DIGICOR: Decentralised Agile Coordination Across Supply Networks

WP 6 : Governance & Knowledge Protection

D 6.1 : Collaboration rules & procedures specification

Deliverable Lead: AGI

Contributing Partners: HAW, SGL, UniMan

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The deliverable contains the specification of the collaboration rules and procedures for the DIGICOR platform based collaboration in the supply chains. The report includes the description of a governance system concept, of collaboration rules and procedures necessary for running the DIGICOR platform.

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See Annex

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This deliverable is subject to final acceptance by the European Commission.

Further Information

www.digicor-project.eu

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Executive Summary

The deliverable contains the specification of the collaboration rules and procedures for the DIGICOR platform based collaboration in the supply chains. The report includes generic rules and procedures necessary for running the DIGICOR platform in a collaboration within supply chains.

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1 Introduction to Deliverable

1.1 Deliverable Purpose and Scope

The overall purpose of this document is to specify the generic collaboration rules and procedures for the DIGICOR platform based collaboration in the supply chains.

1.2 Target Audience

The document aims primarily at project participants and is baseline for the further formalization of governance rules in the WP 6.

1.3 Deliverable Context

This document is a result of task T6.1: “Collaboration rules & procedures specification” and describes the generic governance concept, requirements and specification of rules and procedures for the DIGICOR platform.

1.4 Document Structure

This deliverable is broken down into the following sections:

- **Section 1: Introduction**
- **Section 2: Collaboration and Governance:** This section analyses the basic principles and specific requirements of governance in the aviation industry, external and internal aspects and expectations of OEM and SME suppliers based on literature and expert interviews.
- **Section 3: Governance System for SME Collaboration:** Specification of the governance rules and procedures for SME collaborations to be applied at the DIGICOR platform.
- **Annexes**:
  - **Annex A**: Document History
  - **Annex B:** Abbreviations
  - **Annex C**: Bibliography
  - **Annex D**: Interview Guideline

1.5 Document Dependencies

This deliverable D6.1 “Collaboration rules & procedures specification” inputs generic specifications and procedures into the D6.3 “Formalization of collaboration rules and knowledge protection”.

1.6 Glossary and Abbreviations

A definition of common terms related to DIGICOR, as well as a list of abbreviations can be found on the DIGICOR website.

1.7 External Annexes and Supporting Documents

No External Annexes or Supporting Documents are referenced by this document.

2 Collaboration and Governance

This report aims to specify governance rules of SME collaborations in the supply chain of a large OEM, in particular in the European aviation industry, for SMEs forming instant collaborations.

Governance extends the concepts of management and coordination by another level in organizational theory and is a result of the increasing management complexity. It aims to provide structures that guide and steer interorganisational management activities, facilitate collaboration and inclusion of new partners. Therefore, it is a research subject concerned with multi-organizational cooperation and collaborative networks. In this context, it can be defined as a framework established prior to the instantiation of a collaboration and by this means supports its formation.

2.1 Basic principles

The concept of instant, demand-driven collaborations is novel in the aviation industry and considered to be a potential solution to meet the structural changes of its supply chains. Within the DIGICOR project, governance is proposed to be a promising concept to tackle the challenges that arise from the instant character of the aimed collaborations.

2.1.1 Forms of Multi-Organizational Cooperation and Collaborations

Cooperation between companies has gained importance for decades. Starting from the traditional supplier-customer constellations, various forms of cooperations have evolved. In literature, there is a wide range of different terms used synonymously or with blurring definitions (see Camarinha-Matos & Afsarmanesh, 2005; Putnik & Cruz-Cunha, 2013).

There are other forms of cooperation, such as mergers or joint ventures, that are operated under a shared legal identity. These are not in scope of this report – the DIGICOR project is clearly focused on collaboration of legally sovereign partners.

Cooperations can be compared and distinguished by various aspects. In relation to governance mainly two types should be distinguished, depending on the overall cooperation scope. In case that the goal is rather generic and long-term oriented, it is a strategic cooperation mainly affecting the management and orientation of the company. In contrast, if it is focused on a concrete goal, demand or business opportunity and is therefore short- to mid-term, it is an operational collaboration. Consequently, they affect and involve interacting companies to different degrees which is why the first is referred to as strategic cooperation and the other as operational collaboration. This term emphasizes the increased number of cross-organizational interactions (Shamsuzzoha et al., 2017). Strategic cooperations range from loose partnerships for information exchange and mutual consulting, over long-term R&D partnerships, strategic alignment along the supply chain or shared investments to multi-purpose cooperation networks. The latter evolved from associations and regionally limited industrial clusters to complex and globally interacting collaboration networks and Virtual Enterprise Breeding Environments (VBEs) (Shamsuzzoha et al., 2017). VBEs and other manifestations of collaborative networks increase the cooperation interactions and particularly establish preparedness for collaboration of member companies (Camarinha-Matos & Afsarmanesh, 2005; Noran, 2009).

Operational collaborations, in contrast, are usually formed for a certain goal or business opportunity (BO) and thus are characterized by a limited time frame. Because of the operational character they consist of fewer members and involve contractual commitment towards the goal. The operational interactions between members usually require higher coordination efforts which also leads to higher level of cross-organizational integration and coordination requirements (Camarinha-Matos & Pantoja-Lima, 2001). This increased integration of collaborating companies is often referred to as Virtual Organization (VO) or Virtual Enterprise (VE). However, generally VOs and VEs might be both being formed for a single business opportunity with a very limited life cycle or for an indefinite time frame (Wu & Sun, 2002). In case that a collaboration is formed from a collaborative network such as a VBE it is partly referred to as Instant Virtual Enterprise or Dynamic Virtual Enterprise because the preparedness of network members allows for forming the collaboration in a shorter time frame (Camarinha-Matos & Afsarmanesh, 2005; Grefen et al., 2009).

Figure 1 illustrates the introduced forms of cooperation and classifies them along two characterizing dimensions. One is the life span of the cooperation, while the other the extent of cross-organizational integration. The instant collaboration is characterized by a shorter life span and also lower extent of integration than the traditional VE. It is initiated by a Call for Tender (CFT) from the VBE, which allows a faster formation.

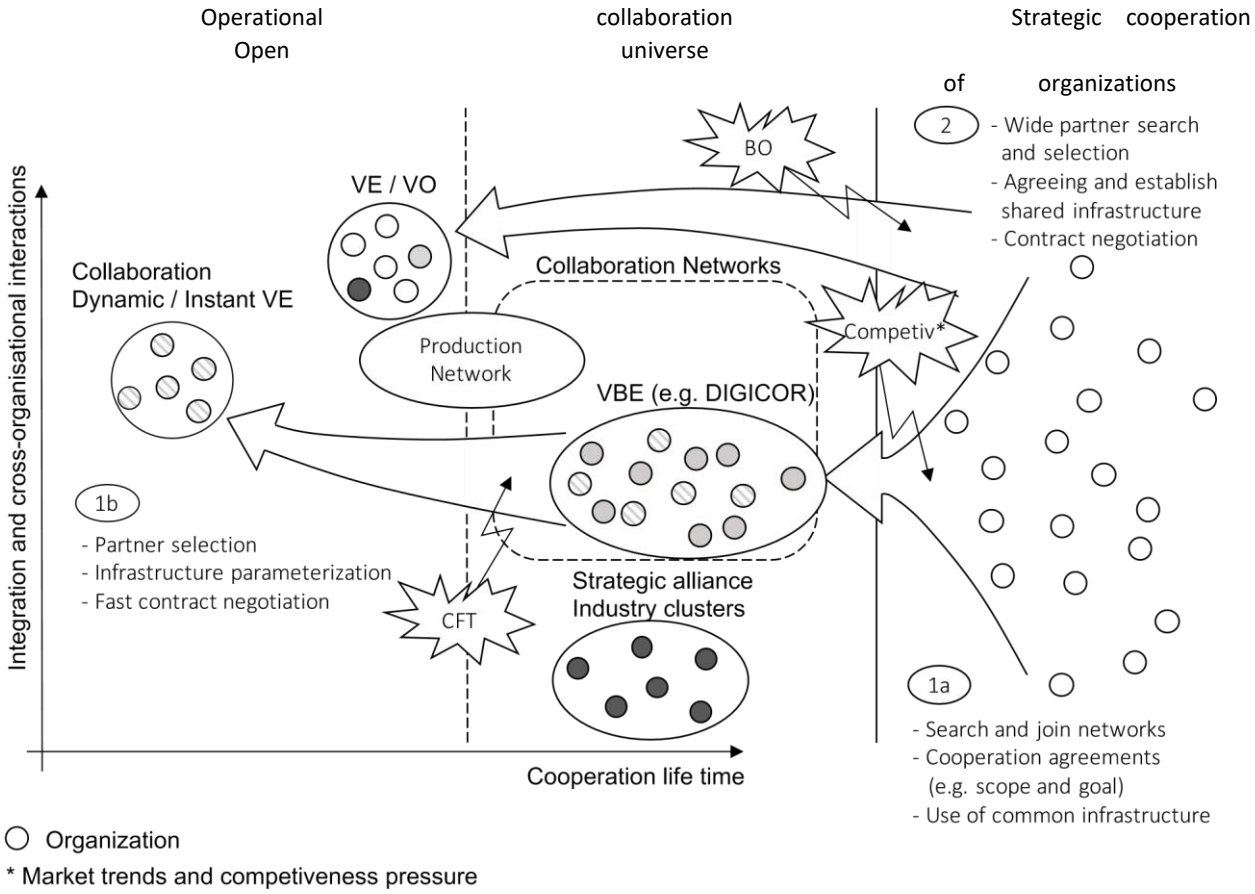


Figure 1: Multi-organization cooperation forms and formation approaches (adapted from Camarinha-Matos & Afsarmanesh (2005, p. 38))

Instant collaboration in aviation industry Collaborations as being considered by the DIGICOR project cannot be clearly and exclusively assigned to one of the cooperation

forms. In DIGICOR it is referred as instant collaboration or just collaboration being characterized by the following:

1. Initiated from business opportunity being a CFT from potential customer
2. Short response time to CFT requires instant formation of collaboration
3. Mid-term time frame corresponding to aviation industry life-cycles
4. Has project character and cooperation is limited to scope of the business opportunity
5. Independent from the contractual setup, contribution to the project is more equally shared than in traditional main-contractor-subcontractor relationships.

The platform and ecosystem being developed by the DIGICOR project consequently represent a collaborative network and matches the definitions of VBEs. The collaboration is of a project character and has many characteristics in common with Virtual Enterprises and especially Instant Virtual Enterprises.

2.1.2 Governance and Governance System

The term ***governance*** is widely used in recent academic works in a variety of different contexts (Lackner, 2014). Originating in the Latin and Greek language, those works share a general understanding of this term as a means of “steering” (Romero et al., 2007). While there are several works on governance in the context of public government, it must be clear that “governance” is not synonymous for “government” and is not limited to the field of public authority (Graham et al., 2003; Finkelstein, 1995).

In the context of organization research, there are different fields related to governance, like corporate governance or project governance amongst others, from which not all have a clear definition nor are broadly established. There are no universal definitions and differentiations yet.

Generally, the concept of governance describes any structures that guide interactions of people and allocation of resources and efforts. Collaboration governance particularly aims at enabling and facilitating sovereign but cooperating partners to approach business opportunities (Romero et al., 2007). Therefore, it is directing human activities of people who are not used to work with each other in order to align these and achieve a collective behavior (Jansson et al., 2008). It is important to understand the differences between governance and management. Governance is not management but a framework setting boundaries within which management can move. These boundaries can be specified in various forms, such as rules, principles, roles and responsibilities, processes or others and might be related to different aspects of management such as decision making, levels of autonomy or coordination activities (Rabelo et al., 2014; Alreshidi et al., 2017,). Thereby, governance represents a high-level guidance and basic principles and agreements that the management of a collaboration needs to follow. Figure 2 illustrates the connection of governance, management and resulting coordination activities.

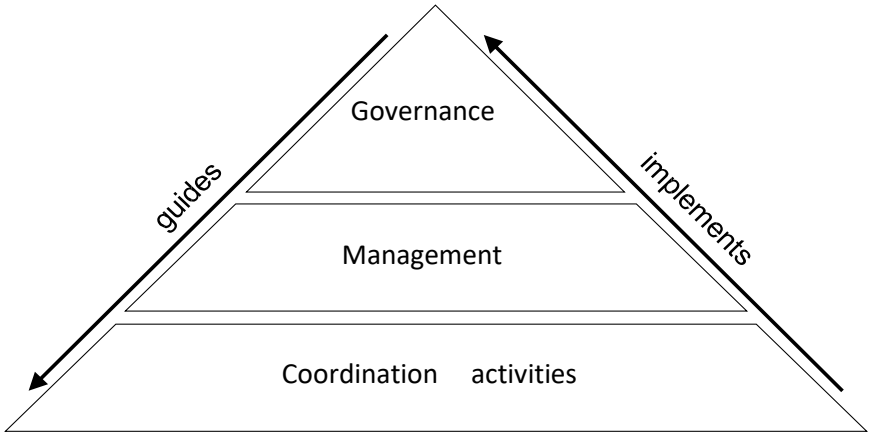


Figure 2: Interdependencies of governance, management and coordination

The actual implementation of the governance concept in terms of guidelines, processes and IT support is referred to as ***governance system***. While governance is just the theoretical specification of relevant rules, agreements and boundaries, the governance system also considers mechanisms, processes and technical solutions that implement governance. The use of any instruments, mechanisms and structural provisions to apply the rules and agreements is what makes a governance system (Albers, 2010, p. 213). Governance systems might also be referred to as governance framework and comprise all measures taken to define, establish and enforce governance. Furthermore, the governance system determines who is defining the governance and how it has to be evolved over time. DIGICOR aims to develop a concept for governance system as it includes approaches for implementation mechanisms.

2.1.3 Governance of Multi-Organizational Collaborations

Multi-organizational governance is part of organizational research and shares many aspects with management. The increasing complexity of organizational structures due to growing interdependencies between multiple organizations across the world led researchers to consider it as an own discipline in recent years (Jansson et al., 2008). In this context, governance aims at establishing structures that allow effective and efficient management of dynamically forming and evolving collaborations that must continuously adapt to changing environments and external requirements. Based on an idealized VO management vision, Jansson et al. (2008) tried to predict the arising requirements towards VO governance in five to ten years by then. They pointed out that the dynamic environment makes it essential to develop efficient measures for setting up governance, emphasizing in particular the need of reducing the additional administrative burdens. This includes removing inter-firm barriers and standardizing common business operations. Because governance is still a relatively new discipline and it is closely linked to *management* and *coordination*, research of these disciplines has also been considered. The various aspects of governance be structured as shown in Figure 3.

One central aspect of a governance approach is to determine the governing authority. Provan & Kenis (2007) studied the ***governance structure*** in networks and its impact on network effectiveness. They point out that the governance of networks cannot rely on hierarchies and associated authority as it does in organizations. This leads to the development of different modes of network governance. Depending on who is the governing institution they distinguish between three different modes: Participant-governed networks,

lead organization-governed networks and network administrative organization. The latter is a governance form in which the governance authority is not involved in the execution of the network operations.

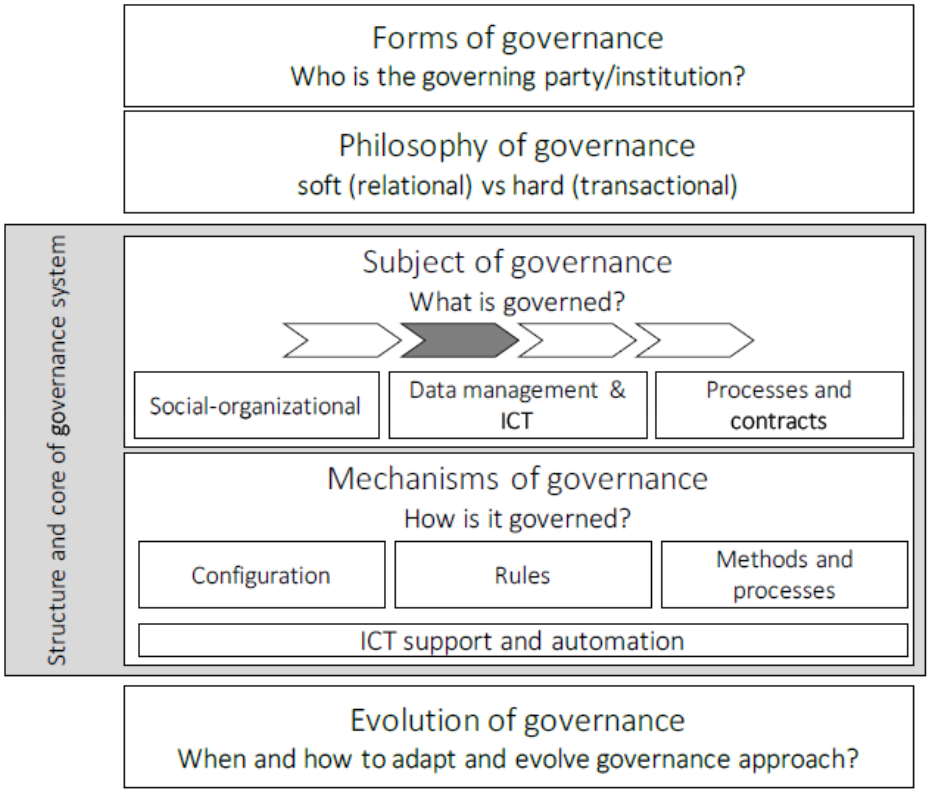


Figure 3: Structure of governance research in context of multi-organizational cooperation

Albers (2010) comes to a similar conclusion and defines five different configurations from an analysis of governance systems of prior researches. They are characterized and vary in terms of two main dimensions: the degree of vertical and horizontal centralization of authority. Vertical decentralization is the delegation of decision-making power to deeper hierarchical levels within the partnering companies. Horizontal decentralization, in contrast, is the distribution of decision authority over the alliance partners. Niesten et al. (2017) believe collaboration itself to be a form of governance. When investigating the management of inter-firm relations they consider there to be three main forms of power distribution: market-economics based on supply and demand, hierarchical, and hybrids. Another common conclusion between Provan & Kenis (2007) and Albers (2010) is that the configuration of the governance system must match certain contingency factors. These mainly refer to the cooperation setup, in terms of member quantity and size or the alliance's scope and goal, as well as to the relation between the partners in terms of trust and goal consensus. Both point out that contingency factors must not be analyzed separately but that the interdependencies and tensions must be carefully considered.

A general topic of discussion in governance research is the optimal balance of trust and autonomy in relation to formal controlling mechanisms such as contracts. Figure 3 refers to this aspect as ***philosophy of governance***. With a focus on technological uncertain development projects and the governance of collaborations between customer and supplier, Melander & Lakemond (2015) stress this philosophy in their work. Based on the transaction cost theory, they compare transactional (hard) governance mechanisms, such as contracts or strict monitoring, and relational (soft) governance mechanisms aiming at trust or goal

alignment. While arguing that the right balance depends on the level of technological uncertainty of the development project, they conclude that contracts generally have a limited role in this context and that the relevance of relational governance increases. The governance philosophy is one factor that can significantly determine a suitable governance form. Therefore, relational governance can also be considered as being shared governance in a way that there is a mutual commitment in the coordination actions. Strong business relationships support shared governance, which in turn has a greater impact on collaboration satisfaction than contractual safeguards (Bstieler & Hemmert, 2015). Trust is a main indicator for the relationship between business partners. Guo-qiang & Ji-ying (2006) even see trust as the "governance foundation". But while it is regularly argued that the relevance of contractual governance diminishes, this is nothing that researchers universally agree on. Camarinha-Matos & Pantoja-Lima (2001) argue that contracts are a main factor regulating the cooperation execution and that the coordination policy could be derived from the contracts. In the aviation industry there are also external regulations that might impose contractual arrangements between collaboration members. In a survey of German aviation SMEs it was found that reducing contractual agreements is not considered to be a success factor for cooperation (Janke et al., 2007).

At the heart of a governance system are the mechanisms that actually direct management (Guo-qiang & Ji-ying, 2006). Mechanisms are designed with regard to the scope of the system which can be considered as being the ***subject of governance***. These two aspects are therefore closely related and represent the structure of the governance approach. An essential consideration when designing a governance system is its scope in terms of the life-cycle phases of a collaboration that it is sought to support (Rabelo et al., 2014). Independent from any life-cycle phases, Alreshidi et al. (2017) identified a list of factors for effective governance being grouped into three main categories: ***social-organizational, data management and ICT and processes and contracts***. A governance system should consider these in order to enable successful collaborations. Using a slightly different terminology, Albers (2010) describes two main pillars of governance system design:

> ***Governance structure*** is the setup of the alliance based on allocation of authority and specialization of members.
> ***Governance mechanisms*** in turn refer to coordination, monitoring and incentive activities.

In contrast to Provan & Kenis (2007) who consider trust as being a contingency factor, other researchers regularly consider building trust as being a governance mechanism itself (Esposito & Evangelista, 2014). In any case, it is agreed that trust and relationship should not only be taken into account, but to be established. In regard to this, Guo-qiang & Ji-ying (2006) argue that the core of governance consists of two types of mechanisms: ***Behavior rules*** referring to trust and culture, and ***running norms*** such as decision-coordination and distribution of benefits. In the context of a VBE reference framework, Afsarmanesh et al. (2008) argue that behavioral rules are a central dimension and are subject to governance. Romero et al. (2006, 2007) come to a similar conclusion and have developed a rule-based governance model in the context of VBEs. It represents a framework of aspects that must be taken into account when implementing governance and follows two ideas. First, it is a hierarchical model: ***Principles***, on the top level, and describe generally shared-values supporting the vision and objectives of the VBE. Rules represent the bottom level and shall guide the management actions of VBE operations. Secondly, there is a clear differentiation of social and functional aspects, arguing that the cooperative and interactive character of a VBE demands shared behavioral culture as well as clear operational rules. While naming

several elements that must be considered when setting up governance, the work lacks concrete measures in how to govern those.

Trying to reduce this gap Romero et al. (2010) transferred previous findings to the governance of VEs. Considering VE governance as an instantiation of VBE governance, it follows the same structure. However, the model is extended by new aspects such as potential tool-support, different governance configurations and VE formation procedures. In addition, the actors' roles were further elaborated. Broadly building on the works of Romero et al. (2006, 2007) and Albers (2010), Rabelo et al. (2014) developed a VE governance reference model facilitating the instantiation of more concrete governance models. Expressing the importance of formalizing and documenting, the governance rules they suggest using the simple 5W2H technique[1] as being suitable for SMEs. A central aspect is a clear definition of actors and their roles and matching functional and behavioral rules. When implementing this framework, mechanisms must be developed to support the rule execution.

Many researchers point out the relevance of proper governance setup in order to enable the establishment of effective and efficient collaborations in a dynamic environment. But only a few consider that the governance system itself must continuously adapt and improve. From a VBE perspective, Jansson et al. (2008) express the need for "VO inheritance" which ensures the transfer of knowledge from VO to VBE in order to continuously improve the value added by the VBE. Transferring this idea to the concept of governance, it can be derived that it is required to setup and establish structures and mechanisms that guarantee a continuous assessment and improvement of the system.

In organizational research, Information and Communications Technology (ICT) is considered to be a main facilitator and driver for functioning of VEs (Esposito & Evangelista, 2014). But it does not only support the operational level of VE execution but also supports the formation of collaborations and therefore is a part of governance (Samdantsoodol et al., 2017). However, most works dealing with ICT support and automation approaches are often rather from the management and coordination disciplines.

As governance is about guiding and restricting the management, it is especially important during the formation of collaboration. According to Wu & Sun (2002), the formation of a VE must be supported by allocating business activities to the members by matching their resources. They developed a mathematical optimization approach in order to find the best setup. However, this approach requires a mathematical instantiation of all activities which seems to be very abstract. In the context of Instant Virtual Enterprises for production networks, Grefen et al. (2009) tackled the same problem and developed an approach for automating integration of partnering companies. The main supporting technologies are workflow management and agent-based software. Using an ontology as knowledge base, local business processes of the different VE members can be arranged to a global business process for the VE. It decomposes the production goal and matches the sub goal with business sub processes of the members. This approach requires the business processes of partners to be well-standardizable as it might be the case in production processes of the automotive industry. While breaking down internal processes and combing these to high level processes for collaboration seems to be a good approach to increase automation, this is not generally transferable to engineering and development processes in the aviation industry. In contrast to this workflow orchestration approach, Camarinha-Matos & Pantoja-

[1] 5W2H is an analyzing approach that shall ensure a holistic view by asking *what?*, *why?*, *where?*, *when?*, *who?*, *how?* and *how much?*.

Lima (2001) developed a workflow based coordination approach focused on the automated execution of low level operational workflows across companies' borders.

Generally, cooperation in aviation industry is very important. However, SMEs are not involved in-depth in the cooperations yet. In a research project funded by the German government, Janke et al. (2007) analyzed the specific characteristics of VEs in context of the aviation and space industry. Its aim was to better understand the research needs in the described area and therefore a broad and holistic view was chosen. They conducted a survey to evaluate the applicability of success factors for VEs, which were frequently identified in literature, to the aerospace industry. It was found that, although most factors are also applicable in the aerospace context, some factors, in particular with regard to coordination activities and contract agreements, are not applicable. Thus, partner selection approaches and possible contractual arrangements have been developed. In addition, they suggest a Key Performance Indicator (KPI) based monitoring framework and show how IT tools can support the VE through its life-cycle. However, the work lacks a clear practical focus and does not point out how the SMEs can overcome burdens imposed by the industry.

The above discussed governance research in context of VBEs in particular helps to understand what will be expected of the ecosystem to be developed by the DIGICOR project and therefore allows to predict potential preconditions for the actual governance system. Summarizing, it can be stated that recent research already examined multi-perspective aspects of governance and built a diverse theoretical foundation for governance frameworks. However, it still lacks practical examples how governance mechanisms can be developed and implemented. Although the literature examined provides valuable input, it does not appear to be fully applicable within the framework of cooperation in the aviation industry. Hence, an analysis of the aviation industry and the special requirements it imposes to the concept of governance is a crucial first step. In the following, this work shall extend the current research by a stronger focus on the concrete design of a governance system for SME collaborations.

2.2 Analysis of (German) Aviation Industry

The following section aims to create a basic understanding of the aviation industry. The analysis is based on investigations in the German aviation industry. The distribution of power and the influence of legal regulations as well as the general structure of the supply industry is described. By this means, the context of the collaborations to be supported is outlined and a basis for understanding collaboration affecting factors is established.

2.2.1 Aviation Legislation and Certification

In 2016, more than 40 million flights carried 3.7 billion passengers worldwide (Statista, 2017; IATA, 2017). This easily illustrates the reason for the high safety requirements in the aviation industry. To ensure the safety of all people in the air as well as on the ground, it is highly regulated by international legislation. The legislation authority for Europe is the European Aviation Safety Agency (EASA). The safety standards are established through regulations for both the actual airplanes and the aviation industry. For the Aircrafts (A/Cs) a set of construction regulations for different aircraft types and system parts is defined. These are the Certification Specifications (CSs). For the industry itself there are regulations covering the development and production (Part 21) as well as the operation and maintenance of A/Cs.

Figure 4 summarizes the regulations and their interrelations. Design Organization Approval (Part 21-J) and Production Organization Approval (Part 21-G) are the most important certifications of the EASA. Only companies approved of these types are allowed to perform aircraft certification tasks with the EASA. The certifications in particular require the companies to establish quality management systems that guarantee the high safety standard. One aspect that the quality systems must allow is controlling of suppliers to ensure conformance and quality of all procured parts and services. Giving measures to prove compliance with this and simplify supplier approval, aircraft manufacturers themselves established certifications.

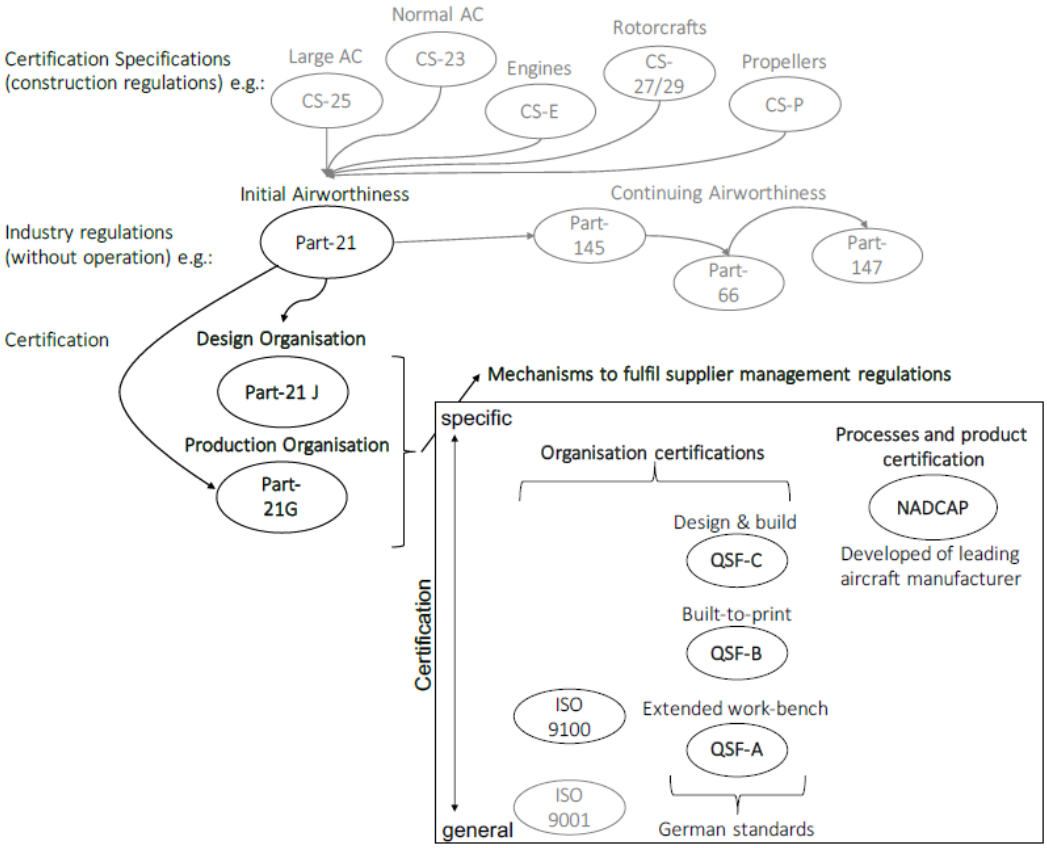


Figure 4: Regulation and certification structure

2.2.2 The Aviation Supply Industry - Status Quo

Power of the Aircraft Manufacturer

The complexity and high safety standards are significant burdens that benefit historically developed aviation nations and still prevent the industry to widely spread into other countries (Rossen et al., 2015). This is why in 2015 more than four-fifth of the worldwide turnover was generated in the USA (47%) and Europe (36%) (ASD, 2016). The size of many parts and the related transport costs as well as the diverse, interdependent, and specialized technologies support the formation of regional clusters. These clusters are especially located in regions of the aircraft manufacturers Boeing and Airbus as they dominate the industry (Rossen et al., 2015). In Germany, the aviation industry is dominated and strongly shaped by Airbus (Bernhard et al., 2007).

A survey of the Initiative Supply Chain Excellence (SCE) revealed that Airbus is by far the most important customer of the aviation industry in Germany. Figure 5 demonstrates this by listing the top customers in terms of business volume of suppliers in Germany. Clearly, the internalization of supply chains is also advancing in the aviation industry. Nevertheless, Airbus' strong influence on the German aviation industry will not fade in the near future. The SMEs in particular will have difficulties gaining international relevance as the cluster formation shows that geographical closeness to the customer is a significant success factor. This is the reason why DIGICOR strongly focuses on Airbus as customer.

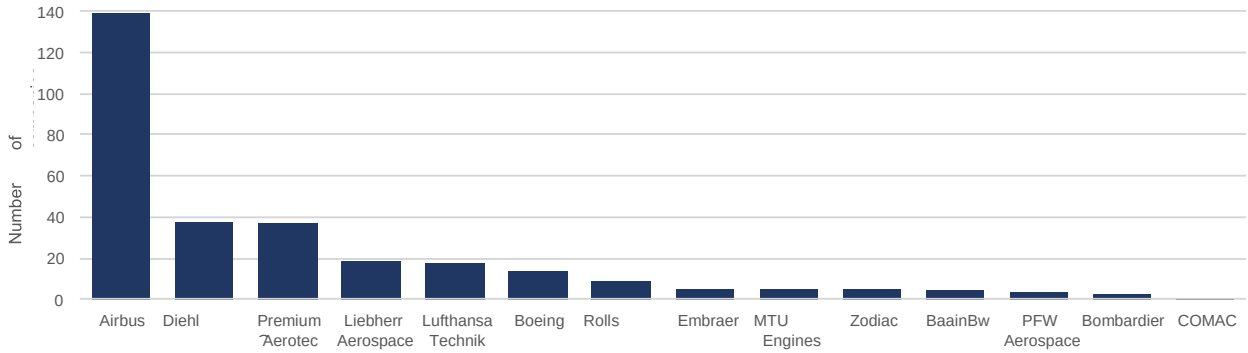


Figure 5: Most important customers, measured by business volume, of German aviation suppliers (SCE, 2017)

Vertical Supply Chain Structure

Figure 6 shows an idealized vertical structure of the supply chain with the OEM being an aircraft manufacturer. In particular, it illustrates the classification of the tier levels depending on the scope of the supplier's activities. From this, it is derived that in the aviation industry the certifications held by a company can be regarded as an indicator of the tier level in which it operates (SCE, 2017). This is a generalizing, homogeneous approach.

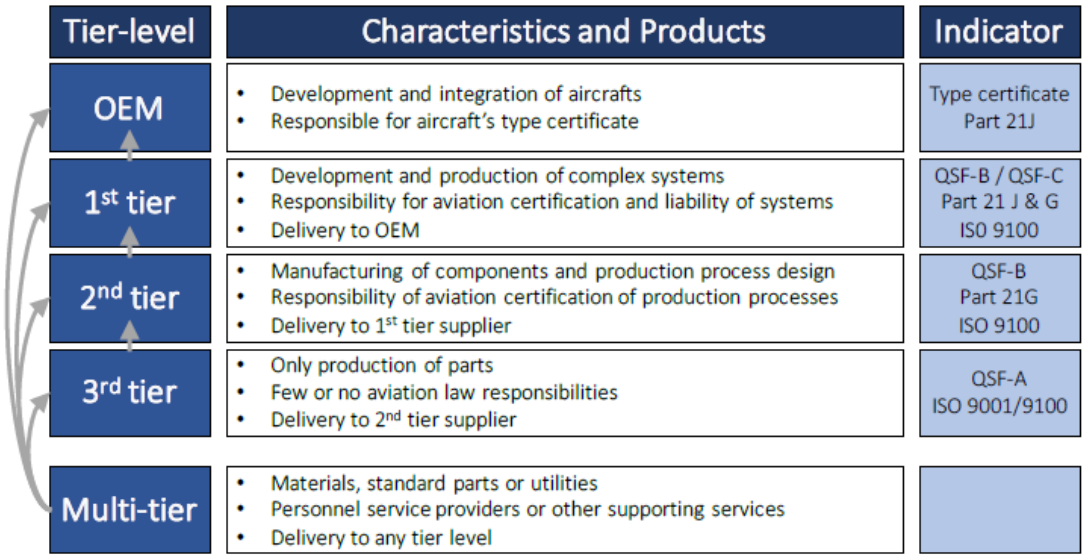


Figure 6: Vertical supply chain structure (SCE, 2017)

In reality there are plenty of exceptions and overlaps but in course of DIGICOR, unless otherwise stated, the characterization of tier levels is defined as shown in the figure.

Relevance of SMEs, Cluster Initiatives and Networks

SMEs are important in any industry. Often they are highly specialized and have a significant contribution to the innovative capacity of a sector which is why they are frequently referred as being “the backbone of economy” (Muller et al., 2016). The representative study of the SCE reveals that 88% of all companies operating in the aviation sector have less than 250 employees. When considering only the employees of a company who are actually involved in the aviation sector, it increases to 93%. Roughly 76% of the asked companies have a turnover of less than e10 million (SCE, 2017). Taking advantage of the innovative capacity and flexibility of SMEs requires a good integration into the supply chain. Due to the high aviation legislation standards this is even more challenging than in other sectors. Furthermore, SMEs do not have the personnel and financial resources for extensive marketing, trade fairs and networking. Helping to overcome this challenge, several industry associations, cluster associations and networks have been formed at global, European, national and regional level. In Germany, there are over 15 associations and networks supporting the SMEs with trade fairs, networking events, marketing and internet platforms to connect each other. One of these is the Hanse-Aerospace Association which contributed to the conducted interviews and is also project partner of the DIGICOR project.

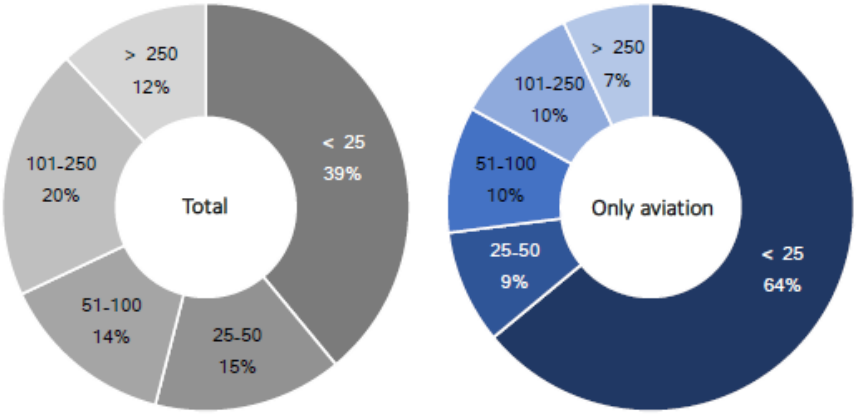
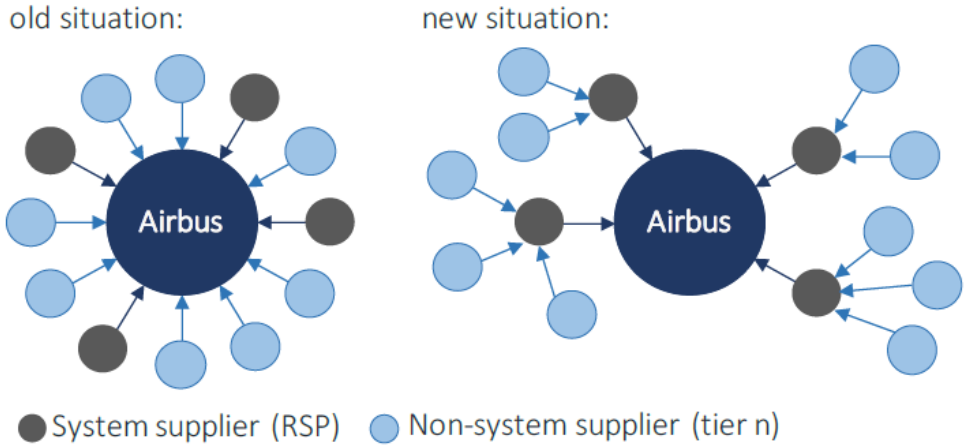


Figure 7: Proportion of companies by number of employees (SCE, 2017)

2.2.3 Structural Changes and Trends in the Aviation Industry

Since the field of strategic management introduced the term core competences, it has gained importance and became a key standard for defining the strategic orientation of companies. Since the early 2000s aircraft manufacturer more and more take the role of a system integrator (Janke et al., 2007). Due to their importance, this has triggered a structural change in the entire aerospace supply industry which is still ongoing. Nowadays, Airbus’ procurement strategy is to decrease the number of direct suppliers and develop close cooperations with large system suppliers. This cooperation also requires the 1st tier suppliers to take risks, which is why they are regularly referred to as Risk Sharing Partners (RSPs).

They have financial and management responsibility of development and production of complex systems. This includes the integration and management of sub-suppliers.



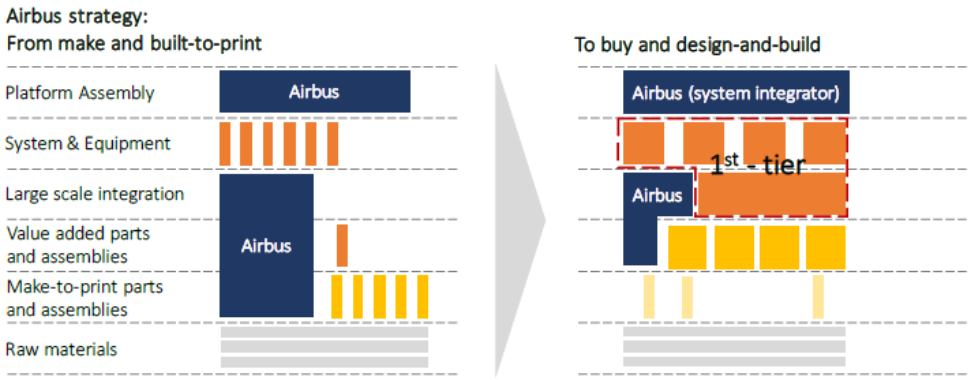


Figure 8: Airbus' refocusing on core competences (Airbus, 2012)

Although the importance of SMEs for the industry is uncontroversial, the structural change of the supply industry is a risk to their integration. The entire industry, but SMEs in particular, need to develop new strategies that are adapted to the changing circumstances. Many SMEs criticize the bad availability of information from the OEMs. OEMs closely coordinate with RSPs but the information is not passed down to lower tier levels (Martens, 2017). The growing concentration of power at the OEM and RSPs puts pressure on the SMEs. Many SMEs desire to develop to higher tier levels (SCE, 2017). Establishing close collaborations between SMEs, forming larger and more powerful virtual suppliers, is a promising approach to encounter these changes and burdens.

2.3 Aspects that Affect Collaboration Governance in the Aviation Industry

The following section identifies factors and aspects that either influence the governance of collaborations or must be considered for the governance. It presents the identified aspects that influence governance of collaborations from both an analysis of previous research and

conducted expert interviews done by DIGICOR. It also outlines why these aspects are relevant to the governance of collaborations and how they might affect a governance system. Because of the characteristics of the aviation industry, namely the high legal regulation and the power concentration at the OEMs, a central dimension distinguishing external and internal factors is introduced. Internal aspects arise from the fact that different organizations are involved and need to coordinate cross-organizational activities and structures. This is, it arises from the nature of multi-organizational collaboration itself. External factors affect collaborations and consequently governance from the context in which the collaboration operates.

2.3.1 External and Mandating Factors

The interviews with experts from aviation industry revealed that external factors significantly affect collaborations in the aviation industry. External refers to aspects that do not originate from the fact that the collaboration involves sovereign companies but from the context and circumstances in which the collaboration is aimed to operate.

Influence of Aviation Regulations and Supply Chain Structure

Aviation authorities do not only regulate the safety standards the products must fulfill but also to a significant extent the way of working of every company in this sector. Interviewees consistently explained that new supply chain structures such as collaborations have to meet the same requirements as today's hierarchical supply chain structures. It must be identified how and to what extent the regulations influence the governance of collaborations and therefore limit the scope of a governance system.

> *"EASA regulations [for POA and DOA] are not just an industry standard - a suggestion - as is ISO 9001. They are legally required quality management mechanisms."*[2]

The regulations introduced by EASA as shown in section 2.1 represent high entry barriers making it a comparably closed branch. Officially approved organizations for development (Design Organisation Approval) or manufacturing (Production Organisation Approval) are required to systematically control and monitor their suppliers. This does not only comprehend the actual products and services being procured but also to cascade many organizational, management, and quality management requirements further down the supply chain. This leads to a hierarchical structure of the industry with strict control mechanisms along the supply chain. To get the authorization to perform more complex or safety related tasks, companies are faced with higher obligation which they need to comply to.

For forming collaborations and their governance this has mainly two consequences. First, the collaboration must be able to fulfil and comply with its customer's control mechanisms. Airbus, as an example, set up a management approach to control the suppliers to be compliant with the legal regulations. These are analysed in the next section. Secondly, when forming a collaboration, it must be guaranteed that the collaboration partners have the required certifications, competences as well as organizational and management structures. This imposes that either all partners fulfil the minimum level of certification or that all tasks

[2] Statement from interviewee

are analysed in terms of what authorization is required to perform these and then be assigned to the different partners with respect to their certification level.

OEM Procurement at the Example of Airbus

Even though an ideal collaboration governance system would be totally independent from any particular potential customer, it is a matter of fact that a governance system can only hope to become relevant in the German aviation industry when it is accepted by Airbus. Thus, staying close to the practical business of the German aviation industry requires to thoroughly understand and consider the procurement process of Airbus.

Airbus' Supplier Management

As Airbus is an aircraft manufacturer and respectively has a Design Organisation Approval it is responsible to control all its suppliers in compliance to the Aviation Legislation. This includes proving that all suppliers are using adequate management systems, processes and standards that suffice the high safety and quality standards of the EASA.

Over the years, Airbus defined and extended internal requirements to manage the suppliers. These historically grown requirements were General Requirements for Equipment Systems Suppliers (GRESS) or General Requirements for Aerostructure & Material Suppliers (GRAMS). However, Airbus realized those were inefficient, partly redundant and insufficient to clearly communicate with the supplier. Thus, the Airbus Supplier Requirements (ASR) were developed and introduced in 2016. All new contracts with Airbus must apply this approach. Although the functionality was even extended and improved, it reduced the amount of documents by more than a half avoiding duplication, deleting obsolescent and simplifying requirements (Airbus, 2016, Introduction to ASR V1.1). The Airbus Supplier Requirements are continuously assessed and will be updated and improved once a year. Its objectives are:

1. To have structured control of the scheduled development plan
2. to gain visibility and transparency via a strong monitoring process
3. to secure the on-quality, on-time performance of the suppliers
4. to offer and use a structured and harmonized approach and tools

Structure and Scope

When Airbus designed the new approach, it has been decided to follow the International Aerospace Quality Group and categorize the requirements by supply chain life-cycle activities (Figure 9). This does not only increase the transparency but is also is a widely accepted standard structure and independent from Airbus' organization. Airbus defined directives for each phase (A1501A15006), covering all requirements that might apply in relation to the particular phase. The A1500 directive, in contrast, describes general, phase-independent rules that supplier must meet. All together, these directives define roughly 800 not part-specific requirements, meaning that they do not include any technical specifications.

The ASR baseline is a quality management process approach and allows a better harmonization and coordination with the suppliers. It is applicable from supplier selection phase till after sales.

The most complex and most extensive part is the development process for which it defines several milestones tracking the maturity of a development project. Airbus Supplier

Requirements are therefore the driver and backbone of the coordination during the development phase.

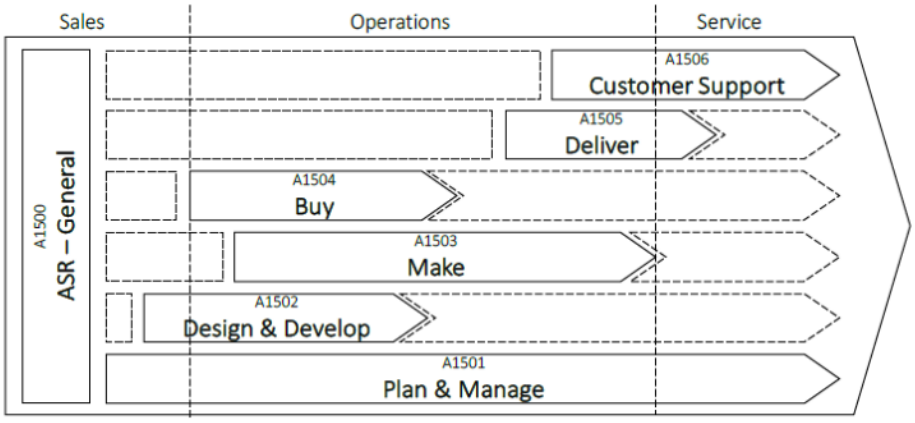


Figure 9: ASR structure following supply chain process life-cycle (Airbus, 2016)

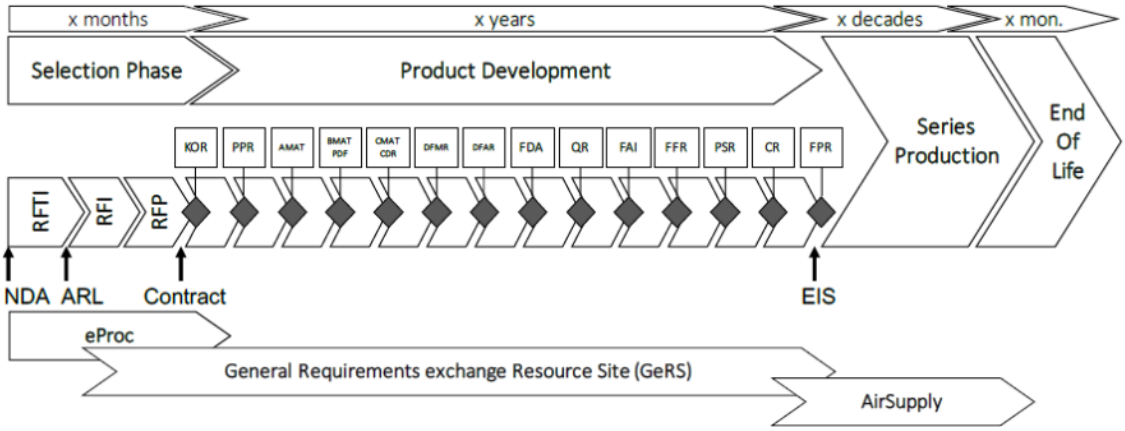


Figure 10: Design & Build project life-cycle (Airbus, 2016)

Procurement Process and Non-Disclosure Policy

When a procurement need arises, Airbus identifies potential suppliers from an Airbus approved supplier list. These suppliers are contacted and asked to sign a Non-Disclosure Agreement (NDA) before further information is provided to the supplier. Afterwards Airbus will send an Request for Information (RFI). The suppliers have a time frame of one month[3] to respond to an RFI, which usually covers a concept of a technical solution which proves the general ability to deliver the item or service to be procured. Following, an iterative selection process starts that is based on a more precise Request for Proposal (RFP) or CFT respectively. For the communication of the project scope and supplier's compliance the Airbus Requirements List (ARL) is used. This iterative process usually takes between six to twelve months. Based on the commercial proposals and technological solutions presented, Airbus finally selects and contracts a supplier.

Two aspects are emphasized at that point as being relevant for the governance of the collaboration. Firstly, only suppliers that have the status of being an approved supplier are

[3] This is not a fixed time frame but interviewee argued from his 15 year experience that it applies to 90-95% of Airbus' RFIs

considered for the CFT. And secondly, the NDA to be signed permits suppliers to exchange information with other suppliers during the tender phase.

Supporting tools of Airbus Supplier Requirements

The most important aspect of the new approach is that ASR is more than just a structured documentation of requirements. It is supported by designated tools to standardize and harmonize the management and monitoring of suppliers.

Airbus tries to gain benefit from the digitalization by using designated platforms for information exchange to standardize and simplify communication, collaboration and data exchange (Information exchange tools). As illustrated in Figure 10, the ***eSourcing tool*** supports the procurement processes, while the ***AirSupply platform*** is used to coordinate the serial production and deliveries with the supplier. The General Requirements exchange Resource Site (GeRS) is used to coordinate the diverse activities with the suppliers from contract definition, through development to Entry Into Service (EIS). It is an i-Share based platform having a separated collaboration space for every project and is mainly used to share reference documents and submit deliverables.

The biggest advance of ASR compared to GRESS and GRAMS is the Applicable Requirement List (ARL). The ARL is an excel sheet listing the requirements for a project. Also, it supports visibility and harmonization of the entire supplier management approach. Interviewee I8 described it as Airbus' main measure to prove its compliance with Production Organisation Approval (POA) and Design Organisation Approval (DOA) by referencing requirements to the corresponding chapters of EASA's Part 21 and linking the requirements to the elements of its internal quality approach. This approach is based on the Advanced Product Quality Planning (APQP) standard defined in EN9145 and especially defines and controls Key Business Deliverables (KBDs) (Airbus, 2016, QPR - ASR User Guide No. 043).

Macros, that are implemented in the ARL, allow Airbus' procurement to automatically predefine all requirements that are actually applicable to the specific project when it starts. Afterwards, if needed, some manual adjustments are made and then it is used as basis for agreeing the actual scope of the project with the supplier. The supplier is provided with the list of applicable requirements and when he creates an offer he is demanded to answer for every requirement whether and how he is going to meet it.

In addition to the communication of the scope the ARL, is also used to automatically create a project baseline. When running the macros, the ARL defines milestones and at which milestones the requirements are reviewed. This helps suppliers managing their projects and delivering ontime and on-quality. Internally, Airbus defines which purchaser function is responsible and which functions are supporting it for each requirement to have a clear responsibility structure.

By this means, ARL is the heart of the ASR approach. It links the requirements with the external regulations and thus proves Airbus' compliance. It also links it to Airbus' internal quality approach ensuring a transparent cascading. Summarizing, it supports two main objectives. On the one hand, it is designed to simplify the fulfillment and cascading of aviation legislation requirements. On the other hand, Airbus wants to enforce that their suppliers use a strong quality management based approach, with strict monitoring and risk mitigation methods.

As it has been pointed out, ASR supports the control and monitoring of the suppliers and their development activities. In order to standardize it and make it more efficient Airbus provides two tools for reporting. One is the Logbook which allows automatic generating of

milestone review agendas and reporting templates. These consist of all requirements due at this milestone, allow a simple traffic-light status tracing as well as deciding and controlling countermeasures for progress deviations (Airbus, 2016, QPR - ASR User Guide No. 210). Forcing the suppliers to control and share the progress of the project between milestones Airbus uses the Supplier Progress Report (SPR). It is of the same structure as the Logbook but updated at least monthly, so that it covers a more detailed granularity of the progress (Airbus, 2016, QPR - ASR User Guide No. 263).

Influence on Governance of Collaborations

Airbus' supplier management exemplary shows how the OEMs' procurement policies and standards influence a potential collaboration in terms of governance. The way a collaboration is governed must be compliant with the OEMs' expectations towards the management of projects. The OEM's rules and requirements therefore represent limitations for the design of the governance system.

2.3.2 Collaboration Internal Factors

Following section will summarize the investigations and expert interviews outcome related to the collaboration internal factors.

2.3.2.1 General Challenges and Barriers for Collaborations

Inter-organizational projects pose further challenges to the coordination, regardless of the industrial context. The existence and involvement not only of different actors but also of sovereign companies represents another level and perspective. (Borys & Jemison, 1989). This gives the governance and management of the inter-organizational activities a "second-order status" (Albers, 2010) resulting in challenges for authority and opportunism to be considered. In a single organization, it can be assumed that the involved actors are aware of and share a common business philosophy and culture and their activities are based on the same organizational and infrastructural conditions. This is not the case when it comes to inter-organizational collaborations. The collaborating companies might not share the same business philosophy and culture and probably do not have the same IT infrastructure (Borys & Jemison, 1989; Camarinha-Matos et al., 2007).

Involving several sovereign organizations does not only make the coordination more difficult. In addition, these entities have their own business objectives, which may be more relevant than the cooperation, which entails a high risk of opportunistic behavior (Melander & Lakemond, 2015). In contrast to opportunity-independent long-term cooperations or strategic alliances, partners of time-limited collaborations usually do not require a strategic alignment. With accepting additional governance structures from the collaboration, collaborating partners do not need to relinquish any of their freedom concerning the strategic business orientation of their own companies.

The characteristic that collaborations are formed dynamically depending on the business opportunity of sovereign companies with heterogeneous infrastructures, management approaches and different business objectives requires the governance system to deal with unknown and different framework conditions. Therefore, it must be flexible to a certain degree to make it usable under different conditions.

2.3.2.2 Relationship, Contractual Setup and Authority Allocation

A central aspect of governance is the allocation of responsibilities and authority. Figure 11 shows the interdependencies of three relating issues.

> *"A clear assignment of roles and responsibilities is needed. Majority decisions reduce the dynamics and make it difficult to keep up with project progress."*

While that relationship and the legal responsibility and liability were widely considered by the experts, only one interviewee explicitly considered the allocation of authority and task responsibilities:

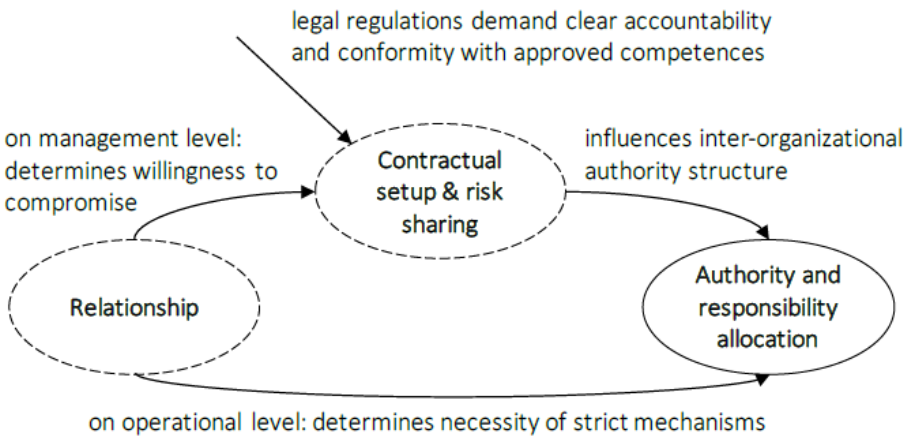


Figure 11: Interrelation of central governance aspects

The relationship is mainly determined by mutual trust as well as shared culture and values. The importance of a good relationship was by far the most discussed and agreed topic among the experts of which six explicitly named it.

Previous research partly considered trust to be a contingency factor and argued that the building of trust is a main governance mechanism. While the interviews highly support the importance of relationship and trust for the collaboration, they disagree and do not consider it as being a mechanism. This is, because they argue that it cannot be established through a governance system:

> *"Business does not happen between companies but between persons. Trust [on which business is founded] can only be build between persons in face-to-face meetings and a history of common projects."*[4]

> *"An [IT] platform cannot build trust. [...] [Rating systems for example], I am not only skeptical about these when it is about me getting rated on an almost public platform. [...]I really doubt their significance. There will be only a very limited number of ratings because of the long duration of industry projects. Further, ratings are highly subjective and not transparent to me. [...] Consequently, I would not pay attention to the ratings."*[5]

[4] Expert interview statement

[5] CEO of a SME during supplier session

The interviews also support Guo-qiang & Ji-ying's (2006) conclusion that trust is a necessary precondition:

> *"A cooperation is only an option if I know the potential partner and his business really well."*[6]

This implies that trust has to be built even before a cooperation can be initiated. The dynamic and instant character, that is, the short time frame in which the collaborations shall be established, support the argumentation to not consider trust as a mechanism of collaboration governance. Instead, it is a contingency factor that strongly influences the other central aspects of governance as illustrated in Figure 11.

No matter how good a relationship is, when forming a collaboration that is related to a specific business opportunity, it is necessary to set up a contract. The customer will always need to see who is liable and also would only consider contracting a collaboration if it can proof that all collaboration partners are legally binding committing to it. This is not only rational business operation but also required by the legal regulations. The contractual setup describes the legal accountability of the partners and their contribution to the project. In literature, opportunistic behavior and therefore Intellectual Property (IP) safeguarding mechanisms are described to be another significant aspect (Melander & Lakemond, 2015). In contrast, from the interviews with the experts it could not be identified that they in particular worry about opportunistic behavior resulting from partnering SMEs. This might not be a relevant aspect for them because they only consider collaborating with trustworthy partners. They were way more worried about the allocation of financial risks and liability towards the customer:

> *"The OEM's strategy to only directly contract risk sharing partners is a blocking point. SMEs cannot take such risk."*[7]

Contracts regulate financial aspects such as risk sharing and allocation of earnings but also the question of liability towards the customer and among the partners. It is an important factor that influences the collaboration and structures for the governance system. However, developing concrete contractual frameworks is a very specific and controversial subject by itself that is not within the scope of DIGICOR. Still, it influences governance and therefore the concept must evaluate what contractual setups are likely to occur in practice and how this might affect the governance approach.

A major aspect of governance is to set up suitable authority and responsibility structures. The governance system must be aligned to the contractual frame conditions as only this allows an "adequate empowerment" (Martins et al., 2004). Efficient governance requires consistent configuration of the legal liabilities between the companies and the inter-firm allocation of authority and governance. For example, decision-making mechanisms are required (Albers, 2010). If there would be inconsistency of the legally liable party and the decision-making party this could regularly be a point of conflict that prevents efficient decision-making. However, the decision-making strategy might be either dominant or cooperative (Martins et al., 2004). In context of governance frameworks allocation of responsibilities is often linked to predefined roles. Lee et al. (2017) in particular show the relevance of distinguishing generalists and specialists.

[6] Expert interview statement

[7] Expert interview statement

2.3.2.3 Communication and Coordination Mechanisms

Communication and coordination are very common aspects in literature. The experts, however, did rarely consider them during the discussions. One even said:

> *"We would manage a collaboration on our own and do not want to give this function to an external platform because it is sensitive data."*[8]

But as it was stated at the beginning of this chapter, the interviewed experts had difficulties imagine an instant collaboration to work in the aviation industry. Hence, it was hard to theoretically discuss how a collaboration could be governed. It is assumed that this is the reason why coordination mechanisms were rarely considered. But because governance guides management and consequently coordination mechanisms it is identified to be relevant and introduced hereafter. It must be governance's aim to establish structures that allow the coordination of the whole collaboration project.

To fulfill a complex goal it is broken down into smaller tasks because all tasks that contribute to a common goal are interdependent at some point. These dependencies across organizational boundaries are not only a reason why coordination is essential, it can also be considered a good reference for the coordination mechanism setup. This is illustrated in Figure 12. It shows the interrelation of task interdependence, coordination requirements and mechanisms as well as authority allocation.

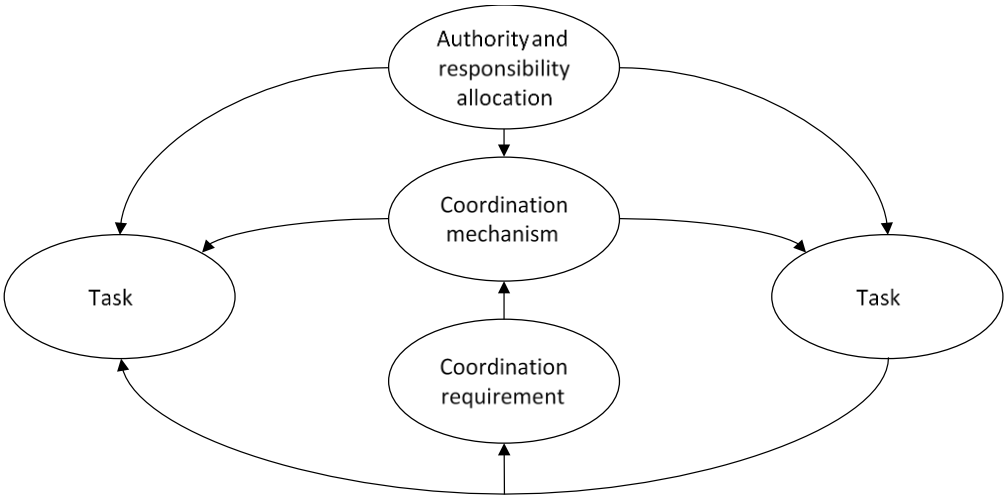


Figure 12: Interrelation of coordination aspects

Achieving congruence of coordination activities and coordination requirements significantly supports effectiveness and efficiency of the collaboration (Cataldo et al., 2006). For establishing coordination structures by the governance system this raises two main questions: Where is coordination required and how is coordination performed?

Because the collaboration is initiated for a certain Business Opportunity (BO) its operating structure is significantly determined by the product decomposition (Martins et al., 2004). A misalignment of product architecture and the organizational structure is likely to endanger the coordination effectiveness and collaboration performance (Sosa et al., 2004).

[8] Statement from supplier feedback session

2.3.2.4 IT-Infrastructure

There are two types of IT-infrastructure to be distinguished: the company-internal infrastructure and the infrastructure of the Virtual Enterprise Breeding Environment, such as DIGICOR. Financial investments in the infrastructure generally impose higher burdens for SMEs than for larger companies. The setup and training costs as well as licenses, in particular of popular and well spread standard solutions, such as SAP, often exceed the benefit for SMEs (Levy & Powell, 1998). The IT landscape of SMEs is therefore very heterogeneous with regard to two dimensions. The functions supported by IT tools in various SMEs and the IT solutions actually selected.

The use of ICT solutions for collaborating processes in development and production in the aviation industry outperforms other industries and as in other industries e-marketplaces and platforms were developed (Nucciarelli & Gastaldi, 2008). An analysis of the frame conditions of the IT infrastructure and the requirements and expectations towards IT integration seems essential. Martins et al. (2004) state that “unless the VE is dealing with only a very small part of each member’s resources, the obvious conclusion is that the VE’s and the members’ resource management policies and practices have to be fully compatible.“ In contrast Esposito & Evangelista (2014) point out that there are also VEs focusing on interpersonal relationships and communication rather than full integration of IT tools. The balance could be a minimal IT system that only focuses on inter-organizational processes, information and data management as well as safe communication mechanisms (Camarinha-Matos & Pantoja-Lima, 2001).

When discussing integration of partnering SMEs with the experts, they pointed out that the SME IT infrastructures may vary a lot and might be considered as a risk due to data sensitivity.

Generally, the IT-infrastructure implemented in any VBE depends on many factors, such as industrial background, objective of the VBE and also of the governance system that shall be implemented. The infrastructure of the VBE and respectively of the VE or collaboration arising from it must meet the conditions of the context and the members. It cannot impose the use of certain IT-infrastructure nor rule strict ways of coordinating as it cannot be applicable to every scenario (Camarinha-Matos & Pantoja-Lima, 2001). A governance system concept must consider both the SME and VBE infrastructure.

2.3.3 Summary

Aim of this section was to identify what aspects must be considered for the design of a governance system. It was identified that collaborations in the aviation industry are highly affected by external mandating factors from legal regulations as well as the customers’ policies. This poses limitations to the governance system design as it must be aligned to it. Table 1 summarizes the findings. It distinguishes aspects to be either design factors and therefore integral part of the governance system or influencing factors that must be respected by the design.

Table 1. Summary of identified aspects affecting governance design

Aspect for governance		Description	Kind of aspect	Explicit consideration by research	Explicit consideration by experts
External factors					
Industry regulations	Certification	The legal regulations of the industry require collaboration partners either directly (DOA & POA) or indirectly (ISO 9001/9100, QSF-A/B/C, NADCAP) to have certain qualifications to be approved to perform certain tasks.	influencing factor	-	high
	Control mechanisms	Collaborations are required to establish cross organizational control and quality management mechanisms resulting from the regulation to cascade requirements and control suppliers.	influencing factor	-	high
OEM policies	Procurement process	Collaborations will be required to reply to the same procurement process and time frames as a single supplier.	influencing factor	-	high
	Requirements	Collaborations must fulfill the same requirements as a single supplier.	influencing factor	-	high
Internal factors					
Partner interrelations	Relationship	Relationship significantly determines if partners are willing to cooperate. But in the short time frame of forming the collaboration the relationship cannot be influenced.	influencing factor	high	high
	Contractual setup	Determines the contractual frame conditions under which a collaboration operates. It underlies requirements of the customer and the industry and might determine governance structures.	influencing factor	high	high
	Risk sharing	The liability to the customer is critical question for the setup of a collaboration. If a collaboration partner fails to perform its obligations this might risk the whole project.	influencing factor	medium	high
	Opportunistic behavior	Safeguarding mechanisms, e.g. for IP might be required. Highly dependent from the partners relationship and to be covered in the contractual setup.	influencing factor	medium	low
	Authority allocation	The design of roles, allocation of authority and responsibilities significantly determines the ability to successfully govern the collaboration.	design factor	high	medium
Coordination	Structure	When forming the collaboration, coordination requirements must be identified and structures must be established.	design factor	medium	-
	Mechanisms	Governance must guide collaboration in how coordination requirements are to be managed.	design factor	medium	-
IT infrastructure	SME level	Diversity of potential IT infrastructures, limited ability and willingness to invest pose limitations to the governance approach.	influencing factor	low	medium
	VBE level	The IT infrastructure being provided by the VBE. It must be aligned to the governance approach and design in respect to SME infrastructure.	design factor	high	low

2.4 Collaboration Governance System - SME and OEM expectations

The idea that instant collaborations could be a solution for SMEs to face the structural change of the aviation industry does not origin from the SMEs but rather from associations, OEM innovation departments and research projects. When being asked what functionality and support SMEs would expect from a platform and a governance system, they cannot really state expectations because they do not really see this an option.

> *"Those visions [of collaboration platforms] exist for years now and ever since I have argued that this does not work. It does not work because no platform can substitute the personal relationship [that is needed for a collaboration] between partners."*[9]

They rather give reasons why instantly forming collaborations is not possible. Therefore, the expectations that are presented in this section are to a big extent derived from challenges and issues that were identified during the interviews. Because no one of the interviewed experts has experience with a cooperation that is comparable to the instant collaboration being subject of this research, they had difficulties to express what support the operation of the collaboration would require.

2.4.1 Comparison of OEM and SME Perspectives

According to one interviewee, Airbus did recognize the need to further develop SMEs in recent years because they make an important contribution to the industry's success. It is their flexibility and specialization that make them important for innovations and better solutions in the future. But being confronted with the structural change of the industry, e.g. the ramp-up of A/C production rates, requires that they change and adapt to future needs (SCE, 2017).

While collaborations are subject of innovation departments, Airbus procurement does not believe this to be an alternative. One interviewee argued that the procurement policy is clearly focused on RSPs as it allows Airbus to better focus on its core competencies. Consequently, the entire procurement process and standards are aligned to this and do not allow an efficient direct integration of SMEs. This also became clear in the interviews with SME managers. They described how Airbus tried 10 to 15 years ago to convince SMEs that they have no other option but to merge their businesses. In his opinion Airbus did overestimate its importance for the SMEs and in addition underestimated the desire of most SMEs to stay legally independent:

> *"In 2000, Airbus' head of purchasing [...] said that if the small ones do not reorganize in the supply chain, they will all be out of the market in 5 years time. This is now [approximately] 17 years ago and there is hardly anyone o↵ the market, but [Airbus'] attempt to re-manage the supply chain still exists. [...] However, one then found out that this does not work out just like this."*[10]

One DIGICOR supplier session made clear that SMEs hope that the platform will help them to overcome burdens that prevent them from being invited to a CFT and making an o↵er.

[9] Expert interview statement

[10] Expert interview statement

This expresses a very important aspect for the governance system: The main expectation is not to improve something that is dealt with already but rather to allow achieving something that is not possible now. The interviewed Airbus employees stated that actually considering collaborations for CFTs would require a collaboration to be dealt with exactly as if it was a single organization. This is, it must fit to Airbus procurement process and must also fulfill the same requirements as any other potential and legally sovereign supplier. Airbus' skepticism towards collaborations is significant and consequently multiple experts consider it unlikely that Airbus might adapt its requirements to better fit collaborations. One expert pointed out that this is not only valid for Airbus but also for other OEMs as it is the consequence of the legislation. An OEM develops a supplier management approach to prove its compliance to authority regulations. Therefore, a collaboration must follow this as well.

Summarizing, the most important expectation from SMEs' point of view is that the use of the governance system will allow collaborations to be accepted by OEMs. The OEM in turn would require his supplier management structures to also apply to collaborations. This is in line with other researches of SME collaborations emphasizing that SMEs " must comply with market standards and the needs of the specific customer" (Brink, 2017). This implies that it is the OEM who shapes the functions and expectations towards the governance system to a significant extent:

> *"The driver of the whole thing is the OEM because he decides whether he wants to accept something like this or not."*[11]

2.4.2 Scope of the Collaboration Governance System

The OEMs' acceptance significantly depends on the collaboration structures and arrangement, which is mainly affected when forming the collaboration. In order to clearly define the scope of the governance system it is referenced to the common definition of a cooperation's life-cycle. It comprises four phases: creation, operation, evolution and dissolution (Jansson et al., 2008). The high level phases can be further detailed illustrated in Figure 13.

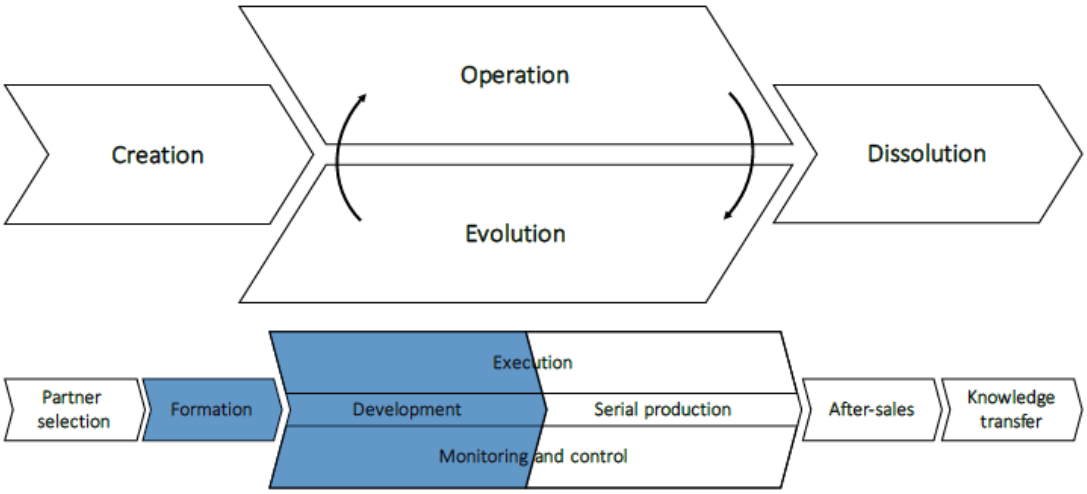


Figure 13: Collaboration life cycle phases and scope of the governance system (based on Jansson et al., 2008).

[11] Expert interview statement

The creation of the collaboration is initiated by a business opportunity, which in this context is a CFT from Airbus or another OEM. It consists of partner selection phase and the formation of the collaboration (Shamsuzzoha et al., 2017). The formation itself comprises the configuration, being the setup of partners and their responsibilities, and the design of collaboration plan and processes (Katzy & Obozinski, 1999). The actual execution and the monitoring take place in parallel and form the operation phase. The objective of the business opportunity determines the actual scope of this phase. For reasons of simplicity it is only distinguished between development and serial production. These are formally separated by the Entry Into Service of the related product. The evolution is a phase parallel to the execution taking into account that the collaboration configuration and design might adapt to changing circumstances over its lifetime. The dissolution of the cooperation must consider after-sales activities and have a systematic knowledge transfer (Jansson et al., 2008).

The focus for the concept of a governance system is highlighted in blue because these phases significantly contribute to an OEM's acceptance of a collaboration. It is pointed out that even though contracts are necessary to define partners' rights and duties and are considered to be a governance mechanism, developing legal arrangements and contractual frameworks is not a goal of the governance system itself.

2.4.3 Analysis of OEM Requirements

2.4.3.1 Overview

The overall expectations allow to derive two central objectives that are presented hereafter. Further, it is evident that the expectations highly relate to the OEM requirements making them a main aspect to be considered for the concept.

Support the bidding process

Even though the overall supplier selection process takes up to nine months, suppliers reported that there is a lot of time pressure to meet the bidding deadlines. SME experts argued that suppliers who are new to the process have difficulties to understand the requirements and prepare an offer in such a way that it fulfills the acceptable means of compliance:

> *"You also have to say very clearly that you have to build up structures for these [complex requirements] and the people who are trained to do it, when there is a CFT. [...] [The requirements] are well made once you fully understand them. But I remember at the beginning [...] Airbus did invite [our entire team] to understand it. [...] From then it took three years until we got [the first] order. [...] [New suppliers] do not understand the Airbus world!"*

> *"[For inexperienced SMEs] those [requirements] are pivotal and tedious issues to be tackled."*[12]

[12] Expert interview statement

Requirements can be differentiated into technical and administrative requirements. Fulfilling the administrative requirements might introduce significant changes to the internal management structures as one expert pointed out:

> *"Our internal procedures and approach was [significantly] changed and strongly aligned with [the management requirements] and we are ISO9100 certified now. [...] [Airbus requirements] go beyond what is required for ISO9100."* [13]

Support the management and coordination of the collaboration

The last statement also directly leads to the next aspect. In case that a collaboration wins a CFT it must actually be able to manage and control the project. While some experts stated that the platform shall not mandate coordination and interfere with their own approaches, other experts generally doubted that most SMEs have competences and willingness to manage complex projects with multiple partners:

> *"I guess that [chances are] 50:50 [...], many probably would not want the additional responsibilities. A few could actually manage the additional responsibilities. [...] Many feel comfortable in the second row [where less responsibility is needed]"* [14]

From this, it is concluded that SMEs generally could require support in managing the collaboration. One expert argued that he does not favour standardization because it does not suit the various situations. Consequently, he does not believe there are big chances for technical support and automation with respect to the management of the collaboration. One interviewee favours the idea of management support structures and added that the management of sovereign SMEs requires additional headcount and experience as well as well-established coordination and communication structures. But he as well is sceptical about the extent and value of automated system support and therefore suggests the integration of qualified parties as support institutions. However, experts would hope for any support that helps SMEs managing the project and therefore allows all contributing parties to spend more time and effort on the technical aspects and solutions.

2.4.3.2 Formalization Based on Airbus' Requirements

Airbus' requirements are used as basis for the analysis but it can be assumed that the general characteristics match other OEMs as well. In general, the requirements mainly consist of two parts. One is the technical specification which is specific to the item to be procured. The second part is the Airbus Requirements List which is selected from a pool of general requirements. While the technical specification determines what is the outcome, the ARL defines how the supplier is supposed to get there. By this means, it greatly affects the way in which the collaboration has to be governed and is thereby an important input to the governance system. Therefore, the analysis will further contribute to the objectives of the governance system. It shall identify what Airbus expects from its suppliers and how this affects a collaboration. By this means, it can be derived what a system actually must be capable of and allows developing a concept which supports it. The general requirements defined in the Airbus Supplier Requirements comprise roughly 500 items, of which roughly

[13] Expert interview statement

[14] Expert interview statement

three-fourth are comprehensively specified in additional documents. It cannot be the goal to analyze every requirement but to work out major elements.

Basic concepts of the requirements

There are two core ideas behind the requirements. First, every procurement of a new part or product from a supplier is considered to be a project. Hence, it follows a structure that is highly oriented on a project management approach. Secondly, key goal is to ensure the suppliers consider and manage every aspect linked to this project. By this means, it embeds key aspects of Advanced Product Quality Planning and TQM. Therefore, the ARL does not only define the scope of the project and represents measures to check the supplier's compliance but it is also an instrument helping the supplier to manage the project. To a certain extent it can be considered to be a checklist referencing to other information as the following example illustrates:

> *"The Supplier shall perform all Flight Test Installation required by Airbus according to the Work Package Specification and the relevant Purchaser rules."*[15]

The set of requirements is a measure for monitoring the project. Every requirement is referenced to one or more milestones. Even though requirements guide the supplier in its way of working and with their milestone structure follow the concept of project management plans, it is very important to emphasize that they are not to be confused with work packages and tasks of an actual project plan. The requirement does not define "develop the finite element model of the fuselage frame" but "the supplier shall provide all data and/or Finite Element Model allowing the purchaser to repeat and check the calculations". The difference is that the requirement just states that the finite element model is necessary, it does not define the scope. So it is the suppliers responsibility to break it down into work packages and tasks, identify what parts are affected and how the finite element model is related to other work packages. Controlling the progress of these systematic requirements is Airbus' approach to govern and monitor its suppliers in accordance to the aviation legislation.

Generalization of Applicable Requirements List

The requirements defined in here can be differentiated into three categories according to their purpose. One type of requirements is of organizational management nature. It comprises requirements related to project independent structures, methods and processes. Examples are Continuous Improvement Process (CIP), foreign object prevention strategies, obsolescence management or risk management approaches. Other central requirements of this type relate to data management, documentation and traceability. It also covers the entire strategy and methods to monitor the progress and initiate countermeasures in cases of problems. This category contains aspects that are typically subject to quality management and quality standards such as ISO9001 and ISO9100. Organizational management also includes rules that allow Airbus or the legal authorities to visit a supplier's sites. It has been identified that almost all of these requirements are essential preconditions that must be presented to Airbus when preparing a tender.

The second category consists of project management related requirements. These comprise typical elements such as project schedules, stake holder management, task breakdown and the requirement management itself. Traditionally, these can be distinguish

[15] (Airbus, 2016, ASR A1502)

from organizational management in a way that these requirements establish an organization within an existing organization relating to the specific goal of the project.

Technical management related requirements form the last category. While actual technical requirements of the product are specified in the technical specifications, these define for example required tests and how they have to be designed. Examples are hardware and software test procedures or specific tests like robustness tests. These are quite specific and often require domain knowledge to be fully understood.

In order to understand how a governance system can support or guide the fulfillment of the requirements, it is not important to understand every requirement in detail, but it is rather desired to generalize common characteristics of the requirements. The topics of all listed requirements represent all dimensions that the supplier must consider and manage. But even if the topics of the requirements vary, they share principles that allow them to be fulfilled. Fulfilling the requirement requires:

a) clear definition of responsibility,

b) staff that is qualified,

c) applicable documentation containing methods, manuals and templates,

d) staff to always have access to these up-to-date documents and

e) definition of interrelation to ensure the communication.

Documentation is a really prominent and important concept in aviation industry as it is often needed as proof for compliant performance of tasks - Both to the customer and to the authorities. The following two examples shall illustrate this:

> *"The supplier shall run continuous improvement initiatives to increase the performance of the project in terms of time, cost and quality."* (Airbus, 2016, ASR User Guide 030)[16]

Being compliant with this requires: Maintaining a formal and documented lessons learned process including a process trigger (e.g. process failure). Defining a person in charge and providing adequate time and resources to capture, analyze and implement the process. Maintaining a centralized repository for findings history that is easily accessible to staff. Supporting it by techniques such as visual performance management and spreading of results. The second example is a risk related requirement:

> *"The supplier shall define, deploy and maintain during the life of the contract a process to perform risk analysis in line with Process Failure Mode and Effects Analysis (PFMEA) methodology in accordance with EN9145."*[17]

Being compliant with this requires: Defining and document the methodology including the relevant inputs, the scoring model and template, as well as event triggers or periodic execution rules. Determining a responsible team and its authority, ensuring sufficient qualification by trainings and allocating resources. Defining the scope and monitor all related activities in a central repository. Determining a tool that allows easily prioritizing the findings

[16] 1.1020.01 Project continuous improvement

[17] 3.3024.02 Process Failure Mode and Effects Analysis process

based on their scored risk and defining a threshold for launching corrective actions. Defining an approach for establishing an measuring the effectiveness of corrective actions.

Both requirements are of organizational management type and need to be presented to Airbus within the tender. If a collaboration only consists of aviation industry experienced companies, it is likely that all of them already have an internal solution for such requirements. But forming a virtual supplier requires them to agree on an approach, establish responsibilities and authorities across the companies' boarders, establish coordination mechanisms and a central repository and ensure documentation of its performance to proof compliance. This will require a lot of time that cannot be spent on developing technological solution and preparing the actual tender.

2.4.4 Objectives of the Collaboration Governance System

In the following, concrete objectives for the governance system are derived from the overall expectations and the analysis of requirements.

(1) Reduce collaboration setup efforts
The expert interviews have shown that understanding the requirements and how to satisfy them is a main challenge if you do not have well-established structures and experienced staff. Therefore, the governance system shall help the collaboration to systematically fulfill the requirements with a focus on establishing cross organizational communication structures that are accepted by Airbus. The goal must be to have measures that proof compliance to requirements and do not need further audits.

(2) Required governance parameters
Generally fulfilling Airbus' expectations towards its suppliers requires to have clear and functioning responsibility and authority allocation, a holistic management of all relevant perspectives as well as communication and coordination mechanisms. These parameters are derived from the formalization of the ARL which is Airbus main measure to govern its suppliers. Consequently, it well fits the factors that Alreshidi et al. (2017) have identified as being relevant for efficient governance.

(3) Desired characteristics
While standardization is required to a certain extent by the customer and can also help to automate, experts emphasized the importance of keeping the system flexible and simple.

> *"[There is no] one-fits-all solution. [...] The system needs to be open and generic, in order to be further developed with experience of actual projects [and] it must be fun and simple."* [18]

This desire to have a simple solution that is extended and improved over time potentially also helps to overcome the skepticism of both OEMs and SMEs. The tenor of supplier session 2 was that SMEs would neglect a complex solution that requires them to invest much time and effort because they do not really believe it to be beneficial.

(4) Visibility and Transparency
It was identified that cross organizational barriers and the fact that cross organizational teams are not well-rehearsed do complicate sufficient communication. This, in relation to the experts assumptions that SMEs might have di cult managing the collaborations properly,

[18] Expert interview statement

introduces a main challenge. The governance system therefore shall tackle this by creating transparency across all team levels and shall guide communication efforts.

(5) Automation, IT support and standards

The potential extent of automation is an aspect of DIGICOR and therefore it is essential to understand the expectations towards this subject. But it is also of interest because the IT infrastructure of the VBE platform must be aligned to it. In recent research, industry 4.0 and digitalization are the key terms that indicate a high level of integration and interoperability of IT systems and production facilities throughout the supply chain. However, section 6.2 already showed that the primary expectations identified through the interviews does not include the production at all. When asked, SME managers answered that industry 4.0 and automation of their production facilities is no business objective in mid-term. Consequently, this is of no relevance for the design of the governance system. But it is not only the integration of production control systems that is not desired by the SMEs. They also do not want an integration of management systems across the partners, such as Enterprise Research Planning (ERP) systems. They do not expect a real benefit, but a more important reason is that they fear to give access to valuable business information.

> *"An integration of my ERP system or other management systems with a platform is generally unimaginable. I would only consider it if the customer demands it. But I can't imagine that. [...] And even if that were to be the case, the business opportunities for my company would have to be so great that it far exceeds the risk [which the loss of sensitive operating data could lead to]."*[19]

In general, it was defined that the experts are skeptical towards any automation. Tools get too complex or require high levels standardization which is not feasible. The fear of "loss of control" and "reduced flexibility" determine the desires towards the IT support.

> *"The question is how much IT is really needed?[...] The most basic and common demand [between collaboration partners] must be found [...] and it must be very simple [...] as otherwise it won't be used."* [20]

While the experts being interviewed agreed on this, the survey that has been performed revealed a different perspective. Respondents for example answered that they do expect "participation in predefined workflows", "information management" and "exchange of information". These answers are not about complex and extensive IT support but do refer to multi-organizational coordination support. It emphases the expectations to have standards when possible but under strict consideration of the loss of flexibility.

(6) Objective of the concept

In addition to the objectives relating to the governance system, there was also an objective derived for the concept itself. Airbus' current strategy often prevents SMEs to get knowledge of CFTs because they are considered being too small and a collaboration is nothing that Airbus considers as alternative at the moment. Therefore, it should be the goal of the concept to show Airbus that a well-designed governance system could overcome challenges that they consider a blocking point for collaborations. In one supplier session experts revealed that SMEs hope that Airbus commits and contributes to the project in order to establish new options and to become more flexible, e.g. relating to its certification requirement strategy.

[19] CEO of a additive manufacturing company in supplier session

[20] Expert interview statement

2.4.5 Conclusion and Resulting Challenges

That experts did express only limited concrete expectations highlights their skepticism towards instantly forming collaborations. Partly this is related to the fact that they are not convinced that SMEs are willing and capable of managing a collaboration. They also see limited chances for a governance system to help. But what they really consider as a blocking point is that Airbus wants to treat collaborations the same way as single suppliers which implies sharing of risk. In this context, contracts and partnership have been identified as important factors for the governance of collaboration but experts do not consider this to be something to be performed by the governance system but rather as being the foundation.

Automation is not considered to be essential nor possible. Integration of SMEs' internal systems is neglected because of limited benefits but increased risks relating to data security. Automation expectations are limited to supporting functions. Because the flexibility of the platform is important to the experts.

3 Governance System for SME Collaborations

The following chapter sketch the concept of a governance system for the SME collaboration within the aerospace supply chain addresses in the DIGICOR project and specifies the related governance rules and procedures to be applied at the DIGICOR platform.

The proposed concept will be used in the DIGICOR project to evaluate to what extent the governance system can overcome or reduce the described challenges and how the expectations can be fulfilled. Aiming at practical focus, all considerations are based on the context of Airbus' procurement strategy, process and requirements.

3.1 Scope of the Concept and Necessary Assumptions

The governance concept to be developed is of theoretical nature because the concept of instant collaborations is yet to be established. This implies that while suggesting suitable technologies and their interaction is a core aspect of the concept, it is out of scope to develop concrete IT architectures and or implementations. As identified in the previous chapter, supporting the formation phase is the prior demand. Based on the previous analysis the aim of a governance system is to establish structures between the collaboration members that are both considered being valuable by the members and accepted by the customer in terms of guaranteeing a proper management and quality.

In order to better illustrate and clarify the scope, a few necessary assumptions which the concept is based on have been made. It is assumed that an IT platform (DIGICOR) is in place which allows customers, mainly OEMs such as Airbus, to publish a CFT to a determined target group of potential suppliers. The platform supports platform members to break down the technical specification of the CFT to find potential collaboration partners, evaluate and select them. Next, the collaboration partners must jointly create a tender for the CFT. This is the point where a collaboration must be formed and therefore the starting point of concept. The breakdown of the technical specification could be considered to be an input to the governance system. But the extent to which the breakdown of a CFT can be automated is expected to be limited. Consequently, a nearly complete task breakdown cannot be taken for granted.

It is also assumed that the platform does not establish a deep IT system integration, because the interviews and supplier feedback sessions have shown that integration of ERP systems or the like is rejected. This is in high contrast to other works arguing that leading VE partners "are requested to not only use ERP information systems but also use the same ERP information systems to become highly integrated and flexible via real-time information exchange" (Wan & Clegg, 2016). If collaborations become a usual business practice in the next decades, the attitude of SMEs might change as well. But at the moment a concept relying on IT integration would be neglected.

3.2 Governance Framework and Structural Design

The governance of a collaboration is closely linked to the governance of the network by which the collaboration is formed, and so are the governance systems. This especially affects behavioral and cultural aspects of governance (Rabelo et al., 2014). Thus, even though this work contributes to governance on the collaboration level, this close connection requires to develop and align it to a high level governance framework.

3.2.1 Governance Framework and Big Picture

Governance of collaborations is a multi-functional topic that can be dealt with from various perspectives. As it was shown above, recent researches have chosen very different approaches in order to contribute to this topic. From the analysis of these different approaches in connection with the findings from the expert interviews, a governance framework is suggested that meets the special characteristics of the German aviation industry (Figure 14). Its purpose is to ensure a holistic view on the issue of collaboration governance. Therefore, this framework draws the big picture incorporating all relevant aspects and will show interfaces of the governance system.

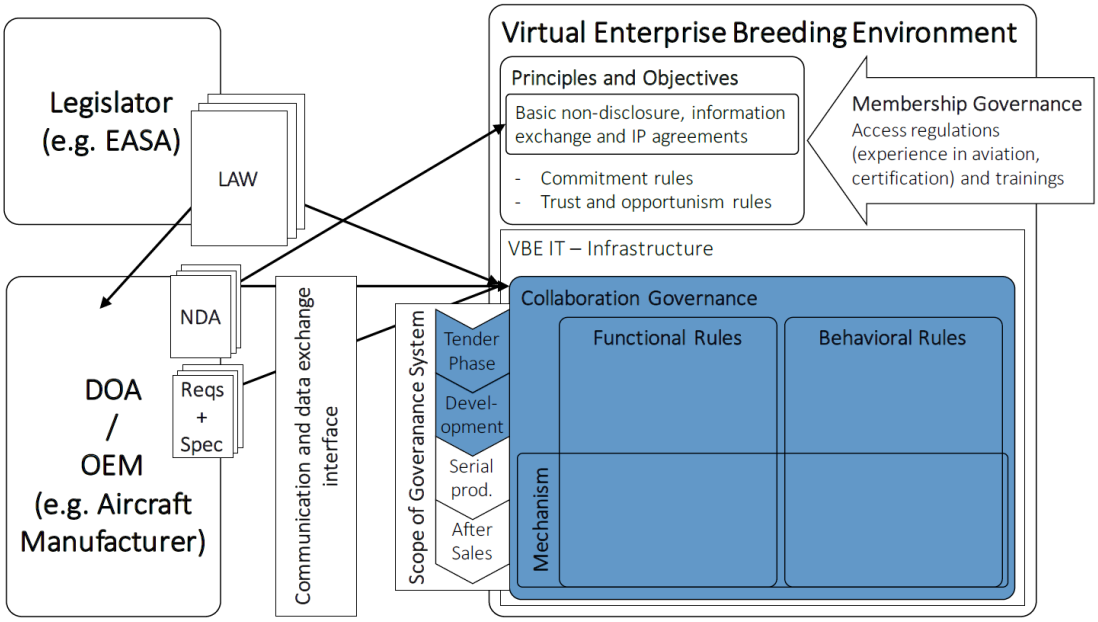


Figure 14: Governance framework and frame conditions of aviation industry

The core of the governance framework design follows the suggestions by Romero et al. (2007, 2010), which is a two level approach. The upper level is VBE-related governance and thereby independent from a specific collaboration. It represents the strategic level and allows the establishment of long-term governance structures that improve the members' preparedness to collaborate. As all members of the platform are considered to be potential collaboration partners, they should share a basis of principles and should prove a minimum understanding of the aviation industry. This is supported by the results of the questionnaire survey. When being asked for the criteria that determines whether to join a VBE, the respondents named the strategic orientation of the VBE and the registered members as being the main factors. Exemplary answers are *"kind of members''*, *"members expertise''*, *"mutual trust"* and *"strategic goals of the network"*. To tackle these issues, ***Principles and Objectives*** in combination with ***Membership Governance*** are suggested as central elements of the VBE governance. From technical point of view, the VBE is also the level that implements the IT-infrastructure which allows member interaction and setup of collaboration support structures. It is represented by the planned platform of the DIGICOR project.

The second level is the ***Collaboration Governance***. It is highlighted in blue because it is the core of the concept and is presented in next sections. It is implemented within the IT-infrastructure of the VBE and is instantiated specifically for one collaboration related to one

business opportunity. As identified in previous section, the governance focuses on the *tender phase* in which the formation of the collaboration takes place and the *development phase*, which are also highlighted in blue. The collaboration is governed by functional and behavioral rules. The execution of rules is supported by mechanisms which thereby contribute to the automation (Romero et al., 2010; Rabelo et al., 2014).

In second section, it was identified that the external factors must be considered by the concept because they significantly affect governance. These are represented in the framework by the elements legislator and DOA/OEM. The law regulates the rights and duties of actors of the aviation industry. This imposes rules to the participating parties like which tasks they are legally authorized to perform.

Legal regulations determine how OEMs have to manage their supply chain and suppliers. The analysis of the requirements in previous section shows that Airbus translated the applicable law into its supplier management approach. Therefore, it is a major input for the collaboration governance.

3.2.2 VBE Governance Level

In the course of this work, it was identified that the relationship is crucial and elementary for a collaboration to be initiated. Trying to build trust in the moment when a collaboration is ought to be started does not work. Consequently, this is a central aspect of the strategic governance level. Experts agreed that a platform can never replace the personal relationship needed for a partnership. Nevertheless, it might contribute to the relationship building to a certain extent. For example, one expert argued that a collaboration platform must be a controlled space to which companies are only granted access under certain conditions. This is the basis for a trustworthy atmosphere.

Principles and Objectives

The purpose of the principles and objectives module is to define the strategic orientation and purpose of the VBE and to establish a social environment that matches this orientation. One interviewee expressed the importance of the system to be generic and that it should be improved with the experience of every project. Relational governance mechanisms and the general willingness to share information with other members are key elements of a collaborative environment. Therefore, it is proposed to set up a commitment agreement that all members need to accept. Developing a concrete agreement is up to the platform operator in close collaborations with all potential members. A few central aspects are proposed in Table 2.

Honesty and integrity	Acting with good faith and considering other members as partners
Support community	Attend get-together events whenever possible and build trust and relationships
Openness	Acknowledge the value and importance of sharing information as foundation of collaboration
Commitment	Contribute to VBE improvement measures and growth of network

Table 2. Basic elements of commitment agreement adapted from Romero et al. (2007)

A very important aspect in order to create preparedness to collaborate is the basic nondisclosure, information exchange and IP agreements module. It must establish a generic agreement between potential customers and platform members in relation to IP and non-disclosure questions. Only through this agreement are potential collaboration partners able to exchange information about a CFT and can consider to prepare a tender. Even though standard NDAs do have disadvantages, having a predefined agreement is essential to deal with the tough response time to RFIs and CFTs. This is a critical point that requires legal consideration and highly depends on the willingness of all parties. For OEMs such as Airbus, the NDAs represent the main measure to prevent information to get in hands of competitors. An IP agreement is essential from the SMEs point of view because potential customers stealing their USPs represent a major risk to their entire business.

Membership Governance

A major risk to the success of a collaboration is that a partner fails to perform its obligations. A general understanding of the aviation industry and its extensive regulations is therefore essential. The platform should allow only companies to become a (full) member that can either prove experience in the aviation industry or show commitment to understand the industry. The Membership Governance is suggested as a measure that acts as a filter, shaping an elitist character of the VBE and therefore establish a basic level of trust and openness towards collaborations with other members.

Two different options to gain access to the VBE are suggested. The first option is a set of indicators that enables the platform operator to draw conclusions on the professional suitability of a candidate. It might be a construct of minimum qualifications, such as ISO9100, references from other members or reputations from projects in the aviation industry. For newcomers, there should be a set of mandatory trainings and awareness sessions that allow non aviation industry professionals to get a basic understanding of the special challenges and characteristics and efforts and investments that it does require. Once, a company has performed these, it is granted temporary and limited access until it passes qualifications such as ISO9100.

3.3 Core Idea of the Governance System

It has been pointed out that the customer requirements have a significant impact on the collaboration governance. Consequently, the concept is built around the requirements and takes them as the major input. Its goal is to systemically guide the collaboration in fulfilling the requirements of which a central aspect is to become a well-managed organization. This implies that the governance system creates visibility and mutual consensus which is the foundation for effective and efficient communication and coordination. Because the project team consists of members from different companies, effective communication between actors is identified as being a main success factor. The three main collaboration governance modules that were presented in the governance framework comprise the following functionality: Functional rules establish the structure that defines the communication and coordination requirements and builds the basis for automation. Behavioral rules determine social-organizational structures and interaction behaviors. It is the main instrument to embed a coordinating philosophy and effective communication measures and by this means, make the collaboration a well-managed organization. Mechanisms are supporting functions and technologies that increase the degree of automation and reduce the effort to implement the functional and behavioral rules.

It comprises the implementation of predefined standards and tools. The governance concept follows three main considerations:

- The governance system uses a project management approach
- Customer's organizational and project management related requirements are in focus
- The governance is subject-oriented

Airbus' ARL is structured by milestones. These represent a mandating factor and therefore build the skeleton of the project schedule. This fits instant collaborations as they share many characteristics with a project. Therefore, project management techniques and structures are an integral part of the governance approach. Other inputs to the governance system are the Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS). There are countless project management tools on the market, with extensive and complex functionality that are often an overflow for occasional users. It is not the aim of the governance concept to reinvent any of these. It only focuses on basics that are required to fulfill the requirements but consequently links these to a smart architecture that eases the collaboration setup and combines it with mechanisms. The mechanisms can be understood as a pool of assets which the collaboration can modulate and use to its needs.

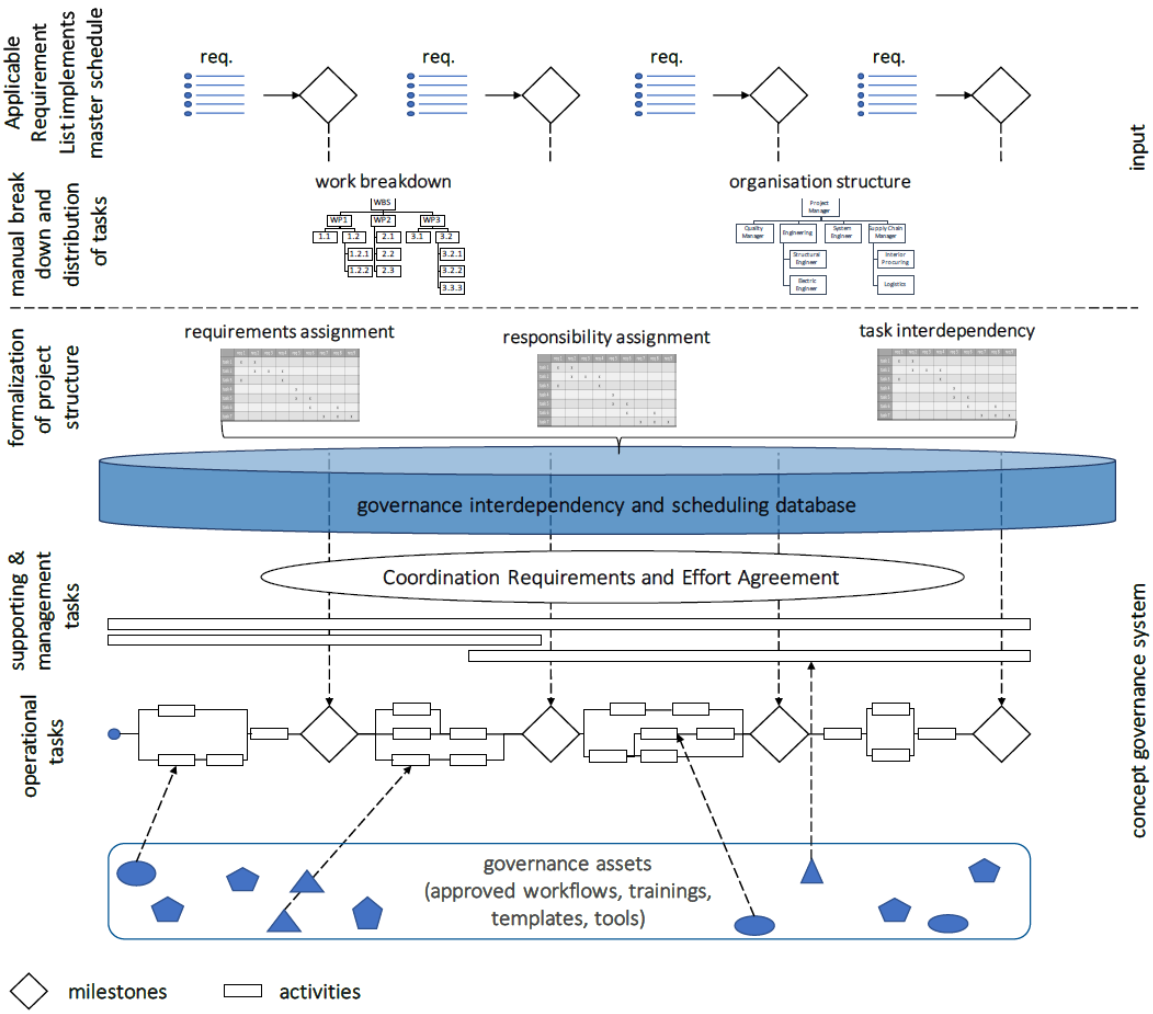


Figure 15: Governance framework and frame conditions of aviation industry

Figure 15 illustrates the overall concept of the governance system. Based on the given inputs, the collaboration partners are provided with alignment matrices that help them to visualize and formalize relevant interdependencies. The matrices therefore are measures to cascade

the requirements and build the structures for coordination. These structures put the actors (subjects) and their interactions in focus. Organizational and project management related requirements are in focus as these represent the main aspects during the formation of the collaboration. Based on the formalized data the governance system is able to generate a project plan.

The mechanisms are also designed in a subject oriented manner. This creates higher flexibility and pays account to the diversity of potential projects (Fleischmann et al., 2012). Mechanisms are different kinds of predefined and approved assets made available to the collaboration to support various activities (respectively tasks). As part of the governance system supporting technologies to match assets and tasks and increase extent of automation are considered as well.

In previous section it was identified that Airbus Supplier Requirements cover all dimensions that management must consider to comply to quality management standards such as APQP. This allows to the governance system to focus on management structures but not management contents. Overall, the governance system is designed to create visibility helping the right people to communicate and coordinate at the right time. By this means, the governance system should reduce the management deficits that collaborations have in comparison to a single organization.

3.4 Functional rules

Functional rules is a core element of the collaboration governance concept which comprises the functional setup of the project structures.

3.4.1 Accountability Allocation and Certification Compliance

The OEMs' certification requirements that result from the industry regulations, are a main aspect that a collaboration must fulfill. Certifications determine the activities that a company is approved to account for. Therefore, the allocation of accountability to collaboration partners must match their certifications. Traditionally, the OEM defines the certification which is required to bid for a CFT. One OEM procurement expert explained that in a collaboration of "equal" partners every partner would be required to have this certification. If this is a higher level of certification, many SMEs are excluded as potential cooperation partners. It is one of the challenges that SMEs hope to overcome by using the platform and its governance system. Therefore, an alternative is proposed that gives more flexibility.

Certifications are issued to companies but not to their employees. That is, the company is accredited to possess the management-, IT- and communication structures that prove the ability to properly train its people, control and monitor its processes and activities and consequently, to perform certain tasks in the required quality. The certification does not prohibit involving temporary workers or subcontractors. Based on this consideration it is proposed to split accountability - the responsibility to validate and authorize results - and operational responsibility - the actual execution and performance of tasks. This is restricted to the assumption that the accountable partner is able to transfer and impose its structures to the executing partners.

Different tasks require different levels of certification. Companies should only need to be issued with the certification that is actually required for the tasks that they are accountable for. Consequently, a company that does not have the required certification must not be

accountable but when being controlled by the accountable company it is generally allowed to contribute to the execution. Theoretically, the requirements of the ARL can be generalized with respect to the required management capabilities and structures. Thus, it s proposed to define for each requirement the needed certification. This implies that the OEM must take extra effort to specify certification requirements more precisely. This approach increases the number of potential partners. Consequently, it gives more flexibility for the partner selection.

This provides easy measures for collaboration partners to assess whether they jointly are able to bid for a CFT. Therefore, checking for each requirement if at least one collaboration partner has the needed certification and could account for it, is the first action that must be completed. If the collaboration partners are able to comply and decide to prepare an offer, this imposes guides and restrictions to the actual allocation of accountability. This approach is in particular valid for technological management related requirements. It can be argued that organizational and project management related tasks must be accounted and performed by the same company because it relates to the overall management of the collaboration (Wan & Clegg, 2016).

3.4.2 Formalization of Project Setup and Structures

To enable the governance system to support the collaboration with automation mechanisms requires to make the parameters of the project structure machine-accessible. These parameters are project entities (project requirements, tasks/activities and actors) and their interrelations. Thus, an approach is presented that systematically guides the formalization of the project.

At first, the collaboration partners must develop the Work Breakdown Structure and OBS to define the entities tasks and actors. Another research subject of the DIGICOR project is a tender decomposition service. Its aim is to automatically break down the CFT into subgoals. It is hardly possible to estimate what granularity and reliability this service will offer. It is likely that this service only offers a template or suggestion because the breakdown is a highly complex task. However, once it is established this is an input to the development of the WBS. Despite this functionality, the governance system cannot provide further automation. The governance system must offer an user interface for the developing and modeling the breakdown structures. This will allow to feed the defined entities into the system. The ARL - which is an excel sheet after all - can be used to automatically import the requirements into the system. In a next step, collaboration partners must analyze the interrelations of the entities - one at a time. These will define the coordination structures, that must follow the behavioral rules and can be supported by the mechanisms. Assignment matrices are used to analyze interrelations. These matrices are simple but effective and well-proven techniques of project management (Yang & Chen, 2009, p. 12586).

Three different assignment matrices that are generated from the entities are used to keep the complexity at a low level (Figure 16): Requirement-Task Assignment Matrix (RTAM), Responsibility Assignment Matrix (RAM) and Task Interdependence Matrix (TIM). The RAM is widely established in practice and its approach was adopted to the RTAM and TIM. Completing one matrix at a time, the collaboration partners are forced to thoroughly analyze all relevant interrelations of the project structure. First, the RTAM is to be completed. On one axis it lists all requirements from the ARL on the other the tasks from the WBS. The relation between task and requirement simply states task xx is part of requirement yy. By this means, the cascading of all requirements is guaranteed and the tasks can automatically be assigned to the relevant project phases. The RAM is a measure to clearly assign

responsibilities to the tasks. Therefore, one axis is represented by the tasks of the WBS whereas the other lists the actors defined in the

OBS.

RTAM	req 1	req 2	req 3	req 4	...
task 1	x	x			
task 2		x	x	x	
task 3	x			x	
task 4					x
task 5					x
task 6		x		x	
...				x	x

RAM	actor1	actor2	actor3	actor4	...
task 1	AR				
task 2	AC		R		
task 3		AC	R		
task 4	C		S	AR	
task 5	I	R		A	
task 6			AC	R	
...					

TIM	task 1	task 2	task 3	task 4	...
task 1		1			
task 2				4	
task 3				3	
task 4					
...					

Figure 16: Conceptualization of relevant assignment matrices

There are different versions of the RAM from which the *RASCI* is proposed to be used.

- *Responsible (R):* the person that must perform the task. Usually, one responsible for one task.
- *Accountable (A):* the person that approves the result and becomes responsible after the approval. Only one person's accountable for one task.
- *Support (S):* persons that might contribute to performing the task. That is, the responsible might delegate work to this person.
- *Consulted (C):* all people whose opinion could be relevant when performing the task. Two-way communication with responsible.
- *Informed (I):* persons that are kept up to date. One-way communication from responsible to informed.

The Task Interdependence Matrix identifies and formalizes different types of task dependencies. The definition of task dependencies and their consequences on the coordination requirements are defined in the behavioral rules and therefore will be introduced later. The completion of the TIM, however, is part of the functional rules. It might also implement execution orders between the tasks that are relevant for the project scheduling.

Once the matrices are completed, all the data of the project structure is fed into the system.

An algorithm can now be applied to generate a project net plan template. The actual development of the algorithm is part of implementation which is out of the scope of this deliverable, but it must apply the following rules:

1. The milestones of the ARL build the skeleton for the project schedule.
2. Based on the RTAM the tasks are grouped into the respective project phases between the milestones:

2a) Tasks that implement *organizational* and *project management* related requirements become *supporting & management functions* across-milestones.

2b) Tasks that implement *technical management* related requirements and are applicable at more than one milestone, will be implemented with one revision per applicable milestone in the project schedule template. The different revisions represent different levels of maturity of the task.

3. Within the milestone-separated project phases, tasks are linked based on the Task Interdependence Matrix. The type of interdependence will determine the required order.

This automated generating of a project plan template is a major reduction of effort which is enabled by the simple use of alignment measures. The collaboration partners must fine grain the planning with duration times for the tasks. The project structure will change during the projects lifespan. By keeping the WBS, OBS and alignment matrices up-to-date, the system allows to easily understand the impact of changes to the project plan and coordination structures.

3.5 Behavioural Rules

The successful operation of a collaboration highly depends on its ability to manage interdependences and to effectively and efficiently communicate. This is supported by the behavioral rules module.

3.5.1 Coordination Requirements and Efforts Agreement

Interdependent tasks must be aligned. Consequently, if interdependent tasks are performed by different actors, it implies that these actors must communicate to coordinate their work. Therefore it is proposed to implement communication and coordination rules that match communication requirements with appropriate communication efforts (Cataldo et al., 2006). Communication requirements vary depending on the characteristics of the tasks' interdependence. Communication efforts are characterized by communication frequency, communication channel and the information that is exchanged.

It is proposed to establish a Coordination Requirements and Efforts Agreement (CREA). It defines characteristics that are used to classify task interdependencies and imposes coordination efforts that are able to properly manage these. Mapping the defined types of task interdependencies in the TIM allows to implement it in the project data set. Therefore, the governance system is able to schedule coordination events of team members based on the defined coordination effort. The basic idea of the agreement is that with increasing interdependence, the required communication and coordination do also increase (Saavedra et al., 1993). Matching coordination requirements and coordination efforts is an own field of research. Traditionally, it origins from management research and gains further importance and complexity with respect to virtual teams (Hertel et al., 2004). (Staples & Webster, 2008). When implementing the governance system, the development of the CREA can be based on a wide field of theoretical and practical research.

With respect to the overall expectation to increase OEMs' acceptance of collaborations, it is required that OEMs are closely involved in the development of the CREA. It is suggested

that this approach increases the acceptance because it can be predefined independent of a specific project. Therefore, it generates transparency of the way in which a collaboration will manage their tasks. What is more, when taking the lead in developing the CREA, OEMs are enabled to define a general standard for coordination that is easily imposed to collaborations.

Applying the agreement in a collaboration must consider that it cannot be guaranteed that all interdependencies are already recognized when initially setting up the project. In complex projects, communication requirements change regularly (Cataldo et al., 2006). Therefore, another aspect is to define rules and processes that involve all team members and continuously keeps the mapped interdependencies up-to-date. Defining coordination requirements is not limited to type of task interdependencies. The way the CREA is embedded in the concept allows to extend it by as many dimensions as OEMs consider relevant. For example, it can be complemented by the dimensions physical distance or trust between the members that must communicate (Staples & Webster, 2008). A simplistic example of a CREA is illustrated in Table 3.

Coordination requirements level:		Task interdependencies		
		unidirectional	bidirectional	multidirectional
Physical distance of responsible persons	same site	1	2	3
	different sites	2	3	4

Coordination effort definition:	frequency, channel, information level	
Level 1	2-4	weeks, email, informal progress updates
level 2	2-4	weeks, email and telephone, informal information exchange
level 3	2-3	weeks, telephone and web conferences, use of templates
level 4	2-3	weeks, web conferences and face-to-face meetings, template agenda and protocol

Table 3. Simplistic template of a Coordination Requirements and Efforts Agreement

It only must follow the structure that a set of defined characteristics determines the coordination requirements. For all levels and types of coordination requirements appropriate coordination efforts must be defined - consisting of frequency, channel and information type.

3.5.2 Information Exchange Agreement

When team members coordinate their work, they are exchanging information. As team members in a collaboration come from different organizations, it can be assumed that they do not know each other well. This makes communication more di cult which is why the governance system implements the concept of preliminary information of Terwiesch et al. (2002). This becomes an information exchange agreement which helps team members exchanging information based on a shared understanding. Terwiesch et al. (2002) define:

> *"If there is no concurrency, information can be exchanged in its final form. If there is no dependence, there is no need to exchange information. Thus preliminary information is the direct consequence of the interaction between task concurrency and dependence."*

Information quality significantly influences the decision making. A common understanding of the quality of shared information between the collaboration partners is therefore essential. The reliability of information can be characterized by its precision and its stability. There are no clear measures for precision and stability but employees can generally give estimations based on their experience (Terwiesch et al., 2002). So the governance system must implement a catalogue of different levels of stability and precision. The catalogue contains rules and guides of how these levels are characterized. By this means, a shared understanding is established to which actors of different companies can align their estimation.

The second aspect that the information exchange agreement considers is the impact of wrong information. If information turns out be to wrong, e.g. the information changed after it was communicated, this can have three different effects (Terwiesch et al., 2002): Rework: tasks have to be done again based on new information. Starvation: tasks cannot be continued because of missing information. Duplication: multiple options are prepared which increases the effort. The implementation of a governance system must establish methods and structures to determine the impact of wrong information. A designated and predefined Failure Mode and Effect Analysis (FMEA) method could be used to determine which of those effects has the least negative consequences. Both, the shared understanding of the quality of information and the standard method for analyzing negative impacts will allow collaboration members to communicate more effectively and efficiently.

3.6 Supporting Mechanisms and Technologies

In this section supporting technologies are identified and the potential extent of automation is evaluated.

3.6.1 Subject-Oriented Workflow Module

The project setup structures that have been introduced are based on well-proven project management techniques. This is an advantage as it increases the acceptance by the OEM. The main benefit of the proposed governance concept, however, is that these formalized structures can be supported by governance assets. A main enabling technology for these is a workflow engine. It establishes the foundation for automated execution of communication structures.

Following the subject-oriented approach of the governance concept, the workflow routines concentrate on automated notification and messaging as well as routinized documenting. The advantage is that this requires less standardization and integration effort as traditional fields of workflow applications do require (Jablonski, 1997). The workflows help to overcome the increased effort required in terms of information flow which arises from the multi-organizational character. Putting the employees and their competences in focus allows keeping flexibility of the approach.

If a collaboration is to be approved by an OEM it must be able to demonstrate that it did not only define processes and structures but that they are also used and followed. Therefore, the workflow module is a measure to prove that the communication and coordination mechanisms are well-established across organizational boundaries. A predefined workflow consisting of tasks is linked to team members that do perform the tasks or must approve the results. The workflow allows automatically passing the results of a task and a notification to

its successor whenever it is submitted. This is in particular valuable to support organizational and project management related tasks.

Consequently, this approach requires the platforms IT-infrastructure to implement a workflow engine and provide workflow monitoring and editor tools (Camarinha-Matos & Pantoja-Lima, 2001). When implementing a workflow engine one should ensure to consider common standards. This allows to complement partners' internal process with intra-organizational processes (Jansson et al., 2008).

3.6.2 Governance System Assets

Two main objectives that the governance concept aims to fulfill are increasing OEMs' acceptance towards collaborations and reduce the effort for setting up the collaboration. One OEM procurement expert pointed out that a general problem of accepting collaborations is, that it would require the OEM to audit all partners. The Acceptable Means of Compliance (AMC) - a non-binding standard of the aviation industry - allows companies to define their own processes, measures and structures (EASA, 2018). While this creates flexibility across the industry, it requires the OEMs to assess whether the structures and processes of their suppliers do actually demonstrate compliance. An integral part of the concept therefore is that the governance system provides predefined and approved structures that when be implemented by the collaboration do not need further auditing. Demanding collaborations to use these standards can increase the acceptance of OEMs. The pool of all available and approved standards is referred to as governance system assets. Once, a significant pool of assets is established, collaborations can choose the best suited assets to build their virtual organization. This is a modular approach that guarantees flexibility.

When implementing approved assets, this is sufficient evident to prove compliance with customers requirements. Three main types of assets have been identified to significantly reduce setup effort and increase the acceptance. The most important assets are subject-oriented workflows. Supporting the modular approach requires the predefined workflows to be applicable in a wide range. To achieve this, it is proposed to focus on generalization instead of standardization. This is supported by focusing on subjects and their interactions, rather than define fine-grained processes. These subject-oriented workflows can be composed of tasks that are linked to predefined roles. The roles define required capabilities and authorities to fulfill the task. When implementing the workflow the collaboration must just assign team members to the tasks that match the predefined roles. Many workflows that can be generalized will relate to organizational and management related requirements. Therefore it significantly reduces the formation effort and allows collaboration partners to focus on the technical aspects of the project.

The second type of assets is closely linked to the approved workflows. In the aviation industry documenting is a central aspect. This is, for example in the context of testing, necessary to be able to prove that the organization did fulfill its legal obligations. Several workflows will produce information that must be systematically stored. Therefore, the workflows can be complemented by approved documentation templates and an automated documenting service.

Putting the actor and his capabilities in focus implies that the collaboration must be able to build sufficient capabilities of its team members. Trainings therefore complement the assets. Approved trainings represent sufficient means to develop and demonstrate that team

members have the required skills. The trainings can relate to applying methods, using tools or having certain engineering skills.

The entire module of governance assets builds on the sharing and collaborating mentality that is to be established on VBE level. The pool of assets can only gain a critical size when many parties contribute to it. Sharing structures and workflows that have been proven to be applicable is therefore an expected commitment of community members.

3.6.3 Automation Approach

The formalization of the project structure in combination with workflows and other assets have been presented as suitable measures to reduce the effort when forming a collaboration. A further reduction of effort can be achieved if the system can automatically suggest or assign existing governance assets with the tasks defined in the WBS. Ontologies are a technology used to formalize domain knowledge and therefore make it explicit. With this formalization a knowledge base can be build that is machine-accessible and which is an integral part of artificial intelligence automation approaches (Ye et al., 2007). The ontology represents a meta-data-model comprised of classes, properties and relationships that are used to describe the conceptual model. The interrelations defined in the ontology allow to perform semantic operations on the established knowledge base (Herter & Ovtcharova, 2016). By is means, “meaning” is given to the data allowing machines to “understand” it and which, for example, improves their search capabilities (Yoo & Kim, 2002). Ontologies help to bridge the gap between the analysis of a domain and the development of applications for this domain. It allows to link defined concepts, such as requirements, to software components, such as the predefined workflows (Smith & Becker, 1997).

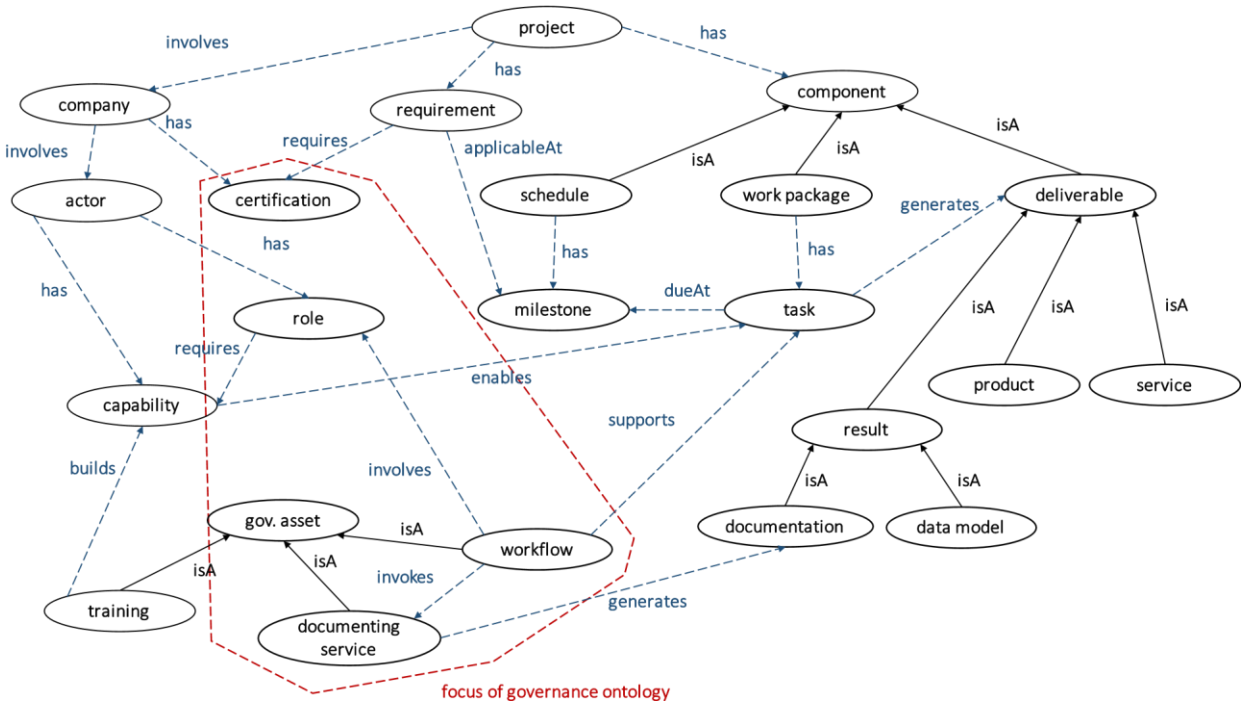


Figure 17: Top-level classes and relations of a conceptional governance ontology (adapted from Ruiz-Bertol et al. (2011))

An aim of the governance system is to increase the extent of automated by matching existing assets to tasks that need to be performed. The potential of ontologies and related

technologies does meet this expectation. It is not aimed to develop an ontology as part of the concept but rather to conceptualize its structure. The top-level of a governance ontology is illustrated in Figure 17. An ontology is only beneficial if its knowledge base is continuously updated. Therefore, when developing it, one must carefully consider already existing ontologies and communities. The governance ontology must rather extend existing concepts than developing an isolated and new solution.

Matching the approach of the governance concept, a governance ontology must connect project management domain knowledge with the domain knowledge of the aviation industry. For supporting and improving development activities in the aviation industry an initiative from both, researchers and industry partners, has been started. It is called CRitical SYSTem Engineering AcceLeration (CRYSTAL). One of its objectives is to develop a domain specific ontology that comprises collaborative activities and engineering methods and capabilities (Viglietti et al., 2014). This is a valuable knowledge base that offers big potential. There are also initiatives developing project management ontologies. Figure 17 illustrates how the main concepts of the governance approach, namely role orientation and predefined workflows should be the main points linking the domain of aerospace development with project management.

The potential of using ontologies and semantics is significant. It could be extended to other aspects of the governance concept and for example could help to identify task interdependencies. However, developing the ontologies and implementing the knowledge bases and semantics is a great effort. Getting the commitment that is needed for this, will require to attract a large community. The extent of automation that can be realized by the developed concept highly depends on the contribution by various parties. This also implies that at the beginning few assets are available and the knowledge base is not established. Consequently, the extent of automation is very limited. Therefore it is not tried to create the illusion that the governance concept instantly offers a fully automated governance approach but rather emphasize that the concept is highly dependent on active contribution. At early stages of implementation, the automation of the system comes down to providing the alignment matrices that formalize the project data and therefore help generating project plan templates.

3.7 Enrichment and Improvement of Governance System

It was pointed out that the potential of the governance concept to reduce the effort for setting up collaborations and increase their acceptance depends on the number of implemented and approved assets. Therefore, it is important that the concept considers how the pool of assets is developed. Figure 18 depicts the proposed approach. It comprises the initial development of assets and the continuous improvement of existing assets.

It has been identified that three parties must contribute to the development of assets: The essential function of OEMs is to verify and approve any developed assets. The governance system shall allow collaborations to prove their compliance to the customers. Therefore, a consortium of OEMs represent the authorizing body of the concept. Both OEMs and SMEs may come up with proposals for new assets. But SMEs, when using the governance system, are the main driver for continuously assessing existing assets and to trigger their improvement. Despite these classical actors of the industry another party is required. It is referred to as platform operator. It is the actor that is responsible for the development and operation of the collaboration platform. The platform operator has a coordinating role and must drive and control the implementation of approved assets.

From this approach, it is deduced that the engagement of these three parties is essential for the concept to work. If any of these parties does not commit and contribute to the system, it is likely to fail.

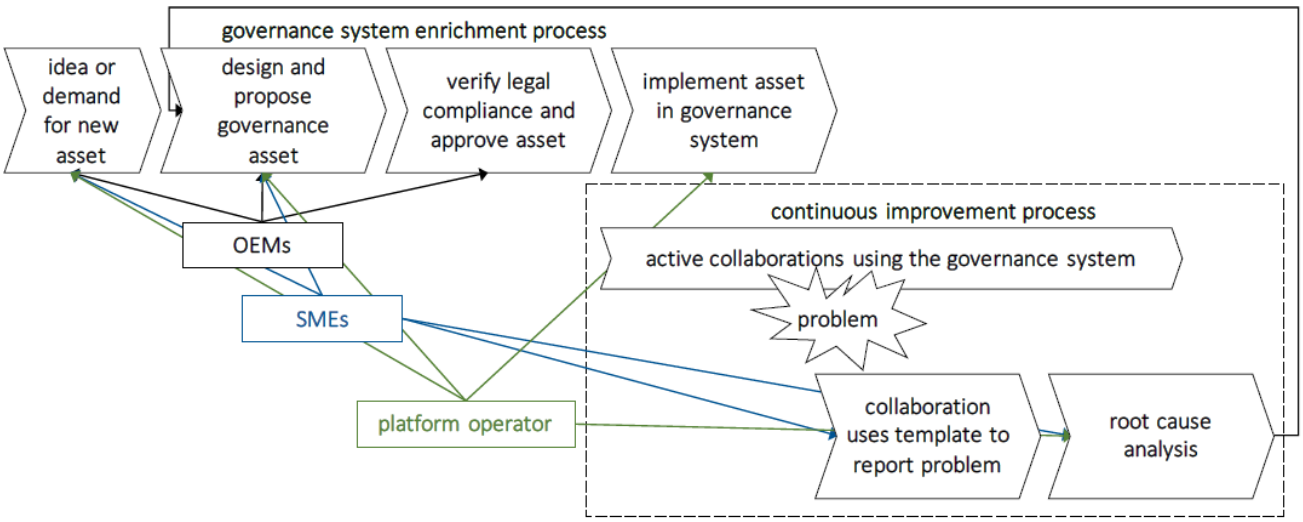


Figure 18: Top Governance assets enrichment process and contributing parties

4 A governance metamodel for SME collaborations[21]

4.1 Demand-driven collaboration and Industry 4.0

Modern collaborative activities involving suppliers of all sizes along supply chains result in building partnerships driven by manufacturer demand and aimed at cooperative order fulfilment (Kazantsev et al., 2018). The movement to Industry 4.0 concepts (Smit et al., 2016) such as “lot size of one” and demand-responsive production means these collaborations would be formed “on the fly” to respond to the needs of a fast-changing market with shorter product life-cycles. A promising approach to implement these concepts is establishing collaborative marketplaces (Cisneros-Cabrera et al., 2017) where demand from manufacturers could be matched with capabilities and capacities of available suppliers, thus accelerating formation of a supplier collaboration that would be able to bid for larger business opportunities (Grefen et al., 2009) and reducing supplier switching costs to such formations (Kazantsev et al., 2018). Current information technologies can support such demand-driven collaborations (DDC) between suppliers, yet the uptake of this approach is impeded by several factors (Kazantsev et al., 2018), one of them being lack of formalization and enforcement of governance rules, which results in high switching costs to such partnerships. To significantly reduce the burden of setting up collaborative networks and shorten the time to jointly respond to business opportunities, we aim such rules to be enabled for all participants of Industry 4.0 scenarios. The goal of this section is to present an abstract syntax of governance rules to underpin demand-driven collaborations in general and in the DIGICOR project in particular.

We use Unified Modelling Language (UML) (Booch, 2009; Brambilla, 2012) to create a metamodel that encapsulates collaboration properties, knowledge protection and security rules — in order to move from an ad-hoc case-specific governance rules management to systematic, industry-enforced governance tools for handling production and logistics service partnership formation concerns. This will lay a foundation for a domain-specific language (DSL) (Fowler, 2011) for Industry 4.0 to increase the speed of DDC formation (Mehandjiev et al., 2010).

4.2 Governance rules in the aerospace industry

Original Equipment Manufacturers (OEMs) commonly collaborate with hundreds of tier-1 suppliers that handle transactions with multiple SME clusters. Considering the presence of sensitive operational data and different attitudes of suppliers to information privacy, we propose a DSL to provide specialised constructs and to explicitly specify governance rules that facilitate demand-driven collaborations and encourage suppliers to join production networks. Table 4 exemplifies three governance rules identified by an aerospace OEM to support interaction with supplier clusters. In the table, the notion of a *meta-rule* refers to an abstract rule template conceivable for different governance modes; each meta-rule needs to be instantiated for a specific governance mode (referred below to as *collaboration regime*, which corresponds to the notion of *supply network archetype* proposed by Pathak et al., 2014; see also Section 4.3 below).

[21] The content of this section is based on: N. Kazantsev, P. Sampaio, G. Pishchulov, S. Cisneros-Cabrera, Z. Liu, N. Mehandjiev (2018). A governance metamodel for Industry 4.0 service collaborations. Submitted to: Proceedings of 2018 IEEE World Congress on Services, San Francisco, July 2018.

Meta-rule	*Instantiation of the meta-rule*	*Instruction or constraint?*	*Priority for DDC*
1	The partners of a DDC act autonomously regarding legal and economic decisions, but have to come to an agreement regarding the decisions in the name of the DDC.	Instruction	High
2	Every partner company has one vote.	Constraint	High
3	Decisions in the meeting of members have to be recorded, subscribed from auditor and made accessible for all partners.	Instruction	Medium

Table 4. Example of governance rules

4.3 Metamodel description

The abstract syntax metamodel restricts the possible structure of collaboration to demand-driven partnerships initiated by the new order (Fig. 19). The model defines the main concepts of a domain-specific language and their relationships, and includes formalisation of rules (Table 4) (Kleppe, 2008; Izquierdo et al., 2015).

The top-level construct in the model is the meta class *Document* (linked with a collaboration *Goal*) that includes: a group of supplier roles (*Role*), rules (*GovernanceMetaRule*) and deadlines (*Deadline*). A *Role* represents any supplier who participates in decision-making (candidate, leader, network coach, and auditor). A governance rule may involve decision making tasks represented in the *DecisionMakingMechanism* class, which also specifies whether a rule is either an additional instruction or process constraint (*ruleType*) and if it is related to knowledge protection, collaboration or security (*ruleScope*). The actual stage of partnership is encapsulated into Stage that could be either a (1) tender preparation, (2) collaborative design, or (3) task execution. *GovernanceMetarules* are linked with Resource and Process classes. They could be applied to a particular secrecy level (*appliedTo SecrecyLevel*) and a particular collaboration regime: *community*, *federation*, *consortium*, or *hierarchy* (*colRegime*) (Pathak et al., 2014). The scope of the rule can also be defined (*queryFilter* attribute) (Grefen et al., 2009) (e.g., high/low priority). Several types of decision rules are predefined: simple majority, qualified majority, or a privileged company's choice. E.g. under the simple majority rule (*Majority* metaclass), to commit a decision, it needs to be supported by over 50% of votes. When a supplier accepts or declines the proposed collaboration, it takes an active position in decision-making that is implemented into *LeaderDriven* metaclass.

4.4 Future work

The developed metamodel is applicable to enforce the governance rules for OEMs and their suppliers. The next steps include the formalization of the governance rules and their validation in an OEM supply chain according to the Description of Work.

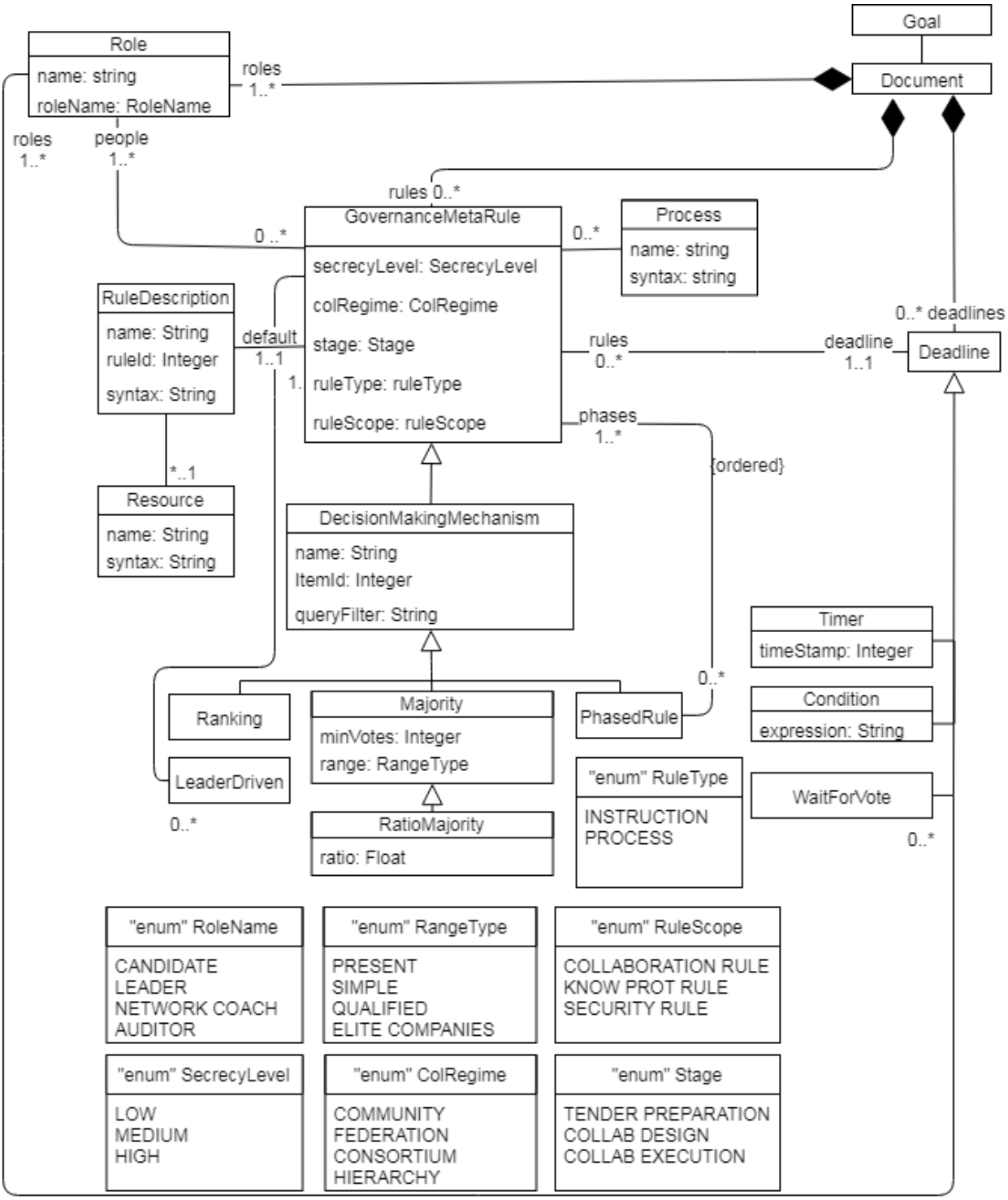


Figure 19: Abstract syntax of a metamodel to represent governance rules for demand-driven collaborations (based on: Izquierdo et al., 2015)

Annex A: History

Version	Date	Changes
V01	30 May 18	First draft
V02	31 May 18	Second draft
V03	01 June 18	Third draft

Annex B: Abbreviations

A/C	Aircraft
AMC	Acceptable Means of Compliance
APQP	Advanced Product Quality Planning
ARL	Airbus Requirements List
ASR	Airbus Supplier Requirements
BO	Business Opportunity
CFT	Call for Tender
CIP	Continuous Improvement Process
CREA	Coordination Requirements and Efforts Agreement
CS	Certification Specification
DDC	Demand-Driven Collaboration
DOA	Design Organisation Approval
DSL	Domain-Specific Language
EASA	European Aviation Safety Agency
EC	European Commission
EIS	Entry Into Service
ERP	Enterprise Research Planning
FMEA	Failure Mode and Effect Analysis
GeRS	General Requirements exchange Resource Site
GRAMS	General Requirements for Aerostructure & Material Suppliers
GRESS	General Requirements for Equipment Systems Suppliers
AIQG	International Aerospace Quality Group
ICT	Information and Communications Technology
IP	Intellectual Property
IT	Information Technology
KBD	Key Business Deliverable
KPI	Key Performance Indicator

NDA	Non-Disclosure Agreement
OBS	Organization Breakdown Structure
OEM	Original Equipment Manufacturer
PFMEA	Process Failure Mode and Effects Analysis
POA	Production Organisation Approval
QPR	Quality Procurement Requirements
RAM	Responsibility Assignment Matrix
RASCI	Responsible Accountable Support Consulted Informed
RFI	Request for Information
RFP	Request for Proposal
RSP	Risk Sharing Partner
RTAM	Requirement-Task Assignment Matrix
SCE	Initiative Supply Chain Excellence
SME	Small and Medium-sized Enterprises
SPR	Supplier Progress Report
TIM	Task Interdependence Matrix
UML	Unified Modelling Language
VBE	Virtual Enterprise Breeding Environment
VE	Virtual Enterprise
VO	Virtual Organization
WBS	Work Breakdown Structure

Annex C: Bibliography

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Annex D: Interview Guideline

Block A - Initial and Warm-Up Phase

1. Welcome and short introducing
2. Introducing myself and explaining my aviation industry background
3. Explaining DIGICOR, objectives of the Governance rules specification and expectations towards the interview
4. Introduction of interviewee, his background and what he or she might contribute
5. Facts of the company (if supplier)
   a) Business, turnover and employees
   b) Tier level, customers and suppliers

Block B - Aviation Supply Chain and Airbus as Customer

1. What are special characteristics of aviation supply industry?
   a) How significant is Airbus power and how does it influence the business?
   b) How do aviation legislation and certification requirements affect SMEs?
2. How is your company (or how are SMEs) involved in the aviation supply chain?
3. What challenges do SMEs face at the moment and in future?

Block C - Strategic importance of collaborations

1. Do you already have collaborations? (if supplier)
   a) Characteristics in terms of volume, frequency?
   b) Kind of collaborations: General long-term cooperation or business-opportunity-related collaboration?
   c) Why and how were these established?
2. Strategic positing of company (if supplier)
   a) How do you want to develop your business and what tier level do you aim at)
   b) How do you assess the importance of business-opportunity-related collaboration for your company in future?
3. How do you estimate the importance of of business-opportunity-related collaboration in the aviation supply chain?
   a) How realistic is a highly business-opportunity-related flexible set up of diverse collaborations with different partners?

Block D - Insight into functioning and coordination of collaborations

1. Can you give and explain any practical examples of collaborations in aviation industry?
2. How are authority, responsibility and duty allocated between the collaborating companies?
3. How is the collaboration coordinated and controlled?
4. What impact do customer requirements have on the way of how the collaboration is coordinated?
5. How do the collaboration partners coordinate with the customer?
6. How are collaborations initiated and set up?
7. Are the collaborations supported by any specific IT tool?
8. Do collaborations partner automate coordination mechanisms or connect internal management systems?
9. What are challenges, barriers and diculties for collaborations?

Block E - Support and improvement of collaborations

1. What aspects of collaborations would you like to (semi-)automate?
2. What potential do you see in IT-based support for collaborations?
3. What issues or risks could be reduced by supporting the collaboration?
4. Do you expect an integration of internal management systems of the partners?

Block F - Airbus internal procurement policies and procedures

1. How does the procurement process at Airbus work?
2. What are Airbus expectations and requirements towards suppliers?
3. What is Airbus' policy and attitude towards SMEs?
4. What are the main challenges for establishing SME collaborations in aviation industry?

Block G - Emotional questions to simulate the discussion

1. What frustrates you most in the aviation supply industry?
2. What frustrates you most about Airbus?
3. What are your biggest concerns for the future?
4. What are your biggest hopes for the future?

What would the ideal aviation industry look like?

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