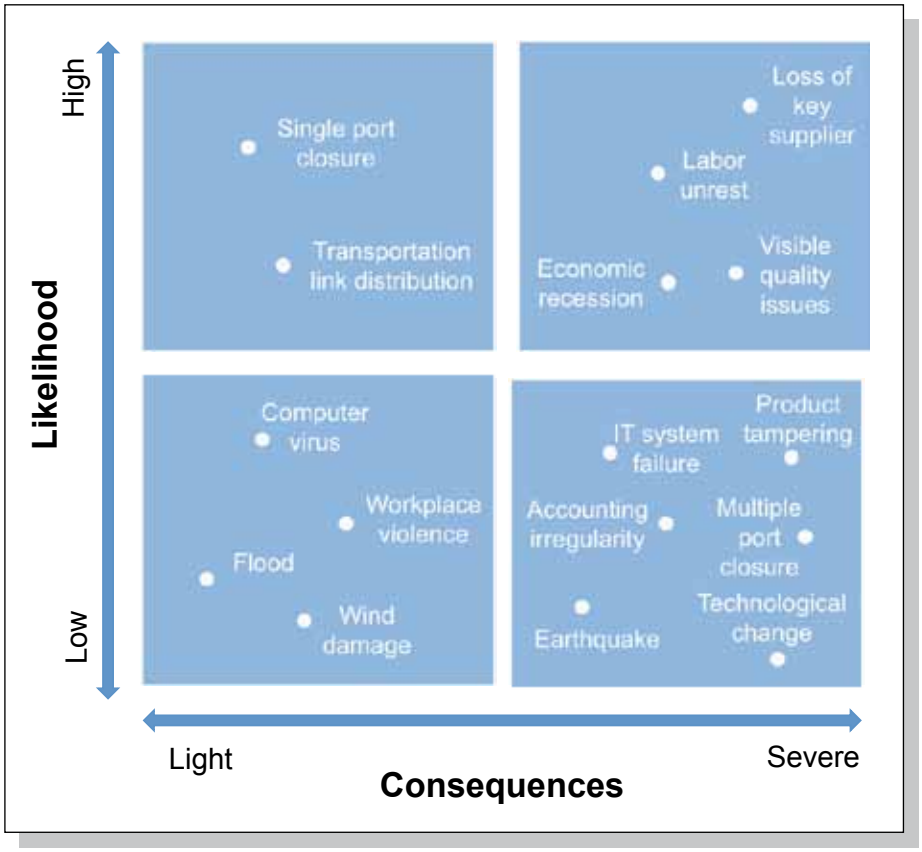

Figure 6: Supply chain risk map [Sheffi and Rice 2005]

An in-depth root cause analysis of potential supply chain disruption risks is the starting point of the SCRM process. To this end an Ishikawa diagram has proven a very powerful tool, as illustrated in Figure 5.

Having identified possible disruption causes, a failure mode and effects analysis (FMEA) rates the risks by occurrence likelihood, business impact and overall risk level. The results of a risk analysis can be visualized in a risk map as depicted in Figure 6.

An alternative result of this stage is a risk ranking that sets the baseline for the final risk treatment definition. Top-ranked risks are the most likely to occur and have severe consequences.

Once the potential risks have been identified and evaluated as well as resolving measures defined, the closed loop SCRM process cycle can be established in daily operations.

Supply Chain Risk Treatment

The treatment of supply chain risk involves the selection of one or more options for mitigating the probability and/or impact of risks. Generally, these treatment options entail either avoidance of supply chain risk by deciding either not to engage or to discontinue a high-risk activity, removing the risk source, modifying the likelihood or consequence, sharing the risk with other parties or retaining the risk by informed decision. Some examples of treatment measures are listed in Figure 7.

Treatment strategy	Example
Avoidance	Airbus refrained from using lithium-ion batteries on the A350 to avoid the troubles encountered by Boeing.
Removal	Airbus acquired financially distressed supplier PFW to prevent its bankruptcy.
Modification of likelihood	In the 787 program Boeing collocated internal staff to supervise and track the recovery process of key suppliers struggling from quality issues on-site.
Modification of consequence	Airbus and Boeing include contractual clauses in supplier agreements in order to ensure operational reliability (e.g. significant penalties for late deliveries as well as bad quality).
Risk sharing	Natural hedging as well as contracts in US$ allow Airbus to share the risk of EUR-US$ currency fluctuations with its suppliers.

Figure 7: Risk management measures

Communication and Consultation

To establish a high awareness, the senior management can express its attention to SCRM regularly over the intranet, in monthly newsletters or in quarterly staff meetings. It is crucial for all employees to know that risk reporting is relevant to the success of the entire company and that ignoring risks may cause major harm. Staff at all levels of the company need to be encouraged and empowered to report looming risks. Such reports must elicit response, even if the risks do not materialize. At the same time, a daily risk information exchange with suppliers is mandatory. In the case of supply chain dis-

ruption, stakeholders must engage in meticulous and timely communication and immediately involve upper management. Governance mechanisms with predefined communication channels facilitate the flow of information to the right recipients.

The communication and consultation with external and internal stakeholders should accompany the entire SCRM process. It should be carried out truthfully and be relevant, accurate and comprehensible.

Monitoring and Review

Once a company has implemented a SCRM system, a periodic but continuous review and monitoring process shall be incorporated within the SCRM process and encompass all aspects of risk. Such diligent reviews will maintain the commitment of employees and ensure that the SCRM system remains up to date. Updated and enriched information can improve the supply chain risk assessment. Past experiences should also be incorporated in the system and create an continuous improvement process.

Conclusion

Today's aviation and aerospace industry supply chains are global, highly complex and more vulnerable than ever. Airbus and Boeing faced severe supply chain disruptions that caused major delays in delivery schedules during the recent launch of next-generation aircraft models.

The aviation and aerospace professionals who participated in the survey presented in this article reported similar incidents. Our respondents claim that they have been severely affected by disruptive events in their operations which were mainly caused in the upstream supply chain outside of their direct influence/control. The main culprits of supply chain disruptions are resource constraints, communication and quality issues, followed by suppliers' insolvency and inevitable environmental events. Our survey findings suggest that a SCRM system contains the negative effects caused by supply chain disruptions. We outline such a SCRM system that consists of a staggered, cyclic approach with emphasis on risk assessment.

The survey shows that setting up and operating a SCRM system in a company will not prevent future supply chain disruptions, but it will prepare for emergencies and contain the impact of materialized risks. SCRM is a powerful tool to anticipate and reduce the potential financial and operational impact of a disruption.

To create a resilient aviation and aerospace supply chain, the attention of senior management is indispensable. In these capital-intensive industries, efficient production processes – including a resilient supply chain – drive financial performance and merit the highest level of attention.

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