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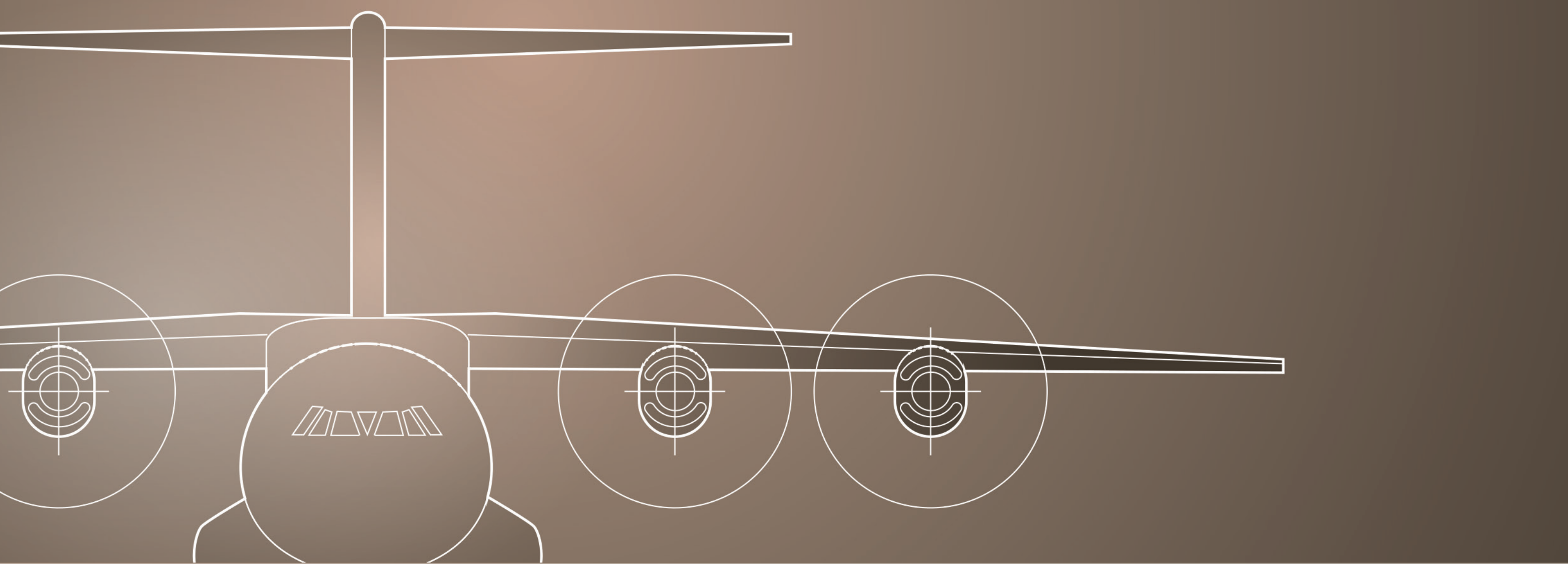

Are large projects in the aerospace and armaments industries still manageable?

The logic behind the problems

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CONTENTS

EXECUTIVE SUMMARY

Over the last few years, the vast majority of the projects associated with the aerospace and armaments industries have been put under the microscope on account of delays, cost overruns and qualitative shortcomings. This occasional report deals with the central issue of the backgrounds of these projects. An analysis of the latest programmes from the aerospace and armaments industries indicates that these problems can be traced back to four causal challenges: The first challenge is a result of the large number of partners involved in the programmes in question and their various interests. This results in the emergence of requirements that can only be fulfilled at a high cost. Excessive and non-reflective project goals are the consequences, which represent the second challenge. The implementation of these project goals in a concrete product concept leads to the third challenge, which manifests itself in the form of a technologically challenging performance system. The results are high risks in development and production. The strong need for developmental and production-related expertise and the associated capacities calls for a globally distributed network of development and production. This fourth challenge immediately leads back to the high number of partners involved in the programme. Such a multitude of partners is necessary, in order to provide the required expertise and resources and distribute the risks. A detailed consideration of the A400 programme which takes the identified challenges into account clarifies the practical relevance of the said challenges.

An analysis of the latest programmes from the aerospace and armaments industries indicates that these problems can be traced back to four causal challenges.

The last section of the occasional report illustrates problem-solving approaches that have proved their worth in other organisations and sectors that face similar challenges. The preliminary management of expectations can minimise frictional losses in the cooperation that takes place between the programme-partners. A critical reflection upon the project goals and an assessment of the requirements (with respect to their practicability) lead to realistic goal-setting and goal-testing processes. A technologically challenging performance system can be managed through the management of developmental and production risks (which is closely linked to the development and production phases). Measures that minimise the reaction-time associated with collaboration that takes place within the respective network and build bridges between the various locations, cultures and languages are part of the management of interfaces and represent the final problem-solving approach.

1. INTRODUCTION

1.1. BACKGROUND AND TARGET-SETTING

Projects in the aerospace and armaments industries subject both the client and the industry as a whole to the most significant challenges associated with the technological implementation of the projects in question, the duration of the programme and the associated costs. The A400M is a recent example of this. Programme costs of more than 20.9 billion euros, a project-duration that has already gone up to twelve years and a current total of seven participating nations (Belgium, Germany, France, Luxembourg, Spain, Turkey and the United Kingdom) indicate the scale and complexity of the project.[1]

Projects of this magnitude are often on the border of technological and financial feasibility, as indicated by the problems and difficulties that go hand in hand with such projects. So far, the A400M programme has been unable to attain its budgetary and schedule-related goals. It has also been unable to attain the performance-related goals that were set at the beginning of the project. Consequently, in the year 2009, the very existence of the project was called into question, and the project was in danger of being cancelled.[2] The project could only be continued after an additional injection of billions was made available and compromises were made vis-à-vis the fulfilment of the requirement profile.

However, the A400M programme is not an isolated incident. Similar problems have plagued a variety of other projects, such as the Boeing 787 Dreamliner, the A380 and the Joint-Strike-Fighter programme that led to the development of the F-35. This indicates that certain common causes are responsible for maldevelopments of this nature. This report presents the result of a study that was conducted in 2012 and which analysed the backgrounds associated with these problems. The results have been applied to the example of the A400M, and practically-orientated problem-solving approaches have been derived. The following goals are at the fore:

- » To identify the central challenges that need to be overcome, in order to avoid the well-known problems associated with complex aerospace and armaments projects.
- » To present proven problem-solving approaches, in order to make it possible to respond to these challenges.

The findings produced by the study open up a new perspective vis-à-vis the backgrounds of the budgetary, schedule-related and quality-related problems that are associated with complex aerospace and armaments projects and which were previously at the fore.

1. OCCAR: OCCAR Business Plan 2012, Bonn, October 2011, page 12.
2. Spiegel interview with Airbus CEO Thomas Enders, 30 September 2009; UK Defence Committee: Defence Equipment 2009: Government response to the Committee’s Third Report of Session 2008–09, 26 February 2009, page 3.

1.2. METHODOLOGY

The study was centred round an analysis of current projects from the aerospace and armaments industries. Agency reports, press reports and reports produced by regulatory authorities were used to reconstruct the workflows of and the problems associated with the following projects:[3]

- Boeing 787 Dreamliner
- Lockheed Martin Joint Strike Fighter F-35
- Airbus A380
- Airbus Military A400M

Based on this, common causes for the illustrated problems were identified with the help of a qualitative data-analysis process. A consideration of the identified challenges that took the form of a case study and which looked at the example of the A400M and the derivation of problem-solving approaches conclude the study. The focus was on problem-solving approaches that have already proven their worth in sectors that face comparable challenges.

3. The study subjected a total of 64 documents to a qualitative data-analysis process.

2. CHALLENGES OF COMPLEX AEROSPACE AND ARMAMENTS PROJECTS

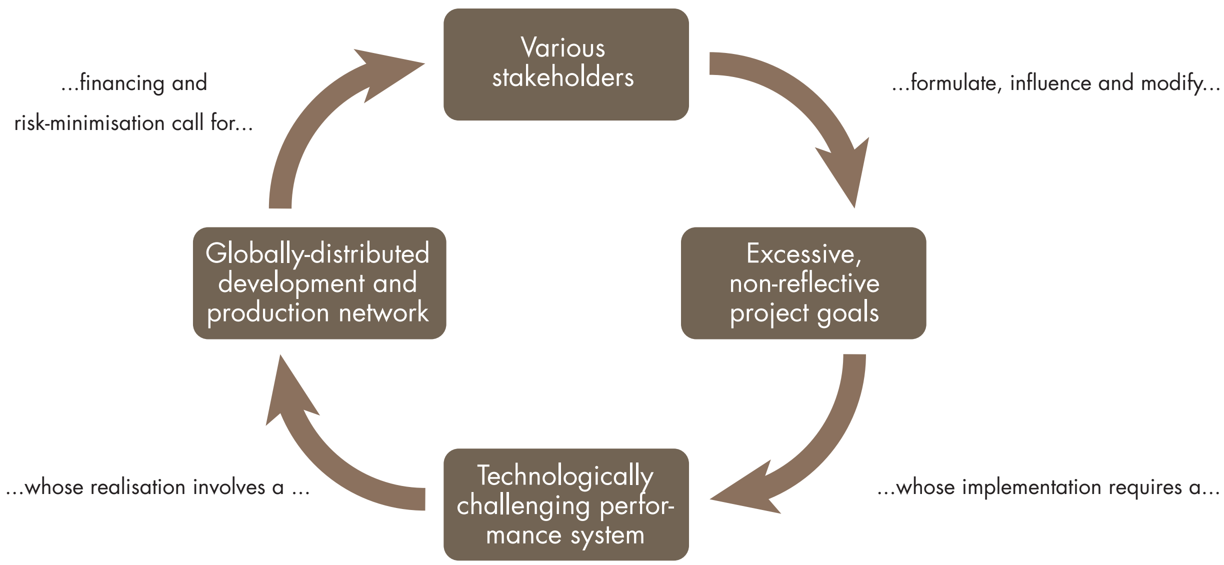
2.1. THE LOGIC BEHIND THE PROBLEMS

The published documents illustrate a large variety of problems. These range from deficiencies in the communication between the participating stakeholders to difficulties associated with the technological realisation of the various programmes. The problems which, at first glance, do not seem to be related to each other, can be classified into four causal challenges:
Various stakeholders,

» Excessive, non-reflective project goals
» Technologically challenging performance system,
» Globally-distributed network of development and production.

These challenges should not be considered to be isolated from each other. Rather, they can lead to a vicious circle in which the challenges keep on intensifying (positive feedback) (figure 1). For example, the various interests of the participating stakeholders can result in the emergence of performance goals that can only be realised at a very high cost. These result in the emergence of production concepts whose implementation is associated with significant technical risks. This goes hand in hand with a high development cost and a complex network of suppliers. The resultant globally-distributed network of development and production is linked with a variety of stakeholders (whose purpose is to minimise the risk and finance the project), who round out the circle.

FIGURE 1: THE FOUR IDENTIFIED CHALLENGES CAN LEAD TO AN INTENSIFYING CYCLE



Source: Cooperational Excellence study - 'Challenges associated with large projects in the aerospace and armaments industries'

2.2. VARIOUS STAKEHOLDERS

Cooperation is sought based on either a gap in capabilities that has been detected by the stakeholders, or an identified market requirement, in order to define a suitable performance system that is based on a common framework. A performance system is understood to be the sum of all measures (hardware, software and service components) that has to meet the expectations of all the participating stakeholders. Based on these capability gaps or the market requirement, requirements are formulated and appropriate technical solutions are identified. For the utilisation phase, additional service components such as logistics, training etc. are integrated.

However, in practice, the complexity of this procedure is underestimated, given the variety of programme partners who are involved in the project and their various interests (economic, civil, military, geo-political and industrial-political). Such a situation is associated with a dynamic network, which consists of a variety of organisations:

- Original Equipment Manufacturer (OEM),
- Suppliers in the various supply stages,
- Development service provider on the OEM side and the supplier side
- Public-sector clients and
- Military and/or civil institutions as future users of the performance system.

Along with the fundamentally different interests that shadow the organisations that are involved with this network, each one of the participating stakeholders introduces various requirements. In civil as well as military programmes, it is the communication between the OEM and the supplier that results in a multitude of problems. Difficulties associated with the synchronisation of the progression of the project and the capacity-related requirements and difficulties associated with the solving of quality-related and production-related problems directly influence the costs associated with the programme and its schedule. In case of military programmes, another critical point is the communication between the industry and the public-sector client. The fundamentally different operating principles and attitudes of these stakeholders give rise to friction between the entities in question. This friction can negatively influence the programme's progress. Furthermore, when it comes to situations involving multinational programmes and public sector clients, the presence of an in-house budget law and in-house provisions associated with the legal aspects of aviation should be taken into consideration. Furthermore, the effects that cultural and linguistic differences have at the working and organisational levels must be taken into account, for both civil and military programmes.

The fundamentally different operating principles and attitudes of these stakeholders give rise to friction between the entities in question.

2.3. EXCESSIVE, NON-REFLECTIVE PROJECT GOALS

The necessity of plugging a capability gap that has been detected or that of tapping new market segments leads to a need that has to be fulfilled. The need for a new performance system can arise as a result of various reasons:

- The end of the service life/product cycle of a performance system has been reached.
- A new mission profile should be covered.
- A gap in the market should be bridged.
- The obsolescence of spare parts makes it necessary to replace a performance system.

In the public sector, this requirement leads to the formation of a requirement profile in the form of project goals that can be fulfilled using a performance system that is already available in the market, or that need to be fulfilled within the framework of a development project that is subject to well-defined budgetary, time-related and quality-related goals. In the civil sector, a development project is initiated after a feasibility study has been carried out. However, in practice, both cases result in problems associated with the definition of this requirement profile and the definition of the project goals. Especially in case of multinational armaments projects, the requirements placed on the performance system by the stakeholders are too extensive and too different to be reduced to a common denominator. This results in an inflated requirement profile that can only be fulfilled with a suitably complex performance system.

Excessive project goals (e.g. range, comfort, operating costs) generate significant production-related and developmental risks.

In an ideal scenario, the requirement profile is satisfied through a performance system that is in the form of an existing physical product. When it comes to military projects, products that are not yet available in the market are, during the initial phase, described with the help of a weapons system specification that has a tendency to try to over-fulfil the requirements. The mechanism that lies behind this phenomenon is based on an attempt to ensure that the performance system to be developed has a competitive edge over existing performance systems.

A similar development can also be seen in civil programmes. Excessive project goals (e.g. range, comfort, operating costs) generate significant production-related and developmental risks. Additional programme risks arise as a result of the instability of the requirements as well as that of the specification related to timeline.

Unlike the situation associated with a system that is already available in the market, a situation involving a system that is yet to be developed offers the option of introducing changes at the concept level without incurring large expenses. Basically, each change (and each intervention) leads to costs that are usually not budgeted to an adequate degree in an early phase of the project and that result in additional charges over the course of the project. This is particularly applicable in case of programmes that follow the cost-plus approach and directly link budgets to the implementation of a specific technical solution.

2.4. TECHNOLOGICALLY CHALLENGING PERFORMANCE SYSTEM

If the situation involves implementing a requirement profile in the form of a new performance system whose performance absolutely has to eclipse that of the established systems or that of the systems that are available in the market, it usually involves breaking new technological ground. A principle of product-development indicates that 70-80% of the costs are established in the phase in which the concept is defined. New product concepts, new production processes and extensive computer-supported assistance systems are faced with proven solutions that are already available and which are associated with a negligible developmental risk. This creates tension between the performance and the risk. This tension directly affects the costs, the schedule and the quality of the programme in question. In case of projects involving public-sector clients, this tension is overlaid with decisions (which have been mentioned in the previous section) that are driven by the interests of the respective parties. The focus is on the following technological fields:

- Fibre-reinforced materials (FVK) are used, in order to reduce the weight of the product. However, these materials can be particularly problematic when it comes to producing structural parts. Furthermore, the fact that it is difficult to repair these materials (with respect to both the manner in which they are used and their operations) results in a high degree of complexity and high costs.
- On the one hand, the introduction of extensive electronic assistance systems improves the performance of a product. On the other hand, the magnitude of the associated expenditure (with respect to the development and qualification of the software) is underestimated and represents an ever-increasing proportion of the programme-risks.
- When it comes to engines, the technological complexity of the task at hand and the interest-driven decisions generate high additional costs, in case of new developments or alternative engines.
- Especially in case of military programmes, the electronic warfare systems, helmet-view systems and thrust-vectoring systems make the avionics complex and extensive. These systems are necessary to reach new ranges of performance, but their implementation also involves a high degree of risk.

Furthermore, the situation also involves extensive service-components (e.g. the logistics associated with spare parts, technical maintenance, training and operations) that need to be provided over the entire life-cycle of the system that is to be developed. In particular, developing complex service-components that are subject to various requirements and parameters is a challenge in itself. When linked with the parallel development of the technical systems, this challenge becomes even more potent.

2.5. GLOBALLY-DISTRIBUTED DEVELOPMENT AND PRODUCTION NETWORK

The task of implementing technologically challenging performance systems calls for a capable network of development sites, production sites and suppliers. The task of setting up a globally-distributed network of development and production is plagued by the following difficulties:

» The outsourcing of value-added parts to suppliers leads to long reaction times in case of changes in the product, production-related problems and quality-related problems,
» The utilisation of different standards and tools in the development and production processes leads to compatibility issues that can often only be detected when the components are being assembled,
» The communication between the network partners (which is particularly necessary for effective collaboration) is made more difficult by cultural differences and their dislocation,
» In case of programmes with public-sector clients, clear and transparent management structures, which are necessary for the demarcation and synchronisation of the work-packets in the network, are distorted due to decisions motivated by industrial-political factors.

Even when it comes to the task of defining the production structures and processes, the principle that indicates that a large part of the subsequent production costs (investments and manufacturing costs) are established in the conceptualisation phase is applicable. Belated changes made to a steady-state system go hand in hand with significant additional costs and productivity losses and represent threats to the very success of the overall programme.

3. BETWEEN REQUIREMENT AND REALITY: DÉJÀ-VU A400M

3.1. INTRODUCTION

The A400M programme is the largest collaborative European armaments project of all time. It is the latest manifestation of a long tradition of European cooperation in the field of armaments, which ranges from the Alpha Jet to the Panavia Tornado, its successor, the Eurofighter Typhoon and the direct predecessor of the A400M, the C-160 Transall.

The study that was conducted shows that in case of the A400M, the known problems are just the tip of the iceberg.

In spite of the multitude of projects and the experience that has been gained from them, the A400M programme has attracted attention due to a variety of problems. The study that was conducted shows that in case of the A400M, the known problems are just the tip of the iceberg. The logic behind these problems corresponds to the four identified challenges:

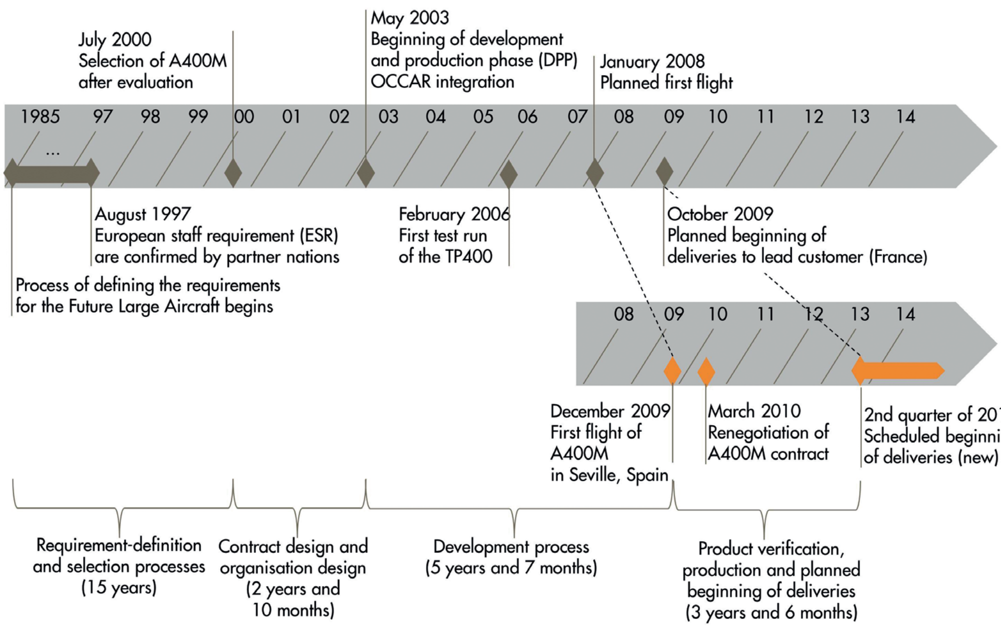
- Various stakeholders,
- Excessive, non-reflective project goals
- Technologically challenging performance system,
- Globally-distributed network of development and production.

The following section examines the A400M programme against the backdrop of the identified challenges. The examination focuses on identifying the effects that these challenges had on the programme and illustrating the problem-solving approaches that can be derived from the situation in question.

3.2. THE STAKEHOLDERS INVOLVED IN THE PROCESS AND THEIR EXPECTATIONS

In 1985, the need to replace Europe's ageing fleet of military transport aircraft with a new model induced Belgium, Germany, France, the United Kingdom, Italy, Portugal, Spain and Turkey to initiate the Future Large Aircraft (FLA) project. The project was implemented in the form of an FLA working group, which was assigned to Panel I ('Equipment, Planning and Replacement Schedules') of the Independent European Program Group (IEPG).[4] The goal of the working group was to standardise the partner-nations' requirements vis-à-vis a new military transport aircraft. Thus, in the first phase of the project, the FLA working group, which was integrated into the IEPG, represented the public-sector clients and the future users of the A400M. In addition to the industrial sector, it is possible to define the two major groups of stakeholders that were involved with the A400M programme. With respect to the individual phases of the project (figure 2), there exists a complex and dynamic network (figure 3) that influences the course of the programme.

FIGURE 2: THE A400M PROGRAMME CAN BE DIVIDED INTO FOUR PROJECT-PHASES



Source: Cooperational Excellence study - 'Challenges associated with large projects in the aerospace and armaments industries'

4. Covington T.G., Brendely K. W., Chenoweth, M. E.: A Review of European Arms Collaboration and Prospects for its Expansion under the Independent European Program Group, A RAND NOTE, July 1978, page 6.

FIGURE 3: THE A400M PROGRAMME IS CHARACTERISED BY A COMPLEX AND DYNAMIC NETWORK OF VARIOUS STAKEHOLDERS

	Requirement-definition and selection processes 1985 – 2000	Contract design and organisation design 2000-2003	Development process 2003 - 2009	Product verification, production and delivery 2009 -
Public-sector clients & users	» IEPG (85-92) » WEAG (92-05) » WEAO (96-06) » National regulations	» IIPO (01-03) » OCCAR (03) » WEAG (92-05) » WEAO (96-06) » National regulations	» OCCAR (03) » EDA (04) » WEAG (92-05) » WEAO (96-06) » National regulations	» OCCAR (03) » EDA (04) » National regulations
Industry	» FIMA (82-90) » EUROFLAG (90-95) » FLA military transport project, (95-99) » Airbus Military Company (99-01) » Airbus Military S.A.S. (01-03) » Other suppliers	» Airbus Military SL (03-09)	» Airbus Military (09)	» Airbus Military (09)

Source: Cooperational Excellence study - 'Challenges associated with large projects in the aerospace and armaments industries'

3.2.1. PUBLIC-SECTOR CLIENTS AND USERS

Right from the beginning, the A400M programme was characterised by the presence of a variety of changing clients who had different interests, expectations and power-relations. In 1992, the IEPG, which was initially responsible for the FLA working group, separated from the Western European Armaments Group (WEAG), which is subordinate to the Western European Union. In 1996, the WEAG was supplemented by a Western European Armament Organisation (WEAO), which turned it into a precursor to a European armaments agency. The task of the WEAO was to coordinate collaborative developmental and technology projects.[5] Due to a lack of resources, unsatisfactory structures and a lack of authority, neither the IEPG nor its

Due to a lack of resources, unsatisfactory structures and a lack of authority, neither the IEPG nor its successor organisation (the WEAG/O) could satisfactorily assume the leadership role that is so critical to the success of projects of this magnitude.

5. WEU Secretariat-General: WEU Today, January 2000, page 16.

successor organisation (the WEAG/O) could satisfactorily assume the leadership role that is so critical to the success of projects of this magnitude.[6] Consequently, in 1986, a further 21 projects were assigned to Panel I of the IEPG (which was already handling the FLA working group).[7] These projects were coordinated on a part-time basis by a small team of permanent employees and national representatives of the participating countries.[8]

However, the difficulties associated with standardising the FLA-requirements are not restricted to the role of the intergovernmental organisations that are involved with the process. Solo efforts by the partner-nations created additional delays and conflicts of interest. For example, the United Kingdom withdrew from the FLA working group to pursue an independent initiative, only to re-join the working group at a later date. Italy and Portugal eventually decided to withdraw completely from the programme.

In 1997, after negotiations that lasted for twelve years, the requirements were confirmed by the partner-nations in the form of the European Staff Requirement (ESR). However, the different interests of the participating countries continued to exert a significant influence on the programme's progress, as shown by the process of selecting the performance system to be acquired:[9]

» In September 1997, Belgium, Germany, France, the United Kingdom, Italy, Spain and Turkey requested Airbus to implement the ESR within the framework of the FLA military transport project.
» In July 1998, a process that was coordinated by the United Kingdom led to an enquiry based on the ESR being forwarded to Airbus, Boeing and Lockheed Martin. This enquiry had the support of Belgium, Spain and France.
» In March 1998, an initiative that was coordinated by Germany and which featured the participation of France and Spain was launched for the AN7x.

The fact that three different enquiries were sent to different suppliers by three different interest-groups indicates that this particular process was also dominated by individual interests and a lack of leadership.
In June 2000, 15 years after the FLA project was launched, the defence ministers of the seven participating nations (Belgium, France, Germany, Spain, Turkey and the United Kingdom) indicated that a decision had been made to re-develop the FLA, which had, in the meantime, been named the 'A400M'. With the reaching of this milestone, the responsibility of negotiating the contracts on behalf of the partner-nations was transferred to an international interim

6. DeVore, M., Eisenecker S.: The Three Ages of Armaments Collaboration: Determinants of Organizational Success and Failure, Paper prepared for the SGIR Conference 9-11 September 2010, page 6 ff.

7. Covington T.G., Brendely K. W., Chenoweth, M. E.: A Review of European Arms Collaboration and Prospects for its Expansion under the Independent European Program Group, A RAND NOTE, July 1978, page 6.

8. Taylor T.: European Defence Cooperation, Royal Institute of International Affairs, London, 1984, page 24.

9. UK Parliament Committee on Defence Appendices to the Minutes of Evidence: Memorandum from the Ministry of Defence on Major Procurement Project Survey, Appendix 8, March 2002.

project office (IIPO). Subsequently, in 2003, the responsibility for the project was passed on to the Organisation Conjointe de Coopération en matière d'Armement (OCCAR), which had been founded to manage multinational armaments projects. However, the attempt to concentrate responsibility for the project (which manifested itself in the formation of the IIPO and the OCCAR) at a single location failed, in spite of the fact that the attempt generated, in comparison with the IEPG and WEAG/O, a significant flow of additional resources. The various interests, expectations and power-relations of the participating stakeholders, which had been dominating the FLA project right from the beginning, continued to exert an unrestrained influence on the progress of the programme. The differences between the industrial sector and the public-sector clients were made clear by the process by which the propulsion system for the A400M was selected. Although the engine offered by Pratt & Whitney, namely, the PW180, was at a higher state of development and would have been associated with lower costs, political pressure induced Airbus Military to go with a European propulsion system.[10] Finally, the European consortium called Europrop International (EPI) was tasked with redeveloping the TP400-D6.

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Ever since the contract was signed, OCCAR has been responsible for handling the client-side management of the A400M programme. However, it wasn't able to fulfil its leadership role vis-à-vis the stakeholders who are involved with the project during the development phase. Delays and cost overruns, whose backgrounds and extent only became clear through an external audit that was carried out in the year 2009, have so far dominated the A400M programme.[11]

3.2.2. INDUSTRY

After the public-sector clients of the performance system, the industrial sector represents the second of the two main groups of stakeholders. In spite of the fundamentally different structures and roles of the industrial sector and the public-sector clients, a similarly complex and dynamic pattern of collaboration became apparent. Constant organisational modifications, changing companies, different expectations and the influence exerted by economic and political interests characterised the collaboration between the partner companies, and this affected the progress of the project.

10. Reuters: Warbus: The Incredible Saga of Europe's A400M, Reuters Special Report, May 2010, page 3 f.

11. Reuters: Auditors blast EADS management over A400M, Reuters Press Release, 20 January 2010.

In 1982, companies belonging to the Airbus industrial consortium (Aerospatiale, British Aerospace, Messerschmitt-Bölkow-Blohm) and Lockheed-Georgia proposed to join forces within the framework of the Future International Military-Civil Airlifter (FIMA) consortium, in order to develop concepts for a new transport aircraft. As an international initiative launched by the aerospace industry, FIMA's goal was to bridge the gaps that were expected to arise in the market for medium-level transport aircraft. At that point in time, there were no homogeneous requirements for a future transport aircraft, which is why many different conceptual designs were drawn up.

These concepts represent an attempt to do justice to the differing requirements of the American, British, French and German air forces.[12] In 1989, against the backdrop of uncertainty regarding when the US air force would acquire a successor of the C-130, Lockheed Martin decided to withdraw from the FIMA and focus on re-developing the C-130.[13] After the dissolution of FIMA by the participating partners and Lockheed's withdrawal from the project, the European Future Large Aircraft Group (EUROFLAG) was founded in 1990. Along with the participation of the European companies that were already part of the FIMA consortium, EUROFLAG also saw the participation of Alenia and CASA. In 1992, Sabca, Sonaca (Belgium), OTMA (Portugal) and TAI (Turkey) were, within the framework of feasibility studies, factored into the project's activities.[14] With the founding of EUROFLAG, the priority of the concept development aligned itself with the existing requirements of the FLA working group, which was associated with the Western European Armament Group (WEAG).

The time that has elapsed since the FIMA was founded in 1982 has been characterised by constant restructuring operations, mergers and realignments on the part of the industrial partners. On the one hand, this dynamic encompassed the cooperation-level in the form of FIMA, EUROFLAG and their successor organisation, namely, Airbus Military Company. For example, after withdrawing from FIMA in the year 1989, Lockheed later attempted to become a partner of Airbus's FLA operational group, which was established in 1995. In 2001, Alenia, a founding member of EUROFLAG, withdrew completely from the FLA project. On the other hand several changes were made at the organisational level of the industrial partners themselves over the duration of the project. For example, Messerschmitt-Bölkow-Blohm, which was a founding partner of FIMA, was taken over by DASA. DASA itself was formed as a result of the merger that took place between Dornier, MTU and AEG.

In 1995, yet another change took place at the cooperation-level, which led to the dissolution of EUROFLAG. As an interim solution, an Airbus FLA operational group was established to continue the project up to the founding of the Airbus Military Company. The founding of Airbus Military Company (AMC), which was part of Airbus Industries, was, with respect to

12. Empson, D. K.: European Future Large Aircraft in Noor, A.K., Venneri, S.L. (Eds): Future Aeronautical and Space Systems, volume 172, 1997, page 106 ff.

13. Flight International: Lockheed quits FIMA group, 17 June 1989, page 32.

14. Flight International: Labourer wanted … Apply RAF, 24 March – 30 March 1993, page 32.

the civilian market, supposed to generate synergies between development projects. During this period of time, the very existence of the FLA project was called into question, due to disagreements regarding the financing of the project[15] and solo efforts in the evaluation of alternative solutions. This delayed the founding of the AMC. For example, the German government commissioned DASA, which was directly involved with the FLA military transport project, to carry out a feasibility study for the A7x. This study irritated the participating programme-partners and created conflicts of interest for DASA, which was simultaneously involved with the FLA project.[16]

In 1999, after several years of political negotiations, the Airbus Industries FLA Operational Group was replaced by the newly-formed Airbus Military S.A.S. (company that is subject to French law and which is headquartered in Toulouse). With the founding of EADS in the year 2000, the responsibility for the newly-christened A400M programme was transferred to the Spanish company CASA, which was a founding member of EADS. After the A400M was selected and before the contract was signed in 2003, Airbus Military SAS became Airbus Military SL (AMSL). At the time, AMSL was part of the Military Transport Aircraft Division (MTAD), which in turn belonged to EADS CASA. This complex structure made it difficult to generate the desired synergies with Airbus Industries. When, in the year 2009, it became clear to the management of EADS that neither the cost-related goals nor the schedules associated with the A400M programme could be attained, the subject of a restructuring of Airbus Military was broached. Furthermore, in the year 2009, the external audit that was mentioned previously led to the public disclosure of a series of management problems (in terms of cost control and progress control) on the part of Airbus Military SL.[17] Within the framework of the restructuring process, MTAD and Airbus Military SL were consolidated into Airbus Military (which was directly subordinate to Airbus Industries) with the goal of simplifying the structures and pooling the responsibility for the A400M programme.[18]

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The combination of a variety of ever-changing stakeholders and the lack of an alignment of the associated expectations led to frictional losses which emerged over the entire course of the project. In this respect, the term ‘frictional loss’ refers to any effort that made no direct contribution towards the processes of defining, agreeing and attaining the programme’s goals. Furthermore, there are inter-cultural and organisation-based cultural aspects that impede collaboration between the international industrial partners and collaboration between the public sector and the industrial partners. The consequences of these frictional losses cannot be allocated to any specific phase. They affect the overall progression of the programme.

15. Flight International: Airbus confronted by defeat on FLA, 22 May - 28 May 1996, page 18.

16. Flight International: Bonn’s high risk An-70 strategy threatens UK FLA participation, 25 February - 3 March 1998, page 22.

17. Reuters: Auditors blast EADS management over A400M, Reuters Press Release, 20 January 2010.

18. EADS: EADS fully committed to succeed in A400M program, EADS Press Release, 10 February 2009.

3.3. AMBITIOUS AIMS AND THEIR CONSEQUENCES

The programme-goals were established in the first two phases ('definition and selection of requirements' and 'contract design and organisation design'). The fact that it took 17 years and 10 months to formulate these goals (which now look excessive)[19] can be attributed to the aforementioned frictional losses, which emerged as a result of the ever-changing stakeholders and their incompatible expectations. A distinction can thus be made between four inter-dependent programme goals:

3.3.1. PERFORMANCE GOALS

In 1997, the collection of the individual requirements of the partner-nations was used to establish the performance goals of the FLA in the form of the ESR. All the performance parameters were subjected to high requirements,[20] which, at the time of creation, could not be fulfilled in their entirety by any of the available performance systems. Consequently, the mission profile, which had a significant tactical component, led to the selection of a turboprop propulsion system. An engine belonging to the desired performance class was not available in the market, and had to be developed from scratch. Another requirement was for the aircraft, the engine and the propeller to be able to acquire a civil licence.[21] The existing civil licensing procedure was supposed to be used as a basis for the simplification and acceleration of the licensing process. In fact, this requirement led to a significant amount of additional expenditure and caused delays in the certification process. Among other things, the fully-automatic, low-altitude flight capabilities that were demanded by Germany right at the outset were, within the framework of the renegotiations that were carried out in with a view to reducing costs, cancelled in the year 2010.[22]

3.3.2. QUANTITATIVE TARGETS

Quantitative targets represent one of the most important project-premises for the economic feasibility evaluation of any performance system. On the one hand, they serve as the basis for a make-or-buy decision. On the other hand, if the decision is made to 'buy', they are necessary in order to be able to evaluate volume effects during the phase in which the performance system is designed. Especially when it comes to the introduction of new systems associated with high development costs, the volume effects can be used to absorb the resultant development costs.

At the beginning of the FLA project, an initial quantitative target of 300 aircraft was set, in order to be able to map the project, within the framework of the necessary requirement pro-

19. Europolitics Insight: Airbus A400M programme, EADS CEO Louis Gallois in his own words, Europolitics Issue 3722, 26 March 2009, page 28.Spiegel Interview with Airbus CEO Thomas Enders, 30 September 2009.

20 Flight International: One size fits all, 9 November – 15 November 2004, page 43 – 45.

21. Mundt, R.: A400M Program, EASA and CQO Collaboration, Lessons learnt from the joint civil-military certification approach on a military transport aircraft, Presentation presented to MAWA Conference, Poland, 6/7 July 2011, page 5.

22. Reuters: A400M talks eyed as bailout draws close, Reuters Press Release, 4 November 2010.

file, in an economically feasible manner.[23] This quantitative figure was revised downwards several times over the course of the project. In June of 2001, at the airshow in Le Bourget, the participating nations confirmed their intention to produce 212 aircraft. However, in December of the same year, Italy withdrew completely from the A400M programme. According to a statement made by the defence ministers in July 2000 during the Farnborough airshow, France, Belgium and Spain were the only countries that were in a position to adhere to the initial quantitative targets. The quantitative figures were changed on a regular basis, thanks to a series of approvals, declarations and contract-signings. The current quantitative target of 174 was reached after Malaysia became the first overseas customers for the A400M and expressed its willingness to purchase four aircraft in the year 2005. This figure represents a reduction of 42 percent from the initial figure of 300 aircraft that was set in order to be able to map the A400M in an economically feasible manner.

The quantitative figures were changed on a regular basis, thanks to a series of approvals, declarations and contract-signings.

FIGURE 4: THE QUANTITATIVE TARGETS OF THE A400M PROGRAMME OVER THE PASSAGE OF TIME

Source	Date	Belgium	France	Germany	Italy	Luxembourg	Portugal	Spain	Turkey	Malaysia	UK	Total
Flight International 14-20 July 1999	July 1999	12	50	75	44	-	-	36	26	-	45	288
Declaration by ministers	27.07.00	7	50	73	16	1	-	27	26	-	25	225
European nations formally commit to A400M program	19.06.01	7	50	73	16	1	3	27	10	-	25	212
Contract signing OCCAR	18.12.01	7	50	73	-	1	3	27	10	-	25	196
Contract signature Airbus Military OCCAR	27.05.03	7	50	60	-	1	-	27	10	-	25	180
Airbus Military Website	Oct 2012	7	50	53	-	1	-	27	10	4	22	174

Source: Cooperational Excellence study - 'Challenges associated with large projects in the aerospace and armaments industries'

23. Flight International: Labourer wanted … Apply RAF, 24 March – 30 March 1993, page 32.

3.3.3. COST TARGETS

In the year 2001, Airbus Military and the IIPO (which, at the time, was representing the partner-nations) agreed on a price for the A400M. A fixed price of 18 billion euros was set for a total of 196 aircraft. A subsequent contract that was signed in 2003 between Airbus Military and OCCAR resulted in the number of aircraft being reduced to 180 and the fixed price being increased to 20 billion euros. If the earnings expectations defined by Airbus Military are deducted from and the volume effects are factored into the consideration, it becomes possible to use the fixed price to derive the cost targets and the budgets for the development and assembly of the A400M. The results of the programme-audit that was carried out in December 2009 indicated that these cost targets did not conform to the functional performance goals and were placed under additional pressure by the multiple reductions of the quantitative targets. A funding shortfall of 11 billion euros was identified.[24] March 2010 saw the beginning of contract negotiations whose goal was to use a series of measures to plug the funding shortfall.[25] The focus was on dividing the additional costs between the industrial sector and the partner nations, sacrificing the functional performance goals and reducing the number of units. Opportunity costs that came about as a result of the delays were also added. On account of the delayed availability of the A400M, the air forces of the partner nations were forced to purchase transport capacities as stopgap measures.

3.3.4. SCHEDULING TARGETS

At the beginning of the A400M programme, it was agreed that there would be a gap of six years between the signing of the contract and the first delivery.[26] An integrated commercial approach was used, in order to sustain such a short programme duration. Towards that end, the development, production, delivery and logistical support of the A400M were pooled into a single contract. In case of the Tornado, the Eurofighter, the NH 90 and the Tiger, the periods of time between the first flights and the initial deliveries amounted to eight years, nine years, eleven years and twelve years, respectively. This does not include the period of time between the signing of the contract and the development and production of the first prototypes. In reality, the agreed upon period of six years was not sustained. The first flight of the A400M was postponed by a period of 23 months, from January 2008 to December 2009. As a result, the goal of delivering the A400M to France (the first customer) in October 2009 underwent several delays. The current delivery deadline lies in the second quarter of 2013. This period of time, namely, ten years, lies in the neighbourhood of the programme durations of comparable European air armament projects.

After an overall programme duration of ten years after the contract was signed in the year 2003, it has become clear that none of the programme targets that were agreed upon during the initial phase of the project have been attained in their entirety. This raises questions about

24. Reuters: UPDATE 3-Auditor blasts EADS over A400M, Reuters Press Release, 20 January 2010.

25. Reuters: UPDATE 2-Buyers meet as Airbus A400M bailout nears, Reuters Press Release, 4 November 2010.

26. Airbus Military Website: A400M The Solution, The Commercial Approach: "A single development and production phase is a vital element of the commercial approach and is how Airbus Military can commit to a 6 year programme from contract effectiveness to first aircraft delivery."

the quality of the process by which the targets were set and the reliability of the statements that were issued. The current critique of the excessively ambitious programme goals shows that the stakeholders did not reflect upon them (the programme goals) in a critical manner and to a sufficient degree.

3.4. THE TECHNICAL CONCEPT OF THE A400M AND THE IMPLEMENTATION-RELATED RISKS

At the time of the selection process associated with the A400M, the aircraft only existed in the form of conceptual studies. In order to make it possible to assess the A400M concept, all the technical performance-related features were defined in an aircraft technical specification. It was adjusted repeatedly until the A400M concept looked like the best option for fulfilling the ESR.[27] Since the required performance goals are very challenging, it was necessary for the performance system described in the specification to be elaborate enough, from a technical point of view, to attain these performance goals. The associated developmental and production-related risks were only detected at a later stage of the programme. In essence, these risks can be traced back to the aircraft concept and the propulsion system.

3.4.1. AIRCRAFT CONCEPT

The aircraft concept for the A400M is, in many ways, quite different from the civilian models that have been developed by Airbus so far. Being a transport aircraft, the A400M is equipped with a loading ramp, a loading door and a cargo-handling-system. The design that was selected for the A400M, which imagines the aircraft to be a high-wing aeroplane with a turboprop propulsion system, corresponds to the well-established configuration of military transport aircraft whose requirement profiles feature tactical components. It was necessary to design the landing gear in a manner that would ensure that the aircraft could, in accordance with the requirement in question, be operated on soft and unfixed runways. In conclusion, the project involved an aircraft whose development, within the framework of the Airbus group, could only be supported by a few references. Even the Spanish company CASA, which developed and produced military transport aircraft before its merger with EADS, had to confront new challenges associated with a model belonging to the size and performance classes of the A400M. The developmental and production-related risks resulting from these special features were not taken into consideration to a sufficient degree during the planning phase and the implementation phase. The approach that assumed the existence of extensive synergies between civil programmes and the A400M turned out to be too optimistic. Instead, Airbus Military was confronted with a variety of difficulties associated with the technical implementation of the aircraft concept, which led to delays and budget overruns.

In conclusion, the project involved an aircraft whose development, within the framework of the Airbus group, could only be supported by a few references.

27. Airbus Military News Release: The A400M Bid - Responding to the Assessment, 08 August 1999

3.4.2. PROPULSION SYSTEM

On account of requirements such as the requirements that called for slow-flight characteristics, those that called for the ability to take off from and land on unfixed runways and those that called for low operational costs, a turboprop engine was the only viable option for the A400M. At that point in time, there were no engines corresponding to the required performance class (up to the Progress D27 engine, which was used in the AN 70).
After an initial selection process, the Aero Propulsion Alliance consortium (consisting of Fiat Avio, ITP Spanien, MTU Aero Engines Deutschland, Rolls Royce, Snecma Moteurs, Techspace Aero) was selected, with the goal of developing a suitable turboprop engine. However, the TP 400-D1, which was supposed to be developed based on Snecma's M88-2 core engine, was discarded in the planning phase.[28] Since neither the required performance-related data nor the required economic feasibility could be attained, a second call for tenders was issued. An engine made by Pratt & Whitney Canada (P&WC) and one made by Europrop International (EPI), which was another European consortium (consisting of ITP, MTU Rolls Royce and Snecma) that produced engines, were on offer. The engine that was offered by P&WC, namely, the PW 180, was based on the PW 800 turbofan engine, which, at the time of the selection process, was being developed. The engine offered by EPI, the TP 400-D6, necessitated a complete re-development process. Although the engine offered by P&WC was more economical and represented a lower development risk, the TP 400-D6 was selected as the drive-solution for the A400M. The re-development of the required digital engine control system (FADEC), when combined with considerations related to the civil licensing of the engine and the FADEC, led to a series of delays and additional costs. There was also a series of additional technical problems that could be traced back to the fact that the engine's degree of maturity was insufficient after a development period amounting to three years.

3.5. A NETWORK OF DEVELOPMENT AND PRODUCTION BETWEEN THE POLICY AND THE COMPETITIVE ENVIRONMENT

The A400M is developed and produced within a complex network consisting of various EADS sites and suppliers. The structure of this network and the division of the activities between the partner nations were not defined on the basis of the project-oriented juste-retour principle that is usually used for military cooperation programmes. Instead, the so-called global balance principle was used. It builds on the juste-retour principle and extends its applicability to several projects and a longer period of time.[29] Since the investments and backflows that exist between the partner nations no longer have to be equalised within a programme, the programme's managers have more flexibility when it comes to distributing the activities and selecting suppliers. For example, the final assembly of the A400M takes place at a single location in Seville (Spain). In case of projects such as the NH 90 or the Eurofighter, which were executed in accordance with the classical juste-retour principle,

28. Flight International: One size fits all, 9 November – 15 November 2004, page 59 f.

29. OCCAR: Global Balance Policy Statement, OCCAR-EA Policy Paper, 12 December 2006.

each main customer had its own final assembly line. This centralisation facilitates a more efficient utilisation of resources, but it also sets up strong inter-dependencies within the network. The associated risk must be taken into consideration by controlling the progress of the programme in an appropriate manner. In case of the A400M project, the Spanish company CASA looked after the final assembly and assumed part of the development-related responsibility. The problems associated with cost control and progress control that became apparent in 2009 indicated that the network's management structure was flawed. Consequently, parts of the development-related responsibility were transferred back to Toulouse.[30]

30. EADS: Towards a leaner organisation, EADS Press Release, 16 December 2008.

4. USING PROVEN PROBLEM-SOLVING APPROACHES TO BREAK THE CIRCLE

4.1. INTRODUCTION

The analysed problems associated with the projects under consideration are just the tip of the iceberg. Strategies that are focussed only on solving these problems do not produce a lasting effect. The logic behind these problems (in the form of the four causal challenges) remains unaltered. Instead, the symptoms are the only things that are countered. A lasting effect can only be produced by problem-solving approaches that directly address the identified challenges (figure 5). Proven problem-solving approaches that are already being used successfully in other organisations and sectors represent the focal point of the consideration. These approaches can be directly correlated with the four challenges, and are introduced in the following section.

FIGURE 5: A PROBLEM-SOLVING APPROACH CAN BE ASSIGNED TO EACH CHALLENGE

Source: Cooperational Excellence study - 'Challenges associated with large projects in the aerospace and armaments industries'

4.2. MANAGING EXPECTATIONS

The management of expectations is based on a target structure that is agreed upon before the project is initiated and which is understood and accepted by all the programme partners. Over the course of the project, this target structure serves as the basis for the communication, the controlling of the programme's progress and the resolution of conflicts. In concrete terms, a situation of this nature can be associated with a framework that makes it possible to select and develop a performance system. At a higher level, this framework defines the basis of all the subsequent problem-solving approaches and contains the following elements:

» Milestones and the associated project results on a defined timeline,
» Work-packets with clear responsibilities within the milestones,
» Controlling at the overall project level and the level associated with the work-packets, to facilitate the monitoring of the project's progress, the risks associated with the project and the costs associated with the project,
» Defined targeting processes and commitment processes that stipulate the functional, technical and above all, the economical requirements.

With respect to locally-integrated project teams that can cut across countries and functions, the project can be implemented efficiently within the framework in conjunction with a neutral moderation role. Inter-cultural training and team-building are effective measures that make it possible to create, at the working level, a strong culture of teamwork that builds on shared trust.

4.3. REALISTIC GOAL-SETTING AND GOAL-TESTING PROCESSES

The selection of a performance system always begins with the project goals. Realistic goal-setting and goal-testing processes require mechanisms that make it possible, within the required budgetary, temporal and qualitative limits, to strike the right balance between the project goals and the subsequent feasibility of the performance system. The following measures form the basis for this equalisation:

» Differentiating between obligatory project goals and useful additional requirements that insert an extra measure of complexity into the implementation process,
» Evaluating all the requirements with regard to the associated costs (development, investment, material and production costs) and the schedule, on the basis of reference products, reference projects or reference programmes,
» Formulating the contractually agreed and measurable development-related, production-related, acquisition-related and qualitative goals for the entire course of the programme,
» Stabilising the project goals through a culture of commitment after the end of the target-setting phases.

4.4. MANAGING DEVELOPMENTAL AND PRODUCTION RISKS

Based on a realistic target-setting process, a suitable technical solution concept is defined, developed and produced. The associated developmental and production risks must be identified, evaluated and addressed. A risk management procedure that is closely linked to the development and production phase has the task of detecting maldevelopments in a timely manner and taking the appropriate countermeasures. This risk management procedure is integrated into the process and product levels, and is characterised by the following measures:

- » Introduction of a programme-spanning risk management procedure that identifies risks in collaboration with the respective departments and implements countermeasures,
- » Implementing quality gates and the associated criteria, which must be fulfilled in order to be able to progress further into the development and production process,
- » Involving future users (at an early stage) in the phase in which the concept is developed, in order to minimise the risk of subsequent modifications,
- » Involving civilian and military licensing authorities (at an early stage), in order to ensure that the risks associated with licensing-related requirements are factored into the development of the concept.

4.5. MANAGING INTERFACES

When it comes to the latest aerospace and armaments projects, the size of the network and, as a result, the number of interfaces have reached a level that has resulted in an ever-increasing amount of importance being assigned to the management of interfaces. An interface-management system that corresponds to the requirements necessitates measures that produce effects at the organisational, process and cultural levels:

- » Designing the development and production network on the basis of principles associated with economic feasibility,
- » Ensuring that the organisational structure and the process landscape consider the linguistic, cultural and geographical barriers that emerge in development and production networks that have been displaced internationally,
- » Agreeing upon network-wide standards (processes, software and hardware) that are followed, checked and developed further,
- » Introducing mechanisms (performance measurement systems, a constructive and critical network-culture, onsite presence of the suppliers’ technical representatives) that reduce the reaction time associated with the cooperation that takes place within the network (development sites, production sites and external suppliers).

5. CONCLUSION

Are large projects in the aerospace and armaments industries still manageable, or have the well-known delays, cost overruns and qualitative defects turned into unavoidable side-effects? A detailed study of the projects considered in the study reveals that all the problems can be traced back to causal challenges. The aforementioned problem-solving approaches can be used to handle these challenges. If they are taken into consideration, and if the process is thereafter reflected upon, it becomes possible to process a project within the planned cost-related, quality-related and budgetary framework. This is particularly indispensable in the age of shrinking defence budgets and ever-intensifying cost pressures.

ABBREVIATIONS

AMC	Airbus Military Company
EDA	European Defence Agency
ESR	European Staff Requirement
EUROFLAG	European Future Large Aircraft Group
FADEC	Full Authority Digital Engine Control
FIMA	Future International Military-Civil Airlifter
FLA	Future Large Aircraft
FVK	Faserverbundwerkstoffe
IEGP	Independent European Program Group
IIPO	International Interim Project Office
OCCAR	Organisation conjointe de Coopèration en matière d'Armement
OEM	Original Equipment Manufacturer
WEAG	Western European Armaments Group
WEAO	Western European Armaments Organization

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