Transport Research Knowledge Centre

AIR TRANSPORT
THEMATIC RESEARCH SUMMARY

Directorate-General for Mobility and Transport

EUROPEAN COMMISSION

www.transport-research.info

European Commission
DG Energy and Transport

Specific Support Action

Transport Research Knowledge Centre

Thematic Research Summary:

Air Transport

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Date 08-10-2010

Foreword

This report has been produced as part of the activities of the TRKC (Transport Research Knowledge Centre) project of the Fifth and Sixth Framework Programme, priority thematic area "Sustainable Development, Global Change and Ecosystems".

The aim of TRKC (as its predecessor project EXTR@Web) is to collect, structure, analyse and disseminate transport research results. It covers EU-supported research as well as research financed nationally in the European Research Area (ERA) and selected global RTD programmes. The main dissemination tool used by TRKC is the web portal at http://www.transport-research.info/web/index.cfm.

The approach to dissemination of results of research projects adopted by the TRKC team includes the following three levels of analysis:

- ✓ Project Analysis, which provides, project by project, information on research background, objectives, results, technical and policy implications;
- ✓ **Thematic Analysis**, which pools findings of research projects according to a classification scheme based on thirty themes, fixed for the life time of the TRKC project; the product of this analysis activity is the set of **Thematic Research Summaries** (TRS); the present document belongs to this set;
- ✓ Policy Analysis, which pools findings of research projects according to combinations of themes based on ad-hoc policy priorities which are agreed with DGTREN of the European Commission and a representative group of research users.

This particular Thematic Research Summary deals with Air Transport. The aim is to provide the reader with a synthesis of results of completed EU-funded projects and a selection of national projects related to the theme of Air Transport. The report is intended for policy makers at European, national and local levels, as well as any interested reader from other stakeholders and from the academic and research communities.

The authors would like to thank Paul Stigell for undertaking an external peer review of this paper.

Disclaimer

The TRKC team is fully responsible for the content of this report. The content of this report does not represent the official viewpoint of the European Commission and has not been approved by the coordinators of the research projects reviewed.

Executive Summary

This Thematic Research Summary on Air Transport aims to provide the reader with a synthesis of results of completed European research projects related to this theme. It consists of two main parts.

The first part includes a brief overview of the scope of the theme and summarises the relevant main policy developments at EU level.

The second part contains a synthesis of the main findings and policy implications from research projects in this area, and identifies the implications for further research. This is done separately for seven sub-themes identified in the aeronautics and air transport related research reported in this summary.

1. The *"Advanced vehicle design / Technology development"* sub-theme deals with radical, environmentally efficient, accessible and innovative technologies that might facilitate the step change required for air transport in the second half of this century and beyond.
2. The *"Aircraft and operational safety"* sub-theme aims to prevent hostile action of any kind to incur injury, loss, damage or disruption to travellers or citizens due to the effects of aircraft misuse.
3. The *"Airport capacity and operation"* sub-theme aims to accelerate the implementation of Airborne Separation Assistance (ASAS) applications in European Airspace, taking global applicability in order to increase airspace capacity and safety.
4. The *"Air traffic control / management"* sub-theme is related to improvement of the Air Traffic Management (ATM) system aiming at a common European airspace.
5. The *"Efficient, quiet and environmentally friendly engines"* sub-theme focuses on development of technologies to reduce the environmental impact of aviation with an aim to halve the emitted carbon dioxide (CO2), cut specific emissions of nitrogen oxides (NOx) by 80 % and halve the perceived noise levels.
6. The *"Customer satisfaction"* sub-theme aims to introduce a quantum leap in passenger choice and schedule flexibility, whilst achieving a five-fold reduction in accident rate.
7. The *"Business process improvements"* sub-theme fosters a competitive supply chain able to halve the time-to-market, and reduce product development and operational costs, resulting in more affordable transport for the citizen.

The **Advanced vehicle design / Technology development** sub-theme provides information on improved technologies for aircraft engineering disciplines like aerodynamics, communication and avionics. Progress has also been made on a system level. A new Tilt-Rotor concept representing a brake through for Europe helps to increase airport capacities. Simulation, experiments and applications improved the aerodynamic design of aircrafts. Reduction of weight has been achieved by advanced materials and new cabling concepts. Improved manufacturing processes were developed in materials,

forming and assembly. New concepts were presented, on system level for VELA (very large efficient aircraft) and high altitude aircraft and airships, but also on subsystem level.

In **Aircraft and operational safety** sub-theme progress in the global harmonization definition and the validation of Airborne Separation Assistance (ASAS) and Automatic Dependent Surveillance broadcast (ADS-B) applications has been made. Furthermore, the research projects related to vortex dynamics have generated systematic results and an understanding of issues related to aircraft trailing wakes. The projects related to the behaviour of aircraft structures have developed impact models for hard debris and obstacles at airports.

The **Airport capacity and operation** sub-theme research results have shown the implementation of information and decision support tools such as Airport Collaborative Decision Making (CDM) concepts. Benefits range from reduced taxi times and hence less emissions, to increased compliance of Air Traffic Flow Management (ATFM) slots. A project focusing on surveillance, guidance and control issues lead to results that supported the regulation and standardization bodies, as well as the industry, in the early and efficient implementation of Advanced Surface Movement Guidance and Control System (A-SMGCS). Further projects were conducted to improve safety by applying emerging technologies to reduce the risk of accidents on the ground and during takeoff and landing.

The research in the **Air traffic control / management** sub-theme provided results which can facilitate the highly needed improvements of the European Air Traffic Management (ATM) system and concept of operations. In the field of Global Navigation Satellite Systems concepts and technologies regarding approaches (arrivals?) and departures using ground or space based augmentation have been finalized. Furthermore, research has looked into the development and improvement of applications like Cockpit Display of Traffic Information (CDTI) and Airborne Separation Assurance/ Assistance System (ASAS)

In the **Efficient, quiet and environmentally friendly engines** subtheme, a project looked at how to increase the efficiency of aero engines, to save operation cost and to minimize negative impacts to the environment. Optimization was achieved by improving subsystems and materials, but also by aerodynamic improvement of the engine design geometry. In order to optimize aero engines regarding emission, improved measurement methods but also computational simulation tools were developed.

Results in the **Human element – convenience, efficiency and safety** subtheme were a new standard for an in-flight cabin system, reduction of the direct operating cost of aircraft and the improvement of the service comfort for both passengers and cabin crew. A concept for assisting airlines' flight operations was developed to make quicker recoveries from disruptions of operation. The aero engine maintenance process was optimized by…. Regarding the impact of noise on third parties, noise reduction technologies were validated, new and acceptable take off and landing procedures were developed and a short-term low-cost technical solution to monitoring the noise caused by air traffic in areas surrounding airports was studied.

The Business process improvements sub-theme established a European airport observatory network to collect, review and assess existing data and information and to maintain and provide relevant data to the end users. A forecasting system for passenger movement between European destinations was developed. Administrative and management support was provided to ACARE in its mission to create, maintain, update and implement its Strategic Research Agenda (SRA). The European aeronautical SME network was extended and SME participation in the aeronautics dedicated calls of the 6th Framework Programme was improved.

In general, the research projects for which synthesis is provided in this Thematic Research Summary are European EU-funded projects that are completed and publicly available with results. These EU projects have been funded by the Fifth and the Sixth Framework Programmes. Also, a small number of national projects are taken into consideration for this document. Projects that were reviewed in the related predecessor report (EXTR@Web project) are summarised briefly in the annex.

The given implications for further research are based on the publicly available results of 84 projects which reflect less than 10% of the overall number of research projects in this area. The findings are consequently indicative only, and many activities are currently in progress by the relevant work programme of FP7.

Research should deal more systematically with far future concepts and potential radical changes hereto to shape in time the necessary boundary conditions for introduction.

Acronyms

ACARE	Advisory Council for Aeronautics Research in Europe
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance (broadcast)
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASAS	Airborne Separation Assurance / Assistance System
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
CBA	Cost Benefit Analysis
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CEC	Commission of the European Communities
CTP	Common Transport Policy
DST	Decision Support Tool
EC	European Commission
ERA	European Research Area
EUROCONTROL	European Organisation for the Safety of Air Navigation
ETIS	European Transport Information System
EU	European Union
EXTR@Web	Exploitation of Transport Research Results via the Web
FAA	Federal Aviation Administration
FP	Framework Programme
FP5	Fifth Framework Programme
FP6	Sixth Framework Programme
FP7	Seventh Framework Programme
GNSS	Global Navigation Satellite System
SA	Situation Awareness
SWIM	System Wide Information Management
TM	Threat Management
TN	Thematic Network
TRKC	Transport Research Knowledge Centre
TRS	Thematic Research Summary

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1. Introduction

This “Thematic Research Summary (TRS) on Air Transport” has been produced within the TRKC project. It provides a structured review of the research relating to air transport, carried out in European transport research projects. The theme “air transport” is one of the thirty themes in the classification scheme adopted by the TRKC project. The full scheme is shown in the table below.

Table 1. The classification scheme adopted in TRKC

Sectors
✓ passenger Transport ✓ freight Transport
Geographic
✓ urban transport ✓ rural transport ✓ regional transport ✓ long distance transport ✓ EU accession issues
Modes
✓ **air transport** ✓ rail transport ✓ road transport including walking and cycling ✓ waterborne transport ✓ innovative modes ✓ intermodal freight transport
Sustainability policy objectives
✓ economic aspects ✓ efficiency ✓ equity and accessibility ✓ environmental aspects ✓ user aspects ✓ safety and security
Tools
✓ decision support tools ✓ financing tools ✓ information and awareness ✓ infrastructure provision including TENs ✓ integration and policy development ✓ Intelligent Transport Systems ITS ✓ regulation/deregulation ✓ land-use planning ✓ transport management ✓ pricing and taxation ✓ vehicle technology

The categories in the classification scheme shown in the above table have been adopted to enable comprehensive searching for project information available through the TRKC portal and to ensure comprehensive coverage of research results and appropriate policy analysis in the Thematic Research Summaries (TRSs). Definitions for each category (which is also a theme in its own right) can be found on the TRKC website available at http://www.transport-research.info.

In the predecessor project EXTR@Web, TRSs were produced for 28 out of the 30 themes (the reduced number of TRSs resulting from merging of some themes into a single TRS). The TRKC project has produced first versions of TRSs for a sub-set of themes for which a critical mass of results from projects was available by December 2008. For this subset of themes the preparation of final versions is planned by the end of the TRKC project in June 2010.

This is the final version of the TRS on the "Air Transport" theme which includes results from projects available by March 2010. A large number of research projects have been related to the theme addressed by this report though these reflect less than 10% of the overall number of air transport projects. The TRS "Air Transport" produced in the predecessor project EXTR@Web (EXTR@Web, 2006) reviewed research from European projects belonging to the Fourth and Fifth Framework Programme (FP4, FP5) as well as selected national projects. This report adds new projects to the analysis that have been completed since that report, including numerous European projects from FP5 and FP6, and a small selection of national projects.

The research reviewed in this document does not represent the whole gamut of research dealing with Air Transport carried out in the European Research Area (ERA). The report focuses on research from those projects which have provided documentation on results available to the TRKC team after the issue of the EXTR@Web report (EXTR@Web, 2006). All projects analysed in the EXTR@Web report are listed in the annex together with the new projects with available results so far.

The report is organised as follows. Section 2 includes a brief analysis of the scope of the theme. Section 3 provides an overview of the relevant policy developments at EU level, explaining at the same time why the theme is important from a policy viewpoint. The sources for this section are principally European Commission documents which have set the policy agenda such as white papers, green papers and communications. EU legislation – directives, regulations, rulings of the Court of Justice – is mentioned where relevant.

Section 4 reports on the results from research projects. The section is structured according to sub-themes to make the broad area of research which has dealt with Air Transport more manageable.

The following seven sub-themes have been considered:

- Sub-theme 1: Advanced vehicle design / technology development
- Sub-theme 2: Aircraft and operational safety
- Sub-theme 3: Airport capacity and operation
- Sub-theme 4: Air traffic control / management
- Sub-theme 5: Efficient, quiet and environmentally friendly engines

- Sub-theme 6: Human element – convenience, efficiency and safety
- Sub-theme 7: Business process improvements

Research objectives are reported for each sub-theme, and findings from research projects are synthesised. A special focus is given to the policy implications of research results. Section 4 concludes with an overview of the research gaps which could be identified from the projects, and hence topics for future research. Sources for Section 4 are documents available from the projects and reporting on achievements, essentially the project final reports and selected deliverables and presentations.

The research projects listed under each of the seven sub-themes are shown in the Annex to this paper. Hyperlinks to project websites (if available) are also included. In several cases these websites make the project documentation available to the public. This may include final reports and other project deliverables.

2. Scope of the theme “Air Transport”

The scope of the research includes all aircraft, passenger travel and airside related aspects of the air transport system as well as all airborne passenger and freight movements that are carried out by heavier-than-air and lighter-than-air vehicles, and also associated ground activities, e.g. at airports, air traffic control centres etc.

Principal means of air transport consist of fixed wing aircraft, helicopters, tilt-rotors and airships. The focus is on commercial aviation by domestic and international airlines, relying on dedicated airport infrastructures and air traffic management systems for regional, European and global transport. It also covers services related to these operations. The Air Transport mode is strongly connected to the long-distance transport sector, as the typical trip length of air transport is defined as being more than 250 kilometres.

Specific topics included in the Air theme comprise:

- Scheduled commercial passenger service;
- non-scheduled (charter) service;
- business aviation;
- air cargo and related land-side logistics;
- infrastructure provision and management for airport facilities, such as terminals (passenger and freight), and freight distribution and logistics centres;
- joint management of European air space with the military;
- Air Traffic Control (ATC) and Air Traffic Management (ATM);
- airline operations (passenger and cargo);
- regulation / deregulation with respect to the Single European Sky initiative;
- aircraft industry (main contractors/'airframers', engine manufacturers, suppliers of other hardware, avionics suppliers, suppliers of software solutions, etc.);
- service providers (e.g. training centres for pilots and air traffic controllers, simulators);
- operators and agents.

The above summary of topics describes the principal breakdown of technical, organisational and managerial aspects that come under the theme, whereas Chapter 4 of this document reflects sub-themes according to priorities in transport research policy and available research results.

3. Policy context

Over the last decades, Europe's outstanding technological and industrial capabilities in aeronautics and the exploitation of space have made continuously important contributions to the standard of living and economic development and growth. Excellence in aeronautics and space can contribute to the creation of highly skilled jobs, to improving the trade balance and to the competitiveness of other related economic sectors.

Air traffic has grown at an average rate of 5% over the last 15 years, thereby contributing to solid growth in the aviation industry which remains one of the strongest sectors of Europe's economy, in spite of recent turmoil such as the terrorist attacks in September 2001 or the financial crisis in 2009 and the Icelandic Ash crisis 2010. The rate of growth in air transport demand is expected to continue for the foreseeable future, leading to at least a doubling in traffic every 12 years. This is still creating serious capacity problems for air traffic management and bottlenecks at airports.

Whilst improvements have been made to the national air traffic management (ATM) systems that constitute the European system, these improvements have not yet fully kept pace with demand.

Based on technological and operational advances and on the European transport policy, it is the general objective to develop integrated, safer, ‘greener’ and ‘smarter’ pan-European transport systems for the benefit of all citizens, society and climate policy. They shall respect the environment and natural resources as well as secure and further develop the competitiveness attained by the European industries in the global market. These activities will contribute to key Community policies as well as to the implementation of the ACARE Strategic Research Agenda. The quantitative objectives correspond to the 2020 time horizon of this Agenda.

The European air transport system is a vital element to European mobility and economy. This theme will address some of the on-going challenges, as recognised in the White Paper on Transport (2), in improving the contributions that transport systems make to society and industrial competitiveness within an enlarged EU, whilst minimising the negative impacts and consequences of transport in relation to the environment, energy usage, security and public health.

A new integrated approach will be taken, which links all transport modes, addresses the socioeconomic and technological dimensions of research and knowledge development, and encapsulates both innovation and the policy framework. The various technology platforms set up in this field (ACARE for aeronautics and air transport, ERRAC for rail transport, ERTRAC for road transport, Waterborne for waterborne transport, hydrogen and fuel cells) have elaborated long-term visions and Strategic Research Agendas (SRA) which constitute useful inputs to the definition of this theme and complement the needs of policymakers and expectations of society.

Selected aspects of the SRAs may justify setting up joint technology initiatives. ERA-NET activities present opportunities to facilitate further trans-national coordination for specific topics within the Transport sector and will be pursued wherever appropriate. Activities of particular relevance to SMEs include efforts to ensure robust technology-driven supply

chains in the various sectors; enabling SMEs to access research initiatives; and facilitating the role and start-up of high-tech SMEs, particularly in the advanced transport technologies and 'services-related' activities specific to transport as well as the development of systems and applications in satellite navigation domains.

Existing policy needs as well as the development, assessment and implementation of new policies (for example maritime policy and the implementation of the Single European Sky), will be addressed within and across the different activity lines. The work will include studies, models and tools that deal with strategic monitoring and forecasting and integrate knowledge relating to the main economic, social, safety, security and environmental issues for transport. Activities supporting crosscutting thematic topics will focus on transport specificities, for example security aspects as an inherent requirement to the transport system; the use of alternative energy sources in transport applications; and monitoring of environmental effects of transport, including climate change; and measures to improve the economic integration. Greening of air transport covers ways of reducing the adverse impact of this mode. Support will also be given to dissemination and exploitation activities and impact assessments, with particular attention to the specific user needs including those of the disadvantaged and policy requirements in the transport sector.

Principal topics of air transport policy by the European Commission in the frame of the given transport research projects cover:

- The Single European Sky initiative, an ambitious attempt at reforming the architecture of European air traffic control to meet future capacity and safety needs;
- aviation safety and security which, among other developments, led to the formation of the European Aviation Safety Agency (EASA) in 2004;
- the approval of formal Air Passenger Rights in the European Union in 2005;
- open skies agreements with major civil aviation markets;
- the environmental impacts of civil aviation and the long-term view to addressing them; and
- Advances in materials, component, and engine technology to meet future requirements of more efficient, greener and cost-effective air transports.

The on-going problem of delays throughout the 1990's, led the European Council in 1999 to request a comprehensive reform of European air traffic management. The proposed Single European Sky (SES) has taken shape with the launch of SESAR, the implementation programme for SES, in 2005. The initiative, which aims to reduce fragmentation of European ATM systems through synchronising and integrating plans and actions, will see two major steps to ensure that organisational and regulatory SES concepts as well as important advances in technology, research and validation are adequately addressed:

This includes a two-year definition phase that is tasked with devising an Air Traffic Management (ATM) Master Plan defining common goals and a vision for the development of the European air traffic control infrastructure, scheduled to be finished by early 2008.

Key areas of immediate action towards the goal of a Single European Sky are:

- Safety – establishing the European Aviation Safety Agency (EASA), and a safety action programme;

- airspace management – enabling a single European airspace through the integrated management of air traffic control centres, air traffic flow management, and free routing;
- integration of military needs – securing civil/military co-operation on airspace usage and management;
- systems and operations – introducing common technical solutions, regulations and standards;
- framework for providers of air traffic control – regulating and providing national services compliant with EC requirements; and
- social aspects – improving recruitment, training and operational procedures.

The key policy issue lies in achieving improvements in three major categories:

- Harmonising the safe and efficient management of airspace across Europe;
- tackling rapidly growing bottlenecks at airports; and
- adapting human operators and users to new emerging technologies in the whole sector.

Further recent policy activities in the air sector – in most cases led by organisations such as Eurocontrol, Airports Council International Europe (ACI Europe) and International Air Transport Association (IATA) – e.g. relate to:

- improved traffic management on the movement area,
- Collaborative Decision Making (CDM),
- airport airside capacity enhancement practices and initiatives,
- runway safety;
- aviation training, aimed at improving management performance; and
- the effects of new EU regulations on slot management based on a recent study to assess the effects of different slot allocation schemes.

On the industrial side, European politics strongly support the competitiveness of aircraft and engine manufacturers, suppliers and equipment specialists. In particular research into new composite materials for use in future efficient and more environmentally-friendly vehicles and next generation engine technology is among the key research objectives.

These policy activities, addressing the highly globalised character of aviation, are reflected in a couple of development projects such as:

- The Airbus A380 mega liner aircraft which took to the skies in April 2005 for the first time;
- advanced engine developments for next generation airliners (such as Airbus A350 XWB and Boeing 787);
- development of the Airbus A400M military transport; and
- various design studies into future advanced concepts such as blended-wing body air-craft, unmanned aerial vehicles (UAVs) for civilian use and next generation civilian rotorcraft vehicles such as tilt-rotors.

The FP6 Aeronautics and Space thematic priority 4 (PTA4) aimed to integrate the EU's research efforts, thereby consolidating the position of the European aeronautics and space

industry vis-à-vis increasingly strong global competition. Moreover, it aims to exploit the research potential in the Member States, candidate countries and other associated countries in this sector with a view to improving safety and environmental protection.

In 2008 ACARE provided an addendum to the strategic research agenda which gives key recommendations in a more systemic view for priority areas as follows:

Environment

- **Global climate change** is the most serious environmental issue which needs to be considered globally with Europe pressing for common actions
- **More investment is needed** involving both public and private capital.
- The application of new **and advanced technologies** is required in the field of aircraft but also in the important area of ATM.
- The technical agenda should remain unchanged for incremental improvements and be **accelerated** towards breakthrough and contributing technologies whether these address reductions in CO2, NOx particles, contrails etc. on local or global levels.
- The **phenomena and data** relevant to aircraft emissions should be better understood and collected respectively.
- **New concepts for the long term** future should be encouraged by support to innovative research

Alternative Fuels

- **The technological options** offered by different alternative fuels need to be studied in detail along with the related environmental and economic aspects.
- **International co-operation** on these issues will probably be necessary.
- Two parallel **research efforts** are needed focusing (a) on drop-in alternatives to crude oil based kerosene fuel, within current basic jet engine technologies and (b) on ‘revolutionary’ aircraft power systems.

Security

- The system by which security requirements are established should be reviewed with a closer look at the causes of **inconsistencies and changes** which rest mainly with regulatory and political networks.
- More capable, wider scope and l**ess intrusive systems** at the level of both deterrence and detection should be developed.
- **Variable** performance capabilities should be investigated to relate to a variable threat scenario.
- Security **research** will need to be focused towards a number of specific solutions at system level.

Many of these recommendations are already taken in the most recent ongoing activities of FP7.

National air transport policy schemes are understood to widely go in line with key European policy objectives, while a particular focus of Accession Countries is to upgrade Air Traffic Control systems to already established Member States standards.

4. Research findings

4.1 Introduction

Research projects contributing to the theme of **Air Transport** can be broken down to the following seven sub-themes:

1. "**Advanced vehicle design / Technology development**" sub-theme deals with more radical, environmentally efficient, accessible and innovative technologies that might facilitate the step change required for air transport in the second half of this century and beyond.

2. "**Aircraft and operational safety**" sub-theme aims to prevent hostile action of any kind to incur injury, loss, damage or disruption to travellers or citizens due to the effects of aircraft misuse.

3. "**Airport capacity and operation**" sub-theme aims to accelerate the implementation of Airborne Separation Assistance (ASAS) applications in European Airspace taking global applicability in order to increase airspace capacity and safety.

4. "**Air traffic control / management**" sub-theme is related to improve the Air Traffic Management (ATM) systems taking aim in a common European airspace.

5. **"Efficient, quiet and environmentally friendly engines**" sub-theme focuses on development of technologies to reduce the environmental impact of aviation *with the aim to halve the emitted carbon dioxide (CO2*), cut specific emissions of nitrogen oxides (NOx) by 80 % and halve the perceived noise.

6. "**Customer satisfaction**" sub-theme aims on introducing a quantum leap in passenger choice and schedule flexibility, whilst achieving a five-fold reduction in accident rate.

7. "**Business process improvements**" sub-theme fosters a competitive supply chain able to halve the time-to-market, and reduce product development and operational costs, resulting in more affordable transport for the citizen.

Subthemes considered and projects analyzed in the present TRKC Thematic Research Summary Air Transport:

Research sub-theme	Contributing projects
Advanced vehicle design / Technology development	ACT-TILT ADFAST ADFCS-II AEROFIL AEROMEMS II AEROSHAPE AGEFORM AWIATOR B-VHF CELINA DART EECS FRESH FUBACOMP IDEA IFATS IMAGE IMCAD INCA KATNET LOADNET M-DAW MACHERENA MALVINA NEFA PIVNET2 RETINA SEDF 3D USE HAAS VELA WAFS WEL-AIR WISE

Aircraft and operational safety	ADS-MEDUP ASAS-TN ASAS-TN2 ASTER ATC-WAKE CRAHVI ESSAI FAR-Wake GIFT HASTAC ROBAIR VERRES WAKENET2-EUROPE
Airport capacity and operation	A-CDM ACE ADAMANT AIRNET EMMA EMMA2 INTERVUSE ISMAEL SAFE-AIRPORT SPADE THENA
Air traffic control / management	AD4 AFAS ASPASIA ATENAA C-ATM Phase 1 CAATS MA-AFAS MFF NUP2 POLARIS

	SAGA
Efficient, quiet and environmentally friendly engines	ADCOMB AEROHEX AEROTEST AIDA ATOS COJEN ICAS-GT2 MENELAS SIA-TEAM TBC PLUS UTAT
Customer satisfaction	Air Travel & Venous Thromboembolism ANAIS AROSATEC ASL DESCARTES HELINOVI ICE IMAGE MONSTER SILENCE(R) SOURDINE II
Business process improvements	AEROSME IV AIRFORCE APRON ASTERA 2 ECARE+ VIVACE

Subthemes considered and projects analyzed in the EXTR@web Thematic Research Summary Air Transport:

Research sub-theme	Contributing projects
Advanced vehicle design	BOJCAS GOING-SAFE IMCAD
Efficient, quiet and environmentally friendly engines	AEROCERT CONSAVE 2050
Air traffic control/management	D8 EYE IN THE SKY ONESKY TALIS VINTHEC II
Aircraft and operational safety	212034 Extending CabinAir ESSAI Air travel & venous thrombolism

The research projects listed under each of the sub-themes are shown in the Annex to this report. Hyperlinks to project websites (if available) are also included.

Furthermore it should be stated that about 1000 projects in the **Air Transport** theme have been initiated by the European Commission within the framework programmes (FP) 5 and 6 and national governments. Even though most of those projects have been finalized, only about 10% of their final reports are available and can therefore be covered in this analysis.

4.2 Sub-Theme 1: Advanced vehicle design / Technology development

4.2.1 Background

Exploring more radical, environmentally efficient, accessible and innovative technologies that might facilitate the step change required for air transport in the second half of this century and beyond, research has addressed aspects such as new propulsion and lifting concepts, new ideas for the interior space of airborne vehicles including design, new airport concepts, new methods of aircraft guidance and control, alternative methods of air transport system operation and its integration with other transport modes.

For this summary, the research projects in this field were classified in four categories:

- Technologies
- Design methods and tools
- Manufacturing
- New concepts

We are currently experiencing a tremendous increase of some 5% per year in worldwide air traffic. To cope with this, the future environment of transport aircraft will be defined by new requirements: more stringent noise regulations, fees or limitations on gaseous emissions, new air traffic management, strong increase of aircraft frequency, and increased demand for passenger comfort. The design of a new aircraft has to take these requirements into account by applying **new technologies**; existing aircraft may be also be retrofitted with those technologies. During **design**, time is a major factor for cost. Currently a variety of stand-alone design and simulation tools exist for each discipline. However, multidisciplinary design is still an iterative process of applying those stand-alone tools. Therefore, standardized and compatible simulation tools can be the key for increasing efficiency. On the other hand, design of a future aircraft influences both operational cost and environmental impact. Hence, new design methods and concepts need to improve aerodynamic and weight characteristics of future aircraft.

Significant saving potentials can be found in **manufacturing** process and technologies. TiAl-alloy for example, is a good candidate material for future aerospace applications, due to its low weight and good resistance at high temperatures. However, reduction of intermetallic machining cost is necessary for the competitive use of this material. In aircraft assembly, welding can provide cost savings of up to 30% and weight savings of up to 10%. But state of the art of modern welding processes needs to be improved for widespread use. Another production method is elastoforming, producing scrap which can be reduced by sophisticated simulation tools. The use of creep forming during aging avoids a lot of manual or, step-by-step, mechanical forming. Age forming is an alternative for shot peen forming, which is labour intensive and has quite a strong impact on the environment due to the generation of dust and noise. Automation could be another instrument to save cost in the aircraft industry, if the precision of a robot becomes sufficient for more applications.

European aircraft industry has achieved a key role in the world market. To keep that position, new technology and production **concepts** have to be assessed and further developed. Driven by this development, new logistic challenges e.g. in maintenance

appear and concepts for solutions have to be found. Economic success boosts air transport demand and requires concepts for a more efficient utilization of air space capacities. Last but not least, concepts for special purpose aircraft widen the bandwidth of future air transport and need to be studied in order to keep the shares in the market.

4.2.2 Research Objectives

Aerodynamic technologies should be identified and assessed that are needed to meet the Vision 2020 [6] goals. Advanced technologies should be integrated into novel fixed wing configurations, aiming at a further significant step in improving aircraft efficiency and reducing far field impact. New technologies in cabling shall be developed which will contribute to reduce aircraft weight. Also, to improve safety for small airplanes, an -open network architecture for avionics should be defined. New broadband communications technologies shall be studied and developed in order to increase safety and comfort compared to the communications technology used in aviation today which dates back to the 1940s. Another objective in technology research has been to contribute to the development of a flying tilt-rotor demonstrator and to study some of the critical aspects of the Tilt-Rotor in order to reduce the development risk.

Design related research aimed at improving aerodynamic efficiency (e.g. new wingtip design, general aircraft shape), saving weight (new materials, improved cabling) and optimizing the design process itself by new tools has been conducted

The main objectives in manufacturing research were reducing cost and increasing quality by improving tooling processes of new materials, improving production of composite structures, welding, elastoforming and ageforming processes and increasing automation in the aircraft industry.

Concept studies have been performed with the goal of assessing technologies for saving resources and decreasing impact to the environment, developing sustainable maintenance concepts, developing aircraft concepts for special applications and increasing capacities of the transportation system.

4.2.3 Research Results

Technologies

The KATNET network provides a communication platform for all aircraft disciplines concerned directly or indirectly with aerodynamic performance improvement including design & system integration, structures, materials, manufacturing, operational & maintenance aspects. KATNET is covering the relevant Technology Areas Low Speed Performance, High Speed Performance and Flow Control Technologies including the ten EU funded aeronautical projects/platforms EUROLIFT, HELIX, HiAer, EPISTLE, HiReTT, AEROSHAPE, M-DAW, ALTTA, AEROMEMS II and AWIATOR. Other relevant non-EU activities addressed by KATNET are AIRnet, GARTEUR, ERCOFTAC and corresponding national programmes.

An aircraft wing with advanced technology operation (AWIATOR project) has been tested on an A340 aircraft. Enlarged winglets were demonstrated to reduce drag. New inner spoilers and landing flaps increase drag for faster and steeper descends. A LIDAR turbulence sensor was successfully tested. In the AEROMEMS II project, flow separation control actuation strategies and configurations were optimized through experimental and numerical studies and validated in basic tests conducted in a large boundary layer wind tunnel. Prototype Microfabricated-Electro-Mechanical-Systems (MEMS) flow sensors and

actuators were developed. It has been concluded that it is reasonable to anticipate overall gains in maximum lift coefficient of the order 0.15 to 0.2 and increases in Cl of the order of 0.4 in the pre-stall lift coefficient.

Besides improving aerodynamic properties, reducing weight of cabling in aircrafts is the second research action performed for saving fuel. The LOADNET project identified commercial off-the-shelf (COTS) networking components for optical avionics data networks. Going even further, the WISE project developed a wireless ultrasonic communication platform suitable for sensor applications.

Research focus in communication technologies was on broadband communication. Simulations conduced within the B-VHF project have shown that a B-VHF system concept is feasible. At the same time, it could be confirmed that interference conditions in the VHF band are severe, requiring further improvement/optimisation interference mitigation techniques and their validation with an improved system demonstrator. Within the RETINA project, a successful development of advanced phase shifting technologies (RFMEMS and ferroelectric capacitors) was performed, which led to the realisation of a partial reflect array antenna, demonstrating electrical beam steering in the operational SatCom bandwidth.

Aiming on improving general safety, research on avionics for small and light airplanes is focussed on reducing avionics weight and volume. The ADFCS II project investigated and reviewed current techniques and technologies, architectures, and processes with a view to identifying cost effective solutions that would make Digital Flight Control System technology more affordable, and within the budget of smaller commercial aircraft. MALVINA project developed a modular avionics network that can be used in aircraft or rotorcraft equipment architectures without any degradation and allow introduction of modern man/machine interfaces (flat panel displays) in light aircraft.

Tilt-Rotor aircraft, a breakthrough concept for Europe, promise to be a solution in increasing airport capacities without major infrastructural changes. Active control technologies for tilt-rotor (ACT-TILT project) were studied, resulting in a significant gain in knowledge that could be exploited in further European Tilt-Rotor activities, in particular in NICE-TRIP. The main outcome of the DART project was a full-scale rotor hub which was produced and tested in laboratory to assess its functional and fatigue behaviour. Trade-off studies in this context have selected a four-bladed rotor as the best suited for the ERICA concept, bringing significant advantages in terms of external noise, performance, stability and vibration.

Design

Research was performed in simulation, experiment and application in order to improve the aerodynamic design of aircrafts. New efficient simulation tools for aerodynamic shape optimisation and drag reduction were developed (AEROSHAPE project). Positive effects of this optimisation inlcude increased safety by better performance, decreased impact to environment but also reduced fatigue problems which result from unfavourable aerodynamic effects. With particle image velocimetry (PIV), an experimental method for aerodynamic optimisation was also researched (PIVNET2 project). A book of scientific papers from all partners reflecting the development of PIV and the variety of applications in many different fields of research (PIV, aerodynamics, combustion, fluid dynamics, turbo machinery etc.) has been composed and published. Wing tip designs have been studied and as a result of the M-DAW project, an advanced downward tip design was demonstrated in high and low speed wind tunnel tests. With such as design both aerodynamic drag in cruise but also the lift/drag ratio at take-off could be improved.

Reduction of weight was intended to be achieved by advanced materials and new cabling concepts. New magnesium alloys with increased strength and good corrosion resistance

have been developed in the IDEA project. In this context, a Magnesium process- and simulation database and a design manual for aircraft designers are under development. A flat cable concept was studied in the EECS project, which promises to save 10% minimum on weight, 300% minimum on implementation time and 20% minimum on overall cost. In addition, improvement in the quality of the electrical signal distribution was achieved. The process from cabling plan to harness design was subject of the FRESH project. Design and change processes will be easier with the developed tool, which converts paper wiring plans to CAD on the one hand, and combines CAD and simulation of physical and electrical behaviour to a harness system on the other.

Improving the design process for cockpit applications, the IMCAD project developed the standard IGF format for the exchange of graphical information of symbology displays as well as interactive displays. Graphical and functional specification tools for cockpit applications design have been improved. The IMAGE project developed a validated generic prototyped environment for numerical and interactive simulations. IMAGE manages and coordinates different available non-compatible simulation tools in both real time (e.g. for flight simulator applications) and numerical (e.g. for multidisciplinary design), promising to save development time and increase productivity.

Manufacturing

Efficiency in machining of heat-resistant alloys used in aerospace applications could be increased by the MACHERENA project. Benefits are related to the increase in productivity, i.e. reduction of machining time with an additional contribution in tool consumption saving.

A manufacturing methodology to produce a 4.5 metre fully integrated fuselage component by fibre placement was developed within the FUBACOMP programme. The cured geometry of the fuselage fell within the defined assembly tolerances, which in turn facilitated an efficient assembly process.

The WEL-AIR and WAFS projects developed new concepts for welding of airframes by laser beam welding (LBW) and friction stir welding (FSW), both promising cost saving of up to 30% and weight saving of up to 10%.

In the SEDF 3D project, software was created which allows simulating the process of part elastoforming in a few minutes. The SEDF software allows analysis of feasibility and risk for defects, and provides tools for optimized blank design. With this simulation, cost will be reduced especially but not only in tool design.

Within the AGEFORM project, the creep-form process was adapted for damage tolerant applications like the bottom wing skin or fuselage panels. New damage tolerant alloys were developed and entirely characterized during each step of the process. Thanks to the new developments, these alloys seem to be perfectly adapted for the application of the AGEFORM process. New design concepts, in particular monolithic structures, can be realized using the advantages of creep forming in a cost-effective way.

Automation for drilling, fastening, assembly, systems integration and tooling was improved by a novel laser tracker controller developed in the ADFAST project. It contains a Tracker Controller with a high level Tracker Programming Interface (TPI), easy to integrate in other systems. The controller was optimised for machine control, linked measurement and assembly planning tools. Standalone application software based on CAD was developed that supports the measurement process.

New concepts

In order to position the future air transport system against the expected increase of transport demand, a new concept for larger aircraft to reduce traffic density and a concept

to increase the capacity of airspace were developed. The VELA (very large efficient aircraft) project improved skills, capabilities and methodologies suitable for the design and the optimization of civil flying wing aircraft. The study considered aerodynamics and structures, but also simulated issues of airport integration as well as ditching and passenger evacuation. Aiming on improving efficiency, capacity and safety of air transportation, the IFATS project provides a comprehensive view of what could be a fully automated air transportation system (ATS) solution. With this study, a clear understanding of its benefits and drawbacks has been obtained.

Conceptual research was also done in the sub-system level. Suggesting fuel cells as future primary electrical power sources for aircraft, the CELINA project generated requirements for such a power system, including assessment of risks, safety and certification. Capabilities and limits of a fuel cell power system were studied in this context. Concerning realization, control laws and integration strategies were developed. Within the NEFA project, multidisciplinary investigations on the feasibility of H-, U- and V-tail designs for a generic twin-jet transport aircraft were carried out. Comprehensive knowledge of V-Tail has been gained and design capabilities have been developed. Grey areas for further research have been identified. Technologies have been developed and validated for the design and the manufacturing of hydraulic filter elements in the AEROFIL project. Beyond improved disposability (100% burnable), mass reduction (30% to 70%) and lifetime increase (30% to 100%) lead to significant reduction of environment impacts either due to manufacturing of the component and also due to mass reduction in the aircraft.

Reacting to new production technologies and materials, different innovate non-destructive test (NDT) technologies in various states of maturity were studied in the INCA project. Suggested technologies have the potential to improve inspection capabilities and to enable the introduction of new, economically and ecologically efficient, aircraft materials, components and designs.

A conceptual study for high altitude aircraft and airships for specific aeronautical and space applications (USE HAAS) came to the result that this sector offers considerable potential to support a range of valuable applications and services. In order to realize this concept, further work has to be done concerning regulation and certification. In addition to its specific capabilities, a main advantage is that the concept has little environmental impact, since it is powered mainly by solar energy. An Italian national project (Final development and flight tests of an aircraft with remote piloting for environmental monitoring) developed an rotary-wing UAV system prototype and a suitable miniature LIDAR sensor to monitor concentration of pollutants on the surface of marine ecosystems.

4.2.4 Policy Implications

Research about aerodynamic performance improvement has been organized in a network called KATNET. It can be assumed that this type of organization has increased research efficiency by organizing relevant conferences and providing a forum for research staff. For future research programs, network organization could also be implemented for other disciplines in order to increase efficiency which is even more essential with decreasing research funds.

Research in broadband communication is fully in line with ACARE Strategic Research Agenda topic Communication Technologies Systems High Bandwidth data link and High Performance A/G data link. As a result B-VHF was introduced as a recommendation for Action AP17 (Future Communications Study) of the Eurocontrol - FAA co-operation agreement. Furthermore the technology was identified for investigation in the L-Band in the

course of this study. B-VHF became part of the Eurocontrol data link policy discussions as a technology for the VHF band and with the term B-AMC as a technology for the L-band.

Considering aircraft design, each single discipline has been optimized within its boundaries during the last years. Currently, potentials for improvement can be found in interdisciplinary approaches. Future policy should aim on interdisciplinary design and interface standards.

The majority of processing difficulties experienced within composite fuselage manufacturing tasks revolved around the control of the outer mould line (OML) surface quality to an acceptable standard. Further work would be recommended in this area to develop a production solution for the approach adopted. The fibre placement deposition achieved during part manufacture was as predicted, but it would be anticipated that the make-span be significantly reduced through further optimisation.

Prospective research concerning the capability of the transportation system produced promising results and outlook for the main stream air transportation. Shaping the future transport system in advance allows finding solutions for show stoppers that may be temporary or only based on unjustified reluctance. Advanced prospective research projects should be continued since they give a vision of the potential long term future, which is a driver to building our industrial strategy. If further advance in also desired in the specialized concepts of high altitude aircraft and airships or unmanned air vehicles (UAV) for environmental monitoring, additional funding but also effective research coordination will be necessary.

4.3 Sub-Theme 2: Aircraft and operational safety

4.3.1 Background

Preventing hostile action of any kind to incur injury, loss, damage or disruption to travellers or citizens due to the effects of aircraft misuse, research will focus on the relevant elements of the air transport system including security measures in cabin and cockpit designs, automatic control and landing in the case of unauthorised use of aircraft, protection against external attacks, as well as security aspects of airspace management and airport operations.

Research focused mainly on the improvement of the air traffic control to guarantee a safe European airspace, the understanding of vortex dynamics, the increase of the safety in all in-flight situations as well as the behaviour of aircraft structures and their maintenance.

4.3.2 Research Objectives

A main objective is to accelerate the implementation of Airborne Separation Assistance (ASAS) applications in European Airspace taking global applicability in order to increase airspace capacity and safety. The next-generation air-traffic control system will have to be able to handle, safely and efficiently, traffic densities which in 2020 will double the 1997 number of flights. The key to achieving a large increase in the capacity of this airspace is a reduction in controller workload, which can be accomplished by introducing airborne separation assistance system and by using air-ground data links.

Another main objective is to gain new knowledge about open issues of vortex dynamics relevant to aircraft wakes, and to provide a more systematic description than previously achieved of the phenomena involved in aircraft wake dynamics. These fundamental developments are necessary to achieve major advances in this domain, in view of a successful application of existing or future strategies for wake characterization, prediction and alleviation. In order to achieve this goal, multidisciplinary contacts and information exchange between specialists active in the field of wake turbulence and end-users of this knowledge in the operational airport environment were promoted. These projects intend to increase the capacity temporarily, improve the management of arrival flows while reducing holding and long-term runway capacity for airline schedule planning.

In order to predict the behaviour of aircraft structures subjected to high velocity impacts and survivable crash loads Finite Element (FE) methods and tools were developed in the xx project. The aim was to enhance safety through damage tolerant aircraft design and the development of crashworthy aircraft concepts, hence reducing the accident rate in case of survivable crash scenarios. Furthermore, a robotic inspection system was developed, which would walk over large areas of an aircraft structure, carrying out automatic data collection and interpretation to identify all structural flaws, without the need to dismantle components.

A further objective was to increase the safety in all in-flight situations, particularly low visibility situations, by improving the transducers used in Air Data Computers (ADC) for aircraft applications. These results are relevant to flying on autopilot in the reduced vertical

separation minima of 1 000ft, as well as to demanding manual flying situations in darkness and low visibility.

4.3.3 Research Results

The main result in the frame of the Airborne Separation Assistance (ASAS) applications were that significant progress in the global harmonization definition and the validation of ASAS and ADS-B applications has been made. However, as for any new concept elements of the future ATM (Air Traffic Management), work is still needed. The relevant projects have proved to be valuable enablers to progress ASAS and ADS-B.

Physical understanding has been established related to aircraft trailing wakes, including the role of vortex instabilities, the influence of engine jets and fuselage wakes, and ground effects. These results represent a solid knowledge base for future applications aiming at the reduction of wake turbulence hazards. Various operational scenarios were proposed in order to increase airport capacity without loss of safety. Furthermore, an integrated platform for ATC (Air Traffic Control) that will allow variable aircraft separation distances, as opposed to the fixed distances presently applied at airports has been developed.

The projects related to the behaviour of aircraft structures have developed impact models for hard debris and obstacles at airports such as lamp posts. These were used to model impacts on a simple wing with skinned panels. Another project developed a robot designed to climb over the fuselage and wing areas of aircraft and inspect rows of rivets for loose rivets and cracks.

The topics of situation awareness (SA) and threat management (TM) have been a matter of in depth investigations.

4.3.4 Policy Implications

ASAS and ADS-B applications shall be an integral part of the European ATM Master Plan. They have the potential to enhance the ATM system in the areas of safety, capacity, flexibility, efficiency and environment. It is now necessary to conduct operational trials in Europe involving revenue flight. This will include in-situ certification and operational approval of the applications. ASAS application should be studied as an integral part of the ATM system. Synergies with other new concept elements should be identified in order to maximize benefits. Stakeholders should participate in ASAS activities to ensure a common understanding. It was also recommended that EUROCONTROL should continue ASAS work and link it with the planned FAA ASAS communication activity.

It has become clear that the wake vortex phenomena during departures is still not fully understood, and further research is needed before the outcome of the departure safety assessment will be ready for approval by regulatory authorities. The introduction of new wake vortex separation procedures can be viewed as a multidisciplinary activity. The disciplines should not work for themselves and a ‘smart integrator’ is needed to bring the implementation closer. The role of the ‘smart integrator’ is to define the particular project goals, to interface with the ‘end users’ and to orchestrate the required specific research actions.

4.4 Sub-Theme 3: Airport capacity and operation

4.4.1 Background

Capacity problems are one of the other major concerns of airports and aviation authorities at present. With air traffic increasing at an average rate of six per cent per year, airports, both large and small, are feeling the strain of managing more and more planes within their limited facilities. The expansion of existing airports with more runways and other facilities or the construction of new ones is becoming less feasible due to environmental concerns. The solution therefore consists of providing tools to airports that enhance the ability to handle more aircraft and to do so safely. Efficiency gains can also be realized during takeoffs and landings by improving the utilization of available ground and air space while at the same time reducing the risk of accidents.

4.4.2 Research Objectives

Information and decision support

A main objective of this sub-theme was to provide an intelligent, personalized, location-based information and decision support system for travellers and airport services. The research within the projects A-CDM, ADAMANT, SPADE and ACE aimed to provide support in airport development (both airside and landside), planning and operations, allowing integrated impact and trade-off analyses for a variety of performance measures (for example capacity, delay, level of service, safety, security, environmental impact and cost-benefits). It addressed a number of important decisions (or "use cases") regarding airport development, planning and operations via a pre-structured, pre-specified and guided "wizard-type" human-machine interface. This environment can take autonomous action to ensure that the travellers' journey is completed in line with their intentions and wishes and with the least possible impact in case of emergency conditions. It also maximizes the business opportunities for the airport.

A key was to develop Airport Collaborative Decision Making (CDM) concepts concerning airport operations with the following goals:

- enhance the operational efficiency;
- improve the predictability of events (off-block, take-off);
- improve punctuality;
- reduce ground movement costs (reduced fuel consumption and emissions);
- enhance the use of ground handling services;
- enhance the use of stands, gates, and platforms;
- optimize the use of airport infrastructure and reduce congestion;
- maximize capacity in times of disruption and system recovery.

Surveillance, guidance and control

Another research area was related to surveillance, guidance and control at airports. Several technologies were utilized in order to improve the communication networks and Interactive Human-Machine Interfaces (HMIs), for example:

- Interactive Human-Machine Interfaces (HMIs) for the drivers of the vehicles and the end-users on the ground, to display the situation to drivers and ground operators and to allow operational interaction between the ground operators and the drivers;
- Communication networks interoperable with aircraft to allow situation awareness both on the vehicle side and the aircraft side;
- Innovative communication networks using wireless technologies for communication between the ground and the vehicle (position, identity, alerts, instructions, etc.);

In this perspective, the detailed objectives of the AIRNET project were to prototype satellite navigation based low-cost platform for the surveillance, control and management of airport vehicles (catering, baggage, fuel, maintenance, firemen, police, customs, etc.). This platform is based on the EGNOS satellite navigation system for providing the position of the vehicles with the required high-level of accuracy. The low-cost of the AIRNET infrastructure makes AIRNET attractive to small and medium sized airports.

Applications

The objective of the ISMAEL project was to determine whether recent advances in magnetic sensors could provide a better means of surface movement surveillance at airports. either as a cost-effective alternative to Surface Movement Radar for smaller airports or as an additional point sensor in multi-sensor Advanced Surface Movement Guidance and Control Systems (A-SMGCS) at major international airports. The main objective of EMMA was to enable the harmonised A-SMGCS implementation at European airports while EMMA2 consolidated Advanced Surface Movement Guidance and Control System (A-SMGCS) functions in the operational environment. An extension of the A-SMGCS concept by EMMA was the holistic, integrated air-ground approach that considers aircraft equipped with advanced systems for pilot assistance in a context where tower and apron controllers are supported by A-SMGCS ground systems. A mature technical and operational concept, as developed through EMMA, ensures consistency of traffic information given to controllers and pilots.

The project INTERVUSE focuses also on the SMGCS. In order to make those systems affordable, the project dealt with a low-cost solution for SMGCS by combination of radar tracking, flight plan processing and digital video processing. The SAFE-AIRPORT acoustic system, the first to employ phased array microphones in civilian aviation, intends to alert controllers of the deviation of planes when they leave their flight path by over six nautical miles.

The main objective of the THEmatic Network on Airport Activities (THENA) was to create and develop a coordination and collaboration environment for airport activities in order to gain transparency and effectiveness in the development of projects related to this issue. THENA aimed to provide a focal point for collaboration between the different programs where the stakeholders involved in airport operations had the chance to meet in order to improve the coordination and avoid redundancy between completed and ongoing projects in the airport domain.

4.4.3 Research Results

Information and decision support

Currently 25 Airports are implementing the Airport Collaborative Decision Making (CDM) concept. They include the most important airports in the core area of Europe (London Heathrow, Amsterdam Schiphol, Paris Charles de Gaulle, and Frankfurt Airport). The concept is currently operational in three airports (Munich, Brussels and Zurich), which are the first airports to successfully implement Airport CDM and connect to the network for more flexible slot exchange. Benefits range from reduced taxi times and hence less emissions to increased compliance of Air Traffic Flow Management (ATFM) slots.

Several projects addressed information-sharing to allow stakeholders to receive, in a short amount of time, the right information needed for their operations. This included the ability to efficiently utilize the airport capacity in a collaborative decision-making environment between ATC, aircraft, ATFM, handlers and airport operations. Through integrated and systematic impact analyses, the airport decision-making process quality was improved. By addressing a standard set of questions or user cases related to airports, the decision-making process at a European level was homogenized and rationalized. Demand and supply-side analyses were conducted regarding tools for assisting airport-domain experts.

Surveillance, guidance and control

The projects focusing on SMGCS, such as EMMA have lead to comprehensive results that supported the regulation and standardization bodies, as well as the industry, in the early and efficient implementation of A-SMGCS. Significant progress in maturation of technical equipment and on operational issues such as proper transponder operating procedures were made. The projects have made a further step to promote the use of A-SMGCS in all weather conditions by proposing adapted procedures. Within the EMMA project, A-SMGCS test-bed systems were installed, verified and validated at three different airports, in several real time simulations and by on-board installations in simulation.

The advanced operational concept for A-SMGCS has been proven and strengthened by the implementation of levels 1 and 2 at three different European airports (Milano-Malpensa, Prague-Ruzyne, and Toulouse-Blagnac).

Applications

Three related projects have developed an alternative to ground radar and are designed to improve safety. Two projects, AIRNET and ISMAEL, are also applying emerging technologies to reduce the risk of accidents on the ground and during takeoff and landing. Most importantly, they are all complementary, opening the door through their collaborative efforts to multi-sensory detection, tracking and identification systems for planes and ground vehicles. The development of magnetic detectors within the ISMAEL project improved the detection of targets moving on the airport surface which is achieved by detecting their ferromagnetic parts such as vehicle motors or aircraft engines and gears, based on their interaction with the earth's magnetic field. Regarding innovative communication networks, the AIRNET partners have included technologies currently under evaluation and standardisation (e.g. Wi-Fi) for use in operational systems in air transport.

The project results indicate that INTERVUSE technology can achieve most of the performance requirements of a Surface Movement Radar (SMR).

The SAFE-AIRPORT project developed an innovative acoustic system based on two Passive Phased Array Microphone antennae capable of discovering and tracking airplanes up to at least six nautical miles' distance in air and on ground. The main advantages of the system with respect to radar is the lower cost and that the electromagnetic and acoustic devices are pollution free.

The ACE project has developed a structured methodology that enables any airport to assess its existing airside capacity and to evaluate the potential for maximising runway throughput. Through working closely with some of Europe's busiest and fastest growing airports, the ACE project has identified a number of Best Practices that are applicable for all airport stakeholders. These Best Practices have undergone rigorous evaluation at EUROCONTROL and trial airports. Through these benefits, additional runway slots have been provided during peak demand times, leading to reductions in delays and increased revenue for all airport stakeholders.

4.4.4 Policy Implications

The objective to increase safety by developing an application to avoid inadvertent runway incursion as well as the application of a block-wise SMGCS are of major importance in the future and not only for smaller airports.

Further research is recommended in airport Collaborative Decision Making (CDM) applications, in order to support its further implementation and widely harmonized adoption. When more European airports implement CDM concepts, additional benefits at network scale for all partners are expected. Expected time of the return on investment is less than two years, with an average cost/benefit ratio of nine to one.

CDM applications must be developed in conjunction with other ATM innovative ideas in order to be consistent, such as the System Wide Information Management (SWIM) concept, which has to be investigated in detail and exploited in the aeronautical world. In addition, there is a need to pursue a social dialogue among all relevant stakeholders with the purpose of building consensus and establishing a close collaboration environment to promote the efficiency of airport and air transport operations under the prism of regulations/policies, technologies, management and strategic planning, as well as operations. A wide dissemination of the benefits in term of capacity, punctuality and efficiency, gained through a proper information exchange, will improve the willingness from the different stakeholders to make their information available.

In the short term, effort should be concentrated on enhancement of current procedures and the application of CDM principles to the current practices. In the long term, studies should address implementation of new applications. An integrated management of arrival, departure and ground operations would contribute to the implementation of these principles by providing earlier and more accurate time estimates and collaborative decision making processes.

An economic-driven approach has to be developed and implemented in all solutions and measures employed to solve the current airport problems as well as in all proposed improvements. It is recommended to promote Cost Benefit Analysis within the technical solutions considered in further research to provide the society with quantitative evidence of the costs of improvements and the foreseen benefits of the changes in every aspect: e.g. reduce noise, increase capacity or reduce delay. Investment has to be optimised to maximise efficiency.

In general, it is unanimously agreed that infrastructure projects and airport investments/expansions should be closely monitored and evaluated under the prism of the overall effectiveness and efficiency by simultaneously considering qualitative and quantitative aspects of costs and benefits.

The role of regional airports has to be fully clarified and thoroughly exploited. Since regional airports might play an important role in facilitating airport growth it is recommended to devote further research to the factors influencing the use of regional airports and the possible impacts of using these airports, in terms of their effect on increased accessibility, environment, economics, capacity and so on.

In the same line, although re-hubbing and traffic redistribution into secondary airports are quite interesting options, their applicability and anticipated effectiveness are in question due to strong opposition expected mostly by airline operators. To avoid this opposition, the advantages and disadvantages have to be evaluated from the point of view of airlines, service providers, airport authorities and passengers, whilst not forgetting the global network effects of such.

A drastic revision of the slot allocation regime needs to be promoted through studies that will analyse its impact on the air transport system in Europe. Examples include incorporating market-driven orientations for allocating scarce airport capacity with the aim of removing market entry barriers and discriminatory practices, ensuring transparency, equity and unrestricted access to airport resources, and boosting the operational (e.g., delays, level of service) and financial (e.g. Revenues) efficiency of airport operations. It is imperative to establish new procedures and rules for allocating slots at congested airports by allowing more transparent exchanges of slots and criteria for allocation priorities with a clear orientation towards greater flexibility and increasing adoption of market mechanisms (i.e., pricing schemes).

Regarding ATC (Air Traffic Control) at airports, the use of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) and its procedures at airports to increase safety and capacity in all weather conditions, especially to reduce runway incursions, is considered quite essential. Although substantial effort has been made to improve the performances of A-SMGCS and to add new functions, safety implications of its implementation should be further researched.

Some metrics are quite common when analysing airport characteristics such as aircraft delays, taxi times, and capacity of airport components or queue lengths. However, there is a wide field for enhancing the spectrum and variety of data related to the airport world, such as ground conflicts, fuel burn, pollution emissions, noise impact, taxi costs, safety metrics, and security metrics. Logically, the definitions and use of these metrics have to be agreed within the airport community. In addition, these new metrics have to be added as output, results or information received from airport models in order to provide information on capacity, efficiency, safety, security and environmental impact, as direct result of the airport analyses tools.

The ten new states joining the European Union are harmonising their structure with the EU standards and they are trying to use the same models and procedures. Besides, it is expected that through the process of economic integration, traffic growth will raise similar problems for the current major EU airports. However due to the significant differences of the past harmonisation to most recent standards is not always possible. Therefore larger focus on their situation and joint solutions for the problems are advised.

4.5 Sub-Theme 4: Air traffic control/management

4.5.1 Background

A step-change in aviation was needed in order to accommodate the projected growth of three times more aircraft movements by improving punctuality in all weather conditions and significantly reducing the time spent in travel-related procedures at airports. Simultaneously maintaining safety is an essential part of this sub-theme. Research develops and implements an innovative Air Traffic Management (ATM) system within the context of the SESAR initiative. Particular elements are integrating air, ground and space components, together with traffic flow management and more aircraft autonomy. Design aspects of aircraft to improve handling of passengers and cargo, novel solutions for efficient airport use and connecting air transport to the overall transport system have also been addressed.

The SESAR initiative aims to develop the new tools and technologies needed to sustain air traffic growth in Europe for the next 20 years, in an economically and environmentally sound way. The target operational concepts, as well as the associated research programme, have been developed in the SESAR definition phase, which is a cooperative, industry-led effort. In order to rationalise and organise ATM research so that it leads to actual operational and industrial implementation, all ATM research in the 7th Framework programme will be undertaken within the SESAR initiative.

4.5.2 Research Objectives

Air Traffic Management (ATM) systems

The objective of most research projects within this sub-theme was related to improving the Air Traffic Management (ATM) systems operating in a common European airspace. All projects in this sub theme have highlighted goals in the following fields:

- environment,
- efficiency,
- cost-effectiveness,
- predictability,
- safety,
- capacity,
- flexibility and
- security.

The target of the ‘Aircraft in the future Air Traffic Management System’ (AFAS) and ‘North European ADS-B Network Update Programme Phase 2’ (NUP2) projects were to define and propose an achievable ATM operational scenario and guideline for the core European airspace which will yield to potential benefits in terms of increasing capacity and safety. The main goal of ‘The more autonomous - aircraft in the future Air Traffic Management system’ (MA-AFAS) project was to develop an operational concept that would fit into the

future European ATM concept, as well as a corresponding avionics package that would allow for more autonomous aircraft operation within the European airspace.

The intention of the Cooperative Approach to Air Traffic Services (CAATS) was the coordination of processes and methodologies across ATM related projects in relation to safety, human factors and validation domains. The objective was the achievement of a coordinated, cooperative European approach to ATM research. The operational and technical baseline defined in Co-operative Air Traffic Management Phase 1 (C-ATM) aimed to refine and assemble the most promising aspects of recent research. A major challenge for this project was to integrate these elements into one overall, fully inter-operable and integrated air/ground concept of operation, ensuring both operational and technical coherency. The main objectives of the 'Mediterranean Free Flight' (MFF) programme were to provide technical and operational evaluation of integration, interoperability and safe use of CNS/ATM technologies and applications, suitable for future Mediterranean ATM scenarios, including operational requirements and procedures enabling the introduction of free flight operations in the Mediterranean area.

Global Navigation Satellite Systems (GNSS)

Projects such as SAGA, GIFT, POLARIS and ASPASIA have supported Galileo standardisation activities so that Galileo becomes recognised and adopted world-wide as a Global Navigation Satellite Systems (GNSS) standard. Standardisation included interoperability constraints with other current GNSS standards such as GPS and its modernisation. The objective of the 'Standardisation Activity for Galileo' (SAGA) project was to identify needs, to issue a set of draft standards for Galileo and to improve it through presentation and discussion in the framework of the relevant standardisation bodies up to the level of maturity required for formal approval. The 'GNSS Inertial future landing techniques' (GIFT) project aimed to assess high level requirements and the conceptual design, simulation and evaluation of a combined GBAS/ABAS configuration for the achievement of CAT II/III landing operations. POLARIS demonstrated the benefits to be gained from a wide variety of combinations of systems and sensors in different user environments and assessed the performance of any combination of standard navigation devices in their particular operating environment. The 'Aeronautical Surveillance & Planning by Advanced Satellite-Implemented Applications' (ASPASIA) project assessed the benefits of satellite communication (SatCom) systems for ASAS applications and analysed the performance of test bed ADS-B applications when using SatCom technologies. Its aim was to provide a first architecture for SatCom systems used for surveillance purposes adapting existing satellite platform for surveillance applications

Airborne communications and applications

The future definition of a new airborne platform aiming to integrate different technologies will realise a new concept of airborne communications. Such architecture will provide high flexibility due to the possibility of communicating with different data rate technologies. Other activities focused on airspace traffic management applications for communication. The '4D Virtual Airspace Management System' (AD4) project aimed to explore the application and benefits of three dimensional (3D) displays and interaction technologies with a view to determining the qualities required to produce an effective 3D information visualization environment for the air traffic controller. The main objectives of the 'ADS Mediterranean Upgrade Programme' (ADS MEDUP) were to establish an extended air-ground digital data link infrastructure based on VDL-4 as well as developing ADS-B and other ATM applications. In order to provide the infrastructure for the MFF project, potential future beneficial attributes for the Mediterranean area were assessed. The intention of the 'Advanced Technologies for Networking in Avionic Applications' (ATENAA) project is to define a new concept of integrated network architecture through the use of different

technologies, introducing advanced techniques for networking, broadband satellite RF data links, outside-aircraft, point-to-point optical data links and inside-aircraft diffuse optical links.

4.5.3 Research Results

Air Traffic Management (ATM) systems

The programmes provided valuable scientific results which can facilitate the highly needed improvements of the European ATM system and concept of operations. The projects resulted in operational concepts that have benefits in several areas. In the safety domain, the number of accidents and incidents per movement can be reduced by applying the recommended outcomes. Through an interaction with a number of projects and safety experts, a rich list of emerging good practices and measurements for improvement of safety key elements in ATM were identified. It is now possible to make better use of existing maximum airport capacities and to increase the en-route capacity. In the efficiency domain, punctuality can be increased and movements of? are better predicted. Air Traffic Situational Awareness (ATSAW) has been identified as an enabler for innovative operational applications like free route, ASAS spacing, ASAS separation, and ASAS self-separation in free flight. 4-D trajectory exchange principles and collaborative flight management has been refined and the compatibility between 4-D and ASAS in the TMA has been developed. Recommendations, guidelines and ATC instructions regarding partial delegation, station keeping, passing and crossing, autonomous operation, taxiway management, and data linked taxi routes have been built. Furthermore, the surveillance of air traffic could be enhanced and therefore the separation assurance improved.

Global Navigation Satellite Systems (GNSS)

In the field of Global Navigation Satellite Systems, concepts and technologies regarding take off and landing using ground or space based augmentation have been finalized. The overall progress made on Galileo standardisation is significant and the results are globally in line with the initial objectives. The Galileo system is recognised as a future GNSS positioning standard in major domains like air, maritime, road, and rail. Most of the standards are ready to include potential benefits from combined Galileo / GPS standards. An efficient feedback from the standardisation point of view has been provided on the Galileo system definition and this will ease future standardisation. Two different categories of standardisation activities have been identified: the safety of life related applications, for which standards are driven by regulations and the mass market application by commercial aspects. For CAT III high level performance requirements derived from instrument landing system (ILS) analogy, the GNSS availability could be increased to 99.9% instead of 98.5% availability for a reasonably feasible standalone ground based augmentation system (GBAS) configuration.

Airborne communications and applications

Several applications like Cockpit Display of Traffic Information (CDTI) and Airborne Separation Assurance/ Assistance System (ASAS) could be developed or improved. Various data linking communications, point to point, ATN compliant, broadcast, ADS-B, TIS-B have been designed. Requirements of GS/AS applications in a SatCom environment have been developed and Sat-Com architectures have been designed. The AD4 project has developed a 3D air situation display based on the representation of visual elements within a purely synthetic 3D virtual environment. Such an environment provides a 3D perspective display of the ATC controlled sector and is capable of both 3D visualisation and 3D navigation. Furthermore, an augmented reality (AR) D4 technology and

demonstrator to prove the applicability of the AR visualization technology in the development of an HMI for tower controllers have been developed. The VDL-4 network, composed of 8 Ground Stations, covers the major part of Western and Central Mediterranean. Two aircrafts have been equipped with VDL-4 transponders and cockpit display units. They have been used to perform technical verifications and pre-operational evaluation. The interoperability of these systems within various manufacturers of equipment and with the parallel NUP Programme has been tested successfully.

4.5.4 Policy Implications

For Air Traffic Management, safety deserves attention from different perspectives. An ATM design that is perceived as being unsafe will not easily be accepted by the pilots and controllers involved. Indeed, the positive perception about the safety of an ATM design is a training and deployment critical requirement. By its very nature, however, safety perception is a subjective notion, and therefore insufficient to really guide the approval of safety-critical changes in ATM. Moreover, the safety perception by passengers and human society cannot be identified on the basis of an ATM design. The dependability of a technical system (e.g. an automation support system, an aircraft navigation system, a satellite based communication system) stands for a collective term used to describe its performance in terms of availability, reliability, maintainability and maintenance-support, Metrics for dependability elements have been widely studied in the literature for technical systems and are in use, for example, by the Joint Aviation Authority and EUROCONTROL. Accident risk metrics are commonly in use for human controlled safety-critical operations in chemical and nuclear industries, and in civil aviation. Two well-known ICAO-adopted accident risk metrics are for an aircraft to collide either with another aircraft en-route, or with fixed obstacles during landing. Risk may also be expressed in economic or societal terms.

In order to cover the next steps towards implementation of the different concepts, it appears necessary to involve a larger group of stakeholders including airlines, aircraft manufacturers, avionic industry, and airports.

It has to be highlighted that such support activities toward future Galileo standards should be continued in the next few years. Galileo will constitute a common tool for all European citizens in the near future. Therefore, users must have an understanding of the Galileo system and provide requirements for the system's design. New GNSS services have to be identified, optimizing the Galileo system from a user point of view. This optimization will result in multiple social benefits, in addition to the direct commercial benefits of Galileo.

The various research initiatives have identified a set of strategic objectives to be pursued for the implementation of the European ATM of the future. Improved safety can be achieved by the use of 3D displays for air traffic control in order to improve local situation awareness thanks to the visual representation of third and fourth (time) dimensions. Furthermore, use of augmented reality techniques in the airport environment can alleviate most of the visibility problems experienced by tower controllers (low visibility due to bad weather conditions, occlusion, etc.). Improved security at the IT level can be achieved by the adoption of developed technologies. Reduced operating costs can be achieved by the use of 3D displays and augmented reality techniques as building blocks for the implementation of virtual/remote towers concept (i.e. by the use of synthetic visual elements superimposed on video images). An effective use of 3D technologies for the air traffic control has to take into consideration the integration of 3D displays with (existing) 2D air situation displays by the provision of 2D-3D combined air traffic control displays. Several possibilities exist and some of them have been investigated. The need for such

combined displays arises from the fact that while 3D representations improve local situation awareness, pure 3D visualization tends to be disruptive for controllers' global situation awareness. The solution to this problem would be to conserve a global 2D display while properly integrating in it appropriate 3D displays.

Another possibility is of more operational character, including deeper pre-operational experimentation with more extensive operator involvement and taking into account the frame of the Single European Sky policy, in terms of interoperability and seamless operations, although within the specific traffic pattern and structure of the Mediterranean Area. Moreover, the assessment of the potential obtainable performances constituting the results of the different research projects and the demonstration of the applicability of the new technologies may trigger the realisation of a new generation of avionic communication systems and, possibly, the adaptation of existing airframes or the realisation of new ones. From this point of view, the European Aircraft manufacturing industry has received a strong benefit by the availability of the related know-how within the European Community.

4.6 Sub-Theme 5: Efficient, quiet and environmentally friendly engines

4.6.1 Background

The background to this sub theme includes developing technologies to reduce the environmental impact of aviation with the aim to halve the emitted carbon dioxide (CO2), cut specific emissions of nitrogen oxides (NOx) by 80 % and halve the perceived noise. Research will focus on furthering green engine technologies, including alternative fuels technology as well as improving vehicle efficiency of fixed-wing and rotary wing aircraft (including helicopters and tiltrotors), new intelligent low-weight structures, and improved aerodynamics.

The most recent 'Clean Sky' Joint Technology Initiative aims at realising a quantum leap in the technological capability of Europe to produce aircraft that satisfy environmental needs and are economically viable. The activities will contribute to a future air transport system with lower environmental impact while securing EU industrial leadership, thereby contributing to a more sustainable air transport system in Europe and world-wide. Projects in this context started 2009 and are not yet a matter of consideration in the present result analyses.

In this sub-theme, the focus is on

- Technology Concepts for more efficient engines
- Design methods for more efficient engines
- Computing and measuring engine emissions

4.6.2 Research Objectives

Concerning new technologies, the objective is to save operation cost and to minimize negative impacts to the environment by increasing the efficiency of aero engines. In detail, the objectives of the considered projects in this field were:

- Increase of turbine entry temperature by thermal barrier coatings (TBC)
- Utilization of exhaust heat by designing an exhaust gas recuperator for the Inter-cooled Recuperative Aero-engine (IRA)
- Development of innovative transmission and oil system concepts

Optimization of engine geometry is another approach to increasing efficiency. In this context, research objectives were:

- Optimization of gas-turbine internal air systems
- Improvement of physical understanding and modelling capacities of unsteady transition from laminar to turbulent flow in axial turbo machines
- Development of advanced 3D steady and unsteady viscous methods for multi-stage compressor design

In order to optimize aero engines regarding emission, improved measurement methods but also computational simulation tools are required. Objectives were:

- Advanced non-intrusive emission measurement methods and equipment
- Development of computational soot and noise simulation models and tools

4.6.3 Research Results

New Technology Concepts

Component tests on all selected thermal barrier coating systems were started in a burner rig facility and showed initially promising results. However, tests could not be completed and were still on-going at the end of the TBC PLUS project. It is planned that after passing all required tests and approvals, selected coating systems will be subjected to a component test in the aircraft industry as well as the gas turbine industry.

Design philosophy, technology and tools needed for the engineering development of an exhaust gas recuperator were acquired in the AEROHEX project. The tools developed and validated allowed selection of a heat exchanger configuration, which meets the targets, out of a number of alternatives. The heat exchanger designed for and integrated into the IRA-engine meets the desired weight, reduces manufacturing costs by more than 50% and promises to exceed the life requirements of the engine. It was demonstrated that pressure drop and heat exchange rates depend strongly on how the heat exchanger elements are arranged in the exhaust duct of the IRA engine.

Prototypes of electrically driven oil pumps were designed, manufactured, and tested for function in the ATOS project. In order to develop shafts that can sustain higher torque at given dimensions, buckling and dual alloy shafts have been experimentally investigated. Predictive tools such as computational fluid dynamics (CFD) and Finite Element codes were validated to measured data.

Design Methods

The ICAS-GT2 research programme addressed fluid flow and heat transfer in the following distinct, but related areas of gas turbine internal air systems design: turbine rim sealing, rotating cavities, turbine stator wells, pre-swirl systems and engine parts testing and windage losses. For each of these areas, most promising computational fluid dynamics (CFD) methods are being suggested. With these results, new designs were tested and showed their ability to reduce specific fuel consumption.

In the same context, project AIDA has been successful in achieving an improved understanding of the flow in aggressive intermediate ducts between low and high pressure systems and its interaction with neighbouring components. AIDA's outcomes shall act as enablers for the successful design of new promising engine configurations such as those proposed in FP6 European Engine Integrated Projects (VITAL, NEWAC) and FP7 JTIs& IPs, helping to achieve the ACARE noise and emission reduction targets.

The UTAT project developed, tested and evaluated six new CFD models which improve physical understanding and modelling capacities of unsteady transition from laminar to turbulent flow in axial turbo machines. The major results of this project have been exploited and/or disseminated in different ways by both industrial and academic partners. Partners concerned with education have made the use of UTAT knowledge on a regular basis for education of undergraduate and graduate students as well as of professional engineers. Exploitation by the industrial partners comprised intensive use of the newly generated technology and design procedures in their own low Reynolds number applications, where the benefits of transition control were incorporated at the design stage.

The ADCOMB project exploited advanced 3D steady and unsteady viscous methods for multi-stage compressor design. These tools have been used to maximise performance improvement by control of internal flow structures, particularly tip and end wall regions and blade row interactions. As a result, design concepts were developed and test components both with radical and incremental improvements were made available. A lifetime prediction concept for turbine seals was developed.

Emission Computation and Measurement

The AEROTEST and MENELAS projects dealt with remote emission measurement technologies. The aim of AEROTEST was to achieve a high level of confidence in aircraft engine emission measurements with a view to using the remote optical technique for engine emissions certification. However, AEROTEST results are confidential and have not been published. The MENELAS project developed two prototypes of novel optical instruments (MidDropo and Pico-second Lidar) for probing in the infrared spectrum which were not mature for their final designation at the end of the project. Field experiments to demonstrate the capability of spectroscopic measurements, based on classical infrared absorption spectrometers using diode lasers were performed. Calibration and infrared beam propagation studies lead to the upgrade of a calibration hot cell for high temperature purposes, which will be necessary for field experiments of the novel instruments.

A number of different computational fluid dynamics (CFD) techniques, which can be used by the aerospace industry to assess and optimise jet-noise reduction techniques, have been investigated and developed in the COJEN project. Understanding of their use and limitations with respect to jet aerodynamics and noise prediction has been improved. Advanced acoustic analogy methods, validated direct methods, (LES, DES) and Hybrid methods which can predict the acoustic fields from the CFD results have been developed. Expertise in the use of these techniques and methods has been transferred to the industrial partners. An extensive test campaign for acquisition of aerodynamic and acoustic data for validation of the CFD codes has been successfully completed. A database is now available to support further development and validation.

Investigation on the influence of some kerosene fuel compounds and blends on soot formation in the SIA-TEAM project allowed a better prediction of soot formation. The complexity of scientific CFD codes could be reduced by implementing a validated and reduced reaction mechanism for a kerosene model fuel. A new model approach has been investigated and implemented into CFD code. This “bisectional” model approach reduces the complexity of the soot model itself as well as the computational efforts.

4.6.4 Policy Implications

The research undertaken in this sub-theme has advanced the design data, technology and tools at the disposal of the European gas turbine manufacturers. It would not have been possible for any of the European OEMs in this field to have covered the breadth of the work scope independently. The work performed has made a significant contribution to the declared policy of maintaining European competitiveness in the field of gas turbine technology.

4.7 Sub-Theme 6: Human element – convenience, efficiency and safety

4.7.1 Background

Development of future air transport related technologies has to consider the demands of human relations as a central element. This subtheme considered three types of relations:

- Passenger and service staff relations
- Cockpit crew and ground staff relations
- Third party relations

Passenger and cabin crew related research focused on comfort, well-being and new services, cabin logistic systems and active and passive safety measures, with special emphasis on the human element. Research regarding operators' demand considers efficiency, safety and human effectiveness in cockpit and ground operation but also in airline operations planning and maintenance. Third party related research includes the adaptation of airport and air traffic operations to 24-hour utilisation at acceptable community noise levels.

4.7.2 Research Objectives

Some research considering passenger safety and well-being (e.g. "212034: Extending Cabin Air", "Air Travel & Venous Thromboembolism", "GOING-SAFE") has already been published in the EXTR@Web project. Additional objectives were

- combined effects of cabin environmental parameters on the health of passengers
- new standard for an IFC (In-Flight Cabin) system providing services to up to 1000 passengers and to the crew members, increased availability and fault tolerance and significantly lowered weight, volume and power consumption
- reduction of aircraft direct operating cost (DOC) and the improvement of the service comfort for both passengers and cabin crew

While cockpit crew related projects (e.g. "TALIS", "VINTHEC II") have been published on EXTRA@Web, the objective for research in this paper was to improve the efficiency of the European transportation system by assisting airlines' flight operations to recover faster from disruptions. Furthermore, the aero engine maintenance process was to be optimized by employing adaptive machining technology and developing a data management system.

Objectives for research considering reduction of noise impact to third parties were

- validation of noise reduction technologies whose development was initiated by EU and national projects and assessment of their applicability to current and future European products with minimum cost, weight or performance penalty.
- development of new and acceptable approach and departure procedures and technology necessary to introduce them
- development of a short-term low-cost technical solution to monitor noise caused by air traffic in areas surrounding airports

4.7.3 Research Results

Cabin comfort and service efficiency

The results of the Ideal Cabin Environment project (ICE) indicate that flights of up to eight hours in current commercial aircraft environments pose, in general, no significant health risk for passengers. Nevertheless, passenger behaviour (e.g. leg exercise, support stockings, modest alcohol consumption) and control of the cabin environment parameters such as air temperature (21-25°C), relative humidity (25-40%) or ventilation rate (around 25-34 m^3/h) are recommended to improve comfort and impact on health

An Advanced Network Architecture for In-flight Cabin Systems (ANAIS) test bed was set up which improved existing services and allowed new services. Productivity tools for the cabin and maintenance crew will be centrally managed and can be accessed from different locations in the aircraft. Electrical consumption per seat and system weight was reduced by around 50%. An evaluation of the benefits and viability of implementing wireless technology at the seat has been made. Customized COTS products improve performance, fault tolerance and ease of installation. Flexible system architecture allows services or functions to be added, removed or reconfigured without the need to remove seat equipment.

Reduction in the turnaround time on ground and an increase in passenger capacity of 2-5% can be achieved for wide-body aircraft (ASL). It was proved that the concept is feasible and will reduce direct operation cost, fuel consumption and crew workload. ASL concept recommends relocation of service products to designated locations the cargo compartment, using standardized aircraft containers which can be pre-loaded at the caterer facility. This measure allows parallel passenger boarding and catering and reduces storage space on the passenger deck. Due to the available space on the cargo deck only wide body aircrafts were considered in the ASL project.

Airline Operations and Maintenance

Disruptions in airline operations lead to misplacements of resources (passengers, aircraft and crew) which can be efficiently solved in two steps by the decision support tool for integrated aircraft and crew recovery on the day of operations (DESCARTES). The tool has been proven through a set of business experiments, whereby realistic scenarios have been written and run through, both with a controller and the system. In all cases the system has been able to come up with solutions that are of similar or better quality (with regard to cost) than those of the controllers. In addition, the calculation time for one useful solution has been radically reduced.

The maintenance, repair and overhaul (MRO) of aero engine components consists of a chain of different processes, e.g. inspection, de-coating/coating, welding, milling and polishing. Today, most of these processes are carried out manually. Research (AROSATEC) supports automating these processes by improving the optical scanning system and the milling process by adding adaptive technologies, automating the scanning process using macro functionality and implementing adaptive technologies into the laser welding process. Furthermore, a data management system allows monitoring the status of each individual repair part. The process chain can be tracked by the user. It is possible to connect the AROSATEC data management system to systems used at the MRO shops.

Noise Reduction

A data base capable of covering interactional phenomena between main rotor, tail rotor and fuselage was established in the HELINOVI project with the goal of reducing noise and vibration of helicopter rotors. Noise reduction was predicted and validated by changing the tail rotor sense of rotation from "Advancing Side Down" to "Advancing Side Up" and tip speed reduction, but also with design changes (particularly the clearance between main rotor and fuselage).

Large-scale validation of 10 noise reduction technology concepts, concerning the engine (aero acoustic design, active technologies), nacelle (aero acoustic design, innovative acoustic treatment, active noise control) and airframe (aero acoustic design) was performed by testing more than 35 prototypes. Several advanced low noise fan rotors, as well as components for a complete low noise nacelle were flight tested on an Airbus A320. Flight tests were also carried out on the Airbus A340 with landing gear fitted with aerodynamic fairings. Combined with innovative low noise operational procedures studied at the same time, the SILENCE(R) project has achieved a 5 dB noise reduction.

SOURDINE II developed and analysed departure and approach procedures which provide significant noise reduction compared to current day practice. It has been demonstrated that the SOURDINE II reference approach procedure, featuring an increased final glide path angle, reduces noise by more than 5 dB in a very large range of the procedure. The optimized departure procedures provide noise reduction in the targeted zones compared to current procedures, either close-in or at distant positions. In detail it was identified that major noise benefits for approaches are mainly determined by higher altitudes, while for departures the thrust settings are relevant. The distribution of the fleet mix will influence the shape of the noise contours considerably (i.e. unbalanced use of runways).

For short-term noise monitoring a system prototype (MONSTER) has been assembled based on COTS components, which is able to identify acoustic signatures of airplanes. System functionalities have been demonstrated, but for commercial use further refinement will be necessary.

4.7.4 Policy Implications

This research has impact on further research, standardization and certification activities but also on aircraft and airline industry policies. Research results show that flying in current commercial aircraft environments poses, in general, no significant health risk for passengers. However, existing cabin air standard covers indoor air quality and thermal comfort only. A new cabin air standard is required to cover cabin air pressure.

Potentials for optimization of service logistics efficiency were discovered by relocating storage space to the cargo compartment. In order to exploit this potential, further research and development is necessary to obtain an airworthy, jam free and damage tolerant system. Proposals for certification requirements have been made by the project and need to be implemented. Likewise, system adaptation to single aisle aircraft as well as retrofit solutions for existing aircraft needs to be expedited.

New departure and arrival procedures will contribute to the reduction of noise around airports. As a next step to their implementation, it is recommended that flight trials are conducted in low-density situations to get detailed feedback on aircraft performance, as well as pilot and controller acceptability following their hands-on experience. Results from these flight trials can support additional assessments, as performed in this project to reach the ultimate goal: continuous descent approaches during peak-hour operations at major European airports while maintaining or even improving capacity and safety.

While noise reduction technologies and procedures are relatively mature, further research efforts are necessary to make short-term and low-cost noise monitoring available for all airports.

4.8 Sub-Theme 7: Business process improvements

4.8.1 Background

Air transport is in itself a significant contributor to European wealth. The resultant benefit is spread across all Member States, either as a result of its direct contribution (2.6% GDP and 3 million jobs) or, even more importantly, as a consequence of its lubrication effect on all modern economies enabling our life-style and the way we do business. Its total contribution to the economy is estimated in excess of 10% of GDP.

Business process research targets to establish a competitive supply chain which halves the time-to-market, and reduces product development and operational costs, resulting in more affordable transport for the citizen.

The sub-theme includes improved simulation capabilities and automation, technologies and methods for the realisation of innovative and zero-maintenance, including repair and overhaul, aircraft, as well as lean aircraft, airport and air traffic management operations. Since the latter topics intersect with other air transport sub-themes, projects regarding special airport (Sub-Theme 3) and air traffic (Sub-Theme 4) management operation content have been outlined in the corresponding section in this paper.

Research is focused on improvements to the whole business process, starting from policy making and conceptual design to product development, manufacturing and integration of the supply chain into operations. Considered projects deal with:

- Information tools for policy development
- research strategies
- involvement of small and medium enterprises (SME)
- faster implementation of research results

4.8.2 Research Objectives

Purposeful development of research and development policy depends on reliable and appropriate knowledge of the air transport sector. Of interest was information about the current situation but also about expected future developments. Research objectives in this context were:

- Establishment of an European airport observatory network to collect, review and assess existing data and information and to maintain and provide relevant data to the end users
- Develop and evaluate a high performance forecasting system for passenger movement between European destinations

The Advisory Council for Aeronautical Research in Europe (ACARE) was established with the aim of increasing the effectiveness of aeronautical research in Europe. ACARE's mission is to establish and carry forward a Strategic Research Agenda (SRA). Objective

was to provide administrative and management support to ACARE in its mission to create, maintain, update and implement its Strategic Research Agenda (SRA).

In air transport related research and development, small and medium enterprises (SME) play an important role in air transport related research and development. Due to the variety of SME, special coordination and support is necessary for effective utilization of their capabilities. Related objectives are:

- maintenance and extension of the European aeronautical SME network
- facilitation and improvement of SME participation in the aeronautics dedicated calls of the 6th Framework Programme
- establishment of a high quality database to structure SME technological offer at European level

In order to win global leadership for European aeronautics, advanced capabilities in multiple disciplines need to be developed which halve the time to take research results to market. Goal was to contribute to 50% cost reduction and 30% lead time reduction in engine development and to achieve 5% cost reduction in aircraft development.

4.8.3 Research Results

Information tools for policy development

An airport observatory (APRON) prototype was established, which includes different data categories with a sufficient level of detail to cover important decision making and policy needs. Its main function is to be an information platform, which retrieves requested information, data or analyses based on data (supplied mainly by the participating airports) and to be the communication and information platform for the EU policy makers to share information concerning the (on-going) policy formulation processes. The proposed structure for the APRON Observatory links the main entities together via a central web-based service to retrieve the necessary data from the participants (e.g., the network of airports) in order to produce requested analyses for the user.

Both short term (several days) and long term (several months) passenger flow forecasts can be generated by the AIRFORCE management tool. The tool combines extracts of data bases (data mining technology) and published news and events in the internet (text mining) with a forecast probabilisation layer to predict passenger flows. Short term forecasts can be used by airports (e.g. for human and material resource planning), airline companies (e.g. for demand based deployment of aircraft types) and reservation companies (e.g. to manage overbooking). Long term forecasts can be used in policy and strategy planning.

Research strategies

Based on the previously existing Strategic Research Agenda a new research agenda (SRA-2) has been developed (ASTERA 2 project), which is expected to improve the efficiency of the research process by highlighting activities that are most value-adding and also those which are duplicative. SRA-2 reflects alternative socio-economic scenarios and their associated technologies in the holistic approach advocated by ACARE (Advisory Council for Aeronautical Research in Europe). It provides an indication for the importance of each separate technology and the timescale of its importance. Important new planning aids to research programmers are included. An Observation Platform has been launched that will provide a snapshot of current status and trend over time, will guide and inform future research programmes and will facilitate better co-ordination.

Small and medium enterprises (SME)

By the AEROSME IV project, exchange of information in the aeronautical sector was improved and resulted in an established procedure to promote SME participation in IPs submitted by larger companies. SMEs were assisted in assessment of their suitability as a potential partner for research projects and by proposing their technical contribution. To increase the awareness of the SMEs, for each call the IMG4 IP proposals intended to be submitted were issued on the AeroSME website and an international conference was organised with the aim to present publicly the mentioned IPs and to promote a direct contact between SMEs and the project co-ordinators. Individual consulting was provided to every company which expressed the intention to set up a project.

ECARE+ is another project to strengthen SME contribution to European aeronautical research. Its methodology consists of five blocks: training (regional contacts are trained on FP7 opportunities and peculiarities), multiplying and networking (regional sessions), assessing (SME profiles undergo a quality control procedure before being uploaded into the data base) and liaising (with AeroSME). For FP6 figures show that between call 1 (ECARE not yet involved) and calls 2 & 3 (ECARE involved), the SME share of funding in IPs grew from 5% to 9%.

Faster implementation of research results

The main result of VIVACE is an innovative Aeronautical Collaborative Design Environment and associated processes, models, and methods, which strongly reduces the development costs of new aircraft and engines. This virtual environment, which has been validated through real industrial use cases, supports the design of an aircraft and its engines by providing all the required functionalities and components for the design phases of the aeronautics product life cycle. In specific, a Virtual Aircraft and a concept for a Virtual Engine have been developed, which allow collaborated simulation and optimization of technical and business related influences. A tool box was developed that enables the creation of the right “Aeronautical Collaborative Design Environment” required to support the collaboration between teams in a Virtual/Extended Enterprise context, depending on the specific needs of collaboration.

4.8.4 Policy Implications

Recommendations of the Strategic Research Agenda are that European research needs more money, more people and it needs to be more efficient. But money alone is not enough. European companies have to be encouraged to retain their European bases and to conduct their own research in Europe. A number of additional policy actions are needed to ensure that the entire community involved in the aircraft and air transport sectors sustain a coherent and stable future. Part of this policy challenge is to ensure that the competition between major regions is recognised as a major factor in the development of industrial plans. Stability will be encouraged by equality of treatment both inside and outside of Europe.

The relevance of a European Airport Observatory was acknowledged, as was underlined the importance and usefulness for the European Airport Industry to have an one-stop shop for airport related data. Moreover, the airport observatory prototype includes useful data categories with a sufficient level of detail to cover important decision making and policy needs. It is therefore, considered of vital importance to promote the participation in the airport observatory of more European Airports.

The projects in this Sub-theme will strengthen and improve the support provided to aeronautical SMEs in order to help them to maintain their competitiveness in a rapidly

changing global market. Workshops addressed to aeronautic SMEs will be organised in order to raise awareness on European research issues and Industry's future needs, as well as to facilitate contacts with large companies in the supply chain.

4.9 Implication for future research

It has to be noted that the given implications for further research are based on the publicly available results of 84 projects which reflect less than 10% of the overall number of research projects in this area.

For future research programs in the **Advanced vehicle design / Technology development** sub-theme, network organization could also be implemented for other disciplines in order to increase efficiency which is even more essential with decreasing research funds. Considering aircraft design, future policy should aim for interdisciplinary design and interface standards. Further work would be recommended in the area of composite fuselage manufacturing tasks.

Shaping the future transport system in advance allows finding solutions for show stoppers that may be temporary or only based on unjustified reluctance. Advanced prospective research projects should be continued since they give a vision of the potential long term future, which is a driver to building our industrial strategy. If further advance is also desired in the specialized concepts of high altitude aircraft and airships or UAV for environmental monitoring, additional funding but also effective research coordination will be necessary.

In the field of **Aircraft and operational safety**, ASAS and ADS-B applications shall be an integral part of the European ATM Master Plan. It is recommended that EUROCONTROL should continue ASAS work and link it with the planned FAA ASAS communication activity.

Further research is also needed to understand the wake vortex phenomena. The introduction of new wake vortex separation procedures can be viewed as a multidisciplinary activity.

In the frame of the **Airport capacity and operation** sub-theme, further research is recommended in airport Collaborative Decision Making (CDM) applications, in order to support its further implementation and wide harmonized adoption. CDM applications should be developed in conjunction with other ATM innovative ideas in order to be consistent, as the System Wide Information Management (SWIM) concept. Safety implications in the frame of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) should be further researched. The definitions and usefulness of data related to airport world, such as ground conflicts, fuel burn, pollution emissions, noise impact, taxi costs, safety metrics, and security metrics have to be agreed within the airport community. A drastic revision of the slot allocation regime needs to be promoted through studies that will analyse its impact on air transport in Europe.

Larger focus on the new member states situation and joint solutions for the problems are advised. Furthermore, the role of regional airports has to be fully clarified and thoroughly exploited. In general, it is unanimously agreed that infrastructure projects and airport investments should be monitored and evaluated under the prism of the overall European effectiveness and efficiency.

The research in the **Air traffic control / management** sub-theme suggested that improved safety and reduced operating costs can be achieved by the use of 3D displays for air traffic control. Improved security at the IT level can be achieved by the adoption of developed technologies.

Furthermore, activities to improve future Galileo standards should be supported in the next few years. New GNSS services have to be identified, optimizing the Galileo system from a user point of view.

The research undertaken in the **Efficient, quiet and environmentally friendly engines** sub-theme has advanced the design data, technology and tools at the disposal of the European gas turbine manufacturers. It would not have been possible for any of the European OEMs in this field to have covered the breadth of the work scope independently. The work performed has made a significant contribution to the declared policy of maintaining European competitiveness in the field of gas turbine technology.

Research undertaken in the **Human element – convenience, efficiency and safety** sub-theme has impact on further research, standardization and certification activities but also on aircraft and airline industry policies. A new cabin air standard is required to cover cabin air pressure. Proposals for certification requirements have been made regarding implementation of solutions for optimized service logistics efficiency and need to be implemented. New departure and arrival procedures will contribute to the reduction of noise around airports while maintaining or even improving capacity and safety. Further research efforts are necessary to make low-cost noise monitoring available in short term for all airports.

In the **Business process improvements** sub-theme it has been recommended by the Strategic Research Agenda that European research needs more money, more people and it needs to be more efficient. The airport observatory prototype supports decision making and policy needs. It is considered of vital importance to promote the participation in the airport observatory by more European Airports. Other projects in this Sub-theme will strengthen and improve the support provided to aeronautical SMEs in order to help them maintain their competitiveness in a rapidly changing global market.

5. References

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6. Annex: List of projects by sub-theme

Sub-theme 1: Advanced vehicle design / Technology development				
Project acronym	Project title	Programme	Project website	Coverage
ACT-TILT	Active control technologies for tiltrotor	5th RTD Framework Programme (FP 5)	http://www.cert.fr/dcsd/TILT-ROTOR/ACT-TILT/index_ACT_TILT.html	This report
ADFAST	Automation for drilling, fastening, assembly, systems integration and tooling	5th RTD Framework Programme (FP 5)	www.euadfast.com	This report
ADFCS-II	Affordable digital fly-by-wire flight control systems for small commercial aircraft (second phase)	5th RTD Framework Programme (FP 5)	N/A	This report
AEROFIL	New Concept of High Pressure Hydraulic Filter for Aeronautics Preserving Environment	5th RTD Framework Programme (FP 5)	N/A	This report
AEROMEMS II	Advanced aerodynamic flow control using MEMs	5th RTD Framework Programme (FP 5)	N/A	This report

AEROSHAPE	Multi-point aerodynamic shape optimisation	5th RTD Framework Programme (FP 5)	N/A	This report
AGEFORM	Ageformable panels for commercial aircraft	5th RTD Framework Programme (FP 5)	N/A	This report
AWIATOR	Aircraft wing with advanced technology operation	5th RTD Framework Programme (FP 5)	N/A	This report
B-VHF	Broadband VHF - Aeronautical Communications System based on MC-CDMA	6th RTD Framework Programme (FP 6)	www.b-vhf.org	This report
BOJCAS	Bolted Joints in Composite Aircraft Structures	5th RTD Framework Programme (FP 5)	www.smr.ch/bojcas	Extr@web report
CELINA	Fuel cell application in a new configured aircraft	6th RTD Framework Programme (FP 6)	N/A	This report
DART	Development of an advanced rotor for tilt-rotor	5th RTD Framework Programme (FP 5)	N/A	This report
EECS	Efficient and Economic Cabling System	5th RTD Framework Programme (FP 5)	N/A	This report

	Final development and flight tests of an aircraft with remote piloting for environmental monitoring	National (Italy)	N/A	This report
FRESH	From Electric Cabling Plans to Simulation Help	6th RTD Framework Programme (FP 6)	http://www.aero-scratch.net/fresh.html	This report
FUBACOMP	Full barrel composite fuselage	5th RTD Framework Programme (FP 5)	N/A	This report
IDEA	Integrated Design and Product Development for the Eco-efficient Production of Low-weight Aeroplane Equipment	6th RTD Framework Programme (FP 6)	http://idea-fp6.net/	This report
IFATS	Innovative Future Air Transportation System	6th RTD Framework Programme (FP 6)	http://www.ifats-project.org/	This report
IMAGE	Interoperable management of aeronautical generic executive software	5th RTD Framework Programme (FP 5)	www.aero-scratch.net/image.html	This report
IMCAD	Improving the Cockpit Application Development Process	5th RTD Framework Programme (FP 5)	www2.nlr.nl/public/hosted-sites/imcad	This report

INCA	Improved NDE concepts for innovative aircraft structures and efficient operational maintenance	5th RTD Framework Programme (FP 5)	N/A	This report
KATNET	Key aerodynamic technologies for aircraft performance improvement	5th RTD Framework Programme (FP 5)	N/A	This report
LOADNET	Low Cost Optical Avionics Data Networks	5th RTD Framework Programme (FP 5)	N/A	This report
M-DAW	Modelling and design of advanced wing tip devices	5th RTD Framework Programme (FP 5)	N/A	This report
MACHERENA	New Tools and Processes for Improving Machining of Heat-Resistant Alloys Used in Aerospace Applications	6th RTD Framework Programme (FP 6)	N/A	This report
MALVINA	Modular avionics for light vehicles in aeronautics	5th RTD Framework Programme (FP 5)	N/A	This report
NEFA	New empennage for aircraft	5th RTD Framework Programme (FP 5)	N/A	This report

PIVNET2	A European collaboration on development, quality assessment, and standardization of particle image velocimetry for industrial applications	5th RTD Framework Programme (FP 5)	pivnet.dlr.de	This report
RETINA	Reliable, Tuneable and Inexpensive Antennae by Collective Fabrication Processes	6th RTD Framework Programme (FP 6)	N/A	This report
SEDF 3D	Simulation of elastic die forming process for 3 dimensional parts	5th RTD Framework Programme (FP 5)	N/A	This report
USE HAAS	Study on High Altitude Aircrafts (HAAS) and Airships, Deployed for Specific Aeronautical and Space Applications	6th RTD Framework Programme (FP 6)	N/A	This report
VELA	Very efficient large aircraft	5th RTD Framework Programme (FP 5)	N/A	This report
WAFS	Welding of airframes by friction stir	5th RTD Framework Programme (FP 5)	N/A	This report
WEL-AIR	Development of Short Distance Welding Concepts for Airframes	6th RTD Framework Programme (FP 6)	N/A	This report

WISE	Integrated Wireless Sensing	6th RTD Framework Programme (FP 6)	www.wise-project.org	This report

Sub-theme 2: Aircraft and operational safety				
Project acronym	Project title	Programme	Project website	Coverage
ADS-MEDUP	ADS Mediterranean Upgrade Programme	European (Other)	www.adsmedup.it	This report
ASAS-TN	Airborne Separation Assistance System Thematic Network	5th RTD Framework Programme (FP 5)	www.asas-tn.org	This report
ASAS-TN2	Airbourne Separation Assistance System - Thematic Network II	6th RTD Framework Programme (FP 6)	www.asas-tn.org	This report
ASTER	Aviation Safety Targets for Effective Regulation	5th RTD Framework Programme (FP 5)	www.eurocontrol.int/eatmp/ardep-arda/servlets/SVLT014?Proj=CEC096	This report
ATC-WAKE	Integrated Air Traffic Control wake vortex safety and capacity system	5th RTD Framework Programme (FP 5)	http://www.nlr.nl/?id=502	This report

CRAHVI	Crashworthiness of aircraft for high velocity impact	5th RTD Framework Programme (FP 5)	www.crahvi.net	This report
ESSAI	Enhanced safety through situation awareness integration in training	5th RTD Framework Programme (FP 5)	N/A	Extr@web report
FAR-Wake	Fundamental Research on Aircraft Wake Phenomena	6th RTD Framework Programme (FP 6)	www.far-wake.org	This report
GIFT	GNSS - Inertial future landing techniques	5th RTD Framework Programme (FP 5)	N/A	This report
HASTAC	High Stability Altimeter System for Air Data Computers	6th RTD Framework Programme (FP 6)	www.sintef.no/Projectweb/HASTAC/	This report
ROBAIR	Development of a robotic system for the inspection of aircraft wings and fuselage	5th RTD Framework Programme (FP 5)	N/A	This report
VERRES	VLTA Emergency Requirements Research Evacuation Study	5th RTD Framework Programme (FP 5)	http://fseg.gre.ac.uk/fire/VERRES_Project.html	This report
WAKENET2-EUROPE	A European thematic network for aircraft wake turbulence	5th RTD Framework Programme (FP 5)	www.mip.onera.fr/projets/WakeNet2-Europe/contacts.htm	This report

Sub-theme 3: Airport capacity and operation				
Project acronym	Project title	Programme	Project website	Coverage
A-CDM	Airport Collaborative Decision Making	International	www.euro-cdm.org	This report
ACE	Airport Airside Capacity Enhancement	European (Other)	www.eurocontrol.int/airports/public/standard_page/ace.html	This report
ADAMANT	Airport Decision And MANagement NeTwork	5th RTD Framework Programme (FP 5)	http://adamant.elec.qmul.ac.uk/	This report
AIRNET	Airport Network for Mobiles, Surveillance and Alerting	6th RTD Framework Programme (FP 6)	www.airnet-project.com	
EMMA	European airport Movement Management by A-SMGCS	6th RTD Framework Programme (FP 6)	N/A	This report
EMMA2	European airport Movement Management by A-SMGCS, Part 2	6th RTD Framework Programme (FP 6)	N/A	This report
INTERVUSE	Integrated Radar, Flight Plan and Digital Video Data Fusion for SMGCS	5th RTD Framework Programme (FP 5)	www.iti.gr/intervuse	This report

ISMAEL	Intelligent Surveillance and Management Functions for Airfield Applications Based on Low Cost Magnetic Field Detectors	6th RTD Framework Programme (FP 6)	N/A	This report
SAFE-AIRPORT	Development of an Innovative Acoustic System for the Improvement of Co-operative Air Traffic Management	6th RTD Framework Programme (FP 6)	http://xoomer.virgilio.it/safe-airport/	This report
SPADE	Supporting platform for airport decision-making and efficiency analysis	6th RTD Framework Programme (FP 6)	http://spade.nlr.nl/	This report
THENA	THEmatic Network on Airport Activities	5th RTD Framework Programme (FP 5)	http://thena.aena.es/	This report

Sub-theme 4: Air traffic control/management				
Project acronym	Project title	Programme	Project website	Coverage
AD4	4D Virtual Airspace Management System	6th RTD Framework Programme (FP 6)	www.ad4-project.com	This report

AFAS	Aircraft in the future Air Traffic Management System	5th RTD Framework Programme (FP 5)	N/A	This report
ASPASIA	Aeronautical Surveillance & Planning by Advanced Satellite-Implemented Applications	6th RTD Framework Programme (FP 6)	www.aspasia.aero/	This report
ATENAA	Advanced Technologies for Networking in Avionic Applications	6th RTD Framework Programme (FP 6)	www.atenaa.org/	This report
C-ATM Phase 1	Co-operative Air Traffic Management Phase 1	6th RTD Framework Programme (FP 6)	N/A	This report
CAATS	Cooperative Approach to Air Traffic Services	6th RTD Framework Programme (FP 6)	www.caats.isdefe.es/	This report
EYE IN THE SKY	New Services for (i) Fleet management and Customised Mobility Information plus (ii) Emergency Support for Crises during large-scale events, based on the use of low-altitude platforms and floating car data	5th RTD Framework Programme (FP 5)	N/A	Extr@web report
MA-AFAS	The more autonomous - aircraft in the future Air Traffic Management system	5th RTD Framework Programme (FP 5)	N/A	This report

MFF	CNS/ATM Integrated Programme "Mediterranean Free Flight"	European (Other)	www.eurocontrol.int/eec/public/standard_page/proj_MFF.html	This report
NUP2	North European ADS-B Network Update Programme Phase 2	European (Other)	www.nup.nu	This report
ONESKY	One Non-National European Sky	5th RTD Framework Programme (FP 5)	http://www.nlr.nl/?lang=en	Extr@web report
POLARIS	Detailed Service Analysis (Galileo). Subtask 2: User Tools	5th RTD Framework Programme (FP 5)	N/A	This report
SAGA	Standardisation Activity for Galileo	5th RTD Framework Programme (FP 5)	N/A	This report

Sub-theme 5: Efficient, quiet and environmentally friendly engines				
Project acronym	Project title	Programme	Project website	Coverage
ADCOMB	Advanced 3D compressor blade design	5th RTD Framework Programme (FP 5)	N/A	This report

AEROHEX	Advanced exhaust gas recuperator technology for aero-engine applications	5th RTD Framework Programme (FP 5)	N/A	This report
AEROTEST	Remote Sensing Technique for Aeroengine Emission Certification and Monitoring	6th RTD Framework Programme (FP 6)	N/A	This report
AIDA	Aggressive Intermediate Duct Aerodynamics for Competitive and Environmentally Friendly Jet Engines	6th RTD Framework Programme (FP 6)	N/A	This report
ATOS	Advanced transmission and oil system concepts	5th RTD Framework Programme (FP 5)	N/A	This report
COJEN	Computation of Coaxial Jet Noise	6th RTD Framework Programme (FP 6)	N/A	This report
ICAS-GT2	Fluid flow and heat transfer within the rotating internal cooling air systems of gas turbines (2)	5th RTD Framework Programme (FP 5)	N/A	This report
MENELAS	Minority effluent measurements of aircraft engine emissions by infrared laser spectroscopy	5th RTD Framework Programme (FP 5)	N/A	This report

SIA-TEAM	Soot in aeronautics - towards enhanced aeroengine combustor modelling	5th RTD Framework Programme (FP 5)	N/A	This report
TBC PLUS	New increased temperature capability thermal barrier coatings	5th RTD Framework Programme (FP 5)	N/A	This report
UTAT	Unsteady transitional flows in axial turbomachines	5th RTD Framework Programme (FP 5)	N/A	This report

Sub-theme 6: Human element – convenience and safety				
Project acronym	Project title	Programme	Project website	Coverage
212034: Extending CabinAir	Extending CabinAir measurements to include older aircraft types utilised in high volume short haul operation	National (United Kingdom)	http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/aviation/hci/hacc/bre/finalreport	Extr@web report
Air Travel & Venous Thromboembolism	Air Travel & Venous Thromboembolism	National (United Kingdom)	N/A	This report
ANAIS	Advanced Network Architecture for In-flight Cabin Systems	5th RTD Framework Programme (FP 5)	N/A	This report
AROSATEC	Automated Repair and Overhaul System for Aero Turbine Engine Components	6th RTD Framework Programme (FP 6)	http://www.arosatec.com/	This report
ASL	Aircraft service logistics	5th RTD Framework Programme (FP 5)	N/A	This report
DESCARTES	Decision support for integrated aircraft and crew recovery on the day of operations	5th RTD Framework Programme (FP 5)	N/A	This report

Sub-theme 6: Human element – convenience and safety				
Project acronym	Project title	Programme	Project website	Coverage
GOING-SAFE	Addressing technical and human factors involved in the implementation of 3-point shoulder harnesses, on all seats, in passenger aircraft	5th RTD Framework Programme (FP 5)	http://www.aeroseatingsafe.com/	Extr@web report
HELINOVI	Helicopter Noise and Vibration Reduction	5th RTD Framework Programme (FP 5)	N/A	This report
ICE	Ideal Cabin Environment	6th RTD Framework Programme (FP 6)	http://www.ice-project.eu	This report
IMAGE	Interoperable management of aeronautical generic executive software	5th RTD Framework Programme (FP 5)	http://www.aero-scratch.net/image.html	This report
MONSTER	Monitoring noise at European airports	5th RTD Framework Programme (FP 5)	http://www.monsterproject.net	This report
SILENCE(R)	Significantly lower community exposure to aircraft noise	5th RTD Framework Programme (FP 5)	N/A	This report
SOURDINE II	Study of Optimisation Procedures for Decreasing the Impact of Noise around Airports II	5th RTD Framework Programme (FP 5)	http://www.sourdine.org	This report

Sub-theme 6: Human element – convenience and safety				
Project acronym	Project title	Programme	Project website	Coverage
TALIS	Total Information Sharing for Pilot Situational Awareness Enhanced by Intelligent Systems	5th RTD Framework Programme (FP 5)	http://talis.eurocontrol.fr/	Extr@web report
VINTHEC II	Visual interaction and human effectiveness in the cockpit, Part II	5th RTD Framework Programme (FP 5)	http://www.vinthec.net/	Extr@web report

Sub-theme 7: Policy, Research and Business process improvement				
Project acronym	Project title	Programme	Project website	Coverage
AEROSME IV	Support for Aeronautical SMEs, Phase IV	5th RTD Framework Programme (FP 5)	http://www.aerosme.com	This report
AIRFORCE	AIR FOReCast in Europe	5th RTD Framework Programme (FP 5)	N/A	This report
APRON	Aviation Policy Information Resources based on Observatory Networks	5th RTD Framework Programme (FP 5)	N/A	This report
ASTERA 2	Aeronautical Stakeholders Tools for the European Research Agenda 2	6th RTD Framework Programme (FP 6)	N/A	This report

Sub-theme 7: Policy, Research and Business process improvement				
Project acronym	Project title	Programme	Project website	Coverage
CONSAVE 2050	Constrained Scenarios on Aviation and Emissions	5th RTD Framework Programme (FP 5)	www.dlr.de/consave/index.html	Extr@web report
D8 (NRP 41)	Deregulation of air traffic	National (Switzerland)	http://www.nfp41.ch/	Extr@web report
ECARE+	European Communities aeronautics research +	6th RTD Framework Programme (FP 6)	http://www.ecare-sme.org	This report
VIVACE	Value Improvement through a Virtual Aeronautical Collaborative Enterprise	6th RTD Framework Programme (FP 6)	http://www.vivaceproject.com	This report