



The
Federal Government

Aviation Strategy of the Federal German Government



Imprint

Published by

Federal Ministry for Economic Affairs and Energy (BMWi)
Public Relations
10119 Berlin
www.bmwi.de

Text and editing

Federal Ministry for Economic Affairs and Energy (BMWi)
Public Relations
11019 Berlin
www.bmwi.de

Design and production

PRpetuum GmbH, Munich

Status

February 2016

Print

Spree Druck Berlin GmbH

Illustrations

Rolls-Royce (Titel, p. 20), BMWi/Maurice Weiss (p. 4),
AIRBUS S.A.S. (p. 5), Airbus Helicopters (p. 9), MTU Aero Engines
AG/Pratt & Whitney (p. 10, p. 16), Bauhaus Luftfahrt e. V. (p. 14),
Diehl Aerosystems (p. 15), DFS Deutsche Flugsicherung GmbH
(p. 18), ZF Friedrichshafen AG (p. 25), DLR (p. 29), Airbus Defence
and Space und Deutsche Flugsicherung (p. 30), MTU Aero
Engines (p. 31, p. 33)

This brochure is published as part of the public relations work of the Federal Ministry for Economic Affairs and Energy. It is distributed free of charge and is not intended for sale. The distribution of this brochure at campaign events or at information stands run by political parties is prohibited, and political party-related information or advertising shall not be inserted in, printed on, or affixed to this publication.



The Federal Ministry for Economic Affairs and Energy was awarded the audit berufundfamilie® for its family-friendly staff policy. The certificate is granted by berufundfamilie gGmbH, an initiative of the Hertie Foundation.



This publication as well as further publications can be obtained from:

Federal Ministry for Economic Affairs
and Energy (BMWi)
Public Relations
E-mail: publikationen@bundesregierung.de
www.bmwi.de

Central procurement service:

Tel.: +49 30 182722721
Fax: +49 30 18102722721



The
Federal Government

Aviation Strategy of the Federal German Government

Table of contents

| | |
|--|-----------|
| Foreword | 4 |
| I. Aviation – industry of the future with special conditions | 5 |
| I.1 Aviation – industry of the future..... | 5 |
| I.2 Strategic role of the aviation industry..... | 7 |
| I.3 Competition and market conditions for the aviation industry..... | 7 |
| I.4 Research, technological development and innovation - keys to success..... | 9 |
| II. Guiding principle and framework for the Federal Government’s aviation policy | 11 |
| III. Aviation in Germany – strengths, opportunities and challenges | 13 |
| III.1 Civil aviation industry..... | 13 |
| III.1.1 Prime contractors or OEMs..... | 13 |
| III.1.2 Parts supply industry..... | 14 |
| III.1.3 Engine industry..... | 16 |
| III.1.4 Maintenance service providers..... | 16 |
| III.1.5 General aviatio..... | 17 |
| III.2 Research landscape in the civil aviation industry..... | 17 |
| III.3 Air transport industry..... | 18 |
| III.4 Military aviation..... | 19 |
| IV. From guiding principle to reality – fields of activity and measures | 20 |
| IV.1 Global pioneering role for an efficient, safe und clean air transport system..... | 21 |
| IV.1.1 Investments in research and development..... | 21 |
| IV.1.2 Improving the commercial application of research findings..... | 22 |
| IV.1.3 Securing and promoting highly-qualified junior personnel for research, development and production..... | 23 |
| IV.2 Overall system capability of the German aviation industry..... | 23 |
| IV.2.1 Overall system capability for commercial aircraft in the European context..... | 24 |
| IV.2.2 Overall system capability for helicopters and engines..... | 24 |
| IV.2.3 Overall system assessment capability in parts suppliers and the MRO industry..... | 26 |
| IV.2.4 Retaining the overall system perspective in training and research..... | 26 |
| IV.2.5 Securing sustainable military aviation..... | 26 |

| | | |
|------------|---|-----------|
| IV.3 | Strengthening German core competencies | 26 |
| IV.4 | International supply capability and competitiveness of the German parts supply industry..... | 27 |
| IV.4.1 | Setting up successful, international supplier associations..... | 28 |
| IV.4.2 | Greater participation of German parts suppliers in aircraft programmes of non-European OEMs..... | 28 |
| IV.5 | International fair and comparable competition conditions for the aviation industry | 28 |
| IV.5.1 | International agreement on funding terms and conditions for commercial aircraft..... | 29 |
| IV.5.2 | Promoting trade in aircraft and engines..... | 29 |
| IV.5.3 | Promoting functioning commodity markets..... | 29 |
| V. | Specific instruments to implement the Aviation Strategy | 30 |
| | Research..... | 30 |
| | Promoting basic research..... | 30 |
| | The Federal Government's Aviation Research Programme..... | 31 |
| | Aviation research in intersectoral innovation and technology programmes..... | 32 |
| | Research advisory board for DLR..... | 32 |
| | Technology roadmap as a substantive guideline for aviation research..... | 32 |
| | Market access..... | 32 |
| | Loans for financing development costs in international programmes..... | 32 |
| | Private equity capital fund..... | 33 |
| | Evaluation..... | 33 |
| VI. | Glossary/List of abbreviations..... | 34 |

Foreword

Our civil aviation industry and efficient air transport system are guarantors of employment, prosperity and competitiveness in Germany as an industrial nation. Our research-intensive and innovative aviation industry combines high technologies such as electronics, robotics, metrology and control, materials and regulatory technology. They call for innovation from the whole of German industry. In our country, some 850,000 jobs depend directly and indirectly on air transport. Global aviation is a large growth market. Air traffic worldwide is expected to double in the next 20 years.

With its Aviation Strategy, the Federal Government is looking to make Germany into a global technological pioneer for a clean, safe, efficient, competitive and also passenger-friendly air transport system. For this, the economic and technological strength of the European prime contractor, Airbus Group, is just as important as the innovative power and global competitiveness of the many different parts suppliers located in Germany.

The key elements of the Aviation Strategy are the promotion of basic research by the German Aerospace Centre (DLR), financial research assistance from the national Aviation Research Programme (LuFo) and EU research programmes under Horizon 2020 as well as the lending programme for financing development costs in industry. With these long-term instruments, we give the industry planning certainty, while also setting incentives for private investments in innovation and vertical value added in Germany's aviation industry.



A major concern of mine is to ensure that the aviation industry keeps to its ambitious goals in research and development so that it can extend its technological lead. In future as well, Germany will continue to focus on the successful collaboration among prime contractors, parts suppliers and the scientific community. In the years ahead, I shall therefore do my best to make sure that German industry can take full part in the growing global aviation market.

Your

A handwritten signature in black ink that reads "Sigmar Gabriel". The signature is written in a cursive style.

Sigmar Gabriel
Federal Minister for Economic Affairs and Energy



I. Aviation – industry of the future with special conditions

I.1 Aviation – industry of the future

Technologically and economically, the aviation industry plays a special strategic role for Germany as an industrialised nation. The Federal Government took due account of this special significance through the acquisition of company shares in EADS N.V. (Airbus Group N.V. since 1 Jan. 2014) in December 2012. The resultant consolidation of the Franco-German balance is of major import for the future of the whole industry in Germany.

Mobility is a basic human need and a major economic factor. Air passenger and freight transport plays a key role. No other means of transport is able to cover large distances at equal speed. This is of great importance for both business travel and national and international tourism, but also time-critical freight haulage over medium and long distances.

An effective air transport system is crucial for the global division of labour in its present form, which enables us to put the world's available resources to their most efficient use. As an economy that is closely networked and highly integrated in global trade, Germany benefits from this in special measure. Studies show that the connection to international air traffic is one of the foremost locational factors for enterprises with international operations,¹ as evidenced by well above-average foreign direct investments in the vicinity of closely interlinked international airports.

Air transport will play an even greater role in future: With their strong economic growth, emerging nations will increasingly be looking to travel and transport goods with aircraft and helicopters, which will also raise the demand for aircraft. Aircraft and engine manufacturers anticipate a steady rise in market volume for the next 20 years.

The latest world market forecast by Airbus predicts a demand for more than 28,000 new, large commercial aircraft from 2012 to 2031, an increase in the entire global fleet of almost 110% from today's 15,560 to 32,550. This estimate is based on anticipated average annual global growth in air traffic of around 4.7% measured in revenue passenger kilometres (RPK).

For the short-haul and medium-haul segment, Table 1 compares the growth forecasts of different aircraft and engine manufacturers, which all share similar expectations.

Air traffic growth in this order of magnitude is firstly the consequence of increased mobility needs. In Germany, it is also the result of the public perception that flying no longer represents a luxury and air transport will also remain available and affordable for a broad group of users in future. For aircraft manufacturers and their supplier chain, the growth scenarios afford a very promising development potential.

1 On this, see Harsche, M. et al (2008): Katalytische volks- und regionalwirtschaftliche Effekte des Luftverkehrs in Deutschland, Ed.: ECAD GmbH and Cech, P. (2004): The Catalytic Effect of the Accessibility to Air Cargo Services, Chapel Hill.

Table 1: Demand expectations of various manufacturers in the single-aisle sector

| | Airbus | Boeing | Rolls-Royce |
|--|-----------|-------------|-------------|
| Period | 2012–2031 | 2012–2031 | 2009–2028 |
| GDP growth | 3.4% | 3.2% | 4.0% |
| RPK growth | 4.7% | 5.0% | 5.0% |
| Demand in single-aisle sector | 19,520 | 23,240 | 15,733 |
| Of which replacements | 7,681 | 9,050 | 6,994 |
| Decommissioned in % | 63.2% | 75.2% | 65.3% |
| Current fleet | 12,160 | 12,030 | 10,711 |
| Fleet in 20 years | 24,000 | 26,220 | 19,450 |
| Annual growth in single-aisle fleet | 3.5% | <i>N.I.</i> | 3.03% |

With these high growth rates, however, air transport must also pay greater attention to its impacts on the environment. For its future viability, it is of crucial importance for the air transport system to make decisive reductions in its adverse impacts on the local and global environment.

In densely populated regions, it is increasingly difficult to convince local residents of the need for additional infrastructure measures, as clearly attested by the protests of directly affected citizens near prospective new or extended airports. Central points of criticism are noise and air pollution by aircraft and another issue are the environmental impacts of feeder transport to the airport. On the other hand, the only way to cope with the steady growth in the volume of traffic is to expand the requisite infrastructure.

Innovative technologies can contribute to resolving these conflicts, new aircraft and engine designs as well as new landing and take-off procedures for noise reduction, for example, but also low-emission methods for moving aircraft around the airport compound. The consistent application of additional measures listed by the International Civil Aviation Organisation (ICAO) in its Balanced Approach can also help abate flight noise pollution at airports with noise problems. Besides quieter aircraft (aircraft noise reduction at source), these include rationalising land use planning and management in the airport vicinity, noise-abatement operational procedures and operating restrictions.

Aside from difficulties in the airport vicinity, the impacts of air traffic on global environmental and climatic conditions pose another problem: With its emissions of carbon dioxide (CO₂), nitric oxides (NO_x), carbon and water vapour, global air traffic contributes to climate change. About 2.5% of all anthropogenic CO₂ emissions are currently emitted (base-line figures for 2005) by global air traffic.

Technical alterations to aircraft will also make a major contribution here to emissions reduction. The Strategic and Research and Innovation Agenda (SRIA) of the Advisory Council for Aviation Research and Innovation in Europe (ACARE) for implementing Flightpath 2050² anticipates that the bulk of the CO₂ and NO_x targets cited therein (savings of 75% and 90% respectively in a 2050 aircraft compared with the technology available on the market in 2000) will have to be met by making changes to the airframe and engine. It also predicts, however, that improved air traffic management and operational procedures by airlines and airports can contribute about a quarter of the emission reductions. To effect improvements as fast as possible through modern air traffic management, the Federal Government advocates implementing the Single European Sky. It is important here, however, that the EU member states make the necessary infrastructure available.

According to similar figures in former research agendas, improved air traffic management (rationalising landing and take-off procedures, etc.) can reduce noise by a fifth in aircraft and two-fifths in helicopters; here also, the bulk of the noise abatement targets set by ACARE will have to be met through aircraft alterations.

Without technological advances, the large forecast increase in international air traffic can raise its ratio of emissions.

To ensure that the effects of air traffic on the local and global environment do not impede the above-outlined growth scenarios, in the medium term the industry must succeed in decoupling pollutants emissions from air traffic growth. The ACARE technology targets may not be sufficient for this. To help advance progress towards these targets, it would be useful to introduce internationally binding CO₂ thresholds so as to ensure that highly efficient

2 Flightpath 2050 is a European-wide aviation strategy drafted in 2011 by the so-called High Level Group around the Airbus CEO, Dr Thomas Enders, on the initiative of the EU Commissioners Kallas and Geoghegan-Quinn

aircraft are available for fleet renewal in the foreseeable future. ICAO has set itself the aim of carbon-neutral air traffic growth as of 2020 and halving CO₂ emissions by 2050 compared with 2005. This will require further measures in addition to technological solutions: market-aligned climate protection instruments, but also the appraisal of alternative fuel use and improved air traffic control to reduce climate impact.

I.2 Strategic role of the aviation industry

The only way to be able to take part in global air traffic growth and create a clean air transport system is with an efficient and innovative aviation industry in close cooperation with the other main actors. It also calls for a research and technology development strategy that sets the right priorities in noise abatement and air pollutant and greenhouse gas emissions, but also in safety, resource efficiency and cost effectiveness, so that the aviation industry can meet these challenges with groundbreaking technology. If it can manage to do this, it can make a decisive contribution to clean air transport, but also take successful part in the growth potential in this sector.

This will afford the German aviation industry the opportunity to continue its above-average growth path over the last 10 years: While gross domestic product (GDP) in this time rose by an annual average of 2.5 %, growth in aviation industry turnover during the same period amounted to 5.4 % a year, more than double. The number of employees engaged in the aviation industry also rose quickly in this period, averaging 3.1 % a year, as compared with the number of total gainfully employed (0.6 % annual increase).³

Besides its importance for a viable air transport system and its dynamic development prospects, with its leading-edge and key technologies the aviation industry also plays a key role for the whole of Germany as an industrial and technological nation.

Today's aircraft technology is highly complex and very advanced. It entails very long research, design and product cycles as well as high marginal costs for technological innovation. This is why aviation is a very research-intensive industry: Some 12 % of turnover in Germany is invested in R&E activities,⁴ so that the aviation industry and/or aircraft and engine manufacturing rates as a leading-edge technology in terms of the usual classifications.⁵

The outcomes and innovations from research and technology projects in the aviation sector are not, however, just channelled into new aircraft and helicopters: They have large technological spillover effects in other industries and scientific-technological specialisms, such as motor vehicle manufacturing, mechanical and plant engineering, power engineering, electronics, robotics, materials technology and instrumentation, control and regulatory technology. The aviation industry also makes a decisive contribution to upgrading and shaping major technologies in the entire mobility sector in particular, such as lightweight construction, new materials, simulation, communication, control and regulation, aerodynamics or new propulsion technologies. With its particularly high demands on safety, durability, reliability, availability, energy efficiency, sizing and power/weight ratio, aviation is a major technology and innovation driver for the whole economy and therefore meets the criteria for a key or basic technology.

A significant current example of technological spillovers is upgrading lightweight construction with fibre composite materials, such as carbon-fibre reinforced plastics (CFK) for aircraft structures. It was developed at great cost for the latest generation of aircraft to meet their weight-saving and reliability requirements. These technologies are now also being used in the motor-vehicle industry. Particularly for the development of electric vehicles, it is in urgent need of new, lighter materials to make substantial weight savings.

While manned aircraft will continue to play the main role for air transport in future as well, unmanned aerial vehicles are taking an initial niche position on the commercial market. Before these aircraft can achieve greater commercial success, international regulations must first be set on their deployment in controlled airspaces.

I.3 Competition and market conditions for the aviation industry

The high research and development intensity of the aviation industry and its strategic role for the overall economy call for special competition and market conditions.

The historical development of the modern aviation industry also attests to this: The unique position of American suppliers on the market for large commercial aircraft could only be contested through the decision by the European nations of Germany, France, Spain and the United Kingdom to found and promote Airbus. A similar development also took place in civil helicopter construction.

3 Statistics: Destatis and the German Aerospace Industries Association (BDLI)

4 Statistics: German Aerospace Industries Association (BDLI)

5 On this, see Gerke, B. et al (2010): *Listen wissens- und technologieintensiver Wirtschaftszweige*, Ed.: Expert Commission on Research and Innovation

The aviation industry generally faces very high market entry barriers, in the shape of high development and certification costs for aircraft and their systems, the complexity of the requisite supplier chain and the limited market access for 'new' aircraft suppliers. One reason for this is that the operation of a new type of aircraft entails considerable input for the airline companies, so that they have to cater for a high level of so-called commonality between in-service aircraft and the fleet, as can be clearly seen from examples of major airlines such as American Airlines, Southwest, but also Ryanair, which have so far only operated with aircraft from one manufacturer (in these cases Boeing).

Above all the high fixed costs incurred by technological development and the development and authorisation of a new type of aircraft, however, make it very difficult for large commercial aircraft to enter the market. This was the reason why the development of Boeing into a monopolist could only be prevented by Airbus' advancement to become its commercial equal and technologically leading competitor. Today, the market for commercial aircraft with a capacity of over 100 seats is dominated by the duopoly of Boeing and Airbus. Competition has had a beneficial effect on the innovation momentum in aviation technology, as evident from the technological development of aircraft models since the previous period where Boeing held a market-dominating position. The models produced today, for example, consume up to 70% less kerosene than equivalent models from the 70s.

In civil aviation, Airbus now stands on an equal footing with Boeing. This was achieved by the considerable joint efforts on the part of the four Airbus states to stimulate the necessary research and development activities. Owing to its special strategic role, but also its specific competition conditions, the industry is, however, still subject to pronounced government influence worldwide today.

Some countries with an established aviation industry expend substantial (public) funds to secure and enhance the technological competitiveness of their companies and locations. This also has an indirect influence on general conditions in Germany as an aviation location, as it is engaged in locational competition with these countries.

Alongside the established aviation nations, new competitors are also gradually gaining huge importance. This has to do with a long-term shift of growth markets in air traffic from Europe and North America to the high-growth regions of Asia and the Middle East: These regions in particular have been making efforts in recent years to establish their own suppliers of commercial aircraft, helicopters and maintenance, repair and overhaul (MRO) services. With massive deployment of public funds, China and Russia are also developing their own regional and short-haul aircraft to secure their aviation industry permanent access to the

world market. India and the United Arab Emirates are also in the process of building up new industrial research and production capacities in the aviation sector. Added to this are the already successful and growing aviation industries in Canada, Brazil, Japan and Israel.

Large amounts of public funds are also provided in these countries for investments in infrastructure and RTD projects that make a decisive contribution to advancing development. The aim of the new competitors is to close the technological backlog with the established aviation nations. They have already made increasing progress in recent years: With a technologically and commercially competitive aircraft for up to 150 passengers, the CSeries model, the Canadian manufacturer, Bombardier, for example, is contending for the lower segments of the highest-turnover market of short-haul and medium-haul aircraft. According to information from the manufacturer, the kerosene consumption of CSeries aircraft is some 15% less than that of the current models of the large competitors, Airbus and Boeing (A320 or B737). To successfully hold its current leading position, the European aviation industry will therefore have to considerably step up its efforts in research and technology development (RTD) in the years ahead.

This is a welcome development from the competition-policy standpoint, because it affords parts suppliers in particular with access to new sales markets. With technologically and commercially convincing products, these can engage in business fields that have so far been unoccupied by the respective firms for various reasons. Finally, it affords large potential for economic cooperation – especially also with strategically important emerging countries, such as China, India and Brazil.

On the other hand, this development – which is not driven by the free market, but by government interventions – will sharpen competition for companies in the German aviation industry.

Curbing government influence in the aviation industry worldwide is therefore a long-term and basic policy goal. International, balanced competition conditions must, however, be in place for this (level playing field). Binding regulations are needed that apply for all countries with a globally operating aviation industry. This will help ensure that no supplier can take up a market-dominating position and the European and German aviation industry does not forfeit its current role.

The pronounced government interventions in the above-mentioned countries currently conflict with this aim. Government interventions also entail buyer power, as larger aircraft orders are partly placed in the expectation that the contracted manufacturer will expand its industrial engagement in the respective purchaser country. Besides direct

job creation, the underlying intention is usually also to facilitate technology transfer for establishing a domestic aviation industry.

I.4 Research, technological development and innovation – keys to success

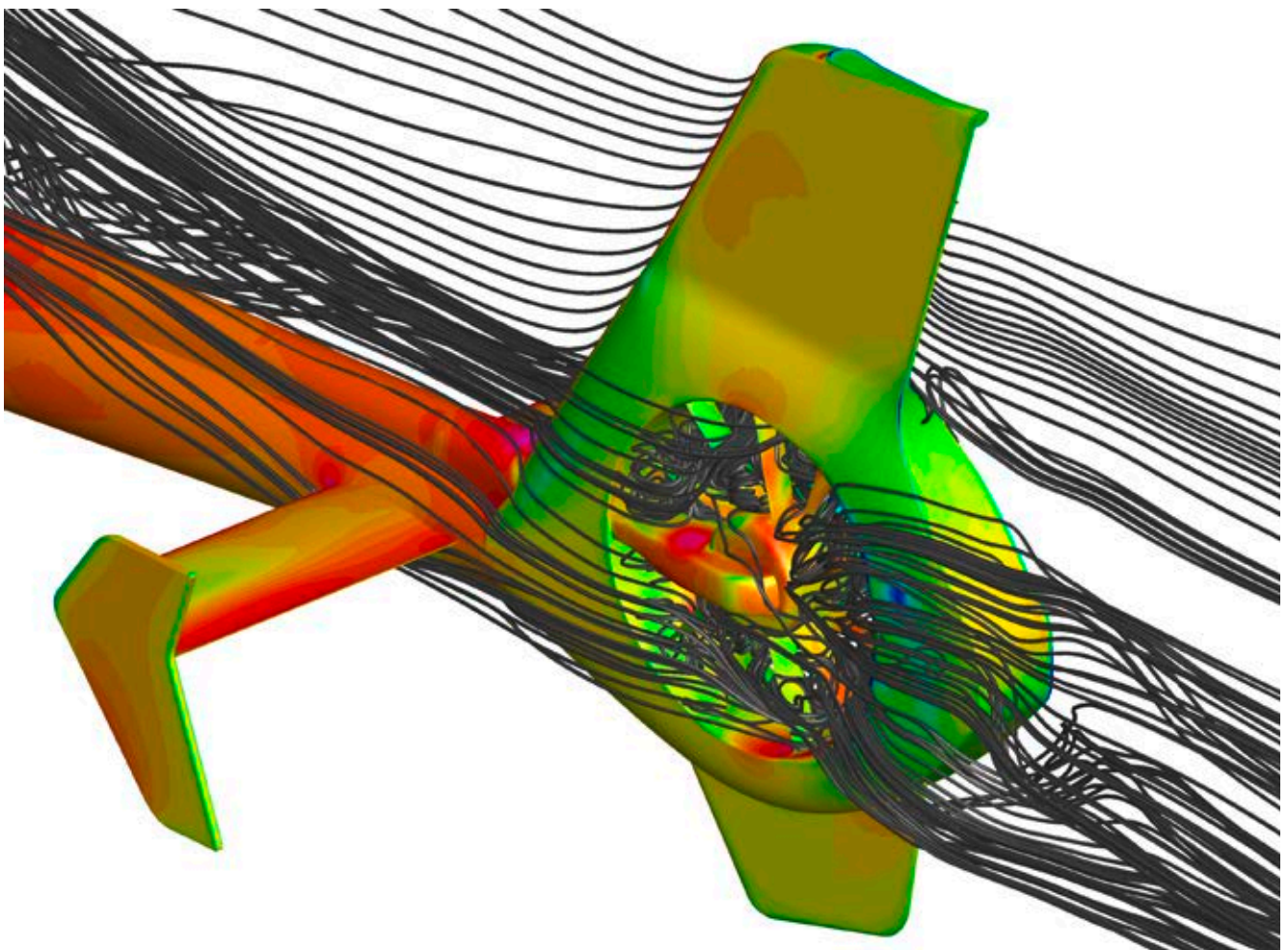
A key to the future position of the German aviation industry and its successful participation in anticipated sectoral growth is research and development in innovative technologies for aircraft and engines and their efficient use throughout their whole life cycle. This way, together with its European partners the German aviation industry can establish itself as a pioneer for an efficient and clean air transport system.

The policy agenda in Europe is also conducive to this: Owing to high population density, capacity constraints on all transport operators and high public environmental awareness in Europe, greater attention is being paid to the adverse impacts of air transport than in other regions. This is embodied in the ambitious strategic documents for a viable European transport system, such as the European Commission's

Transport White paper or the already mentioned aviation vision, Flightpath 2050. To achieve the goals they set for the air transport system, considerable funds must be expended for investments in research and technology development. The aviation industry bears particular responsibility here.

Imperfect capital markets can, however, hinder companies from obtaining finance for research and development costs in the aviation sector. This is due to high technical and financial development risks and very protracted product cycles and also affects small and medium-sized enterprises in particular: For one thing, external financiers are hardly able to precisely assess this situation and quantify the opportunities and risks. For another, they are reluctant to grant loans for the very long periods until the investment outlay has been recouped. If at all, then, access to the private capital market is only possible at inefficiently high prices.

An added factor is that some of the newly acquired knowledge does not just benefit the investing company, but also broadens the general knowledge base in other technology sectors in the course of spillovers. This initially impacts the aviation industry's own researching companies, which profit from a high-quality knowledge base in this segment.



CFD (Computational Fluid Dynamics) Simulation – enhanced wake survey for tail boom, fin and Fenestron of H135.



MTU Aero Engines is one of the leading world class manufacturers for Blade Integrated Disks used in highly efficient high pressure compressors.

In a second step, however, other industries also come to benefit through spillovers. As their gains from the investment decision of the investing enterprise are not, however, taken into account, they may not result in Pareto-efficient investments in RTD activities (i.e. in this case they are inefficiently low).

Nor is the benefit of innovative technologies for the local and global environment usually fully internalised by the aviation industry or airline companies, as the external costs of noise and emissions are not reflected in prices. This can in part be effected via prices for kerosene, but since the emissions of various harmful exhaust gases are not linearly dependent on fuel usage, for example, but are contingent to a large extent on the combustion technology used, developing the best possible technology in aircraft engines can be expected to have beneficial external effects.

As a consequence of this, private enterprises deliberately make inefficiently low investments in research and technology development and too little account is taken in particular of research topics aimed at a clean air transport system for the benefit of society as a whole.

II. Guiding principle and framework for the Federal Government's aviation policy

In response to the above-outlined challenges, the Federal Government pursues two goals.

1. First, it is aiming at creating a viable air transport system that meets high standards of efficiency, safety, environmental cleanliness and competitiveness as an integral part of the overall transport system.
2. Second, it is seeking to set a framework for an internationally competitive aviation industry in Germany to enable it to retain and extend its position in international competition in the long term with high-tech and innovative products.

Enhancing the Franco-German balance through the acquisition of corporate divisions of EADS N.V. also makes up a major component for achieving these goals. Airbus Group N.V. is of key importance for developing the parts supply industry in Germany, because as the European civil systems manufacturers with their aircraft and helicopter programmes they make up the largest sales market, but they also play a spearheading role in developing and researching new technologies.

The following guiding principle summarises these goals and provides a benchmark for the specific strategic alignment of the aviation industry and the related framework. It thus marks the point of departure for the Federal Government's Aviation Strategy:

Guiding principle

With its products, the German aviation sector makes a decisive contribution to a clean, efficient air transport system that constitutes a major pillar of the overall economy. As technology leader, the aviation industry makes a permanent and substantial contribution to value added in Germany, also for other industries.

The way society will view and assess a continued expansion in air traffic depends on its consequences for the local and global environment, including the people living in the vicinities of airports. The commercial success of products and services for air traffic will therefore depend on whether they can bring about a clean air transport system.

Crucial for the **future viability of air transport**, therefore, are not only its efficiency and safety, but in large measure also its environmental cleanliness and sustainability. Air traffic must not be allowed to place excessive burdens on the natural environment and impair its sustainable conservation.

Impact evaluation here must apply the eco-balance sheet principle over the whole product life cycle and include noise, emissions and resource consumption also during production, maintenance and disposal processes.

Table 2: Environmental and other targets of the strategic documents, VISION 2020 and Flightpath 2050⁶

| | VISION 2020 | FLIGHTPATH 2050 |
|----------------------|--|---|
| CO ₂ | - 50 % | - 75 % |
| NOx | - 80 % | - 90 % |
| Noise | - 50 % | - 65 % |
| Other targets | 99% of flights take off and land with less than 15 minutes delay. Fivefold reduction in average rate of accidents in globally operating, commercial aircraft operators. | Four-hour travel time from door to door in Europe is possible for 90% of passengers. Improved safety, including fewer than 1 accident per 10 million flights |

⁶ Reference point in each case is a typical new aircraft in 2000.

With the strategic documents, Vision 2020 und Flightpath 2050, the European aviation sector (industry, research and policy) has set ambitious targets for the air transport system and aviation industry at European level (see Table 2). The Federal Government's Aviation Strategy is also based on the targets cited in the table.

They can, however, only be implemented in an international joint effort by the European aviation industry. Supported by research in higher education institutions and (large-scale) research facilities, the German aviation industry must make the necessary contribution in its areas of competency.

Besides the ACARE targets, the Committee on Aviation Environmental Protection (ICAO – CAEP) is working on a steady reduction in noise and emission thresholds.

An EU-financed research project has reviewed the progress made since the drafting of Vision 2020 in 2000. It concludes that beyond the research projects already begun considerable efforts will still have to be made in the years ahead to accomplish Vision 2020. Due to the diminishing marginal returns of technical innovation, the far more ambitious targets of Flightpath 2050 set in 2011 can only be met at great cost and with the help of fundamental changes in state-of-the-art technology. This will call for considerable investments in researching and developing new technologies in the coming years and decades.

In addition to making air traffic cleaner, there is also a need to develop technological, but also process-based solutions to further improve its convenience, safety, reliability and networking. With the steady increase in traffic volume, this poses a major challenge but it is also of paramount importance for the future viability of the air transport system. To improve safety, the pilot needs better support from assistance systems, his situational awareness needs to be raised and his workload must be further reduced in certain flight phases and emergencies.

Apart from a sustainable and clean air transport system, the guiding principle includes the goal of maintaining and expanding a globally positioned, competitive aviation industry in Germany. This calls for a framework to enable businesses in this sector to adapt to constantly changing market conditions and demands in prevailing global competition and take advantage of new opportunities. For their part, companies must be prepared to respond to changes and make the necessary structural adjustments as the only way to maintain their innovative power and competitiveness in the long run.

To retain its competitiveness in research, development and production, the German aviation industry must continuously improve its development and manufacturing methods and related procedures and capabilities. This will also contribute to producing aircraft at a price that keeps air transport accessible to a broad clientele.

The Federal Government has framed an Aviation Strategy to provide a guideline for measures that will set out the parameters for the civil aviation sector. The timeframe extends over the next years 10 and the substantive focus is placed on the aviation industry and the dominant business field of civil commercial aviation.

The scientific community and business and industry were involved in drafting the Aviation Strategy.

The interests of military aviation are addressed only where its technological potential and role as a national consumer are concerned.

The present strategy is primarily directed at three target groups:

1. Policy and administrative decision-makers. The aim of the Aviation Strategy here is to concisely outline the basis, goals and fields of activity of aviation policy so as to provide a benchmark for the strategic alignment of individual measures.
2. Interest groups in the aviation sector, i.e. large-scale aviation companies, small and medium-sized enterprises (SMEs), trade unions and labour representatives, research facilities, higher education institutions and air transport firms. To take due account of the long investment periods involved, the Federal Government's Aviation Strategy will set out and communicate a long term, reliable framework for these.
3. The interested public. The strategy will raise public awareness of the role and responsibility of the aviation industry, as is the case in other aviation nations, and foster broad public discussion on the future development of aviation.

III. Aviation in Germany – strengths, opportunities and challenges

III.1 Civil aviation industry

Historically, as a strategic high-tech and industrial sector, the aviation industry (military and civil) has been heavily regulated and had close ties with public administration and policymaking. In the past, this has given rise to largely independent national or regional industries that took up large parts of the vertical value chain. In recent years, however, under mounting competitive pressure in the civil sector and owing to diminishing military budgets, there has been an increasing liberalisation and globalisation of markets and supply chains.

In the following, we shall report on the status quo of the individual sectors of the German aviation industry in more detail and then infer fields of activity and implementation measures for the Aviation Strategy.

III.1.1 Prime contractors or OEMs

The civil aviation industry is undergoing a continuous transition from nationally or regionally delimited units to a global sector with a worldwide division of labour among supply chains. With their decisions, the prime contractors or original equipment manufacturers (OEMs), such as Airbus, Boeing or Airbus Helicopters (formerly Eurocopter), exert a major influence on the structural and technological development of the supplier markets. Their locational decisions and procurement policy distribute value added across countries and regions. Due to the influence of the public sector on the industry (and particularly prime contractors), in addition to business management and technological issues policy and foreign trade considerations also play a role worldwide.

With its amalgamation of the predominantly German competencies at overall system level both in the civil and military sector in the Airbus Group, the Federal Government has advanced a European approach and reaffirmed this with its equal partnership with France.

Together with an extended international division of labour, as a result of this there is no longer any independent national supplier of large commercial aircraft in Germany today. This is why an intact Franco-German balance in the Airbus Group N.V. and the development of the prime contractors under its joint auspices, Airbus and Airbus Helicopters, makes up a major strategic factor for the future of the entire German aviation industry. The German locations of Airbus

and Airbus Helicopters have been assimilated as subsidiaries of the respective divisions in Airbus Group N.V.

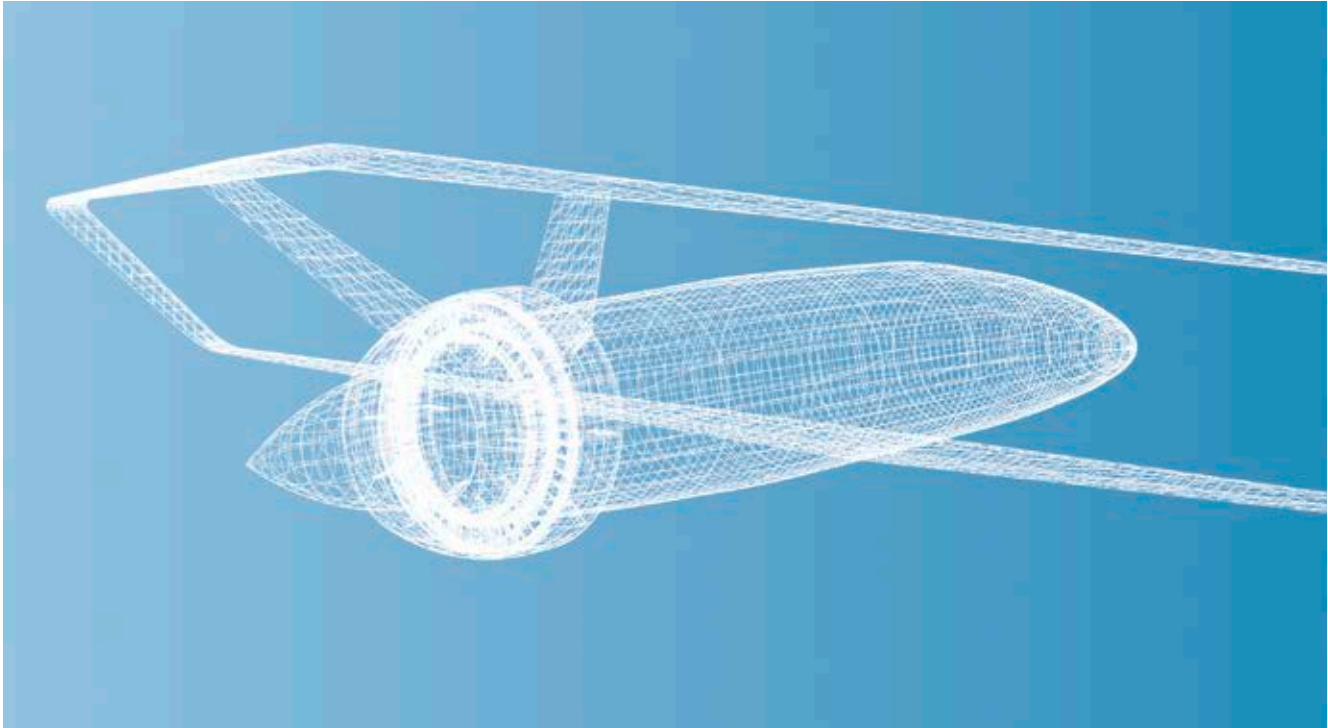
The location of central management, development and cross-cutting functions plays a particularly important role for the future development of the German Airbus and Airbus Helicopters locations.

In the Airbus sub-group, the main organisational units are made up of the central key and cross-cutting functions, the various centres of excellence and competency and finally the management of the respective aircraft programmes. While the central key and cross-cutting functions, including the managements of the A330/340, A380 and A350XWB programmes, are largely located in Toulouse, France, the respective managements of the centres of excellence for cabin and fuselage and for rear fuselage and tail as well as the management of the A320/A320neo programme are located at the German Airbus sites. Alongside the above-outlined responsibilities, a final assembly facility for the A320 family is located in Hamburg. As part of the wing/pylon centre of excellence, the Bremen location is also responsible for the high-lift system.

In recent years, Airbus has heavily centralised major key and leadership functions at the Toulouse location. When allocating major key and leadership functions, attention should, however, be paid to efficiently harnessing the available technological and business potential at all locations in Europe. In this connection, future pending product and corporate policy decisions should be taken with a view of striking a balance of responsibilities among the European locations. There will be adequate opportunities for this in the next few years, especially in the forthcoming development programmes in core business (e.g. in the future short-haul and medium-haul programme – A320 sequel programme, A30X).

At Airbus Helicopters, the German locations in the civil sector are traditionally responsible for twin-engine helicopters in the weight class of up to 4 tonnes and have overall system capability for helicopters in research, development and production. The key and cross-cutting functions are distributed among the locations and are therefore also available in Germany. This will also remain so in future.

Beyond strengthening and enlarging responsibilities and capabilities in individual segments and disciplines, retaining and/or strengthening overall system capability is a decisive factor in Airbus Helicopters; Airbus should at least



The “Propulsive Fuselage” concept from Bauhaus Luftfahrt in Munich: the interdisciplinary research Institute analyzes the distribution of thrust around the rear of the fuselage. This could be an opportunity for applying boundary layer suction in order to reduce drag and increase efficiency substantially.

retain or extend its capabilities and competencies to able to take the leading role in the European group for the short-haul and medium-haul programme (A320 sequel programme, A30X) in future.

These capabilities will enable the group to upgrade individual technological abilities in the long term and frame an appropriate RTD strategy.

The technological demands of the market on future aircraft are very high. The next generation must include innovations that significantly improve all the cited requirements. In this connection, configurations and aircraft will also play a role in future that are only of importance in the military sector today due to their high technological standards and investment costs. To bring these innovations to maturity, there is a need to research and develop the requisite technologies in good time as part of a long-term research and product policy. This can only be done in collaboration with the engine and parts supply industry and requires the early and reliable involvement of strategic partners.

Owing to their long useful life, the market also increasingly requires improvements to aircraft and helicopters in service. This applies for both efficiency and improved reliability and safety. When developing new technologies, account must therefore also be taken of their practical relevance for current aircraft generations.

III.1.2 Parts supply industry

The increasing globalisation of supply chains has also changed the market conditions for the German parts supply industry.

For one thing, firms can no longer rely on automatic consideration in the programmes of the European prime contractors and must instead continuously contend with a larger range of competitors.

For another, besides technological excellence and innovative power financial aspects and new business/operation models are coming increasingly to the fore as considerations in selection procedures for awarding new work packages: One of the most important factors here is the ability to take over larger packages, including responsibility for development and the coordination of the parts suppliers at downstream levels. This also includes financing the development of the contracted components and systems and bearing the related investment risk. This is being forced by prime contractors seeking to cut their integration and coordination costs by reducing the number of direct (Tier 1) parts suppliers.

A good example of industrial reorganisation here is the company Diehl. By amalgamating the former Airbus location, Laupheim, with the enterprises DASELL and Mühlentberg under the auspices of Diehl Aerosystems, the Diehl Group has formed a Tier 1 supplier in the cabin competency

segment that has directed its technological development and innovative power at taking responsibility for larger packages in the cabin and cabin systems segment.

For large-scale enterprises with good access to the capital market, this can improve their earnings prospects as compared with a situation without risk-sharing. Especially for small and medium-sized enterprises in international competition, however, it will be difficult to attain or retain a status as a Tier 1 supplier.

This also affects the German parts supply industry in particular, whose structure is heavily fragmented. Apart from a few larger and some medium-sized enterprises, many small firms are often only engaged in aircraft construction as one among several lines of business.

They face the strategic question of whether they descend to deeper levels of the supply chain or enhance their horizontal or vertical value added through integration (e.g. through acquisitions, greater RTD investments or mergers with other companies). The latter, however, also presupposes the willingness to take over larger work packages and with that bear higher risks.

The Federal Government can set the requisite framework for this by creating research and innovation incentives and maintaining operational capital markets. For their part, the

parts supply firms must develop their own RTD strategy to cope with volatile global market requirements and future technological challenges; this must, however, also be aligned with overriding goals. They can make effective use here of the available research infrastructure in Germany, by setting up their own research networks, for example. This way, businesses can ensure their international, technological and economic supply capability and competitiveness in the long term.

The changed global competitive environment with new actors as outlined above increasingly affords primarily larger enterprises the opportunity to take part in non-European aircraft programmes with extensive work packages. This calls for an intelligent product policy aimed at timely and technologically favourable positioning for forthcoming aircraft programmes, also as part of research collaborations.

The prerequisite for this are adequate research and development capacities to participate in promising development programmes. As these can only be built up to a limited extent and take considerable time, the programmes for participation must be carefully selected. There are presently numerous international programmes in the regional and short-haul aircraft segment especially. It is usually difficult to predict which of these will ultimately gain acceptance and achieve commercial success.



Diehl Aerosystems is not only a tier-1-supplier for avionics but also for cabin interiors.

III.1.3 Engine industry

The engine industry makes up an independent subsegment of the aviation industry, so to speak. The prime contractors there have their own supplier chains and in part also other product cycles than the rest of the aviation industry.

Owing to the technical complexity of modern engines and the attendant technical and financial development risks, the large, globally operating engine manufacturers have joined to form consortiums in many programmes to share technological responsibility among themselves. The regional focus of the German engine industry is located in Bavaria and Brandenburg, but also Lower Saxony and Hesse.

MTU Aero Engines is a large Tier 1 supplier with an excellent technological reputation that is broadly integrated in the international supplier chain and with various work shares in international, civilian and military engine programmes has the ability to design overall systems. Responsibility for major components of the geared turbofan engines of Pratt and Whitney, which also helped the new engine option, A320neo, to achieve its resounding market success, is also located at MTU. For the most part, the technology for this was developed as part of the Federal Government's Aviation Research Programme.

As part of the Rolls-Royce Group in Germany, Rolls-Royce Deutschland is an enterprise in the engine industry complete system leadership in engines for commercial and regional and medium-haul aircraft. It has also taken over significant tasks of the Rolls-Royce Group, such as conducting all component tests and undertaking module developments for large long-haul aircraft, such as the high-pressure compressor of the Trent-XWB engine for the A350XWB programme. This development to a major location of the overall group is also evidenced by the construction of a test facility for large engines.

Besides these integrators, there are a number of smaller and medium-sized suppliers of engine components, which are in part highly specialised in and operate successfully in their segments.

Generally, the initial position for the engine industry is similar to that for the parts-supply industry. The main questions for future development are the technological approach to be pursued and the strategic partnerships and alliances to be entered into with other globally operating engine manufacturers.



Together with its partner Pratt & Whitney, MTU offers the geared turbofan, the engine of the future.

III.1.4 Maintenance service providers

As another subsegment of the aviation industry, service providers in maintenance, repair and overhaul (MRO industry) accompany the longest part of the lifecycle of an aircraft. Here too, the firms have increasingly positioned themselves internationally. This affords the opportunity to channel experience from operation, maintenance and repair into new developments and reliably monitor the lifecycle of products.

With the available competencies and capacities in cooperation with the manufacturers and parts suppliers, it also provides the possibility to systematically develop and install improvements in existing aircraft types, systems and engines, which can be exploited as another distinctive feature setting companies apart from international competitors.

Growing international competition, especially from Asia and the Middle East, also requires enterprises to keep a technological lead so as to secure future viability in the long term.

III.1.5 General aviation

Another branch of the German aviation industry manufactures products for so-called general aviation. According to the definition of the International Civil Aviation Organisation (ICAO), this term denotes the air traffic outside of commercial aviation and aerial work. It can be roughly divided up into the following areas:

- In-company individualised business travel
- Recreational aviation and meeting private mobility requirements with small and lightweight sports aircraft – including the ultralight aircraft segment

Substantial growth has been recorded in recent years in individual sectors, especially in light (ultralight) and business aircraft. Many developments as part of earlier RTD measures in the aviation industry have been disseminated into general aviation, where they have enabled new or modernised designs (gyrocopters, seaplanes, ground-effect vehicles, for instance). At least for lightweight and ultralight aircraft, some smaller enterprises in Germany also have overall system capability for these aircraft as well.

Some products and companies in general aviation could develop from purely recreational aircraft to entering the business line of commercial application.

III.2 Research landscape of the civil aviation industry

The ability to draw on a well-developed research community and associated research infrastructure is a decisive factor for the technological performance of the aviation industry. In recent years a research network of industrial enterprises, SMEs, higher education institutions and (large-scale) research facilities has been built up in Germany that makes for an outstanding locational factor. The backbone of this is provided by the German Aerospace Centre (DLR), which has achieved world standing in research in many sectors and disciplines of modern aircraft construction and takes a leading role in Europe overall. Besides DLR, other (large-scale) research facilities, such as the relevant institutes of the Fraunhofer Society (FhG) or other Helmholtz Centres contribute excellent research and development work in collaboration with universities in major areas, such as manufacturing methods and materials science.

In collaboration with research institutions, this research landscape enables companies to research and validate promising technologies that entail high financial and technical risks. This has had a substantial formative effect on the existing technological competencies of the German aviation industry. Its future development also depends on effective networking and intensive exchange among business and industry and the scientific community. It is therefore an important function of publicly-financed (large-scale) research facilities to provide substantial support to industrial value added in this sector in Germany. An aim of forming research collaborations is to effectively involve SMEs early on in research projects – either as independent project partners or by awarding subcontracts. Consideration should be given here to whether the open-theme instrument, SME Innovative, as tried and tested in other thematic programmes, might be appropriate for also introducing other SMEs to the ambitious collaborative projects in thematic funding in aviation research.

Besides the excellent institutional research facilities, of decisive importance for the previous development of German civil aircraft construction has been the Federal Government's Aviation Research Programme (LuFo). Many technologies that have made a decisive contribution to the market success of respective businesses today have been and are developed as part of LuFo projects. It also supports in particular the involvement of SMEs through higher funding quotas and bonuses for large-scale enterprises that engage SMEs as subcontractors in their projects.

At European level, LuFo is supplemented by the EU Framework Research Programme, which has so far encompassed a specific aviation sector. Also under the forthcoming EU Framework Research Programme, Horizon 2020, a specific aviation sector can promote cooperation with the European aviation industry as part cross-border research consortiums. Companies in the German aviation industry can also derive great benefit from this by accessing new partners and market segments.

III.3 Air transport industry

With its main actors, the airline companies, the airports, air traffic control and service providers, the air transport industry plays a decisive role in efforts to establish a sustainable and clean air transport system. On the one hand, it brings technologies onto the final consumer market as user. On the other, through innovative concepts in flight guidance and efficient coordination with other transport operators, it can make its own important contribution to the performance and environmental cleanliness of the whole transport system.

Also due to its central geographic location, the German airspace is one of the busiest in the world. Over three million flight movements are carried out annually here and must be supervised accordingly. Increased air traffic in recent years has resulted in capacity constraints at certain times at individual hub airports. To gain acceptance for the expansion of the requisite infrastructure, it is essential to make a careful trade-off assessment. Discussions on this are frequently held among a broad regional and even transregional public, shaping the policy agenda in the regions concerned. To ensure the consensual implementation of infrastructure projects, this discussion should therefore begin as early as possible.

An adequate, efficient national and European infrastructure and a competitively neutral framework are crucial for the German aviation industry. Where European businesses are subject to the strict state aid regulations of the European market, it must be ensured that their foreign competitors engaged on the same market are not given preferential treatment through direct government subsidies or other concessions.

In a densely populated country like Germany, the operational restrictions at airports must strike a good compromise between the needs of air transport and the concerns of the affected local population. Relocations and distortions of competition at the expense of German aviation hubs should be avoided. These in turn are indispensable for a high-performance air transport system with worldwide connections and networking.

Another major part of infrastructure is air traffic control, particularly German Air Traffic Control (DFS). It plays a central role in implementing the Single European Sky (SES). This should be completed as speedily as possible, taking account of the interests of civil security and without exempting EU member states from their obligation to provide the requisite infrastructure.



Novel human-machine-interface design for an ATC panel.

III.4 Military aviation

Only nations with an efficient defence technology industry have sufficient planning scope and sway to remain capable of cooperating in European and/or international military programmes in the long term. This industrial competency has been built up and maintained thanks to the long-term commitment of the Federal Government in this area.

The competencies of the German defence aerospace industry range from military aircraft and helicopters to engines designed for military purposes. With its innovative system developments, subsystems and components, the German armaments and parts supply industry makes a contribution to this and also renders services in simulation, testing, servicing and maintenance as well as technical-logistical component and systems support. From overall system capability to component level, core competencies are available in various segments in different degrees of detail.

The market for military aircraft is currently in a state of flux. For one thing, the security-policy situation in Europe has undergone far-reaching changes over the last few decades and for another military aviation has been particularly affected by budget constraints and public expenditure cuts.

In addition, many modern flying weapon systems are currently being introduced or are just entering a long-term phase of service. Sequel systems with a long-term time horizon are presently being developed in the European environment. Of decisive importance for the German defence aviation industry at the moment is securing the deployed resources and available knowledge to retain its industrial competencies.

The introduction of unmanned systems also poses new technological challenges that call for suitable RTD activities.

Alongside innovative research in these technology sectors, building and sustaining capacities for the development, production and maintenance of unmanned systems also requires appropriate development and procurement contracts. Only with the findings and economic returns from serial production and product support can the industry retain its self-reliance in global competition. In relation to the ratio of all German RTD activities, the defence – just as the civil – aviation industry invests large amounts of its own funds in RTD projects.

To be able to position itself in the best way in European and international competition, the industry must set priorities and bundle the necessary resources and it must harness possible synergies between civil and military RTD.

In some cases, the products and technologies developed for military high-performance aircraft provide a basis for innovation in aircraft manufacturing. Conversely, experience from civil aircraft construction also finds its way into military aviation. The requirements of civil security agencies for aircraft are frequently similar to those of the military.

As a high-tech location, Germany needs to be internationally competitive. This applies for research, development and production. Maintaining and extending industrial defence know-how with related capacities is in the security interests of the Federal Republic of Germany.

From an armaments-policy standpoint, the Federal Armed Forces need to pursue the following main goals:

1. Retention of selected own capacities to close military capability gaps
2. Promotion of research and technology sectors that can help to close military capability gaps
3. Retention and expansion of aviation industry capacities in Germany to be able to bear overall system responsibility in key areas still to be identified
4. Where technologically unfeasible or economically disadvantageous, assured replacement of national overall system responsibility through international cooperation – based on intergovernmental or industry agreements
5. Taking account of national supplier capacities, including foreseeable deficits in supply chains
6. Early and continuous cost controlling and long-term planning reliability, also through integrated joint project management
7. Avoidance of complex organisational and management structures

A military aviation strategy will be prepared for this under the leadership of the Federal Ministry of Defence.



Rolls-Royce Deutschland took over responsibility for core components and the system integration of the TP400, the engine of the A400M programme.

IV. From guiding principle to reality – fields of activity and measures

In response to the present state of the German aviation industry, five main fields of activity are needed to implement the guiding principle of the Aviation Strategy.

We intend to:

1. make the aviation industry in Germany into a global pioneer for an efficient, safe, clean air transport system;
2. maintain and upgrade the overall system capability of the German aviation industry in major areas at national or European level;
3. strengthen and expand the competencies of the German aviation industry;
4. maintain the global supply capability and competitiveness of the engine, parts supply and MRO industry on a broad basis;
5. facilitate functioning competition through fair and comparable national and international competition and framework conditions.

If we are successful in these fields of activity, we can preserve and create jobs along the entire value chain of the aviation industry from research to development and production to MRO services as well as in the German air transport industry in the long term.

To be able to secure permanently reliable framework conditions for necessary future investments in the aviation industry as well, sound government finances are also essential. The Federal Government is pursuing a pro-growth consolidation course. All the financially relevant measures in this strategy must therefore fit in with the framework of the respective benchmarks of the federal budget and financial plan.

IV.1. Global pioneering role for an efficient, safe and clean air transport system

Basis

Germany is committed to a strong and competitive aviation industry and an efficient and clean air transport system. This is an indispensable locational factor for our export-dedicated economy with its high level of global integration. Moreover, mobility with aircraft and helicopters provides a valuable benefit to citizens, including business travel, airfreight, tourism and medical care as well as police and border protection tasks. The aim is to make the air transport system efficient and safe, also for future needs and users.

At the same time, however, the greenhouse gas, air pollutants and noise emitted by air traffic are also coming under growing criticism in Germany. Also, fuel supply at moderate prices for the aviation industry is progressively becoming a risk factor for the future. Research and development in new, cleaner and lower-consumption technologies that can compete on the market as innovations is therefore crucial for the future development of aviation.

Goal

The German aviation sector, that is, industry, the air transport sector, research institutes, universities and higher education institutions engaged in aviation, play a technological pioneering role worldwide for an efficient, safe and clean air transport system and thus make a substantial contribution to meeting the ACARE targets.

Implementation

The following measures can contribute to this: (1) investments in results-based research and development, (2) an effective utilisation and application of research findings for genuine innovations and (3) securing the next generation of well-trained scientists, engineers and other skilled personnel.

IV.1.1 Investments in research and development

Especially in aviation, marketable technologies require long and careful preparation. Research therefore already needs to be conducted today for application in 10–20 years. Added to this is the long lifespan of the individual type of aircraft. Aircraft available on the market are not usually replaced nationwide for 30 to 50 years by a new generation. The current Airbus A320-200 model, for example, took off for its official maiden flight in 1987. Due to the decision to re-engine, these models (though in part with new engines) will remain on the market until at least 2025. For reasons of cost, only limited improvements in technology and efficiency are possible during the lifespan of a programme. This increases the technological and economic pressure for new aircraft generations and necessitates timely and extensive investment in research and development.

For the future, this also affords an opportunity to make use of new technologies for improving the efficiency, reliability and safety of existing aircraft types to ensure the earliest possible application.

Due to spillover effects and favourable external impacts of higher efficiency, the above-described extremely long product and innovation cycles and the attendant uncertain returns, private enterprises may not invest in RTD activities on the most socially beneficial scale. This holds in particular for research with less direct market relevance (basic research).

Measures

Aviation industry

- Develop a long-term technology and research strategy with minimum exposure to normal fluctuations in the business cycle
- Lay the technological foundation in good time for the successful development of innovative products that contribute to an efficient, safe and clean air transport system and develop applications for aircraft (e.g. also for unmanned aerial vehicles). Research institutes, higher education institutions and SMEs should be specifically engaged to harness their potential and advance (technology) developments.
- Take active part in collaborative research and joint technology initiatives at EU level

Federal Government

- Set a suitable framework for dismantling barriers to innovation, also taking account of the special role of small and medium-sized enterprises
- Extend the leading position of the German research community in aviation to remain internationally competitive and advance research into innovative, cleaner technologies
- Provide an efficient and needs-based research infrastructure as a major pillar for the research landscape, also including large-scale research facilities, airborne research carriers and validators, and enabling research to conduct experiments and validation together with industry under real conditions at system or overall system level
- Retain scope for funding more applied research projects as part of project funding closely aligned with cleaner technologies
- Support appropriate technology and research programmes for this at EU level that cater for the needs of the German aviation industry

Scientific community

- Attach priority in independent research to technologies for a clean air transport system
- Develop appropriate schemes for the operation of large-scale research facilities aimed at sharing costs and benefits efficiently between industry and scientific institutions
- Strengthen aviation research in DLR as a core sector of institutional research, particularly with a view to aircraft as an overall system

IV.1.2 Improving the commercial application of research findings

We can only bring about a cleaner air transport system if research findings are put into technological practice and ultimately developed into marketable products. This also the only way to secure jobs in the long term and generate significant value added in the aviation industry in Germany. Applied research must therefore be more closely aligned with market requirements. At the same time, basic research must be continued to pave the way for future innovations.

The excellent research facilities and higher education institutions and well-endowed research programmes by international standards at national and at regional level provide an outstanding foundation for this.

Measures

Aviation industry

- Involve SMEs, research institutes and higher education institutions more closely in the industry's own RDT activities and research agendas and establish more effective networking. Continue engagement in research infrastructures jointly supported by industry and the public sector
- Step up engagement and coordinating role in basic research projects

Federal Government

- Improve steering and incentive mechanisms in project funding and promote effective cooperation between industry and the research sector
- Improve the framework for spinning off innovative enterprises from universities and (large-scale) research facilities in keeping with the BMWi's innovation strategy, Lust auf Technik, especially the provision of venture capital

Scientific community

- Strengthen the networking and coordination of independent research with the activities of the aviation industry
- Step up spinoffs through incentive mechanisms and support measures

IV.1.3 Securing and promoting highly qualified junior personnel for research, development and production

An excellent research landscape lives from the scientists engaged in it. It also crucially depends on young scientific talent that needs excellent and comprehensive training. This applies equally for all the other levels of the value chain: development, production and MRO services. Long-term success is only possible with highly qualified and motivated personnel (and entrepreneurs).

Scientific and non-scientific training must therefore be based on the latest scientific knowledge. Courses of study in engineering should also uphold the German university tradition of a broad and sound education. Moreover, it is increasingly important that training prepare engineers and scientists, but also other skilled personnel for an international working milieu.

To recruit enough young people for technical or scientific studies and related training, educationalists should impart enthusiasm and fascination for technology and aviation early on and reduce psychological inhibitions. The aviation industry must also make efforts to attract personnel with appropriate working conditions and suitable human resource development schemes to compete with other technology-intensive industries for the best professionals.

Measures

Aviation industry

- Coordinate and sustain image campaigns both industry-wide and instigated by individual companies
- Offer attractive, long-term occupational prospects through a long-term recruitment and training policy early on and improve the standard of qualification of personnel and their occupational prospects with effective further training schemes
- Raise the attractiveness of aviation compared with other competing industries through a stable human resource policy, particularly also for female specialist and executive personnel
- Ensure the early integration of young scientific talent through joint research projects

Federal Government

- Flank efforts to secure the next generation of skilled personnel by stepping up marketing and communication on the role of aviation for the German economy
- Dismantle barriers to internationalisation, especially in research and academic teaching

Higher education institutions

- Advance the international networking of higher education institutions in the study phase
- Place greater emphasis on social skills and foreign languages in courses of study

Research institutions

- Step up networking with higher education institutions
- Promote qualification also in the doctorate phase with specific courses

Aviation industry

- Conduct a programme to foster fascination among pupils for aeronautics
- Coordinate and sustain image campaigns both industry-wide and instigated by individual companies
- Offer attractive, long-term occupational prospects through a long-term recruitment and training policy early on and improve the standard of qualification of personnel and pupils in aeronautics

IV.2 Overall system capability of the German aviation industry

Overall system capability is a central factor for the long-term maintenance of independent research and development competencies in the German aviation industry. There is no general, uniform definition for this term: A distinction must be made between various types of overall system capability depending on the project.

IV.2.1 Overall system capability for commercial aircraft in the European context

Basis

Modern commercial aircraft programmes are normally carried out by transnational teams and in a European/international division of labour. Airbus, for example, only has overall system capability in the sense of the complete development and production of an entire commercial aircraft in collaboration with the European Airbus partner countries. This is expedient for efficient risk sharing and making the best possible use of the available competencies. The German aviation industry makes up an integral part of the European aviation industry here, with a leadership role in certain areas or aircraft classes.

Goal

Maintaining and strengthening capabilities and competencies in Germany with the aim of taking the lead role in European collaboration for commercial aircraft as an overall system in research, development and production as part of the future short-haul and medium-haul programme (A320 sequel programme, A30X)

Implementation

To achieve this goal, a suitable foundation must be laid for forthcoming development programmes both in industry and in higher education and science.

The specific concern here is primarily preparation for the future short-haul and medium-haul programme (A320 sequel programme, A30X). It is not a future aim of this strategy to have entire commercial aircraft developed and manufactured in Germany alone.

Although programmes are normally managed today in transnational teams, a development programme requires central management that is capable of designing (and integrating) the aircraft at overall system level and taking programme leadership.

The German Airbus locations will also bear responsibility in future for aircraft programmes in collaboration with the other Airbus locations and take on the leading role in the Airbus Group for certain programmes, such as the future short-haul and medium-haul programme (A320 sequel programme, A30X).

This leading role comprises in particular:

- Engineering for the pre-design layout of the overall system
- Programmatic project management (programme management), including the adequate definition of all major interfaces
- Non-specific design work, at least for the traditional German competencies and the components
- Integration of individual systems and subsystems into an operational aircraft in the European context

To be able to cope with this task, the German Airbus locations need to have adequately qualified engineers with relevant professional experience at their disposal.

IV.2.2 Overall system capability in helicopters and engines

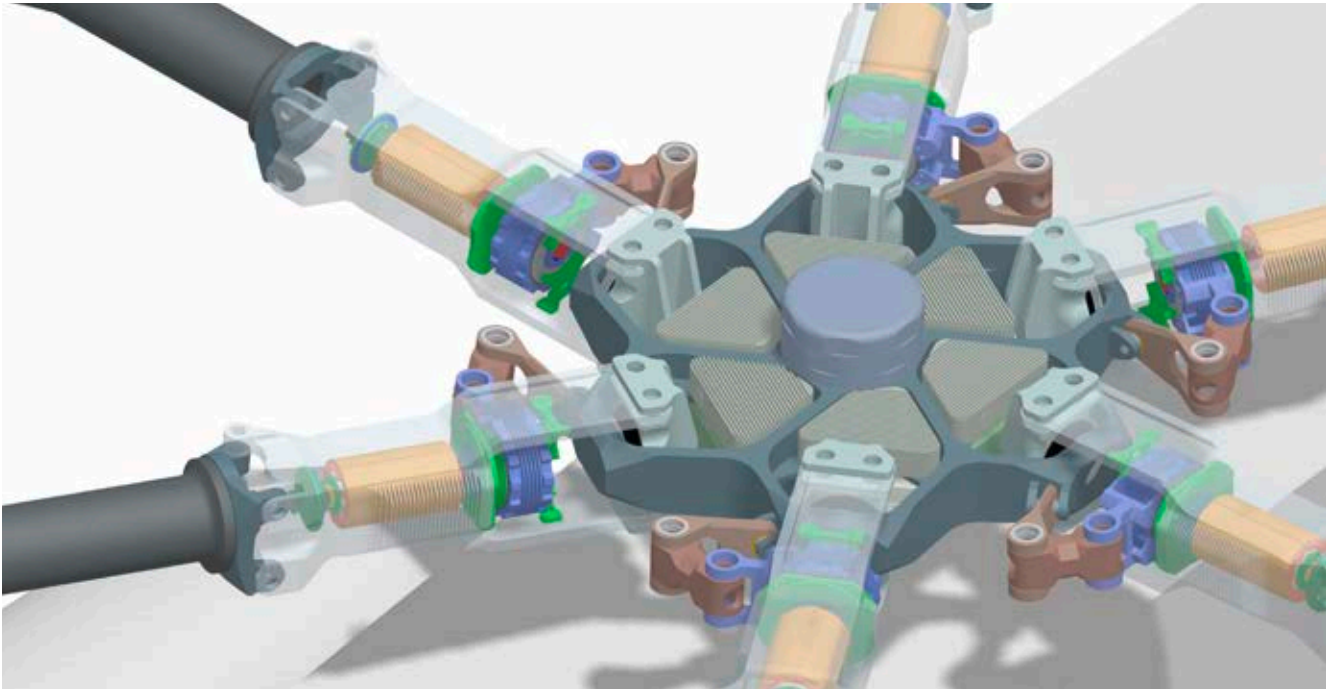
Measures

Aviation industry

- Lay the structural, research-policy and human resource foundation in good time to ensure that all the necessary capabilities and competencies are in place for the leading role at German locations before the commencement of the future short-haul and medium-haul programme (A320 sequel programme, A30X).
- Locate the programme management and the main development plateau – including the chief engineer teams – with the leading role described in IV.2.(1) for the future short-haul and medium-haul programme (A320 sequel programme, A30X) at the Airbus location in Hamburg. The main development plateau also coordinates and integrates the operations of the sub-plateaus.

Federal Government

- Define strengthening and maintaining the described capabilities and competencies in commercial aircraft with relevance to the leading role of the German Airbus locations as an essential element for public funding instruments.



IBC (Individual Blade Control) by means of direct root actuation for swashplate elimination.

Scientific community

- Also gear research topics and learning contents to maintaining and extending the necessary fields of competency to facilitate taking over the above-described lead role for a commercial aircraft as an overall system in Germany.

Goal

Maintaining and strengthening overall system capability in Germany for research, development and production in all relevant sectors of the aviation industry

Basis

Overall system capability is a key factor for the long-term sustainability of independent research and development competencies of the German helicopter and engine industry.

This has been broadly available in Germany with light-weight, twin-engine class helicopters to date, including the development and production of the main individual systems and subsystems. This will also remain so in future.

Preserving overall system capability in this inclusive sense is also an important criterion for the future development of the engine industry as a particularly complex subsector of the aviation industry.

Overall system capability in general aviation will be secured and enlarged through the strategic upgrading of existing regional networks and clusters and linkage with allied, relevant technology and innovation clusters.

Measures

Aviation industry

- Sustain and strengthen full system capability in helicopter and engine construction at Airbus Helicopters, MTU Aero Engines und Rolls-Royce in Germany
- Locate the management and responsibility for an additional civil helicopter development programme by Airbus Helicopters in Germany, also with a view to extending the current civil product portfolio

Federal Government

- Define maintaining and strengthening overall system capability for helicopters and engines as a key element for public funding instruments

Scientific community

- Maintain and expand the necessary fields of competency in overall system capability

IV.2.3 Overall system assessment capability in parts suppliers and in the MRO industry

Parts supply firms at higher levels of the supplier chain must be able to understand and assess the overall system and the interdependencies among various individual systems. This is a particularly important capability for parts suppliers and the MRO industry to be able to conduct independent technological development. It can also be described as overall system assessment capability.

Measures

Aviation industry

- Specifically pursue the development and maintenance of overall system assessment capability as part of supplier-led collaborative research

IV.2.4 Retaining the overall system perspective in training and research

Overall system capability can only be maintained in the aviation industry in the long term if the supply of suitably trained junior personnel is assured.

Measures

Scientific community

- Ensure overall system training in engineering courses of study at German higher education institutions when drafting the relevant curricula

IV.2.5 Securing sustainable military aviation

- Integrate the parts supply industry into the whole product development chain through OEMs

In response to the increasingly complex tasks of the Federal Armed Forces with their stagnating resources, military aviation in Germany must be organised and sustained as far as possible in interaction with industry.

Measures

Federal Government

- Frame a military aviation strategy to identify problems and propose solutions

IV.3 Strengthening German core competencies

Basis

The German aviation industry contributes its greatest value-added and can draw on its most outstanding individual engineering competencies (besides its programme management capability) in large commercial aircraft in the segments fuselage and fuselage structures, cabin, fin, final assembly, wings and high-lift as well as flight physics. Added to this are competencies in the parts supply industry, such as avionics, flight control and undercarriage, and in engine manufacturers and the MRO industry. Another core competency is the highly-automated production technology segment. This has to do with technologies for producing the growing number of structural components made of CFK, but also components in hybrid construction or on a metallic basis. With its manufacturing technologies and automation competency, involving German mechanical engineering enables substantial technological progress and spillovers to be made in other industries, such as motor vehicle manufacturing.

Pilot assistance systems will play a greater role in future. Today's systems are reaching their limits and will be replaced in future by certified and more autonomous assistance systems, especially for extreme situations and emergencies.

When planning research, both publicly funded project research and institutional research in DLR and in other (large-scale) research facilities should aim at contributing to strengthening German core competencies and growth segments.

Goal

Expanding existing core competencies in Germany in future and supplementing these where useful

Measures

Aviation industry

- Focus investments in research and development activities on core competencies with the aim of retaining or achieving technological leadership in these areas
- Develop new technology fields with prospects for expanding the share of German components in aircraft programmes in the long and medium term, a specific example being the hydrogen fuel cell for supplying secondary energy
- Expand lines of business in the engine industry to include new engine classes and in maintenance repair and overhaul (MRO)
- Place greater focus on the overall lifecycle and expand possible measures for improving/modernising aircraft in service
- Develop new lines of business in the commercial sector in general aviation.

Federal Government

- Draw up a technology roadmap for civil aviation technology together with business and industry and the scientific community, subject it to a critical review and upgrade it without bias to any specific technology during the term of this Aviation Strategy. This can form a substantive basis for project funding in the aviation sector.
- Promote research projects in scientific institutions and research collaborations generally of importance for strengthening core technological competencies

- Focus on strengthening and usefully supplementing core technological competencies when financing development costs, also technology fields and product segments of the parts supply industry

Scientific community

- Enter early on into interdisciplinary research collaboration in new high-potential technology fields
- Support the aviation industry in identifying these new technology fields

IV.4 International supply capability and competitiveness of the German parts supply industry

Basis

Owing to the changed procurement policy of prime contractors, market conditions and requirements for the parts supply industry have changed greatly in recent years. The German parts supply industry must also cope with this change, if it wants to remain globally competitive. For Tier 1 suppliers, this means that in addition to technological capabilities management competencies and financial resources will play an increasing role. Small and medium-sized enterprises must either extend their leading technological position through renewed efforts in research and development or improve their ability to provide complete systems or a broad, coherent product portfolio.

Goal

Strengthening the global competitive position and supply capability of the German parts supply and engine industry. Companies must improve their competitiveness, possibly also through commercially viable horizontal and/or vertical integration to position themselves as Tier 1 suppliers.

IV.4.1 Setting up internationally successful supplier associations

Measures

Aviation industry

- Harness potential for useful horizontal or vertical integration
- Strengthen and extend technological leadership in relevant areas of competency
- Implement a separate research and product strategy for outsourced former Airbus locations to strengthen their competitiveness in the long term, which will afford them supply capability in international development programmes. Adequate endowment with private capital is essential for this.

Federal Government

- Support the parts supply industry in financing participation in aircraft programmes where commercially viable and economically eligible for assistance, where necessary due to capital market failure and where feasible under the EU state aid framework

IV.4.2 Greater participation of German parts suppliers in aircraft programmes of non-European OEMs

To improve their market and competitive position, German suppliers could take greater part in non-European aircraft programmes. This would make them more independent of individual clients and could help offset capacity fluctuations due to programme cycles. It would also enable them to achieve higher economies of scale, including the application and commercial use of technological know-how and a simultaneous broader diversification of risks. Participation projects should, however, be carefully selected based on market prospects, as the scope for building up and subsequently reducing development and financial capacities is usually limited. In this connection, future possible cooperative projects among OEMs could afford scope for harnessing synergies and thus contribute to a better return on higher investments in development and financial capacities.

Measures

Aviation industry

- Develop effective strategies to enhance business/export opportunities, while avoiding the risk of an inadvertent and unregulated knowledge drain (especially in technologies developed with public support)
- Form marketing alliances to be able to offer larger work packages to the respective systems manufacturer

Federal Government

- Provide political flanking for the participation of German enterprises in non-European development programmes and if necessary risk hedging support (e.g. in the shape of sales-based repayable loans for pro-rata financing of development costs, as described under IV.4(1)).

IV.5 International fair and comparable competition conditions for the aviation industry

Basis

The long-term goal is to curb government influence on the industry. This, however, also calls for internationally balanced competition conditions (level playing field). There is therefore a need for binding regulations that apply to all countries with a globally operating aviation industry.

Both the European Raw Materials Initiative and the Federal Government's Raw Materials Strategy set a major frame of reference for the secure supply of the aviation industry with raw materials and inputs for the production of very complex components (such as CFK fibres or metallic structural materials, such as titanium and rare earths).

This must also take particular account of the related supply and supplier chains for raw materials, semi-finished products and components.

Goals

Curbing public-sector influence on the aviation industry under internationally balanced competition conditions

Dismantling trade barriers on international commodity markets

Implementation

To implement these goals, there is a need to draw up an international agreement on uniform funding conditions for the aviation industry, promote trade in aircraft and engines and continue to provide flanking support for securing raw material sources.

IV.5.1 International agreement on funding conditions for commercial aircraft

Measures

Federal Government

- Reach an agreement on the framework for promoting the aviation industry among EU member states. The Federal Government's medium-term aim here is to curtail government influence.



Friction-stir-welded integrated structure for weight reduction.

- At international level and in the course of the current WTO dispute with the USA, advocate a multilateral agreement in the tradition of the Large Civil Aircraft (LCA) Agreement of 1992. Besides large commercial aircraft, this should also comprise regional aircraft and involve the emerging aviation industry nations, such as China, Russia, India, Brazil and Canada.

IV.5.2 Promoting trade in aircraft and engines

Measures

Aviation industry

- Develop a sustainable export strategy that trades off the advantages of market access with the disadvantages and external effects of technology transfer

Federal Government

- Provide political flanking for foreign projects of German aviation companies in keeping with the relevant guidelines

IV.5.3 Promoting functioning commodity markets

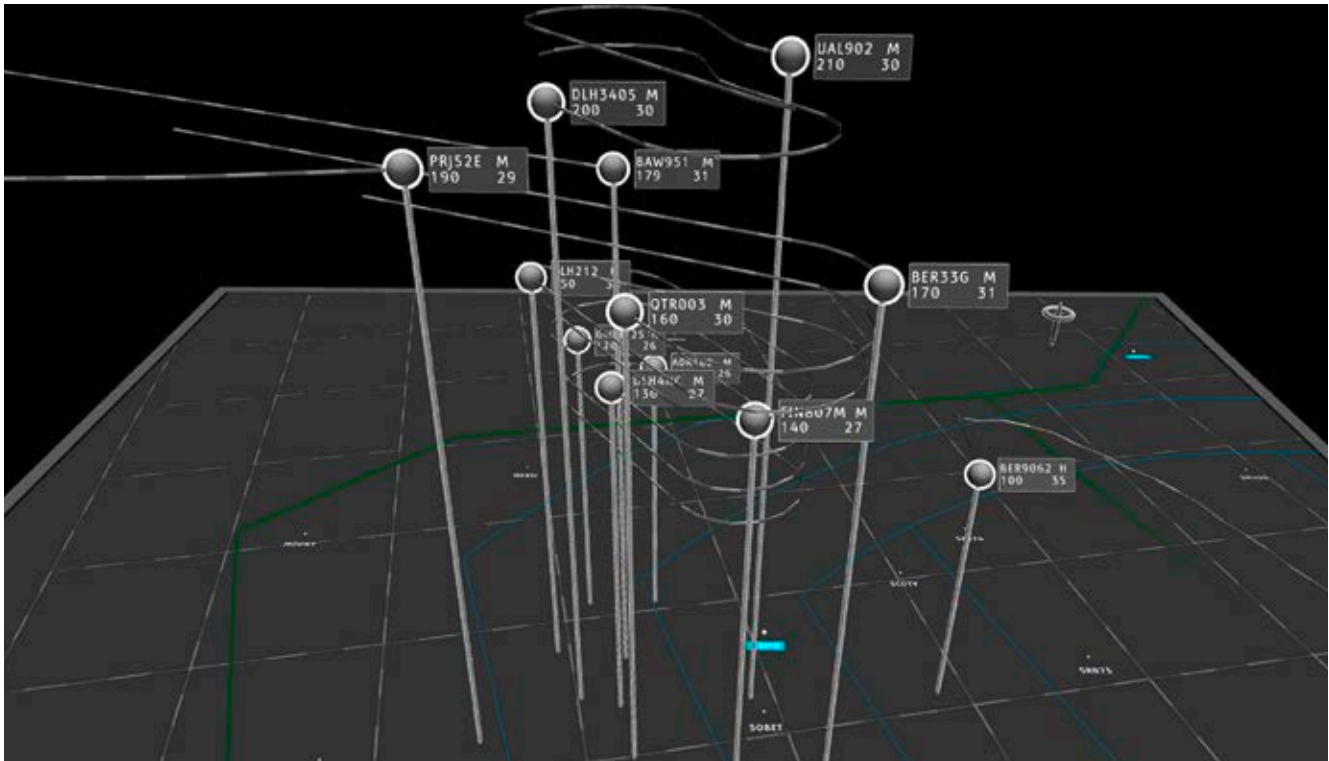
Measures

Aviation industry

- Step up diversification of raw materials sources, initiate research and development on new and innovative, functionally specific raw materials use to lessen dependencies on strategic raw materials

Federal Government

- Continue to implement the measures cited in the Federal Government's Raw Materials Strategy, with the focus on initiatives for free trade and against protectionist measures
- Place a heavier focus on developing the necessary technologies for obtaining materials and inputs in public research programmes



3D traffic visualization for an ATC display.

V. Specific instruments to implement the Aviation Strategy

The goals defined in the previous section address all the actors in the aviation industry. These include policymakers and public administrators, industrial enterprises, SMEs, trade unions and labour representatives, (large-scale) research facilities and higher education institutions as well as semi-public organisations, such as German Air Traffic Control and also society as a whole.

Various measures have also been discussed for the Federal Government and these will be presented in more detail in the following along with some instruments. The goals cited in Section IV will ultimately provide a benchmark for evaluating measures and specific instruments.

The instruments of technology promotion are divided up along a scale of technological maturity. Specific funding should already start with aviation-related basic research at low levels of technological maturity and should extend over the laboratory or theoretical level to validation and demonstration. As a general approach, suitable, targeted instruments will be identified, depending on the level of maturity of technological research and development.

The public sector sets the framework for an internationally competitive aviation industry. For the Aviation Strategy to

succeed at all, however, the guiding principle and the related goals must be pursued by the enterprises themselves.

Research

Promoting basic research

Adequate funds will be provided to non-academic research and higher education institutions both in institutional and project promotion for basic research with a bearing on aviation.

- As a major pillar of basic research, institutional (basic) funding by central and federal state governments enables the particularly important continuity of research in this sector and at the same time ensures adequate scope for unconventional approaches motivated by scientific curiosity.
- Project funding for low levels of maturity should draw on various resources with different objectives and obligations. These include funding from research programmes of various ministries at federal state and

central government level (examples: DFG, BMWi, BMBF, BMVg, BMVI). Added to this are funds from cross-cutting and thematic programmes and foundations of general relevance (examples: materials research, research on alternative fuels) that should bring more resources to bear on aviation.

- Moreover, funding facilities for project promotion will be set up in the Aviation Research Programme (LuFo) for areas with low technological maturity. As an innovative research programme, LuFo must already be geared to the subsequent implementation and application of research findings in this area.

As a general rule, projects should be assisted in this area up to proof of concept (Level 2 maturity).

The Federal Government's Aviation Research Programme

The Aviation Research Programme (LuFo) should be continued at the current level of expenditure, while upgrading the conceptual design, including the major step of ongoing evaluation of completed, current and future programmes.

LuFo is substantively geared to the two target fields of the European strategic document, Flightpath 2050: (1) Gearing aviation to societal needs and requirements and (2) the industrial leadership of the European aviation industry.

Under LuFo, technologies can therefore be funded that are suitable for application on the civil, commercial market with prospects of high and sustainable value added in Germany.

The evaluation criteria for research projects that can apply for funding under LuFo are:

- Prospective application and (industrial) commercial use of the research findings and/or the developed technology in Germany on the civil commercial market
- Scientific excellence
- Networking between industry and the scientific community

In future also, LuFo will continue to focus heavily on the parts supply industry, including innovative and research-intensive SMEs. With appropriate incentive mechanisms, it will in particular seek to advance networking among industrial enterprises, SMEs, higher education institutions and research institutes. Moreover, depending on the planned degree of technological maturity, the Research Programme will distinguish among different funding categories. Funding terms and conditions must be adapted accordingly to comply with EU state aid law and allow for different options.

- The first category comprises projects in industrial research, i.e. up to the validation of the respective technology under idealised conditions. Non-refundable grants are awarded for these projects, whose specific design is geared to the already familiar framework from predecessor programmes.
- The second the category is made up of projects in industrial research and experimental development with a closer bearing on markets and products. In future, therefore, the Aviation Research Programme will also allow for



Within the national LuFo aeronautics research programme MTU developed highly efficient core compressor technologies.

testing and validation of prototypes under real operational conditions and improve the transition to a demonstrated and securely operating technology. This category will apply funding terms and conditions in keeping with EU state aid specifications. In addition, it can facilitate (partial) finance for programmes with alternative financing instruments (loans, for example).

Beyond this, a larger contribution by scientific institutions and research facilities to the research projects they conduct (depending on the degree of technological maturity) can upgrade prospective commercial use and the internal coordination of research projects. This can be financed from funds of collaborative partners from business and industry or through basic funding.

Aviation research in intersectoral innovation and technology programmes

Besides the options available in the Federal Government's Aviation Research Programme, the Central SME Innovation Programme (ZIM), for example, makes up a major pillar of research funding, especially for small and medium-sized enterprises from the aviation sector. The programme, SME Innovative, also offers similar facilities. Additional intersectoral programmes, in which aviation research actors can take part or are involved, are available in knowledge and technology transfer (KTT) (e.g. Leading-Edge Cluster Competition, Research Campus).

The funding terms and conditions here are directed more specifically at the needs of SMEs so that they make a major contribution to maintaining or enhancing the technological competency that SMEs often have at their disposal, especially in niche sectors.

These programmes should continue to be available to the aviation industry with a broad scope of application.

Research advisory board for DLR

(Large-scale) Research facilities often act as a bridge between basic research and industrial application. To perform this function, research activities must be effectively coordinated with industry. These must contribute to medium-term and long-term competitiveness and strengthen the competencies of the German aviation industry, particularly also the parts supply and engine industry.

BMWi will therefore set up a research advisory board at DLR tasked with improving consultation between the aviation industry and DLR. Representatives from the scientific community, business and industry and administration will take part in the advisory board.

At the same time, the framework needs to be improved so that research findings and technologies from higher education institutions and research facilities can be put to better commercial use. This can be done, for example, through patenting, trade-mark protection or spin-offs, but also as part of agreements with industrial partners.

Technology roadmap as a substantive guideline for aviation research

Technology sectors of key importance for the future development of the German aviation industry will be defined in a technology roadmap with the involvement of the scientific community and industry. The areas described therein will provide a guide for project promotion and the programmatic alignment of (large-scale) research facilities.

BMWi, the relevant research and scientific institutions and industry (along with the relevant associations) will step up dialogue on the structural conditions that need to be created for all participants to identify with the technology roadmap.

As part of the institutional arrangements, the Aviation Research Advisory Board, which along with the aviation industry includes all relevant ministries, higher education institutions, DLR and the air transport sector (including DFS), will be upgraded and suitably incorporated into this new architecture.

The Federal Government places special responsibility for general aviation segment on the federal states. In addition to the Aviation Strategy presented here, an assessment, forecast and description of possible fields of activity for general aviation will therefore be prepared together with the federal states.

Market access

Loans for financing development costs in international programmes

Lending programmes for parts suppliers and systems manufacturers for pro-rata co-financing of development costs in aircraft programmes are a major instrument for reducing risks in large-scale aircraft development programmes. As such, these should also be continued in future in keeping with international regulations.



The innovative geared turbofan PW1100G-JM has been tested by MTU Aero Engines in Munich.

Costs incurred at home for participation in non-European development programmes can also be funded, provided a corresponding, additional economic benefit from research findings and a strategic value added can be generated for the respective parts supply firms. The assessment will not only cater for market and programme risks, but also the long-term contribution to value added in Germany.

Private equity capital fund

To raise equity capital for high-growth medium-sized enterprises in the German aviation industry and enhance their competitiveness and positioning as Tier 1 suppliers, consideration should be given to the possibility of the aviation sector establishing an equity capital fund.

As the customary terms for equity investments by investment companies (5–7 years) are too short for the aviation sector, it will be supported by private core investors in the sector and supplemented by funds from private investors. The funds should be allocated by an independent fund management on market terms and conditions tailored to the specific needs and conditions of the aviation industry.

Evaluation

After an adequate period, the Aviation Strategy will be subjected to an external review to assess progress in objectives achievement.

VI. Glossary/List of abbreviations

| | |
|---------------------------|---|
| ACARE | Advisory Council for Aviation Research and Innovation in Europe |
| Airbus A30X | (Preliminary) Project title of the future successor model to the Airbus A320 family |
| Anthropogenic | The term ‘anthropogenic’ (from the Greek ‘ánthropos’, man and the verbal etymology meaning ‘engender’) denotes everything that is engendered, caused, produced or influenced by man. |
| BMBF | Federal Ministry of Education and Research |
| BMVg | Federal Ministry of Defence |
| BMVI | Federal Ministry of Transport and Digital Infrastructure |
| BMWi | Federal Ministry for Economic Affairs and Energy |
| CFK | Carbon-fibre reinforced plastics |
| CO₂ | Carbon dioxide |
| DFG | German Research Foundation |
| DFS | German Air Traffic Control |
| DLR | German Aerospace Centre |
| EADS | European Aeronautic Defence and Space Company |
| Eco-balance sheet | Systematic analysis of the environmental impacts of products during their entire lifespan (from cradle to grave) or up to a specific stage of processing (from cradle to factory gate) |
| Economies of scale | Rate at which production increases in proportion to increases in all production factors |
| EU | European Union |
| Fixed costs | Part of total business expenses that remain constant in a specific period even if a reference variable changes. |
| Flightpath 2050 | Europe’s Vision for Aviation: By 2050, air traffic is to produce about 75 % less CO ₂ emissions compared with 2000. Also planned is the reduction of noise emissions at airports by approx. 65 %. |
| GDP | Gross domestic product |
| Geared turbofan | Turbofan engines with two or three shafts with a reduction gearbox between the fan and the low-pressure turbine. As this allows for reducing fan speed and increasing low-pressure turbine speed, both components can operate in their respective optimum speed range. This considerably reduces the consumption and noise level. |

| | |
|----------------------------------|--|
| Hub airports | Airports where several airline companies provide an integrated service network for a multitude of various destinations with a high frequency of connections |
| Hybrid design | System, where two technologies/materials are combined with each other, such as combinations of plastics and metals |
| ICAO | International Civil Aviation Organisation |
| KTT | Knowledge and technology transfer |
| LCA | Large civil aircraft |
| LuFo | German Aviation Research Programme |
| Marginal costs | Higher costs incurred by the increased production of a unit of output |
| MRO | Maintenance, repair and overhaul |
| NO_x | Nitric oxide |
| NV | Naamlooze vennootschap, equivalent to a German stock corporation |
| OEM | Original equipment manufacturer: prime contractor/manufacturer of the overall system, such as Airbus, Boeing or Airbus Helicopters |
| Product cycle | Process between market launch or production of a marketable good and its removal from the market |
| R&D | Research and development |
| RPK | Revenue passenger kilometre |
| RTD | Research and technology development |
| Secondary energy | Energy in a different form from primary energy. It is generated in the power industry through energy conversion or refinement to be able to transport or use it more easily. |
| Single-aisle | Commercial aircraft with a fuselage diameter of between three and four metres and only one aisle and with up to six seats per row in the economy class, as in the Airbus A320 family or in the Boeing 737 |
| Single European Sky | Uniform European airspace: The purpose is to reorganise European airspace to rationalise traffic flows and eliminate its fragmentation through national borders and interests by creating a limited number of so-called functional airspace blocks (FABs). |
| SMEs | Small and medium-sized enterprises |
| SRIA | Strategic Research and Innovation Agenda |
| (Technological) Spillover | Impact of a technology in another industry/sector |
| Tier 1 (parts suppliers) | Classification of upstream and downstream parts suppliers, where Tier 1 denotes top priority suppliers delivering directly to the system manufacturer. This status also usually entails development responsibility for the contracted subsegment. |

| | |
|-------------------------|---|
| Trent XWB engine | Modern Rolls-Royce engine planned for Airbus A350 with a much lower consumption and improved exhaust and noise levels compared to Airbus A330 |
| WTO | World Trade Organisation |
| ZIM | Central SME Innovation Programme |

