



Towards a European Strategic Aviation Research, Development, Testing & Evaluation Infrastructure

Report of the Independent Expert Group

Final Report - April 2013

Legal Notice

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information.

The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

Contact:

Dietrich Knoerzer – Stanley Tang
European Commission
Directorate-General for Research & Innovation
Directorate H – Transport
RTD-H.3 – Aeronautics
B-1049 Brussels
dietrich.knoerzer@ec.europa.eu
stanley.tang@ec.europa.eu

Preface

Tasked by the European Commission and ACARE Member States Group in September 2012, a group of independent experts (IEG) has produced the following report on a European Strategic Aviation Research, Development, Test and Evaluation Infrastructure (RDT&E) and has submitted it in February 2013.

The mandate provided very limited time for the group to deliberate and did not allow the complete perimeter to be addressed in the necessary depth. The IEG therefore decided to make sure it covered areas where short-term advice actions were potentially needed and where its own expertise could contribute. Nevertheless the IEG was also able to review the entire spectrum of aviation RDT&E infrastructure (identifying several additional areas as potential "strategic RDT&E capabilities", ranging from aero-engine testing and ATM, E-infrastructures and large scale demonstrators to production technology capabilities) and to recommend further work on these and other topics that it considered necessary to provide a complete and in depth review in the longer term.

The IEG took benefit of the partly complete "Catalogue of the European Aeronautical Research Facilities" developed by the Aeronautics ERA-Net AirTN and also took note of the letter from a group of major European aeronautical industries providing their view on European wind tunnels (February 2012) identifying "core" wind tunnels for their needs. In particular, the IEG has taken note of those wind tunnels indicated by Airbus to be core to its future needs. Since the IEG report covers only civil aviation, the military part of this industry view has not been considered.

The IEG is well aware that in its work there are likely to be "strategic RDT&E capabilities" at a European and certainly at a national/regional level that it has not yet specifically identified. This is partly due to the short time available and to the wish to be sure to focus on the "big stuff" as "strategic & unique at a European level" and considered to be indispensable for securing Europe's future in Aviation. The IEG members agreed unanimously that it was preferable to concentrate on a fairly small number of really essential European "strategic and unique" RDT&E capabilities in the time available.

The IEG considered it most important to establish selection criteria that should be used in future work when analyzing RDT&E capabilities concerning them to be considered as "strategic & unique on a European level" and "strategic and key" at a national/regional level thus deserving special recognition and support from the EU, the member states and industry. The group considers its work to be the beginning of a much longer and complete process rather than a conclusive end. The recommendations made by the group reflect this and intend to guide the future work to complete the review at the necessary depth. The work of the IEG ended with a public workshop, at which the need for following up further actions and the important role for ACARE in leading and supporting such work were emphasized.

On behalf of the members of the group, that have cooperated in an efficient and professional manner, the co-chairmen of the IEG would like to recognize the contribution to its work of the Commission Aeronautics team representatives (namely Dietrich Knoerzer and Stanley Tang), and Nicole Ewinger from the DLR for her administrative support on behalf of AirTN.

Many thanks are due to the other members of the Commission staff and from the ACARE Working Group 5 and Member States Group for their comments and contributions.



Fred Abbink (Co-chairman)



Jürgen Klenner (Co-chairman)

Executive Summary

The availability of substantial and world-class infrastructure facilities for research, development, test and evaluation (RDT&E) is an essential part of securing a decisive competitive edge for the European Aviation industry (i.e. Aeronautics & Air Transport), as well as of the aviation-related public research for sustainable mobility in Europe.

The current large aviation RDT&E infrastructure in Europe has been built over many years and provides its capabilities Europe-wide and beyond. It has been a major contributor to the growth of the European aviation sector to its position today as global leader. Much of this major infrastructure is in national ownership; only the European Transonic Windtunnel (ETW) and the German/Dutch Windtunnel cluster (DNW) are in multinational ownership. Such major facilities are extremely costly to run, to maintain and to upgrade to deal with the technological advances and challenges of the future. In common with all such facilities everywhere in the world these costs exceed the revenues obtained from users. The public supports received by the European major facilities have so far been mainly national and/or regional and they have been progressively shrinking in recent years to the point that the future of some of these facilities is threatened.

By contrast In the US (where federal support budgets for aviation have increased since 2000), Russia and increasingly China, major aviation RDT&E facilities are supported at a federal level, as a strategic means of increasing the competitiveness of their aviation industries and supporting their military research and development capability. This disparity results sets Europe at a disadvantage and is a potential barrier to competitiveness.

In September 2012 the European Commission and ACARE tasked an Independent Expert Group (IEG) to identify, with the help of the ERA-Net AirTN, how the EU can play a major role in establishing a European Strategic Aviation RDT&E infrastructure and in securing its sustained availability. The IEG has begun this task by establishing a set of criteria for European "Strategic and Unique" aviation RDT&E capabilities and facilities as well as for "Key" capabilities and facilities. It has used these criteria to conduct an initial review of some of the large European facilities. The IEG has also conducted a wider review of types of infrastructure that might be considered to be strategic or key for Europe including ATM, production technology and large-scale computational simulation, as well as possible capabilities/facilities for propulsion, icing, electrical systems and environmental RDT&E. Finally the IEG has identified possible approaches for funding improved European supports to qualifying infrastructure.

In doing this work the IEG has recognized that in some cases there is a short term need to take urgent action, that a longer term approach is also needed on a broader front and that more work is required to fully identify and secure a world class aviation RDT&E infrastructure for Europe to ensure that the objectives of 'Horizon 2020' and Flightpath 2050 can be achieved.

This Final report of the IEG makes a number of strategic recommendations, which are summarised as follows:

- That the ETW, DNW-LLF, ONERA S-1 and ONERA F-1 wind tunnels are classified as strategic and unique capabilities/facilities.
- That urgent action is needed to support some of these strategic and unique aerodynamic capabilities in the short term.
- That work is undertaken urgently to identify the dependencies and needs in the SRIA on RDT&E infrastructure.
- That a working group is established to extend the database of possible strategic and key aviation infrastructure to cover the whole range of needs for 'Horizon 2020' and Flightpath 2050.
- That a consolidated list of key and strategic infrastructures is derived using the IEG criteria.
- That a cooperation be established between the European Commission, Member States, Industry and facility owners to investigate co-funding possibilities for the European strategic and unique facilities and to consider possibilities for cooperation and consolidation and thence co-funding for key facilities.
- That initial funding provision is made at a European level for providing support for European Strategic as well as for "Key" Aviation RDT&E Infrastructures:
 - o For the upgrade of facilities: 10 -15 million €/ year
 - o For an access voucher scheme to enable access for science: 5 -10 million €/ year
- That an "ESFRI type" of Group of Aviation Infrastructure Experts is established to judge the proposals from the owners of the Strategic and Unique existing Aviation Infrastructure as well as from future Strategic and Unique Aviation Infrastructures, and from consolidation proposals of key facilities on behalf of the EU.

Content

1. Introduction

2. The Need for a European Strategic Aviation RDT&E Infrastructure

- 2.1 Strategic importance of Aviation to Europe
- 2.2 Excellent Aviation Research, Development, Test & Evaluation Infrastructure, vital to achieve EU goals
- 2.3 US Government and NASA approach
- 2.4 Non-level playing field

3. Establishment of Selection Criteria

- 3.1 ACARE selection criteria
- 3.2 IEG selection criteria
- 3.3 "Strategic RDT&E capabilities"

4. Funding for a European Strategic RDT&E Infrastructure

- 3.4 Rationale and possibilities of EU co-funding
 - 3.4.1 Upgrading and maintaining of existing strategic RDT&E capabilities/ realisation of new strategic RDT&E capabilities
 - 3.4.2 Facilitating access to strategic RDT&E capabilities for excellent science and for research and testing
- 3.5 Co-funding by EU Member States
- 3.6 Long-term commitments by industry

5. Conclusions and Recommendations

Appendices

- A. Terms of Reference and Membership of the Independent Expert Group
- B. List of Abbreviations
- C. List of References

1. Introduction

The aeronautics industry in the EU employs nearly half a million people in direct employment mostly in highly skilled jobs.

Aeronautics exports from the EU (mostly civil) is consistently one of the pillars of the positive export/import balance. The European Aeronautics industry is the 4th greatest net-exporter in Europe (and ranks even higher in France and UK). For example in France aeronautics exports are around 15B€/year, far ahead of wine, luxury goods, etc. Aeronautics is the only steadily positive industrial export/import balance in this member state.

The aeronautics industry is not however without its singularities. The aeronautics industry seems to be less visible than, for example, the IT industry, the pharmaceutical industry and some others, more appealing, although they are about the same age (IBM was created in 1911, and the pharmaceutical majors appeared at the end of the XIX century. This may possibly be because its huge growth is more recent; its sales are business-to-business rather than direct to the consumer. Furthermore its profit margins are lower because of the massive investments and long cycle times involved.

So where did the competitiveness that has fuelled this growth come from? Three key factors have played a major part in coming to this position:

- Massive national investment after the second world war until the mid 1980's, including creation of excellent Research, Development, Test & Evaluation (RDT&E) facilities (ETW and DNW-LLF being the most recent) and support to RDT&E in industry, national research organisations and academia.
- Wise transnational decisions in the civil aviation industry in the 1970's (e.g. Airbus, CFM...). Airbus now holds around 50% of the global, large civil aircraft market.
- Decline of public support to civil aeronautics research in the USA in the 1970's until the mid-90's.

The opportunities for the European Aeronautics Industry remain very high, mainly driven by the continuous growth in the demand for air travel and underpinned by the need to continue efforts towards achieving truly sustainable aviation. Future competitiveness, essential to seize this opportunity, will result from

- The availability in Europe of the most advanced science and technology leading to innovation in application
- The most highly skilled and experienced scientists, engineers and technicians
- Close links to extremely skilled and innovative suppliers
- Fast and efficient design and fabrication processes.

The availability of substantial and world-class infrastructure facilities for research, technology and product development, test and evaluation are an essential part of securing a decisive competitive edge for the European Aviation industry (i.e. Aeronautics & Air Transport), as well as of the aviation-related public research for sustainable mobility in Europe.

The current large aviation RDT&E infrastructure, of strategic importance for Europe, is typically in national ownership, (ETW and DNW are in multi-national ownership) but provides its capabilities Europe-wide and beyond, while public supports it receives have so far been mainly national and/or regional and have been progressively shrinking in recent years.

By contrast in the US (where budgets have increased since 2000), Russia and increasingly China, major aviation RDT&E facilities are supported at a federal level, as a strategic means of increasing the competitiveness of their aviation industries (and supporting their military research and development capability). This disparity results in a non-level playing field.

In September 2012 the European Commission and ACARE tasked an Independent Expert Group (IEG) to identify, with the help of the ERA-Net AirTN, how the EU can play a major role in establishing a European Strategic Aviation RDT&E infrastructure and in securing its sustained availability.

The IEG has met five times and presented its preliminary findings to representatives of the EC and from ACARE/AirTN. In this Final Report the IEG presents its conclusions and recommendations.

The Terms of Reference of the IEG and its membership are given in Appendix A.

2. The Need for a European Strategic Aviation RDT&E Infrastructure

2.1 Strategic Importance of Aviation to Europe

The essential contribution of a world-class and competitive Aviation has been spelled out in a number of recent studies and policy documents. A list of these is included in Appendix C.

Of major significance amongst these is the recent report "Flightpath 2050"¹ produced under the patronage of the EC by a wide group of key stakeholders including representatives of Member States, national research establishments, Industry, and Universities. In this document the strategic importance of Aviation² to Europe has been summarized as follows:

- *"Aviation's economic and societal contribution is substantial: generating around € 220 billion and providing 4.5 million jobs."*
- *"Aviation is a catalyst for growth and skilled employment. As such, it is at the heart of the Europe 2020 strategy and its flagship initiatives, including Innovation Union, an Industrial policy for the globalisation era and resource Efficient Europe."*
- *"On average, 12% of aeronautics revenues, representing almost 7 billion € for civil aeronautics alone, are reinvested in R&D and support around 20% of aerospace jobs."*
- *"Every Euro invested in aeronautics R&D creates an equivalent additional value in the economy every year thereafter."*

2.2 An Excellent Aviation RDT&E Infrastructure, vital to achieve EU goals

Similarly recent policy documents from "trusted" stakeholder groups have made the case for the need for a world-class and accessible RDT&E infrastructure for future competitiveness of the European Aeronautics and Aviation Industry (EAAI).

Flightpath 2050 also spells this out in stating clear objectives that must be achieved:

- *"Strategic European aerospace test, simulation and development facilities are identified, maintained and continuously developed."*
- *"The ground and airborne validation and certification processes are integrated where appropriate."*

The ACARE policy document "Strategic Research and Innovation Agenda"³ spells out the essential nature of an excellent Aviation RDT&E infrastructure in achieving the goals of Flightpath 2050:

- *"[Aviation] R&D infrastructure is an indispensable tool to achieve a decisive and competitive edge."*
- *"Strategic aviation infrastructure is of the highest quality and efficiency, providing the basis for world-class research and competitive product development while supporting education. "*
- *"It ranges from wind tunnels, engine test facilities, via iron & copper birds, structure facilities and e-infrastructures up to experimental aircraft and simulation capabilities for in-flight and airport operations."*

The EC document defining the EU's new programme of research and innovation, Horizon 2020,⁴ also

¹ "Flightpath 2050 - Europe's Vision for Aviation" ISBN 978-92-79-19724-6

² Throughout this document Aviation is intended to mean: "aeronautics and air transport"

³ "Realising Europe's vision for aviation" ACARE

⁴ "Horizon 2020 - The Framework Programme for Research & Innovation" COM(2011) 808 final, the European Commission.

recognises the importance of aeronautics and air transport as well as the need for world-class infrastructure.

- Priority 1: Excellent Science
"Researchers need access to the best infrastructures."
- Priority 2: Industrial leadership *"Strategic investments in key technologies."*
- Priority 3: Societal challenges
".. developing the next generation of transport means.
- .. as the way to secure market share in the future ..
- .. will help enhance European leadership in aircraft.."

2.3 US Government and NASA approach

In the period 2002 - 2011 the following initiatives were taken in the United States to establish a *"US Strategic Aeronautics RDT&E Planning"*:

- 2002: Final Report of the Commission on the Future of the US Aerospace Industry.
- 2005: House of Representative Hearing on the Future of Aeronautics at NASA (106 Congress: Hearing before the Subcommittee on Space and Aeronautics of the Committee of Science).
- 2006 - 2011: Bi-annual publication by the Office of Science and Technology Policy (OSTP), White House Advisory of National Aeronautics RDT&E Plans.

These National Aeronautics RDT&E Infrastructure Plans asked for:

- Analysis of critical shortfalls between the infrastructure that is foreseen to be available in the United States, and that which is necessary to achieve the goals and objectives outlined in the National Aeronautics R&D Plan 2011
- Examination of issues related to the interagency management of aeronautics R&D infrastructure, including recommendations on addressing some of these issues.
- Paths forward for evaluating network infrastructure needs related to national aeronautics R&D priorities and for analysing issues related the international usage of aeronautics RDT&E Infrastructure.

Responding to this White House request, the Aeronautics Science and Technology Subcommittee (ASTS) of the National Science and Technology Council (NTSC) established an Infrastructure Interagency Working Group (IIWG) to develop the Infrastructure Plan.

This Interagency Working Group established 5 specialized Task Forces:

- Ground Test Facilities
- Flight Test Facilities (including aircraft)
- Simulation Facilities
- High-End Computational Facilities
- Network Infrastructure

In the same period NASA issued its Aeronautics Test Program (ATP), from which the following strategy statements can be derived:

- *"The suite of NASA and DOD test capabilities has to meet the US's Strategic Needs and has to be superior to foreign capabilities."*
- *"ATP will lay the groundwork for NASA to invest in new test technologies that will support US*

aeronautics leadership in the future."

In the Aeronautics Test Program NASA also introduced the following "principles":

- National stewardship:
"ATP is committed to ensuring healthy and available aeronautics test capabilities, not just for NASA, but for the nation."
- "The Big Stuff":
"ATP will focus on national-class test capabilities, rather than the quantity or breadth of smaller laboratory facilities. "
- Public Good:
"NASA has a role in providing test capabilities that are not economically viable as independent business and thus not available elsewhere."

As a result NASA presented the Aeronautics Test program as a two-pronged strategic initiative:

- To retain and invest in NASA aeronautical test capabilities considered strategically important to the Agency and the Nation
- To establish a strong, high-level partnership to expand cooperation between NASA and the Department of Defense, facilitating the establishment of an integrated national strategy for the management of their respective facilities.

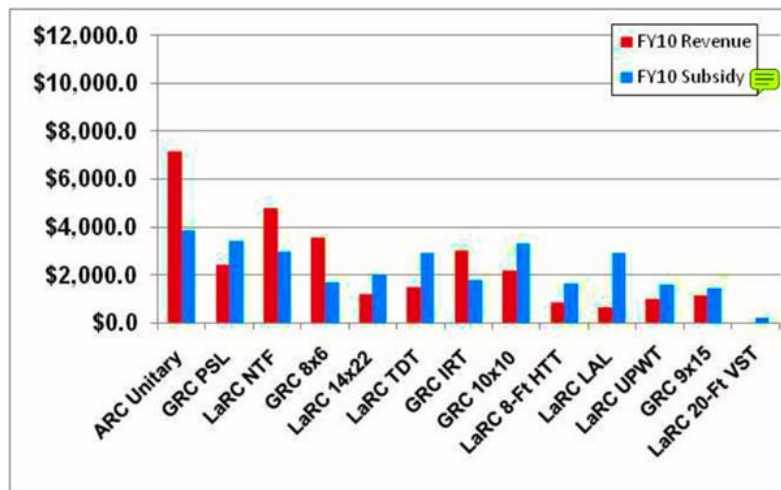
As a result the 2012-2016 federal budget for the NASA Aeronautics Test Program has risen to the equivalent of around 300 million Euro, mainly for RDT&E infrastructure⁵.

The above clearly shows that in the US the federal stimulating approach (and resulting support increase) has become more and more important. The overall effect is an increasingly non-level playing field for the European Aviation sector.

2.4 Non-level playing field

Even after reducing the number of US government subsidized wind tunnels in no case do the revenues received from users cover 100% of the operating costs. For 9 out of the 13 these "commercial" revenues are less than half of the operating costs.

In 2010 these wind tunnels received approx. 30 M\$ US (federal) government subsidy as illustrated in the table below.⁶



⁵ Ref: NASA Budget 2012

⁶ Ref: Mike George: "Aeronautics Test Programme", briefing at the NASA Advisory Committee Review, April 23, 2010

In Europe it is equally true that our strategic aviation RDT&E facilities, that are essential for the societal and economic benefits derived from the aviation industry, are not usually viable as independent businesses. In Europe most RDT&E facilities have been built-up with public support at a national and/or regional level. These supports have been somewhat fragmented and are facing progressively shrinking levels. This has become a major threat, not only to upgrading the facilities in order to maintain their excellence, but also to routine maintenance just to keep their current performance and capability.

Funding of these facilities is still mostly at the single member state level. Notable exceptions to this are:

- The German/Dutch wind tunnels at DNW
- The European Transonic Windtunnel ETW now supported by Germany, UK and Netherlands. (France withdrew its support in 2012).

The non-European competition for the DNW-LLF wind tunnel is a clear example of the nonlevel playing field. DNW-LLF receives a limited national subsidy for the German and Dutch governments. Each of the competing wind tunnels listed below is substantially subsidised by their federal government on a structural basis:

- USA
 - National Full-Scale Aerodynamics Complex (NFAC) 40- by 80-ft
 - 80-by 120-ft. low speed wind tunnels at NASA Ames.
- China
 - Harbin FL10 large low-speed high Reynolds non-pressurized wind tunnel
- Canada
 - NRC 9 by 9 m. low-speed wind tunnel
- Russia
 - T-101 24 by 14 m low-speed wind tunnel
 - T-104 7 m low-speed wind tunnel.

3. Establishment of Selection Criteria

3.1 ACARE selection criteria

ERA-Net AirTN has conducted an initial study on RDT&E Infrastructure including an initial database to which certain selection criteria could be applied. These selection criteria (developed by ACARE Working Group 5 to be used by AirTN) consider only financial measures for investment and operating costs to place the infrastructure into 3 categories:

- Strategic: >100 million € investment, operating budget as high as 10 million €/ year and less than 10 in Europe
- Key: >10 million € investment, tariffs on full operating costs - unique character and less than 100 in Europe
- Common: <10 million € investment, medium or small size capabilities, basic tools

For wind tunnels, strict application of these criteria to the AirTN database would result in four wind tunnels being classified as strategic:

- ETW (D, NL, UK) (high speed, cryogenic, real flight Reynolds number simulation),
- DNW-LLF (D, NL) (low speed, very large test section, ground effect),
- S1 (ONERA) (large models, high speed + engine simulation),
- F1 (ONERA) (low speed, variable Reynolds number).

3.2 IEG selection criteria

IEG decided to develop two more detailed sets of criteria, one for the qualification "strategic" and one for the qualification "key". It is important to note that, despite the use of similar wording, these qualifications use several additional criteria to those used by AirTN.

For the qualification "strategic" the following criteria, considering the research as well as the industrial development needs, were used:

- Size (close to ACARE criteria: investments & turnover)
- State of the art
- User's expectations/experience
- Meeting of all the needs to the time horizon of Flightpath 2050
- Accessibility
- Uniqueness

For the qualification "key" the following criteria, considering the research as well as the industrial development (civil as well as military) needs on national/regional level, were used:

- Size (close to ACARE criteria)
- State of the art
- User's expectations/experience
- Meeting specific needs of Member States or industry to the time horizon of Flightpath 2050.
- Accessibility

3.3 "Strategic RDT&E capabilities"

In order to concentrate on the really major and/or substantial parts of the RDT&E infrastructure, the IEG focussed on "Strategic RDT&E capabilities", i.e. one or more facilities (hardware/software), including related technologies and highly skilled personnel/operators.

These capabilities are essential for the European Aeronautics as well as the Air Transport sector (industry and public research) to maintain and enhance a decisive and competitive edge.

The IEG considered following strategic RDT&E capabilities:

- Aerodynamic and aero-acoustic testing capabilities (wind tunnels)
- Air Traffic Management (ATM) capabilities
- Large Scale Demonstrator capabilities (aircraft)
- Production technology capabilities
- Large scale computational simulation capabilities (E-infrastructure)

Other capabilities (engine testing, icing) might be added at a later stage.

Due to the limited time available, IEG has developed a general approach for the qualification of the two sets of criteria. For further qualification, particularly for infrastructures other than wind tunnels, the criteria may need to be interpreted and adapted in a more detailed way.

3.3.1 Aerodynamic and aero-acoustic testing capabilities (wind tunnels)

Wind tunnels have played and will continue to play a critical role in the design and development of modern aircraft and other aerospace vehicles. The major wind tunnel facilities were constructed in Europe and worldwide to enable the aeronautical revolution of the 20th century, in particular for aerodynamic research and technology development, performance prediction and evaluation and aero-acoustic testing. The rapid development of powerful numerical design tools supports the requirement for accuracy and speed in performance and shape optimization and underpins the industry requirement for advanced accurate and extensive wind tunnel capabilities allowing accurate validation of models, simulation and check-out of aircraft design.

High investment, maintenance and operation costs characterize many of the major wind tunnel facilities that are key for industry and research.

There may be a case for EU support for "strategic but not unique" infrastructure, if they are "core" for industry, needed for cross-calibration and in the case of co-operation and consolidation between the common facilities.

Industry Initiative on "Core" Wind Tunnels

In February 2012 a group of major European Aeronautical Industries¹ on the basis of their own criteria of need and utilisation, identified the following (European) wind tunnels as "core" (for civil and/or military use):

- ARA TWT
- DLR TMK
- DNW LLF
- DNW TMG
- ETW
- ONERA S1
- ONERA S2
- ONERA S3
- ONERA F1
- RUAG LWTE

The table below shows the average envisaged annual use of these wind tunnels by those industries.

Estimated annual use in days	Airbus	Airbus Military	BAE Systems	Cassidian	Dassault	Eurocopter	MBDA
ARA	5 to 20		10 to 15	low			5 to 20
DLR-TMK							5 to 20
DNW-LLF	15 to 25	5 to 10		5 to 10	5 to 10	10	
DMW-TWG							5 to 20
ETW	50				5 to 10		
ON S1	10 to 20	low		low	20	10	low
ON-S2				low	50		5 to 20
ON-S3						10	5 to 20
ON-F1	40 to 60	low			10		
RUAG-LWTE		10		low	60		

From this table it is clear that e. g. for Airbus the following wind tunnels are considered as "core":

ETW	(50 days)
ONERA F1	(40-60 days)
DNW-LLF	(15-20 days)
ONERA S1	(10-20 days)
ARA	(5-10 days)

The other "core" wind tunnels are for military use and/or business jets and helicopters.

Applying its own criteria, the IEG concludes that, for the time being and as far as civil use is concerned:

- Mainly four wind tunnels qualify as "strategic and unique" for Europe:
 - ETW
 - DNW-LLF
 - ONERA S1
 - ONERA F1
- The remaining wind tunnels on the list cannot be considered to be truly unique:
 - RUAG-LWTE has no unique capabilities over DNW-LLF,
 - ARA, ONERA S2 and DNW-HST have similar capabilities.

1) The involved industries were: **Airbus, Airbus Military, BAE Systems, Cassidian, Dassault Aviation and MBDA**

3.3.2 Engine Test Capabilities

The European aero engine community benefits from a number of important RDT&E facilities mainly in France, the UK, Germany and Spain. Examples include ONERA-BD2, INTA-full scale engine test bed, AneCom, ONERA-CEPRA19 and -RACE. Although these facilities may not qualify as strategic from an individual size point of view, the "Engine" as a system of complex components, can only be researched and tested by using a series of test facilities, which increases the total value of the "Engine" R&T infrastructure well above the threshold of 100 M€. While of strategic importance, new investment and support for these facilities will have to consider future needs such as those driven by the evolution in power plant design (higher bypass ratios, higher mass flows, etc.) and new certification requirements (for example propulsion system icing).

The IEG scope does not allow for a well-reviewed proposal for engine R&T facilities at this moment. It can only emphasize the strategic importance and need for support for new investments. Apart from improvement upgrades and expanded functionality of existing facilities, there may be opportunities in integrating some existing facilities in a joined infrastructure.

The IEG recommends the establishment of a working group composed of Industry and Research Establishments to complete the AirTN list with Engine R&T infrastructures, and define a plan for the sustainable support of powerplant system R&T infrastructure.

3.3.3 Air Traffic Management (ATM) capabilities

Air Transport is of essential importance for the European economy and the mobility of the citizens. The European Air Traffic Management (ATM) system plays a crucial role in the European Air Transport system. It consists of more than 60 ATM centres and more than 16.700 Air Traffic Controllers that control the traffic to and from the 450 European Airports and to and from third countries. This complex structure controls daily over 26.000 flights in the EU, by means of air routes optimized nationally and not at a European level.

At present the EU ATM is organized around national, sovereign airspaces and consequently is very fragmented and based on national civil and military monopolies. This results in limitation of capacity, high costs and increased fuel use and emissions. In 2000 the initiative by the European Commission and Eurocontrol was taken for a Single European Sky⁷. In 2004 the EU took the steps to bring ATM under EU control with the aim to reduce the fragmentation of the European Airspace and to increase the capacity.

The Single European Sky ATM Research programme (SESAR) constitutes the technological arm of the Single European Sky, with the ambition of modernizing the equipment of the European ATM in a holistic, total system covering all features of R&D in aviation.

To conduct the required RDT&E on these new systems an integrated ground and airborne simulation and test infrastructure is necessary consisting of:

- Flight test aircraft and helicopters
- Moving-base and fixed-base flight simulators
- Radar simulators with ATCo positions
- Tower simulators

These facilities should be equipped so that they can be used in an integrated way to simulate with and without actual SESAR hardware in the loop, the new SES configurations.

In the DLR-NLR foundation AT-ONE all these facilities are available in an integrated way. When tests

⁷COM (1999)614.

with a great number of actual ATCo positions are necessary these AT-ONE facilities in Amsterdam and Braunschweig can be connected to the Eurocontrol Experimental Centre ESCAPE Facility in Brétigny, France.

Since the IEG considers Large Scale Demonstrators, Production Technology and E-infrastructure as relatively new or upcoming strategic capabilities of fast growing importance, a more extensive view is presented in the following three chapters.

3.3.4 Large Scale Demonstrator Aircraft

The history of Airbus, Eurocopter and the European aero-engine companies has been a European success story. In their designs we have seen step changes in the course of the development. The two-man cockpit, fly-by-wire and the introduction of primary composite structures are just a few examples that paved the way to the world-leading position of Airbus.

The US has, in the past, very successfully fostered and secured step changes in aviation. A combined military & civil approach accompanied by the NASA/DARPA X-plane programmes has paved the way for revolutionary designs. This mainly led to superior military and space vehicles, but also had a significant spill over to the civil side.

There is not a common agreement throughout the aviation community that in-flight demonstration of a radically new aircraft configuration to get a "step change" is necessary. However the extremely high risks involved dictate it is very likely that without this kind of validation only evolutionary steps will be taken.

Neither Airbus nor the European Research Establishments are today set-up to fly and operate "X Plane"-like vehicles. Clean Sky is an example of the way that large technology demonstrator programs are executed today. So first steps in this direction have been taken, but they are relatively small, not at all on an "X-Plane"-level. The flying engine testbeds, the Airbus hybrid laminar flow (HLF) VTP demonstrator, the AVIATOR project, the natural laminar flow (NLF) demonstrator program using the Airbus A340, and planned activities aimed at in-flight testing of the CROR concept are typical examples, as well as the Eurocopter X3 vehicle.

In order to enable the development of such "step change" technologies, and thus foster the creation of a generation of aircraft that both meets the ACARE/Flight Path 2050 requirements and helps Europe to stay competitive and secure the market share, the capability to design, build and operate both reduced and full scale flying demonstrators needs to be considered in the context of the future European Strategic Aviation RDT&E Infrastructure. The planning for developing large demonstrator aircraft must be such that for the successors of the A380 and A320 aircraft the EU industry is fully prepared to remain competitive with the US industry developments. New step change civil aircraft are not to be expected before the 2030-2040 time period.

The present IEG remit does not allow us to submit sound & solid proposals for the set-up of such demonstrator and validation programmes. It can only emphasize that this capability is essential in order to get a next generation "step change" civil transport aircraft and that there is the need to support this at a European level.

The IEG recommends the establishment of a working group composed of Industry, Research Establishments, national governments and the EU in order to develop a plan for a future "European X-Plane Program".

3.3.5 Production Technology

Technologies for aircraft parts manufacturing and assembly have traditionally been considered to be taken care of, almost exclusively, by the Original Equipment Manufacturers (OEMs) and their suppliers. There has been some public support, mainly at a national and regional level, to the development of aircraft production technologies, but this has been at a lower level than for the "front end" technology developments.

When striving for high quality and lower cost aerostructures, the OEMs and the supply chain have invested heavily in the enhancement of their production technology, knowing that this is the only way to compete with low cost countries. Nevertheless offloading of parts production and even assembly to lower cost countries at Europe's periphery and on a global level has been increasing. This has been driven by the general globalisation tendency, the search for further cost reduction, the Euro/USD exchange rate and sometimes offset obligations.

This trend has been expedited by the fact that more and more nations are eager to participate in the booming aircraft business, and to develop their own aircraft industry.

From the employment perspective it is quite clear that the aircraft production phase is much more important than the upstream processes in the design of aircraft. There is of course less of a value and the leverage effect, but certainly a short-term employment benefit.

In the face of this trend it must be underlined that whilst an excellent engineering capability in aircraft design and development is essential to play a major role in the global aircraft business, without parts manufacturing & assembly there will be much less employment in Aeronautics, and, in the long term, the lack of direct and rapid interaction between manufacturing and design that comes from both proximity and from the same cultural environment will be highly detrimental to both capability and success.

Fortunately the period of governments considering the production technology development to be exclusively taken care of by the OEMs and their supply chain (a "live-or-die" philosophy) is over. Even European countries that have been very reluctant in this respect understand that loosing (aircraft) production will cost a very large number of jobs. Knowing that in a free market there is no way of "protecting" the national industry, European governments understand that the only way to prevent loosing this sector is by stimulating innovation and technology in manufacturing.

The public support was in this context in the beginning almost exclusively focused on manufacturing technology development programs. Then the governments recognized that there is a need to help building up an adequate infrastructure for further developing aircraft production technologies. This goes well beyond the capability & capacity that the OEMs and their suppliers were (and will be) able to afford themselves. It also underlines the public interest (and some pressure) to keep production and skilled employment in Europe. In addition we can now see Research Establishments and even Universities getting very much involved in the aircraft production technology development activities, even if this is not yet at a common level in Europe.

This support has occurred at a national level and even more so by the regions. This reflects the major concern regarding jobs at regional level. Thus regional governments in the Airbus countries have played a major role in creating Production Technology Centres, mostly together with Industry and Research Establishments, and often focusing not just on aircraft production but also on related industries. The latter is particularly noticeable when dealing with composite production techniques. In this context we can see some good examples:

- Centre for High Value Manufacturing (HVM Catapult) in UK
- Centre for Lightweight Production Technology (ZLP) in Germany
- Technocampus EMC2 in France

A considerable amount of money has been invested in recent years in the build-up of these centres creating an impressive infrastructure for manufacturing technology and innovation. Now it is up to Industry, Research Establishments and Universities to make maximum use of these facilities.

These capabilities must to be considered as potentially European Strategic Aviation RDT&E Infrastructure when looking into Europe's ability to secure future aircraft production.

The creation of these centres has been a bottom-up process being the only way to get the right momentum in the beginning. In time as upgrades/improvements of these centres will be required, a sustainable support at a European level will be necessary. This is also mandatory in order to achieve an effective complementary approach across the various centres (that, because of their "local" initiators, do have quite a lot of overlap and even competition). It will require the art of combining the continuation of the local "initiative & drive" and the global "support & steering". Thus the EC will have to play an important role here.

The present IEG remit does not allow us to submit sound & solid proposals for a future support of this approach on a European level. It can only emphasize that Production Technology is to be considered as one of the essential European strategic RDT&E capabilities, and therefore strongly recommend that a competent group of experts be convened to develop a plan for the further development and a sustained support of this capability.

3.3.6 Large-scale computational simulation capabilities (E-infrastructure)

The development of modern high performance transport aircraft is one of the most complex tasks in industry. The related technology and capability is very well developed in Europe. It has enabled the united European aircraft industry to become number one in the global civil aviation transport and rotary wing businesses. It is very difficult for new competitors to reach the same level of competence. Nevertheless, given dedication, time, budget and human resources it will be just a question of time until "newcomers" to the global market will have acquired the necessary capability to design & build aircraft that are as good as the today's European ones.

The only chance to maintain a leading position, taking the inherent cost advantage of the new competitors into account, is for Europe to ever increase the technologies and the capability to improve the performance, comfort, efficiency and environmental friendliness of their products. So far this has been mainly carried out at a mono-disciplinary level by improving e.g. the capabilities in aerodynamics, flight control systems, cabin systems, structural design and manufacturing. The very high effort within Industry, Research Establishments and Universities has been quite well and effectively supported by national and European research programs, incl. huge demonstrator projects.

At the same time there is a common understanding that the enhancement of disciplinary capabilities alone will not be enough to enable a step-change in our aircraft performance, and to keep the competition "at distance". It must be complemented by a truly multidisciplinary approach that considers the vehicle in total, taking all interdependencies into account simultaneously during the whole development cycle. Although techniques for Multidisciplinary Optimization (MDO) have been understood to enable such an approach for some time, significant progress in this topic has been disappointingly slow. This is equally true for the US as well as for Europe.

One of the major obstacles to be overcome in this respect, besides the "silo-thinking" of engineers and managers working in the various disciplines is the availability of High Performance Computing (HPC) capability. Most of the disciplinary optimization today already requires HPC capability in order to run the necessary computations and optimizations in a reasonable time. Doing this on a truly multidisciplinary level will require a multi-fold of this capacity. Lacking this capability, as it is the case

today, either leads to an unacceptable elapsed time for an optimization loop (and a fairly high number of them are needed), or the accuracy of the results falling far short of the need. Consequently the present MDO is not ready, and thus not used, or only used in the pre-design phase of the aircraft development cycle.

Besides this there is today, in almost all disciplines within an aircraft development, the need for massive, time-consuming and expensive physical testing & validation. This is true for the aero-design & data, systems design/iron birds, structural design/various test rigs etc. Computational simulation is still far from powerful enough to make the physical testing and validation obsolete. It is clear, that only by a closed MDO loop based on computational simulation without "hardware in the loop" will a truly multidisciplinary design of our future aircraft be possible.

The enhancement of any computational method, be it "Computational Fluid Dynamics (CFD)", "Computational Structural Mechanics (CSM)", the related processes and tools in the design of flight control and cabin systems, or the coupling of these elements within MDO, all require a very much-improved "E-Infrastructure".

Although past experience is not very positive, the continuing significant improvement in "computational capability" is promising enough to proceed in striving for more and more simulation, including MDO. Consequently, in recent years, Airbus initiated its "Future Simulation (FuSim)" initiative that aims at an improvement of the "computational capability" by a factor of 10^3 to 10^4 within the next decade in order to establish the basis for MDO. This not only takes into account the constant improvement of the "computational power" as given by Moore's law, but also encompasses for example much bigger computers and their clustering, more efficient codes and an improved man-machine interface. Together with Universities and Research Establishments, and benefitting from a significant public support (mainly by the regions), Airbus has created the "FuSim" Centre composed of four complementary elements:

- C²A²S²E in Germany
- CFMS in UK
- MOSART in France
- DOVRES in Spain

All are working closely together and involving Research Establishments and often other Industries.

Considering the capability to defend the European leadership in aircraft development, this "E-Infrastructure" is certainly a European Strategic Aviation RDT&E capability. It will be one of the most important elements to enhance the disciplinary and even more the multi-disciplinary optimization capabilities.

So far this initiative has been taken by the OEM and the Research Establishments and sometimes with Universities with local support, but already in a harmonized manner across Europe. Since a huge effort will continue to be necessary in the coming decade a sustained support at a European level seems to be necessary. This would underline the recognition of this activity as being crucial for maintaining European leadership in Aviation, and could give an additional boost by linking other Industry's needs for enhanced computational optimization.

The present IEG remit does not allow us to submit sound & solid proposals for a future support of this approach on a European level. We can only emphasize that E-infrastructure is to be considered as one of the essential European strategic RDT&E capabilities, and therefore strongly recommend that a competent group of experts be convened to develop a plan for the further development and sustained support of this capability.

3.3.6 Possible other strategic RDT&E capabilities

The IEG considers that other capabilities may develop into strategic RDT&E capabilities, e.g.:

- CIRA Icing Wind Tunnel and testing capabilities
- Iron/copper bird
- DLR-HALO Environmental capabilities

Further study of these facilities in conjunction with the correlation of need derived from the SRIA is required.

4. Funding of a European Strategic Aviation RDT&E infrastructure

4.1 Rationale, objectives and possibilities for EU co-funding

4.1.1 Rationale for EU-funding

The rationale for EU co-funding can be summarized by "*restore the level playing field*". In the past the global playing field for aeronautics industry was more or less level. However, by now non-European big countries (USA, Russia, China) have substantially increased their federal funding levels, whereas in Europe the (segmented) national/regional funding has slowly decreased.

"Supra-national" co-funding by the EU (to be compared with, for example, US federal funding, which is also additional to state and/or regional funding) started in 1992 (2nd FP, BRITE-EURAM). Through the introduction of Framework Programmes additional funding became available, also for the aviation sector.

Since the focus of these Framework Programmes is mainly research, the originally level playing field between USA, Russia (and increasingly China) and the present European aviation RDT&E infrastructure, has become increasingly non-level. This non-level playing field disadvantages also the growing number of new Member States that are entering the European aviation supply chain.

Through "supranational" co-funding EU can play an essential role towards harmonizing and focussing towards a European Strategy for Aviation, including its strategic RDT&E Infrastructure (e.g. 'Clean Sky', SESAR) as already envisaged in 'Horizon 2020'.

4.1.2 Objectives and possibilities of EU co-funding

Two different "goals" of co-funding can be defined:

- *Upgrading and maintaining of existing strategic RDT&E capabilities/realisation of new strategic RDT&E capabilities:*

Through the establishment of an appropriate system (perhaps ESFRI-like) facility owners may apply to open calls for bids specifically for support for upgrades or maintenance. These bids will be evaluated against IEG criteria.

- *Facilitating access to strategic RDT&E facilities for excellent science and for research & testing:*

Since excellent science as well as excellent RDT&E is vital for the development of the next generation aircraft and related equipment it is essential that researchers can access the best aviation RDT&E facilities. However, these facilities are highly expensive and often beyond the reach of many Universities and Research Institutes. Establishing a voucher system can stimulate the use of those facilities by universities and Research Institutes in general and in level 0 and level 1 projects.

Researchers and/or organisations may apply for access support via a voucher scheme, to be implemented by the EC. Applications will be evaluated against IEG (facility) criteria as well as relevance of the proposed research.

The FP7 project ESWIRP is a real example of these "vouchers for access", its main characteristics being:

- Access to wind tunnels ONERA S1, DNW-LLF and ETW for research by Universities and Research Institutes;
- 8 days ONERA S1, 12 days DNW-LLF and 7 days ETW;
- Project duration: 4 years (2009 - 2013).

4.1.3 Possible EU co-funding sources

Notwithstanding the possible co-funding by member states and/or industries (see 4.2 and 4.3 below), the following EU co-funding possibilities are drawn from 'Horizon 2020':

- Excellent Science:
European Infrastructures (2.478 million €)
Since ESFRI is focused on basic science and closed until 2015, funds for aviation strategic RDT&E infrastructure should probably be found (within European Infrastructures) outside ESFRI.
- Societal Challenges:
Smart, green and integrated transport (6.802 million €)
The IEG considers this budget to be a feasible co-funding source.
- Structural/Cohesion funds:
Especially for access to strategic RDT&E infrastructures and for the design and construction of new strategic RDT&E infrastructures, the IEG considers this budget to be a feasible co-funding source.
- Loans from European Investment Bank:
This is not seen as a realistic "funding" source for a non-economically viable operation.

4.2 Co-funding by Member States

4.2.1 Rationale and objectives for co-funding by Member States

A thriving Aviation industry (as a result of the strategic RDT&E infrastructure) is clearly also in the interest of Member States, taking into account the opportunities for their industry (including SMEs), being part of the supply chain. This will result in substantial economic and social benefits both to the Member States, in which the facility is located and to all member states.

Therefore, Member States, in which the economy benefits significantly from the competitiveness of the related aeronautics industries, should contribute to ensuring the future oriented enhancement of the strategic and key RDT&E infrastructures in Europe even if, in certain cases, they are located outside their own country.

The willingness and required business models needed for co-funding by Member States of strategic and key RDT&E Infrastructure merits further investigation.

4.2.2 Possible ways of co-funding by Member States

Co-ordinated measures of Member States with mutual interest should be investigated as a joint instrument for the upgrade of strategic and key RDT&E infrastructures in Europe through national funds.

Supporting measures at European level should be established that also allow co-funding through national sources for the upgrade of strategic and key RDT&E infrastructures in joint initiatives.

4.3 Long term commitments by industry

As indicated in earlier chapters of this report, the European Aviation industry has a clear interest in the availability of a strategic RDT&E infrastructure. Industry has already made long term commitments to essential R&T through for example the Clean Sky Joint Undertaking. Furthermore reference has already been made to the expression by European aviation industry of its needs and foreseen utilisation of core wind tunnels.

The willingness and required business models for longer-term commitments by business to other key RDT&E infrastructure, if matched by public support from EU and member states must be investigated and developed further.

5. Conclusions and Recommendations

5.1 Conclusions

Based upon its findings, the IEG has concluded as follows:

- A European Strategic Aviation RDT&E Infrastructure is indispensable
 - For the continued competitiveness of the European aviation industry.
 - For excellent science and RDT&E purposes.
 - To achieve the objectives of “Horizon 2020” and “Flightpath 2050”
 - For future product development.
- The European Strategic RDT&E facilities are not usually viable as independent businesses.
- The European Strategic RDT&E capabilities are more than the facilities alone. They also include a highly qualified, skilled and experienced crew as well as excellent and leading measuring techniques.
- A "Levelling of the Playing Field" is needed with US, Russia and increasingly China. A European Strategic Aviation RDT&E Infrastructure is essential to realize this.
- EU, Member States, research organisations and industry need to ensure jointly an integrated approach to secure the continuity and quality of this Strategic Aviation RDT&E Infrastructure.
- The Commission proposal for Horizon 2020 offers opportunities for partly meeting this challenge.
- The IEG has developed sets of Criteria for "Strategic and Unique" Aviation Infrastructures and for "Key" Aviation Infrastructures.
- According to the ERA-Net and ACARE WG5 criteria as well as to the IEG criteria, the IEG has identified the ETW, DNW-LLF, ONERA S-1 and ONERA F-1 wind tunnels as strategic and unique for civil aircraft development. These and other wind tunnels have also been identified by industry as "core" for the further development of their existing and future civil and military aircraft.
- Urgent action is needed to support some of these European Strategic and Unique aerodynamic capabilities in the short term.
- According to the IEG criteria the combination of the capabilities of the DLR-NLR AT-One facilities with the Eurocontrol ESCAPE facility are identified as a strategic and unique ATM RDT&E capability necessary to develop and test the necessary new Communication, Navigation and Surveillance elements, procedures as well as the Human Factors aspects of the future ATM system to be used in the Single European Sky (SES)
- The IEG has identified the need for strategic "Production Technology" capabilities and large-scale computational simulation capabilities (E-Infrastructure) and has identified the existence of potential facilities for both these capabilities.
- The IEG has identified the need for future strategic facilities for the large-scale integrated development of technology for a "step change" in future aircraft.
- The IEG has identified other aviation research facilities (such as the CIRA Icing wind tunnel, the INTA Engine Testing Facility, the SNECMA Copper Bird and the DLR Environmental Research Aircraft HALO) that have the potential to become strategic or key.
- Further work, beyond that possible within the limited resources and time available in the IEG terms of reference, is needed to identify and launch actions to achieve a world-class aeronautics and aviation RDT&E infrastructure in Europe by 2020. The next steps for this work are included in the recommendations that follow.

5.2 Recommendations

The recommendations of the IEG have been grouped under the following headings:

- General
- Aerodynamic and Aero-acoustic testing strategic capabilities & Air Traffic Management capabilities (requiring short term attention)
- Production Technology, E-infrastructure strategic capabilities and Large Scale Demonstrator Aircraft, (requiring medium/long term attention)
- Budget

5.2.1 General

- Endorse the criteria developed by the IEG for "strategic" and "key" RDT&E facilities at both European and national/regional level.
- Establish a working group composed of Industry and Research Establishments to complete the AirTN list with Engine R&T infrastructures, and define a plan for the sustainable support of powerplant system R&T infrastructure
- Extend and update the existing ERA-Net AirTN Database to include data on candidate strategic and key facilities covering the complete spectrum of infrastructure types as defined by the IEG.
- Determine the requirements against each of these infrastructure types to meet each specific requirement of the SRIA (DLR have proposed a matrix to capture this).
- Develop from the updated ERA-Net AirTN database a consolidated list of strategic and key Infrastructures to achieve Horizon2020 by applying the IEG criteria.
- Develop and implement a voucher system to stimulate access to strategic RDT&E facilities at EU level identified by IEG for excellent science as well as for research & testing.
- Develop and implement procedures and programmes for applications and their assessment for:
 - the qualification "strategic" or "key" in accordance with IEG criteria,
 - for EU co-funding for maintenance and upgrades of strategic and key RDT&E facilities at a European level.
- Support the strategic and unique European Aviation Infrastructure and make sure that they will remain sustainably available for excellent Science and high quality testing by the industry to support also for the future, a worldwide competitive aviation industry.
- Support the consolidation of key RDT&E facilities to further increase quality and cost-effectiveness
- Establish an ESFRI type Group of Aviation Infrastructure Experts to judge the proposals from the owners of the Strategic and Unique existing Aviation Infrastructure as well as from future Strategic and Unique Aviation Infrastructures, and from consolidation proposals of key facilities on behalf of the EU

5.2.2. *Aerodynamic and Aero-acoustic testing capabilities*

- Establish a cooperation between European Commission, Member States, industry and facility owners to investigate co-funding possibilities for the European "strategic and unique" wind tunnels, qualified "core" by industry (ETW, DNW-LLF, ONERA S1 & ONERA F1)
- Establish a cooperation between the European Commission, Member States, industry and facility owners to investigate opportunities for co-operation and consolidation and to develop co-funding possibilities and appropriate operation models for the European "strategic and for consolidation of the not unique" wind tunnels, qualified "core" by industry (e.g. DNW-HST, DNW-TWG, DNW-TMK, ARA-TWT, ONERA S2 and RUAG LWTE).

5.2.3 *Air Traffic Management capabilities*

- Stimulate possibilities for co-operation and further integrated operation of ATM- facilities of AT-ONE (Amsterdam/Braunschweig) and of the Eurocontrol ESCAPE Facility (Brétigny).
- Establish cooperation between the European Commission, Member States, industry and facility owners to investigate opportunities for co-operation and consolidation and to develop co-funding possibilities and appropriate operation models for the infrastructure facilities identified in recommendations above as strategic or key at European and national/regional level.

5.2.4 *Production Technology, E-infrastructure capabilities and Large Scale Demonstrator Aircraft*

- Set up appropriate expert teams that can develop plans for the further development and sustained support of these European strategic RDT&E capabilities identified by the IEG.
- Establish cooperation between the European Commission, Member States, industry and facility owners to investigate opportunities for co-operation and consolidation and to develop co-funding possibilities and appropriate operation models for the infrastructure facilities identified in recommendations above as strategic or key at European and national/regional level.

5.2.5 *Budget*

- Establish new long-term budget line(s) for European Strategic Aviation RDT&E Infrastructures starting with Horizon 2020. The IEG qualified judgement, based upon information received so far and expecting approximately 10 "strategic" facilities, results into the following recommendation (for the Horizon 2020 duration):
 - Upgrade of facilities: 10 -15 million €/ year,
 - Access vouchers: 5 -10 million €/ year.
- These figures do not include potential new needs that may arise as a result of the Recommendations of the IEG.
- Recommended EU budget sources:
 - Research Infrastructure budget,
 - Aviation budget (competing with Aviation RTD),
 - Cohesion funds.

Appendix A

Terms of Reference and Membership of the Independent Expert Group

Terms of Reference

1. Introduction

Appropriate research and testing infrastructures is essential for the competitiveness of Europe's aviation industry and also for the aviation related public research needs in Europe. ESFRI, the European Strategy Forum on Research Infrastructures, performed an assessment process for major upstream research infrastructures in different disciplines (not in aviation) that are only used by researchers and not by commercial customers. An 'ESFRI-like' process on Aviation Research & Test Infrastructures means to perform an assessment exercise on European level with the aim to identify two main categories:

1. Research and Test Infrastructures of strategic importance for Europe and unique in its kind.
2. Research and Test Infrastructures of high importance for individual Member States, Regions or important stakeholders.

Different as in ESFRI, facilities that are used by commercial customers shall also be included in the assessment.

The size and costs for building, maintaining and updating a research infrastructure can be a criterion, but should not be the only reason for categorising a facility as important or strategic.

The often state-owned operators need to maintain and enhance their infrastructures, and the financially supporting Member States and public institutions need to consider the justified support for large infrastructures.

Therefore an Independent Expert Group (IEG) knowledgeable of the complex environment should establish priorities and give advice to ACARE, the Member States and the European Commission. The group should deliver an expert report proposing relevant priority lists including justifications, suggesting measures for related actions and identifying possible ways of funding.

2. Possibilities for the funding of Aviation Research Infrastructures of European interest For the funding of investments, overhaul and update of strategic research and test infrastructures different funding sources should be taken into account:

- Financing within 'Horizon 2020' in the area '*1. Excellence Science*' under '*4. European Research Infrastructure*' (proposed budget 2.800 million € / 7 years). It would be competing with the ESFRI needs and other infrastructure measures.
- Financing within the Cohesion Funds of the EU (MFF). Here restrictions apply, as normally only those infrastructures could be supported, which are situated in Member States or regions eligible for Cohesion Funds.
- Financing within 'Horizon 2020' in the area of '*3. Societal Challenges*' under '*4. Transport*'.
- Co-funding by national funding sources of Member States interested in maintaining a specific research and testing infrastructure (e. g. ETW).

3. Tasks of an Independent Expert Group (IEG)

The IEG should fully take into account the outcome and findings of the ACARE Working Group 5 "Prioritising research, testing capabilities and education" and of the related tasks of the Aeronautics ERA-Net AirTN. While the work of AirTN was mainly on aeronautics and, therefore, concentrated on the vehicle, the approach of the IEG asked for needs to be widened in order to cover all aspects of aviation, e.g. remote tower or airport simulation. The tasks of the IEG include:

- To define a methodology and to list criteria that can be used to identify infrastructure facilities that are "strategic" for Europe.
- To define a methodology and to list criteria that can be used for identifying infrastructure facilities that are "strategic" or "important" on national or regional level.
- To evaluate the infrastructures database of AirTN (by applying the methodology)
- by checking the content on existing gaps, e.g. in the field of air transport;
- by applying the defined methodology for the classification of the infrastructure.
- To identify possible gaps in the existing infrastructure based on the R&I roadmap established by ACARE (SRIA).
- To identify facilities and access mechanisms which support innovation, e.g. Fab Labs
- To identify the infrastructures, for which public (national or European) or private investments are appropriate, and provide a respective rationale.
- To propose new financing concepts for maintaining, upgrading and set-up of (new) facilities.
- To analyse possible financing sources (including EU streams such as ESFRI, Structural funds, 'Horizon 2020', joint national funds, etc.)
- To provide an interim report and a final report to ACARE and to the Commission containing the findings of the IEG.

4. Composition the Independent Expert Group

The Independent Expert Group (IEG) should be composed of senior experts from all over Europe knowledgeable in the field of aviation research and testing infrastructures as well of the needs of the industry and the required future capabilities. They should be able to act independently from the interest of the research institutions operating the relevant research and test facilities.

The Group should consist of about 10 independent senior experts ensuring a fair balance of the needed expertise.

The final identification of the IEG members will depend on the agreed size of the group, the coverage of the needed competences and a certain geographical balance.

The IEG should have a Chairman, a Vice-chairman and a Rapporteur, who acts as an editor of the Group report. The Members of the IEG agree amongst themselves who takes the position of the Chairman, Vice-chairman and Rapporteur. The Working Group 5 and the Member States Group may send a representative to attend meetings of the IEG as observer.

5. Implementation

The IEG should start its work based on the Aeronautics Research Infrastructures database, which was produced by the Aeronautics ERA-Net AirTN-FP7 and is available on-line. Within AirTN efforts will be made to complete the relevant information of the infrastructure database, where needed. The Group should obtain additional information from the infrastructure operators and from the different user groups.

The IEG should take into account the statements and findings of the ACARE Strategic Research and Innovation Agenda SRIA concerning the future role of research and testing infrastructures for aviation, for which the ACARE WG 5 provided substantial inputs.

The Group should agree its way of working and the internal work share and hold a sequence of progress and co-ordination meetings.

The members of the IEG may get reimbursement of their travel expenses for attending their agreed IEG meetings through AirTN. The Rapporteur will receive a fee for the report writing and editing work, which goes beyond the work of a usual IEG member. The Aeronautics ERANet AirTN-FP7 will support the activities and costs of the IEG activities.

The IEG should be established by September 2012 in order to be able to provide its finding in an interim report on time for the implementation process of 'Horizon 2020' and of other measures resulting from the SRIA. The draft version of the report should be provided by 27th November 2012 to allow on time inputs to the preparation of 'Horizon 2020'. The draft version of the report should be presented to ACARE (MSG). The IEG should aim to deliver the final version of the report by 31st January 2013.

The IEG will report to ACARE, AirTN and the Commission. The interlocutors for the IEG will be the co-chairs of the ACARE Member States Group, the co-chairs of ACARE Working Group 5 '*Prioritising Research, Testing Capabilities & Education*', and the coordinator of AirTN. For day-to-day operational matters Dietrich Knoerzer, European Commission is the first point of contact.

Members of the Independent Expert Group (IEG)

Fred Abbink	The Netherlands	(Co-chairman)
Xavier Bouis	France	
Martin Boyce	United Kingdom	(Rapporteur)
Ernst Folkers	The Netherlands	(Rapporteur)
Anders Gustafsson	Sweden	
Jürgen Klenner	Germany	(Co-chairman)
Eugene Kors	France	
Francisco Muñoz Sanz	Spain	
Bruno Stoufflet	France	
Joachim Szodruch	Germany	
Ludovico Vecchione	Italy	
Jürg Wildi	Switzerland	

Appendix B

List of Abbreviations

ACARE	Advisory Council for Aviation Research an Innovation in Europe
ATCo	Air Traffic Controller
ATM	Air Traffic Management
ATP	Aeronautics Test Program (NASA)
ARA	Aircraft Research Association
BAE	British Aerospace
CFD	Computational Fluid Dynamics
CIRA	Centro Italiano Ricerche Aerospaziali
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DNW	German Netherlands Windtunnels
DOD	US Department of Defense
ESFRI	European Strategic Forum on Research Infrastructures
ETW	European Transonic Windtunnel
ESWIRP	European Strategic Wind tunnel Improved Strategic Potential
HPC	High-Performance Computing
HST	Hoge Snelheids Tunnel (High-speed Tunnel)
HVM-Catapult	Centre of High-Value Manufacturing
IEG	Independent Expert Group
INTA	Instituto Nacional de Tecnica Aeroespacial
LLF	Large Low-speed Facility
MDO	Multi-Disciplinary Optimisation
NASA	National Aeronautics and Space Administration
NLR	Nationaal Lucht-en Ruimtevaartlaboratorium
OEM	Original Equipment Manufacturer
ONERA	Office National d'Etudes et de Recherches Aerospatiale
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
SES	Single European Sky
SESAR	Single European Sky ATM Research
SME	Small and Medium Enterprise
SRIA	Strategic Research and Innovation Agenda
TRL	Technology Readiness Level
TWT	Transonic Wind Tunnel
ZLP	Zentrum fuer Leichtbau-Produktionstechnologie

Appendix C

List of References

Aerospace Industry Data and Market Forecasts

- Economic Contribution of Civil Aviation. ICAO Circular 292-AT/124
- Aerospace and Defence Industries Association of Europe. Facts and Figures 2011
- Aerospace Global Report 2011. A Clearwater Industrials Team Report
- Boeing Current Market Outlook 2012
- Airbus Global Market Forecast 2012-2031
- 2012 Global aerospace and Defense industry outlook: A tale of two industries. Deloitte Febr. 2012
- Aerospace & Defence. 2011 year in review and 2012 forecast. PwC 2012
- Aviation Benefits Beyond Borders. ATAG 2012

China

- AirTN Mission to China. Report on the International Conference on Aeronautic Research and Technology. London 13/14 March 2008
- Paul Calver: The Chinese Aerospace Market and C919 Programme. UK Ministry of Trade and Investment, 2008
- Jaroslaw Wagner. Characteristics of Chinese Civil Aviation Market. 2010
- Roger Cliff a.o: Ready for Takeoff. China's Advancing Aerospace Industry. Rand MG 1100, 2011.
- Mark A. Stokes. China's evolving Space Capabilities: Implications for U.S. Interest. April 2012

Russia

- Eugene Kogan: The State of the Russian Aviation Industry and Export Opportunities. Jan 2006
- Vladimir Dmitriev and Sergey Lyapunov: Aeronautics RDT in Russia- An Overview. Vienna, June 2006
- Alexander Belenkiy: Russia-EU Cooperation in R&D: Framework Programmes Experience. 2008
- Kargopoltsev: Overview of Aeronautics Research in Russia. European and Russian Joint Avionics Forum. Oct 2009 Moscow.
- Sergey Chernyshev: The Russian Aviation: Challenges & New Opportunities for International Cooperation. Nice Sept 2010
- Liudmila Rostovtseva: Russian Aeronautics Research Programmes. Madrid, Aerodays 2011

Canada

- Chummer Farina and Jerzy Komorowsky: Canada's Aerospace Sector - An Overview. London March 2008

Brazil

- Walter Bartels: Aeronautics in Brazil. Aeronautics Days Vienna, June 2006
- Pedro Fernandes a. o.: Brazil - Aeronautics Cluster, May 2011
- Embraer News Release 2011: Embraer Delivers 105 Commercial and 99 Executive Jets in 2011
- Anon: Turnover, Export and Employment of Brazilian Aerospace 2009 - 2011.

AirTN

- Strategy for Aviation Infrastructure for R&D in Europe
- Minutes of the Workshop on Aeronautic Research Infrastructures, Brussels, 25 Jan 2012
- Stanley Tang: AirTN Workshop. ACARE SRIA Working Group 5. Contributions on Aviation Infrastructure, Brussels 25 Jan 2012
- Gircquel-Vasseur: Aeronautical Research Infrastructures in AirTN Project (Excel sheet)

ACARE

- Member States Group of ACARE Survey 2010. Report on the Survey of the Implementation of the Strategic Research Agenda for Aeronautics on National Level
- Strategic Research & Innovation Agenda, Volume 1 'Maintaining Global Leadership. Serving Society's Needs'. September 2012
- Strategic Research & Innovation Agenda, Volume 2 'Maintaining Global Leadership. Serving Society's Needs'. September 2012

European Commission

- COM (2010) 2020 Communication from the Commission. EUROPE 2020. A strategy for smart, sustainable and inclusive growth. Brussels 3.3.2010
- European Strategy Forum on Research Infrastructures ESFRI. ESFRI Working Group Report 2010. Regional Issues
- COM (2011) 811 final. Proposal for a Council Decision, establishing the Specific Programme Implementing 'Horizon 2020' - The Framework Programme for Research and Innovation (2014 - 2020). Brussels 30.11.2011
- Horizon 2020 – The EU Framework Programme for Research and Innovation 2014 - 2020 EU Presentation
- COM (2011) 144 final. White Paper. Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system. Brussels 28.3.2011
- Flightpath 2050. Europe's Vision for Aviation. Report of the High Level Group on Aviation Research, 2011

- Final Report of the High-Level Expert Group on Key Enabling Technologies, June 2011
- Horizon 2020. Europe's New Framework Programme for Research and Innovation (2014 - 2020). Extract on Research Infrastructures, Brussels, 19 Nov. 2012
- Global change. Towards global research infrastructures. EU Support for research infrastructures in environmental and earth sciences, 2012
- Work Programme 2013. FP7 CAPACITIES. PART 1. Research Infrastructures. July 2012
- Georg Eitelberg: ESWIRP, a project to improve the aerodynamic research infrastructure in Europe. Modane 2011

USA Documents

Various US Documents

- Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry. Investigation No. 332-414, United States International Trade Commission, Publication 3433, June 2001
- Final Report of the Commission on the Future of the United States Aerospace Industry. November 2002
- House Hearing, 109 Congress. Hearing before the Subcommittee on Space and Aeronautics of the Committee of Science of the US House of Representatives on the Future of Aeronautics at NASA. March 2005
- Weber: Study of European Government Support to Civil Aviation R&D. TECOP Intl August 2005
- Decadal Survey of Civil Aeronautics. Foundation for the future. National Research Council, 2006
- The economic impact of Civil Aviation on the US Economy, FAA, Aug 2011
- Texas Aerospace & Aviation Industry Report. September 2011
- Targeted NextGen Capabilities for 2025, JPDO, Nov 2011
- Destination 2025, FAA, 2012

OSTP

- National Aeronautics Research and Development Policy. Dec. 2006
- National Plan for Aeronautics Research and Development and Related Infrastructure. Dec. 2007
- Technical Appendix to the National Plan for Aeronautics Research and Development and Related Infrastructure. Dec. 2008
- National Aeronautics Research and Development Plan. Febr. 2010
- National Aeronautics Research, Development, Test and Evaluation (RDT&E) Infrastructure Plan. Jan. 2011

NASA

- MOU between NASA and DOD for a National Partnership for Aeronautical Testing (NPAT). Jan 2006
- AIAA Infrastructure Recommendations for Implementation of Executive Order 13419 - National Aeronautics Research and Development, Jan 2008
- The Aeronautics Test Program Strategic Plan. Aeronautics Research Mission Directorate

NASA.29 October 2009

- Jaywon Shin: NASA Aeronautics Research. Then and Now. 48th AIAA Aerospace Sciences Meeting. Jan 4, 2010
- Fayette Collier: Overview of NASA's Environmentally Responsible Aviation (ERA). Project 48th AIAA Aerospace Sciences Meeting. Jan 4, 2010
- Jim Heidmann: NASA's Current Plans for ERA Propulsion Technology. 48th AIAA Aerospace Sciences Meeting. Jan 4, 2010
- Steve Smith: NASA's Current Plans for ERA Vehicle System Integration. 48th AIAA Aerospace Sciences Meeting. Jan 4, 2010
- Anthony Washburn: NASA's Current Plans for ERA Airframe Technology. 48th AIAA Aerospace Sciences Meeting. Jan 4, 2010
- Jean Wolfe: Aeronautics Research Mission Directorate update with emphasis on Integrated Systems Research. 48th AIAA Aerospace Sciences Meeting. Jan 4, 2010
- Mike George: Aeronautics Test Programme. Briefing at the NASA Advisory Committee Review, April 23, 2010 LARC
- Timothy J. Marshall. An Overview of the NASA Aeronautics Test Programme Strategic Plan. 27th AIAA Aerodynamic Measurement Technology and Ground Testing Conference. 28 June- 1 July 2010. Chicago Illinois
- NASA ATP Leaflet B-1240. "NASA's Aeronautics Test Program (ATP) is a model program created to preserve the capabilities of the largest, most versatile, and comprehensive set of testing facilities in the nation"
- Marion Blakey, Aeronautics Committee Report to the NASA Advisory Council, Nov 2012

Library of Congress

- Malinda Goodrich. Aeronautical Wind Tunnels Europe and ASIA. LoC February 2006.
- Malinda Goodrich. Wind Tunnels of the Western Hemisphere. LoC June 2008

Rand

- Philip S. Anton a.o: Wind Tunnel and Propulsion Test Facilities. An Assessment of NASA's Capabilities to Serve National Needs Rand MG-178. 2004
- Philip S. Anton a.o: Wind Tunnel and Propulsion Test Facilities. Supporting Analysis to an Assessment of NASA's Capabilities to Serve National Needs. Rand TR-134. 2004
- Philip S. Anton: Roles and Issues of NASA's Wind Tunnel and Propulsion Test Facilities for American Aeronautics, Rand CT-239. March 2005
- Philip S. Anton: Roles and Issues of NASA's Wind Tunnel and Propulsion Test Facilities for American Aeronautics. Addendum Rand CT-239/1. April 2005
- Liisa Ecola: Equity and Congestion Pricing. Rand TR-680. 2009
- Philip S. Anton: Update of the Nation's Long-Term Strategic Needs for NASA's Aeronautics Test Facilities Rand DB 553. 2009
- Thomas Light. Pricing Strategies for NASA Wind-Tunnel Facilities. Rand TR999. 2011

European Windtunnels

- European Aeronautical Industry View on the Future European Wind Tunnel facility landscape, 13 February 2012

Reaction to European Aeronautical Industry View on Future Wind Tunnel facility landscape. 17 Dec. 2012

