How European research contributes to aviation safety

Fred Abbink

FUTURE SKY SAFETY

Brussels, March 9, 2017

Content

1. Start of EU Aeronautics Research
2. Vision 2020, ACARE and SRAs
3. Safety related projects in the EU Framework Programmes
4. Clean Sky and SESAR
5. ACARE Beyond Vision 2020 and Flight Path 2050
6. Conclusions

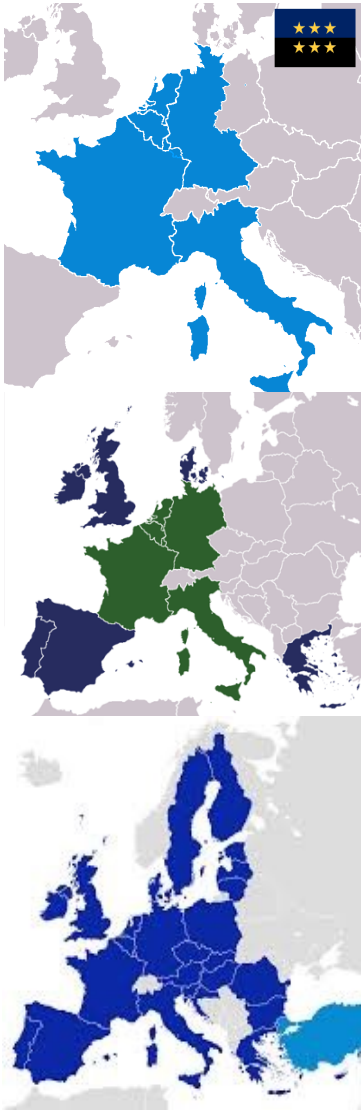
Growth of the European Union

Milestones and enlargement of EU

- 1951 Treaty of Paris (European Coal and Steel Community ECSC)
- 1957 Treaty of Rome (EEC, ECSG, Euratom) (6 members)
- 1986 Single European Act (12 members)
- 1992 Maastricht Treaty (EC, CSFP, PJCC, JHA)
- 2007 Lisbon Treaty (EU)
- 2013 Growth to 28 members
- 2017 Brexit

European achievements

- Single European Market
- Single Outer Border (Schengen)
- Single Currency (Euro)
- European Aviation Safety Agency (EASA)
- European Defence Agency (EDA)
- ESA, ArianeSpace
- Copernicus and Galileo
- Single European Sky (SES)
- European Framework Programmes
- JUs CleanSky and SESAR



1967 Airbus
"Toulouse or not To Lose"

- **1960s** French and UK 200 seater airliner plans:
  - Sud Aviation: Galion,
  - BAC: BAC 2-11,
  - HSA/Breguet/Nord Aviation: HBN 100

- **July 1967** France, Britain and Germany ministers agreed to take appropriate measures for the joint development and production of an "**airbus.**" (FR 37.5 %, UK 37.5%, GE 25%). Rogier Béteille became technical director of A300 Programme.

- **Dec 1968** Britain announced to pull out. (Brexit 1?).
  GE proposed to step up to 50% if FR did the same. HSA needed £35 million for tools to design and build the wings.
  GE provided the loan.

- **May 1969 Paris Airshow** A300 born as partnership (GIE) of Sud Aviation, HSA and Deutsche Airbus.

Airbus (New technology and "Economy of Scale")

1972: A300

- 561 produced

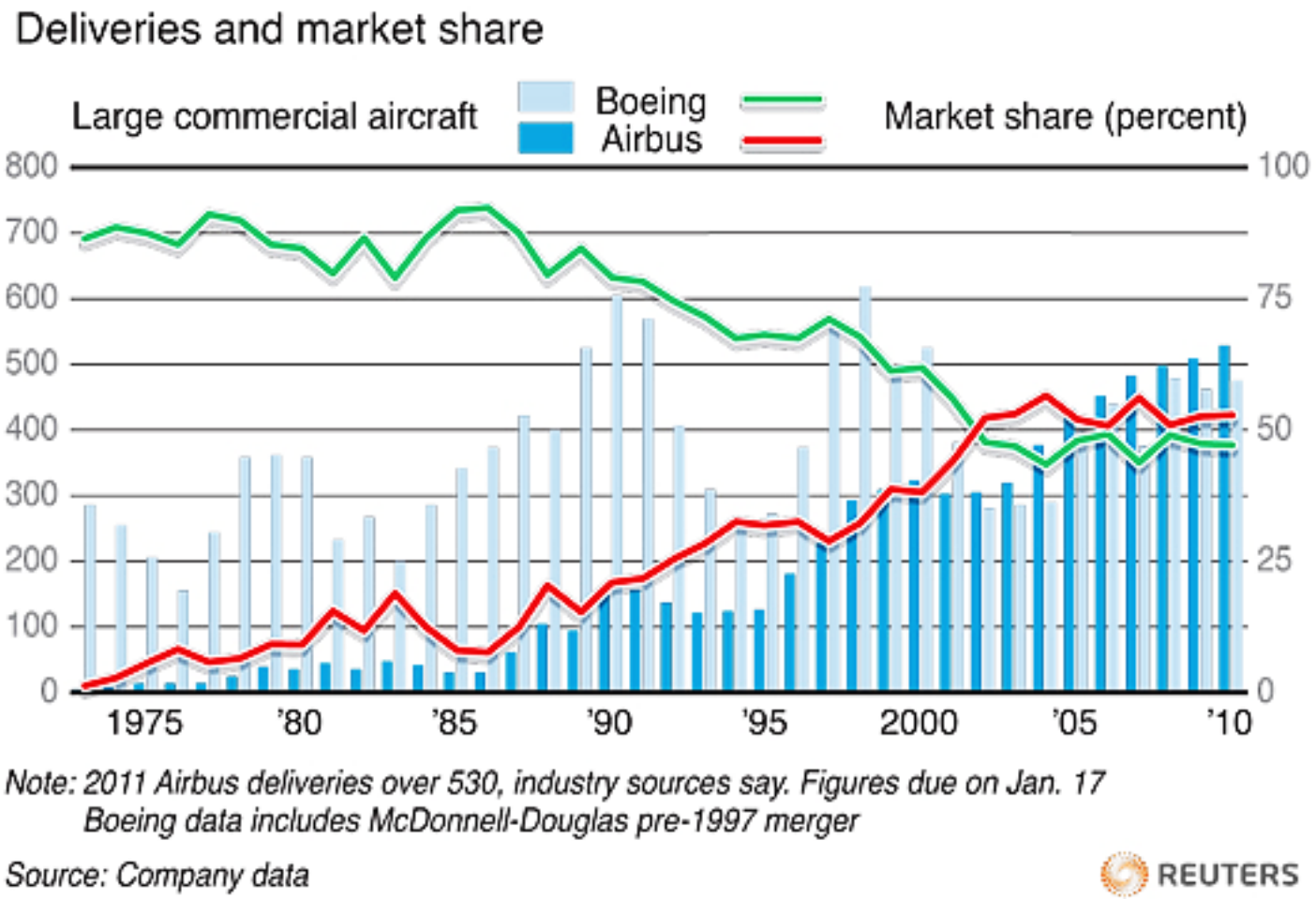
1982: A310

- 255 produced

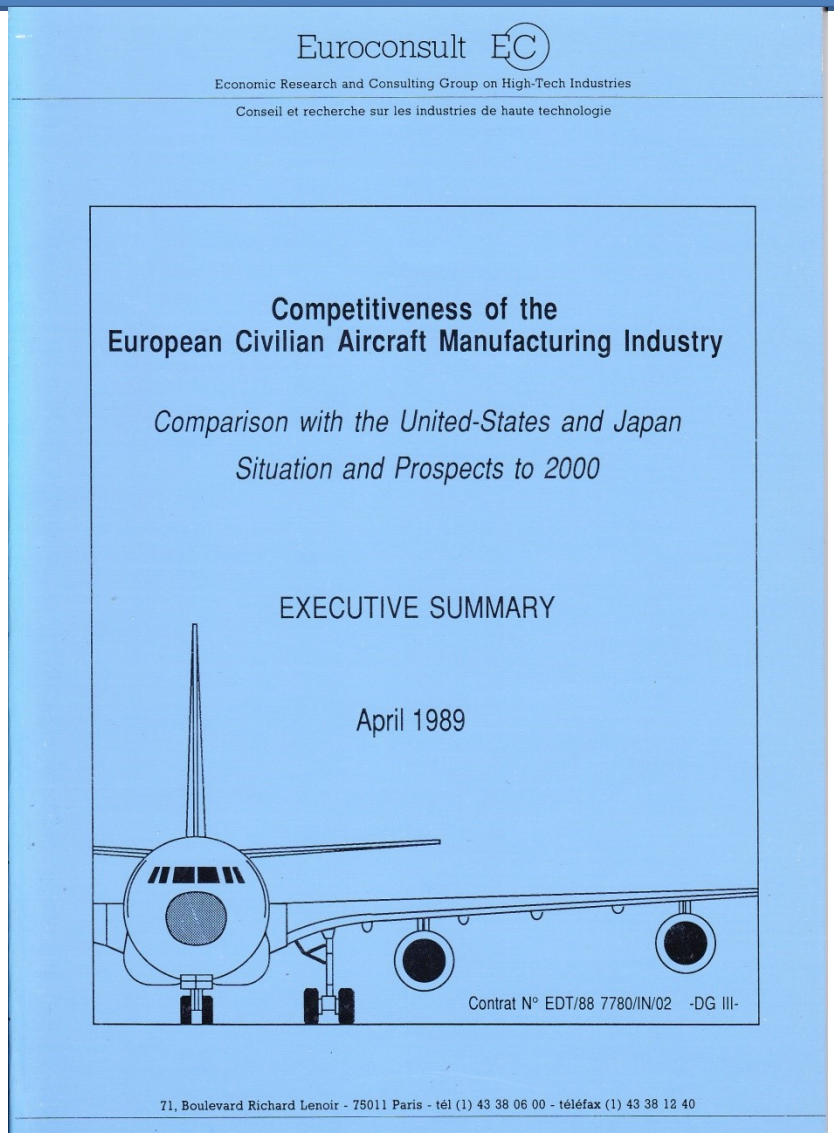
1987: A320

- 7.421 produced

1973-2010 Airbus Market Share Development

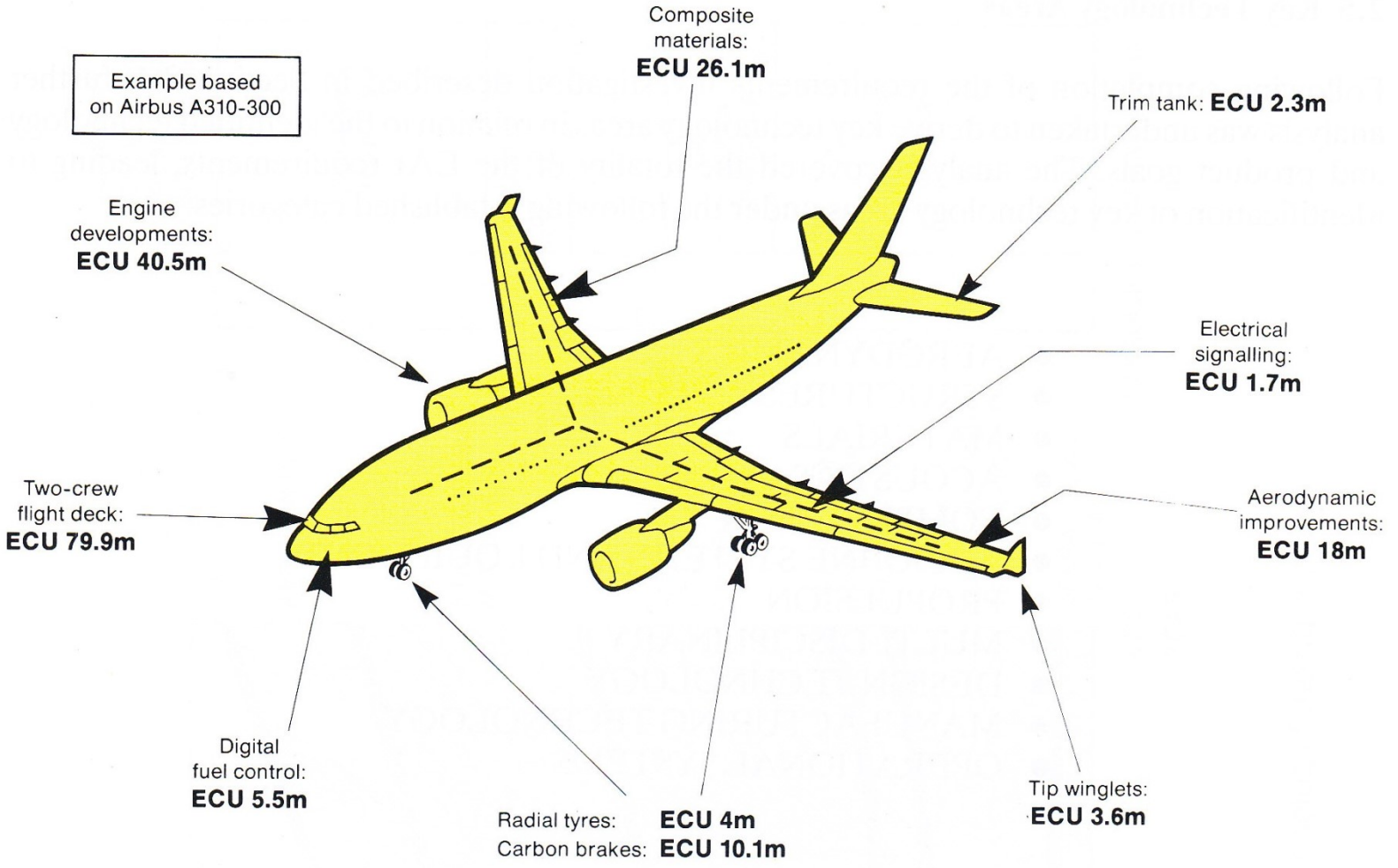


1987 EUROMART and Euroconsult Studies



Euromart Benefit Study of Cumulative Technology Benefit

(192 million ECU on 10 A310-300s for 15 years)



1989 EU FWP 2: BRITE & EURAM - AREA 5

1990 BRITE & EURAM- EREA 5 Evaluation

Commission of the European Communities

EVALUATION OF SPECIFIC ACTIVITIES
RELATING TO AERONAUTICS

(BRITE/EURAM - AREA 5 - 1989/90)

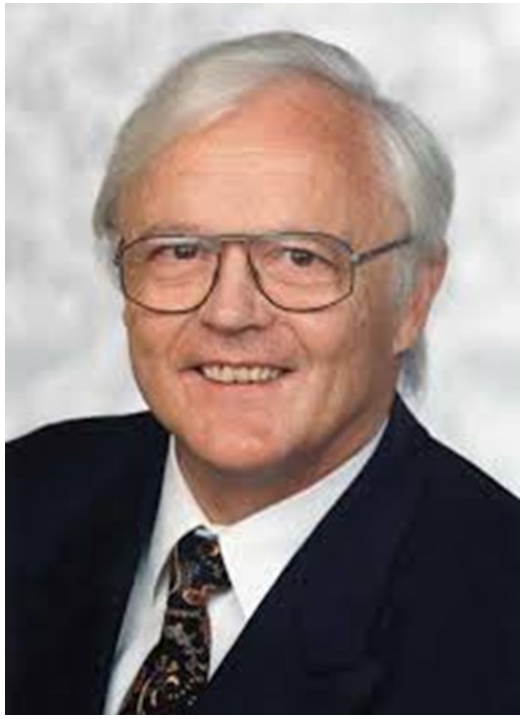
- Interim Report -

Research Evaluation - Report N° 43

EUR 13000

TABLE 1.	LEAD CONTRACT.	N° OF PARTNERS	TOTAL COST ECU	CEC FUNDING K ECU
AERODYNAMICS				
-Investig. of Supersonic Flow Phenom.	AERITALIA	14	2.565	1.522
-Investig. of Laminar Flow Technology	MBB	24	9.539	5.074
-Helicopter Rotor/Fuselage Interactional Aerodyn.	AGUSTA	14	2.447	1.423
-Multi-Block Mesh Generation for CFD	BAE	14	3.335	1.814
-Validation of CFD-Codes	DORNIER	16	3.146	1.693
-Optimum Design in Aerodynamics	AMD-BA	9	1.638	981
-Upwind Schemes for Navier-Stockes Solvers	VKI	5	621	413
-CFD Design Methods for Rotorcraft Blades	MBB	12	2.007	1.057
-Contrib. to Europ. Aeron. Super-computing Network	ONERA	8	800	400
ACOUSTICS				
-Active Noise Control in Aircraft (ASANCA)	DORNIER	22	3.601	1.745
-Rotorcraft Exterior Noise Research	MBB	10	3.074	1.695
-Acoustic Fatigue and Related Damage Tolerance	AMD-BA	14	2.937	1.459
AIRBORNE SYSTEMS AND EQUIPMENT				
-Future Technologies Impact on Cockpit (FANSTIC)	AEROSPA-TIALE	14	3.698	1.904
-Optical Data Transmission	MBB	13	2.620	1.330
-New Optical Sensor Concept for Aeron. (NOSCA)	THOMSON-CSF	5	1.161	587
-Helicopter Health and Usage Moni-toring Research	WESTLAND	6	1.667	834
-Integr. Modular Avionics Software (IMAGES)	AEROSPA-TIALE	16	2.719	1.439
-All-Electric Aircraft Flight Control Actuation	CASA	19	2.273	1.101
-Civil Aircraft Protect. against Ice (CAPRI)	BAE	13	1.664	953
PROPULSION SYSTEMS				
-Ducted Propfan.Investigations (DUPRIN)	MBB	17	2.135	1.163
-Airframe/Propulsions Integr. (GEMINI)	AEROSPA-TIALE	15	2.153	1.044
-Rotor/Wing Interaction (PROPWING)	TU ATHENS	4	300	300
-Transition in Turbomachinery Flows	UNIV. OF THESSAL	3	445	445
-Tip Clearance Effects in Axial Compressors	SNECMA	5	1.424	880
-Transonic Turbine Wake Mixing Process	VKI	6	606	329
-Bearing with Minimum Lubrication	TURBOMECA	10	1.307	778
-Low-Emission Combustor Technology	MTU MUENCHEN	14	3.687	1.597
-Thin-Film Sensors for Aero-engines	MTU MUENCHEN	6	1.606	797
TOTAL			65.181	34.760

1994 European Research Establishments



EREA

Association of European Research Establishments in Aeronautics

- 11 Research Establishments
- 5000 researchers
- 0.5 Billion Euro /yr. research projects
- 175 MSc/PhD thesis/yr.
- 6000 Publications/yr.
- 10 Billion Euro worth of facilities

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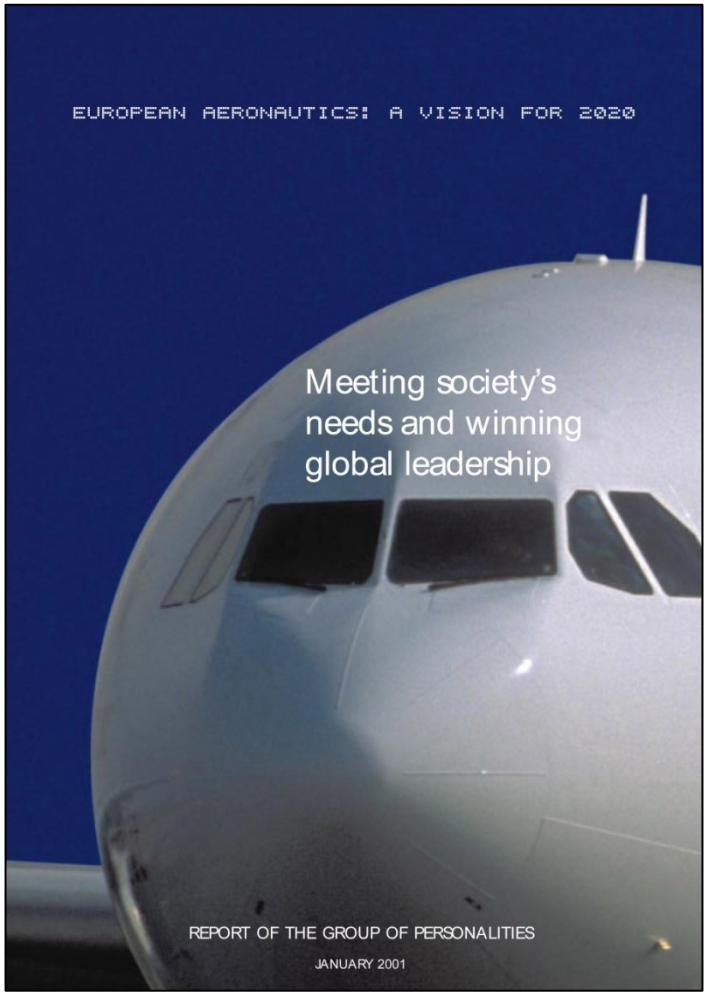
2000-01 Aeronautics for Europe & Vision 2020



2001 Advisory Council for Aeronautics research in Europe (ACARE)

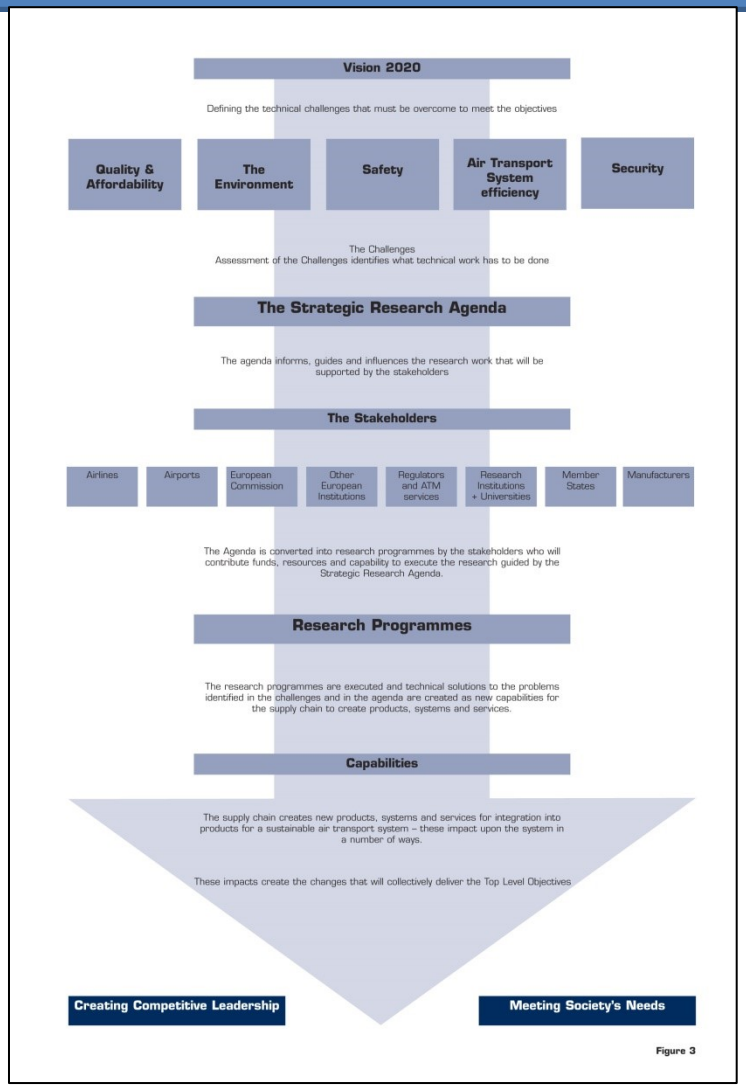
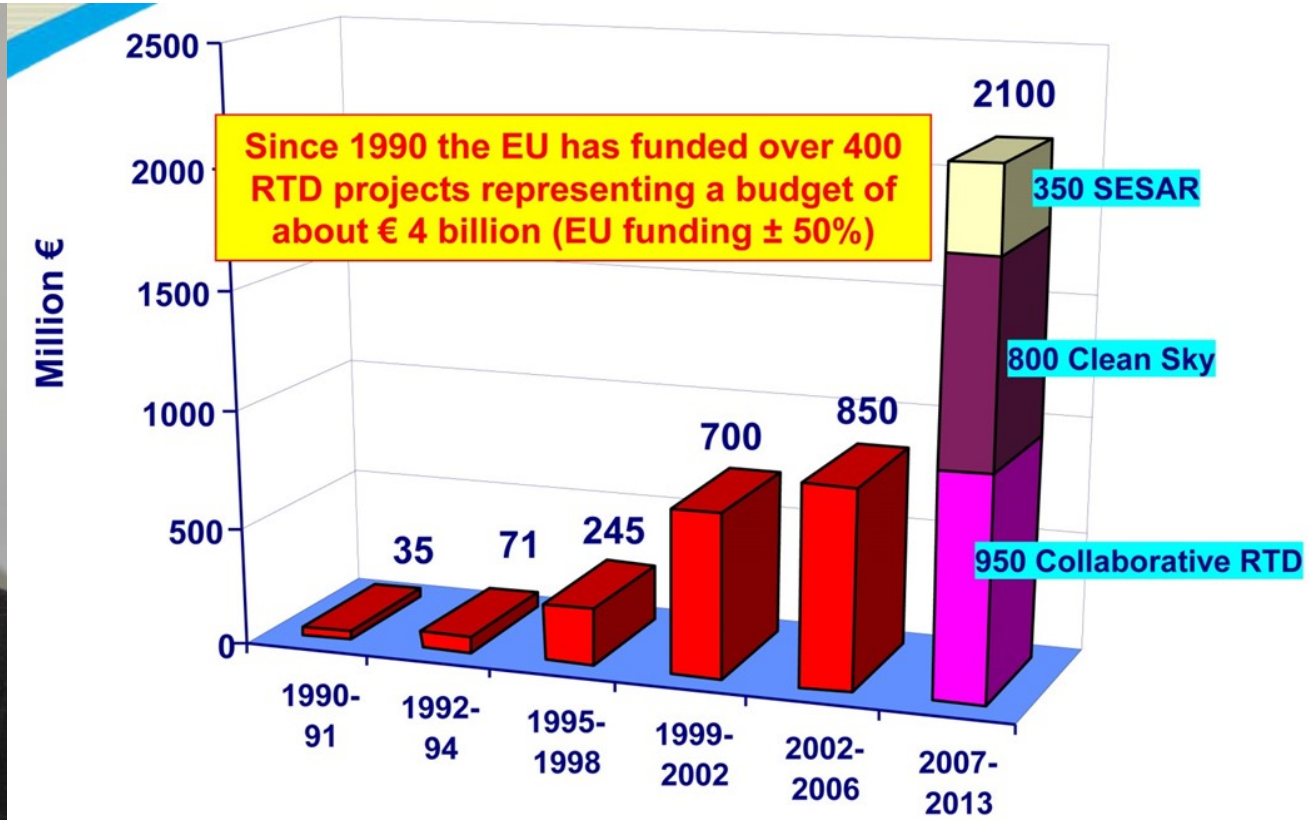


Figure 3

EU Aeronautics RDT Budgets and Projects



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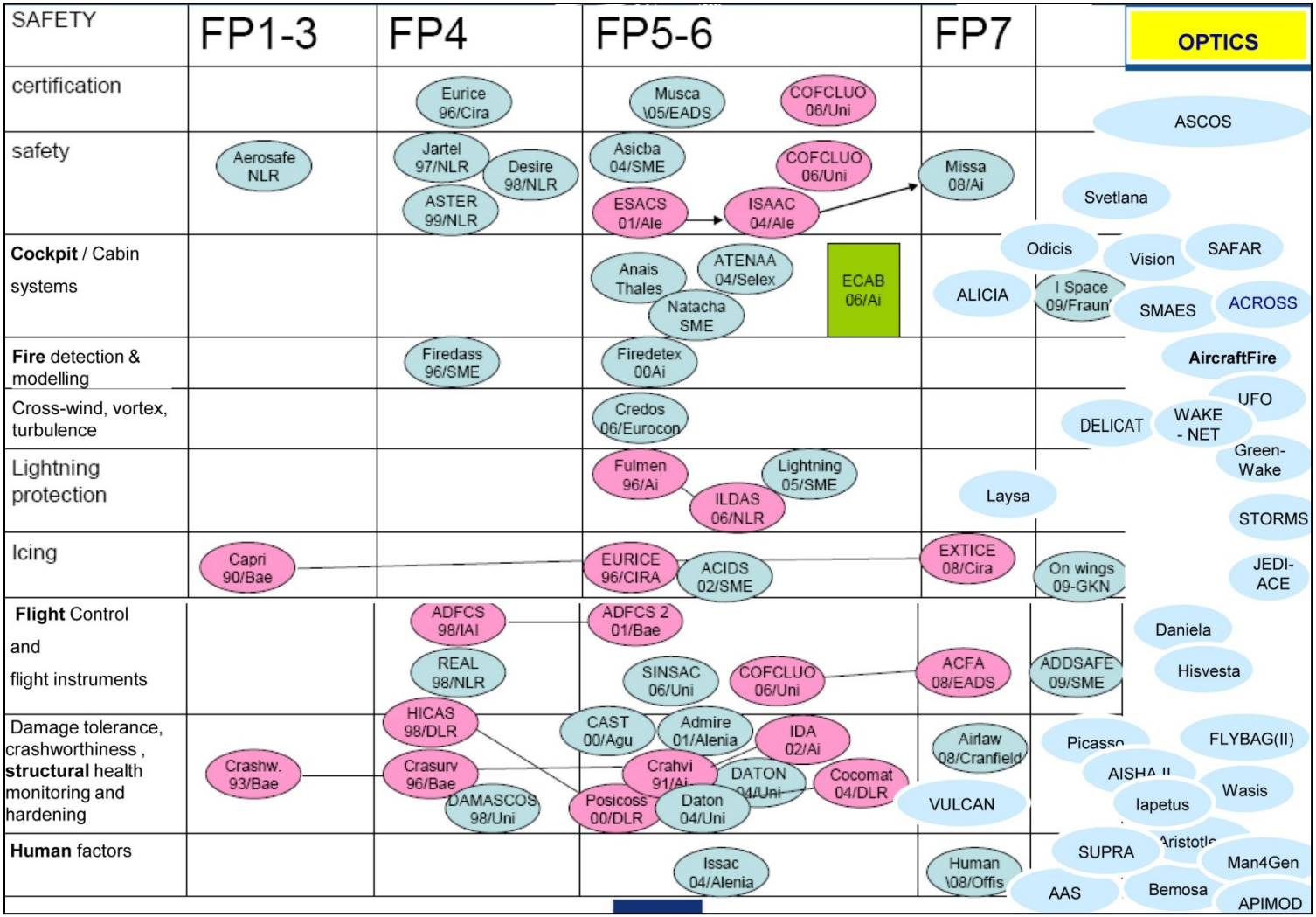
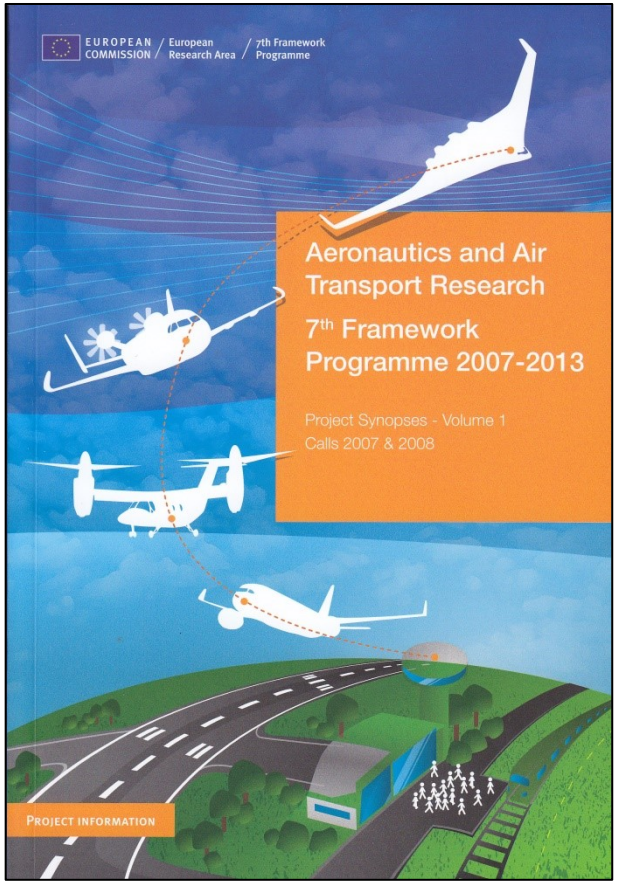
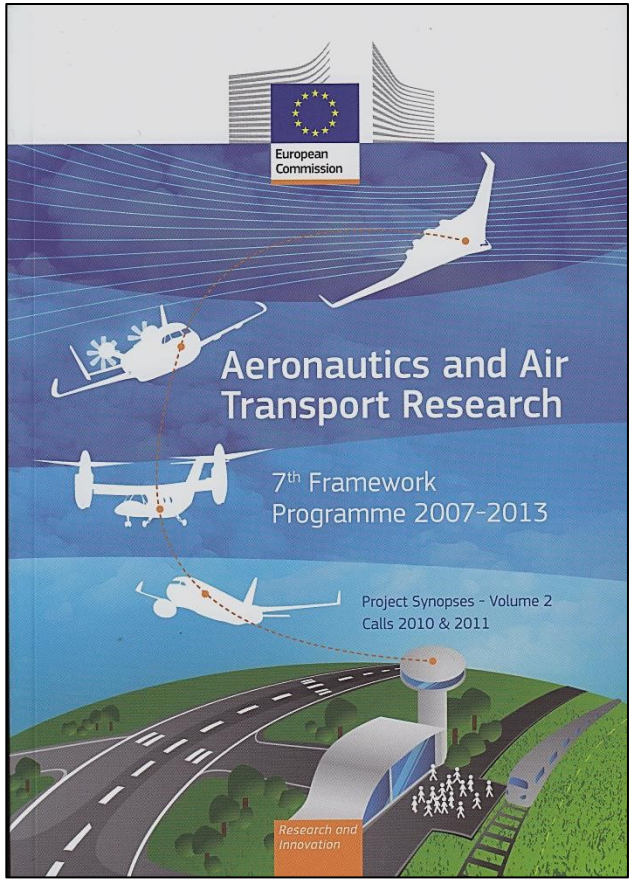
Safety related Projects in FWP 2-7



Ref. Knoerzer Aerodays 2015

Aeronautics and Air Transport Research
7th Framework Programme 2007-2013





Aeronautics and Air Transport Research FWP 7 2007-2013 Calls 2007 & 2008: Safety

- AAS Integrated Airport Apron Safety Fleet Management
- MISSA More Integrated System Safety Design
- ACFA 2020 Active Control of Flexible 2020 Aircraft
- GREEN-WAKE Demonstration of LIDAR-Based wake vortex detection
- WakeNet3-Europe European Coordination Action
- DELICAT Demonstrator of Lidar-Based Clear Air Turbulence Detection
- ALICIA All Condition Operations and Innovative Cockpit Infrastructure
- ADDSAFE Advanced Fault Diagnosis for Safer Flight Guidance and Control
- HISVESTA High Stability Vertical Separation Altimeter Instruments
- HUMAN Model-based Analysis of Human Error during A/C cockpit design
- ODICIS One Display for Cockpit Interactive Solution
- SUPRA Simulation of Upset Recovery in Aviation
- AISHA II Aircraft Integrated Structural Health Assessment II
- ALEF Aerodynamic Load Estimation at Extremes of the Flight Envelope
- EXTICE Extreme Icing Environment
- ON-WINGS ON-Wing Ice Detection and Monitoring System
- HIRF SE HIRF Synthetic Environment research Programme

Aeronautics and Air Transport Research FWP 7 2007-2013 Calls 2010 & 2011: Safety

- AIRCRAFTFIRE Fire-risk Assessment and Increase of Passenger Survivability
- ARISTOTEL Aircraft and Rotorcraft Pilot Couplings. T&T Alleviation and detection
- SVETLANA Safety improvement through Automated Flight Data Analysis
- MASCA Managing System Change in Aviation
- SARISTU Smart Intelligent Aircraft Structures
- GABRIEL Integr. Ground and onboard System for support of A/C Safe T/O and landing
- EDUCAIR Assessing the educational gaps in Aeronautics and Air Transport
- WEZARD Weather Hazards for Aeronautics
- ELECTRICAL Novel Aeronautical Multifunctional Composite Structures with bulk Electrical Conductivity and Self-sensing Capabilities
- AEROPLAN Composites Repairs and Monitoring and Validation
- WASIS Composite Fuselage Section Wafer-design Approach for increasing safety in Worst-case Situations and Minimising Joints
- 4DCO-GC 4-Dimensional Contracts-Guidance and Control

Aeronautics and Air Transport Research FWP 7 2007-2013 Calls 2012 & 2013: Safety

- ACROSS Advanced Cockpit for Reduction of Stress and Workload
- A-PIMOD Applying Pilot Models for Safer Aircraft
- MAN4GEN Manual operation of 4th generation airliners
- IARECONFIGURE Reconfiguration of Control in Flight for integral global Upset Recovery
- SS Improving Aircraft Safety with Self-Healing structures
- HAIC High Altitude Air Crystals
- JEDI-ACE Japanese-European De-Icing Aircraft Collaborative Exploration
- PROSPERO Proactive Safety Performance for Operations
- RESEARCH Reliability and Safety-Enhanced Electrical Actuation System Architectures
- SAFUEL The Safer Fuel System
- UFO Ultrafast wind sensors for Wake hazards mitigation
- REPAIR Future Repair and Maintenance for the Aerospace Industry
- STORM Efficient Ice protection systems and Simulation techniques of Ice release on propulsive systems
- VIBRATION Global in-flight heath monitoring Platform for composite structures
- FLY-BAG2 Advanced technologies for Bomb-Proof Cargo containers
- ASCOS Aviation Safety and Certification of new Operations and Systems
- RESILIENCE2050.EU New Design Principles fostering Safety, Agility and Resilience ATM

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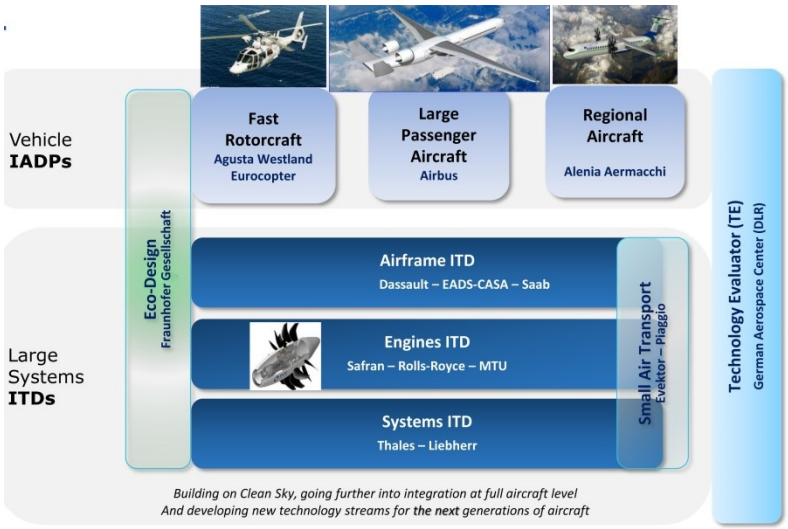
2007-2016 Clean Sky and 2014-2024 Clean Sky 2

- CS: EU Contribution: 800 Meuro
- Targets:
  - 50% reduction in CO2 emissions
  - 80% reduction in NOx emissions
  - 50% External noise reduction
  - Improved environmental impact of A/C Life Cycle



- CS2: EU Contribution 1.755 Meuro
- Targets:
  - 75% reduction in CO2 emissions
  - 90% reduction of NOx emissions
  - 65% External noise reduction
  - Enhanced competitiveness

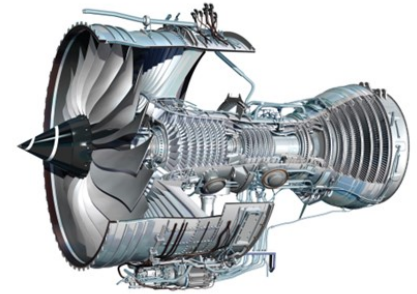
Clean Sky towards Flying Demonsstrators

Clean Sky Large Demonstrators

Counter Rotating Open Rotor (CROR)

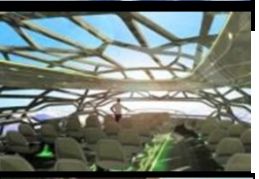
Breakthrough Laminar Aircraft Demonstrator Europe (BLADE)

Diesel Helicopter Engine



Large 3-shaft Advanced Low Pressure

Clean Sky 2 Large Demonstrators




Large Passenger Aircraft:

- Platform 1. Advanced Engine and Aircraft Configurations
- Platform 2. Innovative Physical Integration Cabin-System Structure
- Platform 3. Next Generation Electrical Aircraft, A/C Systems, Cockpits and Avionics

Regional Aircraft

Fast Rotorcraft

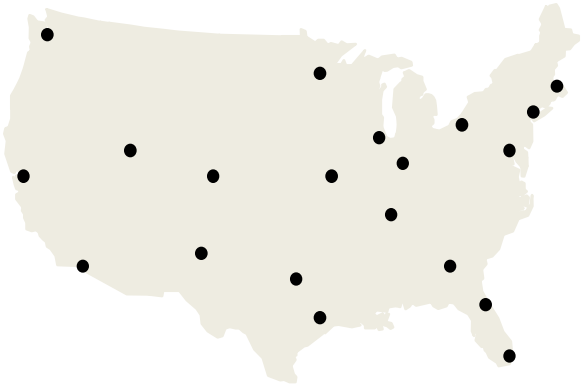
- Tilt Rotor
- Compound

Very/Ultra High Bypass Ratio Architectures

European Single European Sky: Comparison USA and Europe

USA

ATM airspace: 9,8 mio. km²



1 ATC-organisations (civil + mil.)
21 en-route centres
1 operating systems

900 movements per controller

$380 ATM cost / flight

Europe

ATM airspace: 10,5 mio. km²

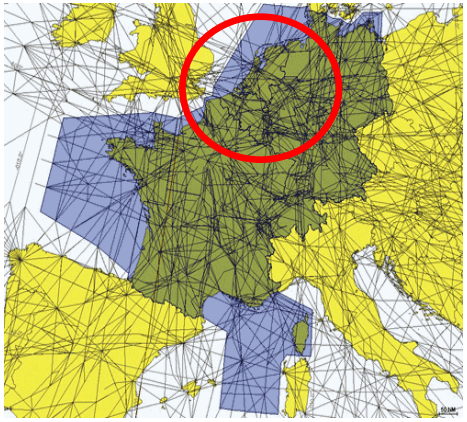
47 ATC-organisations (civil + mil.)
58 en-route centres
22 operating systems

480 movements per controller

$667 ATM cost / flight

FABEC

FABEC Airspace: 1,7 mio. sq km



Belgium, France, Germany, The Netherlands and Switzerland

Integration of 6 large international hubs

FABEC will be operational in 2012!

Study: EUROCONTROL 2003

2007-2014 SESAR and 2015-2024 SESAR 2020

EU Contribution for SESAR 1: 2100 MEuro, for SESAR 2020: 1600 MEuro

SESAR Targets

- **Safety: Factor 10**
- **Capacity: handle 3 times the traffic**
- **Environment: - 10% effects per flight**
- **Costs to airspace users: - 50%**

- **Also address: Security, Flexibility, Predictability, Global interoperability, Access, Equity, Participation**

SESAR 2020 Budget Structure

85 million

Exploratory Research

- Air Vehicle Operations & Technology
- ATM Operations & technology
- Airport Operations & Technology
- System Architecture
- ICT for Information Mgmt., Uncertainty & Optimisation
- Safety
- Security
- Role of the Human in Automation and Ops. Change
- Environment & Weather for Aviation
- Enabling Change: Economics, Legal, Policy & Regulation

1,2 Billion

Applied Research, Pre-Industrial Development, Validation

AIRPORT: Airport Terminal, Surface & Tower Systems	ATM: Airspace, Traffic Management & Systems	AIRCRAFT: Air Vehicle Operations, Mission Management & Integration	INFRASTRUCTURE: ICNS, Training & Simulation Systems

- Priority Business Needs – ATM Key Features & Enablers
- Operations, Technical Interoperability & Performance
- Remotely Piloted Air Systems (RPAS) Integration
- System(s) Architecture
- Safety & Security Management
- Societal Challenges
- Regulation & Standardisation Planning
- European ATM Master Plan Maintenance
- Preparation for Deployment

300 million

Large Scale Demonstrations

- Airspace Users
- Air Navigation Service Providers
- Supply Industries
- Airports
- National Authorities
- Staff Associations
- ESA

SESAR Demonstrators

Remote Tower

System Wide Information Management (SWIM)

Remotely Piloted Aerial Systems (RPAS)

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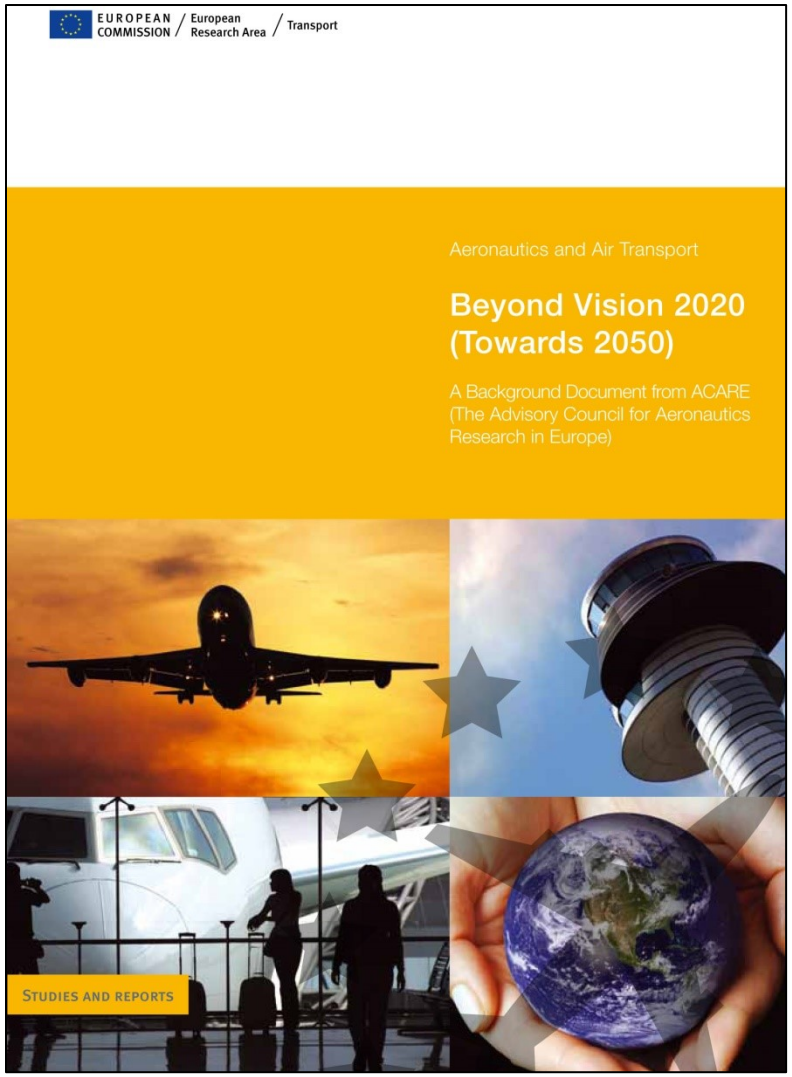
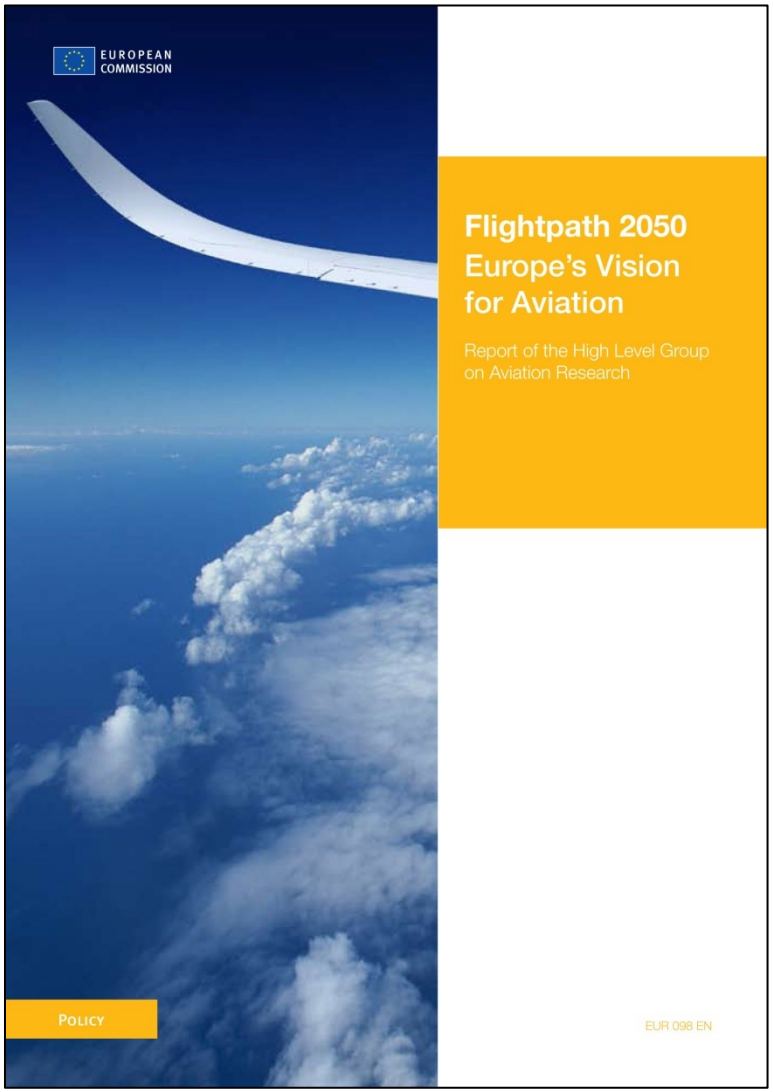
ACARE Beyond Vision 2020 and Flightpath 2050





FlightPath 2050 High-Level Goals

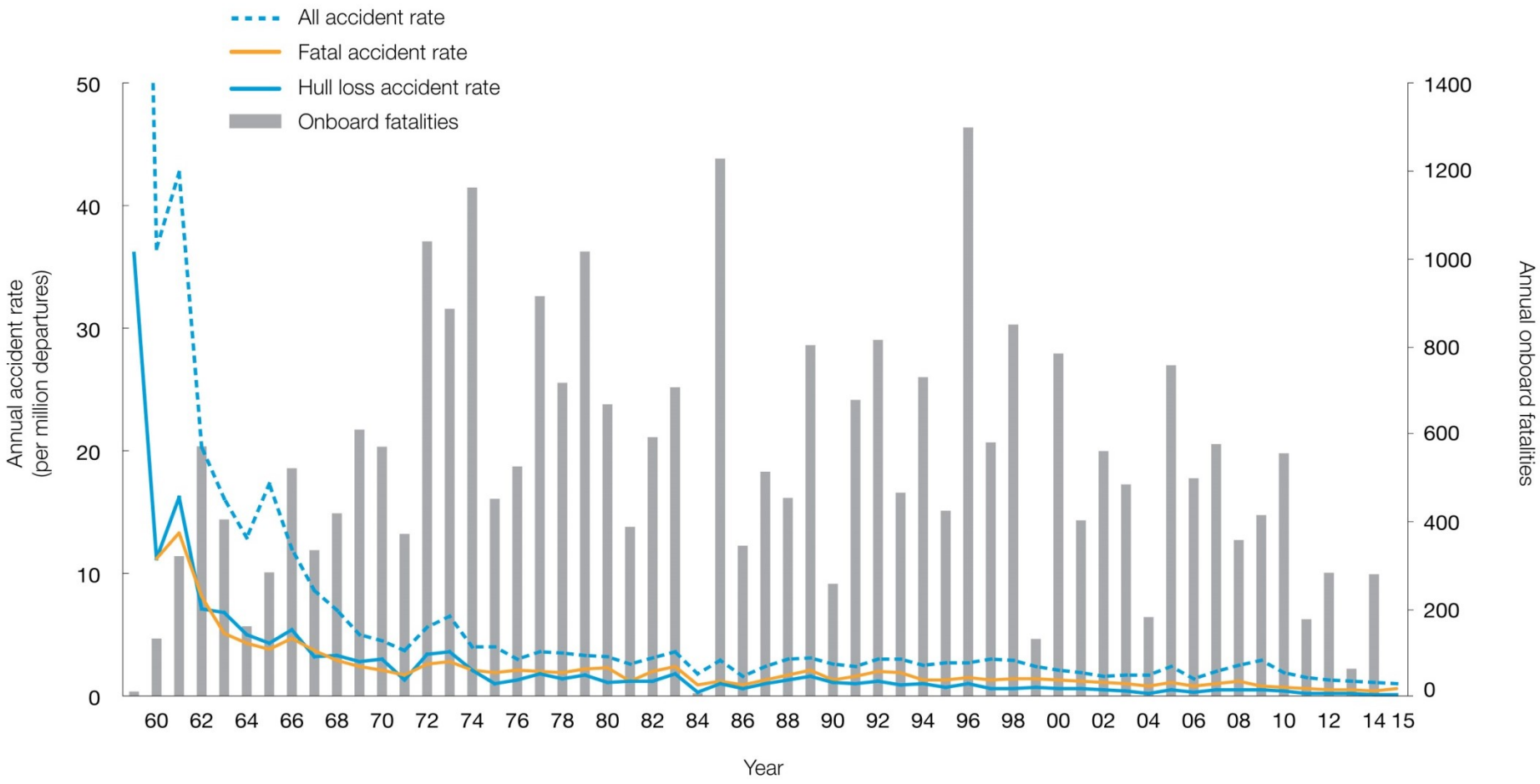
Maintaining Global Leadership

- Providing the best products and associated services in aeronautics and air transport
- Ensuring the competitiveness of European Industry, supported by a strong research network and balanced regulatory framework in the face of fierce competition from established and emerging rivals
- Maximising the aviation's economic contribution and creating value
- Attracting the best people and talents

Serving Society's Needs

- Meeting societal and Market Needs for affordable, sustainable, reliable and seamless connectivity for passengers and freight with sufficient capacity
- Supporting the integration and cohesion of the European Union, its neighbours and partners
- Addressing societal needs with non-transport aerial applications enabled by new flight control technologies
- Protecting the environment and enabling the use of sustainable energy sources
- Ensuring complete and non-intrusive security
- **Ensuring safety**
- Providing opportunities for highly qualified and skilled jobs in Europe

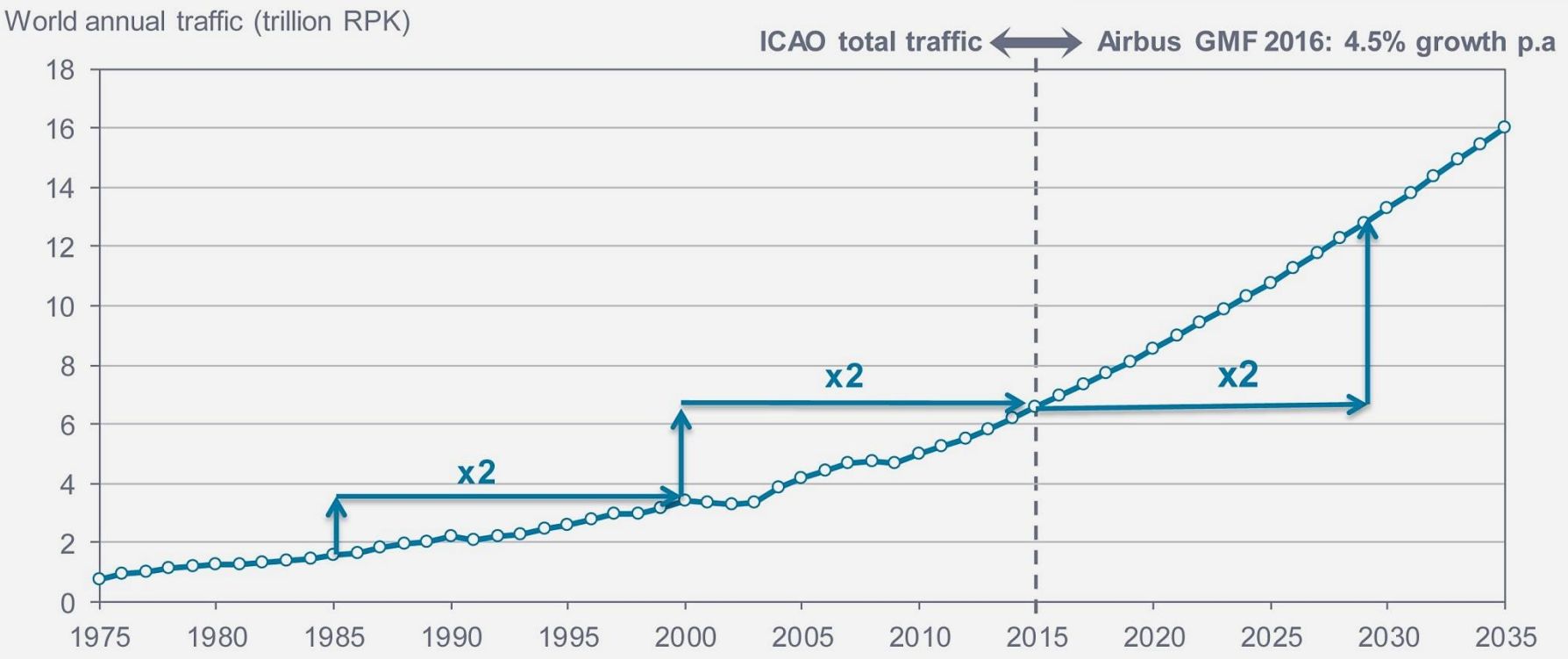
Large Commercial Aircraft Safety Development



Ref. Boeing Safety Statistics 2017

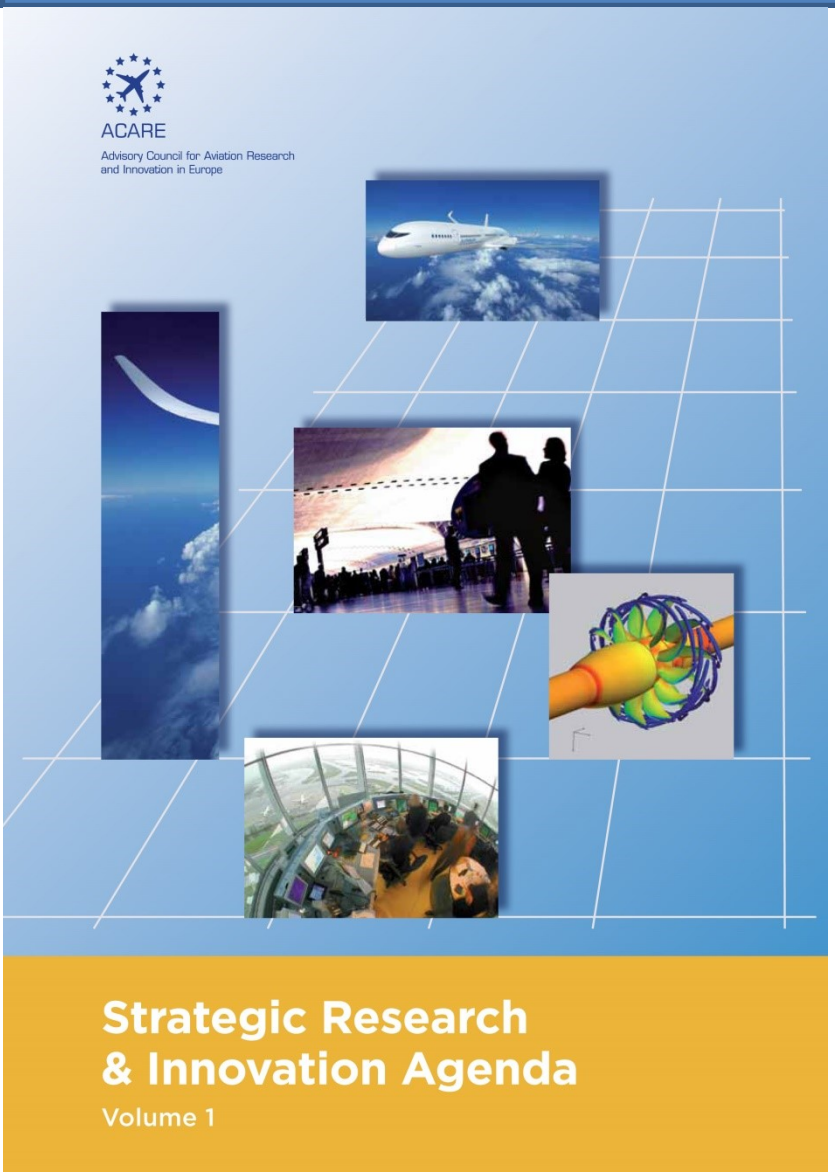
Air Travel Development 1975-2035

Air traffic will double in the next 15 years



Source: ICAO, Airbus GMF 2016

2012 ACARE Strategic Research & Innovation Agenda



Flightpath 2050 Goals and Challenges

1. Meeting Societal and Market Needs
2. Maintaining and Extending industrial leadership
3. Protecting the environment and energy supply
4. **Ensuring Safety and Security**
    1. **Air vehicle operations and traffic management**
    2. **Design, manufacturing and Certification**
    3. **Human Factors**
5. Prioritising research, testing capabilities and education

Aviation Safety Research Goals in Horizon 2020

- More robust, cost-efficient solutions for the whole life-cycle, based on novel methodologies and technologies towards improving the safety of the air transport system.

- Novel systematic identification of hazards and handling of data and processes tailored to the requirements of aviation that are efficient, effective and acceptable by all the relevant parties in the aviation value-chain.

- An improved understanding of environmental phenomena, their detection and the protection of aircraft in order to increase safety and reliability of operation.

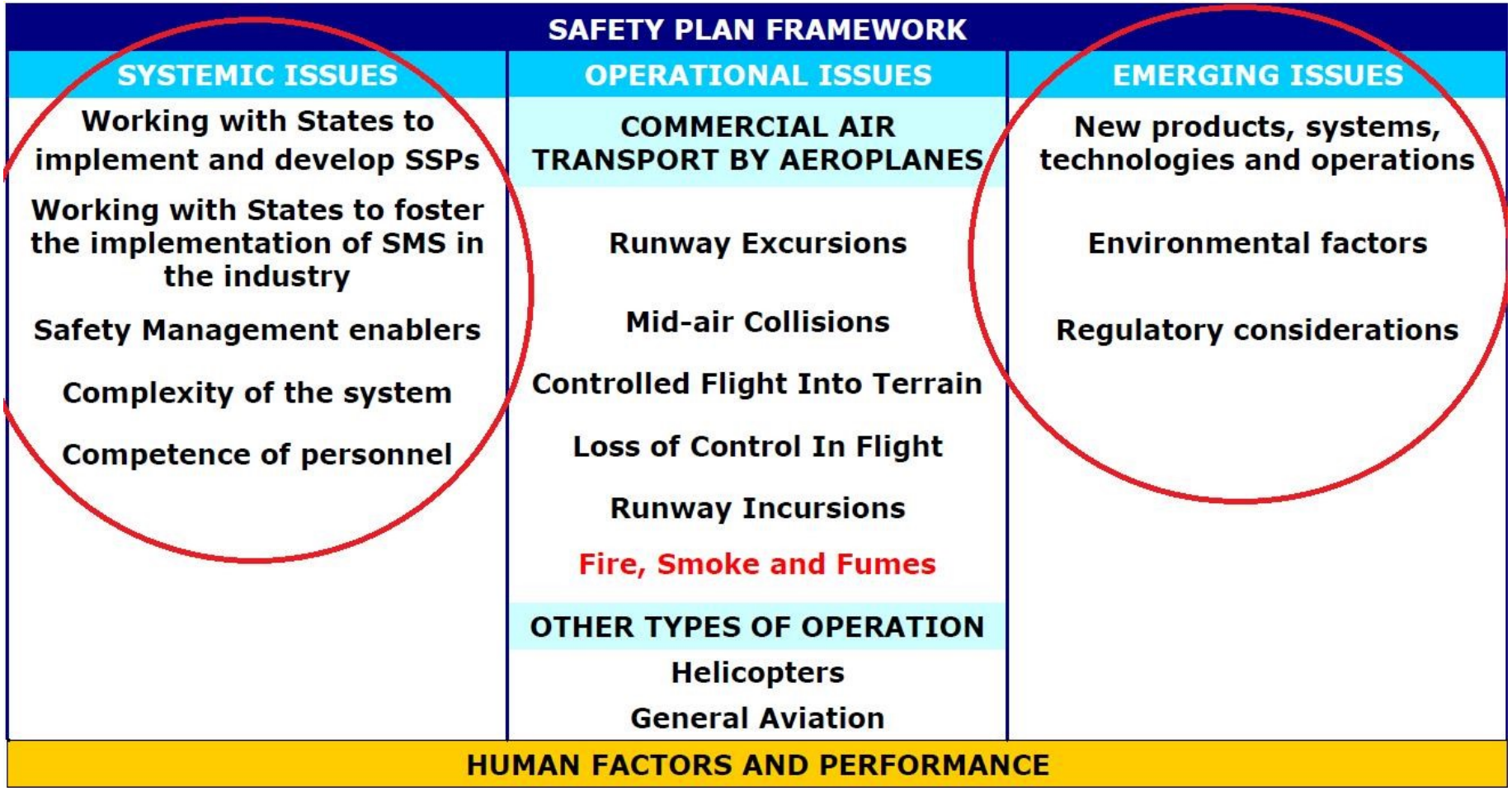
- Performance of studies and research activities towards reinforcing old and developing new EASA capabilities, that will contribute to its performance-based regulatory and certification mission. Proposals may address research areas linked to implementation and monitoring of safety rules, type-certification of aircraft and components and approval of organisations involved in the design, manufacture and maintenance of aeronautical products.

Horizon 2020 Air Transport Safety 2014-2015 & 2016-2017

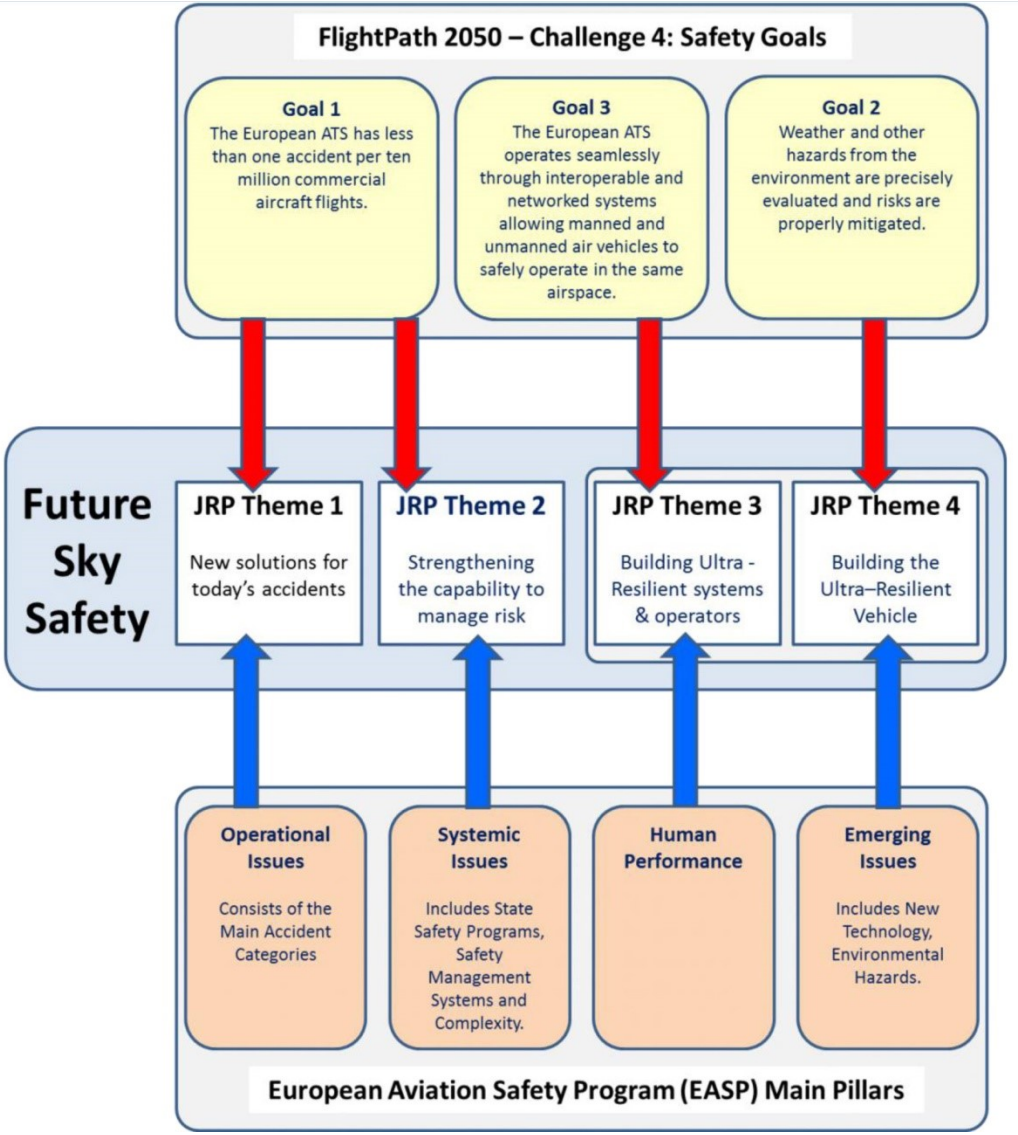
- **Horizon 2020 Work Programme 2014-2015: Mobility for Growth: Aviation**
  - MG.1.1-2014: Competitiveness of European aviation through cost efficiency and innovation
  - MG. 1.2-2015: Enhancing resource efficiency in aviation
  - MG.1.3-2014: Seamless and customer oriented air mobility
  - **MG.1.4-2014: Coordinated research and innovation actions targeting the highest level of safety for European aviation: 15 Meuro**
  - MG.1.5-2014: Breakthrough innovation for European aviation
  - MG.1.6-2014: Improving skills and knowledge base in European aviation
  - MG.1.7-2014: Support to European Aviation research and innovation policy
  - MG.1.8-2014-2015: International cooperation in aeronautics
  - **Total MG 1.1-MG 1.8: 204 MEuro**

- **Horizon 2020 Work Programme 2016-2017: Mobility for Growth: Aviation**
  - MG-1.1-2016: Reducing energy consumption and environmental impact of aviation
  - MG-1.2-2017: Reducing aviation noise
  - MG-1.3-2017: Maintaining industrial leadership in aeronautics
  - MG-1.4-2016-2017: Breakthrough innovation
  - MG-1.5-2016-2017: Identification of gaps, barriers and needs in aviation research
  - **MG-3.1-2016: Addressing aviation safety challenges: 15 Meuro**
  - **Total MG 1.1-MG 1.5 and MG 3.1: 74 MEuro**

EASA European Plan For Aviation Safety



FlightPath 2050, EPAS imputs to Future Sky Safety



Conclusions

- The EU started in 1989 in its 2nd Framework Programme with aeronautics research to support the European Aeronautical Industry. The EU aeronautics RDTE budget increased from 1988-2013 from 35 till 2100 Meuro.

- In 2001 ACARE was founded to advise the European Commission on topics and priorities for aeronautics RDT&E

- In the 7th FWP 1150 of the 2100 Meuro budget was dedicated to Technology Demonstrators in the Joint Undertakings Clean Sky and SESAR.
  In the Horizon 2020 Programme the JUs Clean Sky and SESAR are continued.
  A separate Horizon 2020 budget is available for Mobility for Growth(MG): Aviation.
  - For 2014-2015 a 15 MEuro budget is for MG.1.14-2014: Coordinated research and innovation actions targeting the highest level of safety for European aviation.
  - For For 2016-2017 a 15 Meuro budget is for MG-3.1-2016: Addressing Aviation Safety Challenges. For promoting a culture of safety in aviation, by developing and enhancing cost-effective, safety-related products and processes

- EU-EREA-EASA cooperation through Future Sky Safety is a great step forward!