EXPLORATORY RESEARCH IN ATM

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4th May 2015
ATM Research in Europe

- HORIZON Transport Challenges smart, green and integrated transport
- FlightPath 2050 - five challenges to aviation beyond the 2050 Horizon
- SESAR 1 WP-E Long-term and innovative research
Exploratory Research Challenges

• Meeting Societal and Market Needs (Challenge 1)
• Maintaining and Extending Industrial Leadership (Challenge 2)
• Protecting the Environment and the Energy Supply (Challenge 3)
• Ensuring Safety and Security (Challenge 4)
• Prioritising Research, Testing Capabilities and Education (Challenge 5)
SESAR 1 Long-term & innovative research

- WP-E explores novel, unconventional areas, involving new technologies, concepts and ideas
- The scope covers ATM/CNS and related research activities not covered in the SESAR main stream program
- 40 research projects, 3 research networks, 20 PhDs, SESAR Innovation Days, Young Scientist Award
Encouraging scientific excellence in ATM

With guidance from SESAR Scientific Committee

17 Projects
13 PhDs

Towards Higher Level of Automation in ATM

Mastering Complex Systems Safely

11 Projects
7 PhDs

Focussing on:
- Business Agility
- Decision Support
- Environment & Meteorology
- CNS/ATM (Automation)
- Operating Concepts
- The Human Factor

System Architecture & System Design

3 Projects

Enabling Change in ATM

Information Management, Uncertainty & Optimisation

3 Projects

FROM INNOVATION TO SOLUTION
Long-term Research Networks

• WP-E total **40 projects** of which **22 are ongoing** and **18 are closed**
• The three Research Networks coordinate research, knowledge development and manage PhD research
• **HALA!** – Towards Higher Levels of Automation in ATM
• **Complex World** – Mastering Complex Systems Safely
• **ALIAS** – Addressing the Liability Impact of Automated Systems
• In very early stages research V0 level (e.g. WP-E projects), transfer of research results is difficult into the SESAR mainstream program

• The need to strengthen the link of the ATM research community and SESAR stakeholders through ATM Applications Oriented topics in SESAR 2020

• SESAR will aim at further bridging the results from Exploratory Research through Industrial Research, Large Scale Demos towards implementation/industrialization readiness
SESAR R&I Pipeline

**Exploratory research**
Explores novel concepts, ideas and emerging technologies in order to stimulate creativity in the ATM research domain.

**Applied research**
Takes accumulated knowledge and theories and applies them to practical ATM challenges.

**Development (Release process)**
Takes concepts through a rigorous validation process resulting in new SESAR solutions.

**Demonstration Activities**
Showcases solutions in a real operational environment involving multiple stakeholders across Europe.

**SESAR Solution Packs**
Documentation that comes with each SESAR solution is packed together and made available online to support further take-up by industry.

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* Source: Eurocontrol - **Source: European Commission*
**SESAR Research Maturity – Programme 2020**

**Technology Readiness Level (TRL)**

1. **Open Calls**
2. **Industrial Partnership**
3. **Open Calls**

**Fundamental Scientific Research – To TRL1**
- Thematic Approach
- Establish the Science
- Engage Universities
- Reach outside of ATM

**Application-Oriented Research – To TRL2**
- Structure aligned to Industrial Research for transition

**Industrial Research & Validation – To TRL6**
- High Performance Airport Operations
- Advanced Air Traffic Services
- Optimised ATM Network Management
- Enabling Aviation Infrastructure
- Working in Partnership

**Very Large-scale Demonstrations**

**VLD – From TRL6**
- High Capacity Airport Operations
- Advanced Air Traffic Services
- Optimised ATM Network Management
- Enabling Aviation Infrastructure
- Engaging the wider Community

**FROM INNOVATION TO SOLUTION**
• **Pre-TRL1 Scientific Research: Fundamental exploratory research** investigating relevant scientific subjects and conducting feasibility studies looking for potential application areas in ATM, concentrating both on out-reach to other disciplines as well as educating within.

• **TRL 1 Basic principles observed and reported:** Exploring the transition from scientific research to applied research by bringing together a wide range of stakeholders to investigate the essential characteristics and behaviours of applications, systems and architectures. Descriptive tools are mathematical formulations or algorithms.

• **TRL 2 Technology concept and/or application formulated:** *Applied research.* Theory and scientific principles are focused on very specific application area(s) to perform the analysis to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.
What is Exploratory Research in ATM?

**SESAR exploratory research drives the development and evaluation of innovative or unconventional ideas, concepts, methods and technologies; that can define and deliver the performance required for the next generation of European ATM system, and thus contribute to its successful evolution**

Reviewed, updated and approved by the SESAR Scientific Committee
• To contribute to the European ATM Master Plan towards long term objectives beyond 2035 (i.e. 2050 timescale)

• To contribute to the identification of innovative solutions not yet identified but which would accelerate the realisation of the SES targets

• The delivery sustainable healthy research activities across a range of research networks in Europe
Changes to ATM

Delivering best-in-class, globally interoperable and high-performing Air Transport for Airspace Users and Citizens

- Enabling the delivery of safe, cost-efficient and environmentally responsible Air Vehicle & ATM operations, systems and services

High Performing Airport Operations

Capacity, Safety, Environment, Efficient, Effective, Networked

Optimised ATM Network Services

Collaboration, Balancing Demand & Capacity, Environment, Efficiency

Advanced Air Traffic Services

Synchronisation, Capacity, Safety, Environment, Cost

Enabling the Aviation Infrastructure

- Providing shared technical services across the aviation domain
- Communications, positioning, navigation, timing and SWIM information
- Air vehicle operations, systems & services
Exploratory Research Challenges

• **Automation of the ATM systems** - new paradigms for human-machine interaction, integration of RPAS or highly autonomous aerial vehicles, degradation of automation and impact on ATM performance including safety & security, automation failure scenarios

• **Data Science & Information Management in ATM** – applying complexity and data science in ATM, automating the extraction of knowledge of raw data, cyber-security, using Ontology engineering models in a network environment

• **Environment & Meteorology in ATM** – 4D trajectories taking into account environmental considerations, airborne and ground MET capabilities integration in ATM processes, weather uncertainty impacts 4D trajectories, impact of climate change
Exploratory Research Challenges

• **Challenges of change**
  - evolving market pressures
  - new market entrants
  - new business models
  - variable pricing mechanisms for demand-capacity balancing
  - unbundling ATM services
  - lessons learnt from other industries
  - impact on ATM system architecture
SESAR 2020 Draft Work Breakdown Structure (WBS)
• **ATM Excellent Science & Outreach** - is curiosity-driven and explores unknown research areas. Referred to also as “**fundamental research**”, but also encourages scientists to develop innovative ideas and concepts for the future ATM evolution. Bridging ATM research with wider community and providing scientific support to ATM change, either directly or through connection to other funded research areas in other disciplines and sections if relevant.
SESAR 2020 Exploratory Research Topics for 1\textsuperscript{st} Call

- **ATM Applications Oriented Research** - aiming at supporting new concepts for ATM beyond those identified in the ATM Master Plan as well as help mature new concepts for ATM, emerging technologies and methods to the level of maturity required to feed into SESAR 2020 industrial research.
ATM Excellent Science & Outreach

- ER-01-2015 - Automation in ATM
- ER-02-2015 - Data Science in ATM
- ER-03-2015 - Information Management in ATM
- ER-04-2015 - Environment & Meteorology in ATM
- ER-05-2015 - Economics and Legal Change in ATM
ER-01-2015 - Automation in ATM

• **Automation in ATM** - will study the application of Automation that could provide the key to significant performance improvements across many aspects of ATM, which today rely on high levels of automation. The domains of robotics and autonomy may extend more traditional notions of automation to potentially open up new fields of research.

• **Challenge** develop automation solutions that have the capability to provide substantial and verifiable performance benefits whilst fully addressing safety/security concerns.

• **Proposals for research** in automation should take an ambitious view on automation. Address any parts of the ATM systems from strategic planning through airport operations to tactical air traffic control/collision avoidance.

• **Reference material** - SESAR HALA Network
Data Science in ATM – will study the potential application of the rapidly maturing techniques in complexity science and data science for the ATM domain. Complexity science deals with the application of complexity theory in the ATM domain.

Challenge is to contribute to better understanding of how the ATM system works, in particular the interaction of its subsystems. The availability of ‘big data’ offers a range of research opportunities for data science in ATM and is an emerging field in ATM, concerned with managing and exploiting large data sets and its application to air traffic management.

Proposals for research could address exploiting complexity science’s modelling, focusing on automating the extraction of knowledge from raw, heterogeneous and incomplete sources.

Reference material – SESAR ComplexWorld Network.
Information Management in ATM – will study the management and distribution of all types of information in ATM systems, including flight deck and cabin, with particular attention to scalability, stability and error promulgation that relate to the inherent conflict between consistency, availability and partition tolerance in a distributed computer based global ATM system.

Challenges to address the challenges of the distribution and management of all types of information in ATM between stakeholders.

Proposals of research could address cyber-security concerns in aviation environment, potential use of Ontology engineering models in an network environment and in relation with ATM Information Reference Model (AIRM)
Environmental & Meteorology for ATM

- **Environment & Meteorology in ATM** - the research activities will aim to better understand the impact of aviation on the environment and the ways in which ATM can reduce these effects.

- **Research activities under environment** may address research aimed at developing 4D trajectories that are optimised to take account of all environmental considerations.

- **Research activities under meteorology** for ATM will study enhanced meteorological capabilities and their integration into ATM planning processes for improving ATM efficiency.
Economics & Legal Change in ATM - will study the economics and legal changes in ATM.

Challenges may originate from evolving market pressures, the emergence of new market entrants, innovation in business models or they may be a consequence of regulation.

Research activities may study the relative efficacy of changes and the possibility to shorten the R&I lifecycle, driven by regulation compared with those that derived from natural or forced economic incentive. A better understanding of costs, benefits and impacts of changes, actual and planned, is desirable.
APPLICATIONS ORIENTED RESEARCH

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ATM Applications Oriented Research

• ER-06-2015 - High Performing Airport Operations
• ER-07-2015 - Separation Management and Separation Standards
• ER-08-2015 – Communications, Navigation and Surveillance
• ER-09-2015 – Trajectory Based Operations
• ER-10-2015 – ATM Architecture
• ER-11-2015 – ATM Performance
The SESAR Operational Concept

- Airspace Management and AFUA
- Dynamic Airspace Configurations
- Enhanced ACAS
- Enhanced Ground-Based Safety Nets
- Enhanced ATFCM Process
- System Wide Information Management
- System interoperability with air & ground data sharing
- Enhanced situational awareness
- Integrated Surface Management
- Enhanced Runway Throughput
- Low Visibility procedures using GBAS
- Pilot Enhanced Vision
- Ground-Based Separation Provision
- Enhanced Arrival & Departure Management in TMA and En Route
- Optimised 2D/3D Routes
- Approach Procedures with Vertical Guidance
- Integrated Arrival/Departure Management at Airports
- Enhanced ATFCM Process
- User-Driven Prioritisation Process
- Airport Operations Management
- Network Operations Planning
- Enhanced Airline Services
- Enhanced Air Traffic Control Centre
Priority Strategic Business Needs

- Moving from Airspace to 4D Trajectory Management
- Network Collaborative Management and Demand and Capacity Balancing
- Conflict Management and Automation
- Traffic Synchronisation
- Airport Integration and Throughput
- Supporting Enablers including CNS and SWIM
High Performing Airport Operations – will study the improved visualisation and awareness for airport operations.

Challenges - as the pressure increases on airports, new technologies are emerging that may offer significant potential for improved situational awareness for tower controllers.

Research activities will address new ways of displaying and presenting data on aircraft, vehicles and infrastructure in a manned airport visual control room. The main impact of this research will be increased safety on the surface and in the air in the vicinity of the airport as well as cost savings.
• **Separation management** is about keeping a/c separated from each other and other hazards is at the heart of ATM. Separation needs to be resilient in the sense that if one system or agent fails, another system or agent in the system will detect and assist. Future research into resilient separation is important.

• **Challenge** to define potential new separation standards and separation management techniques to allow a/c to be more closely spaced

• **Investigate the possibility** of defining separation minima that combine lateral and vertical minima. Combined separation minima when attained simultaneously still achieve safe separation between aircraft (e.g. 1 NM and 500 feet).
• Communication, navigation and surveillance (CNS) systems are the building blocks on which air traffic management operates. Despite many activities in the CNS domain there remain a number of areas where more fundamental research is needed.

• Challenge is the use, or adaptation, of new technologies being developed outside ATM to support ATM CNS needs including analysis of the safety, performance and security implications for the ATM system, CNS are currently characterized by lack of integration, GNSS jamming/spoofing.

• Perform research on innovative data-link technologies, CNS integration, interoperability, reducing costs and optimizing spectrum usage. Suitable back-up of GNSS services for navigation integrity.
• **Trajectory Based Operations (TBO)** – will study a number of fundamental questions related to TBO.

• **Challenge** - TBO is a key element of future ATM operating concepts. It is expected to provide the flexibility needed by airspace users to optimise their operations while simultaneously ensuring the predictability needed at ATM network level for maximum overall performance.

• **Research** will contribute to fully understand the benefits and limitations of the TBO approach. Projects to find solutions that balance flexibility and the requirement for trajectory conformance.
• **ATM Architecture** - will study innovative approaches to analysing ATM architecture.

• **Challenges** - to help better understanding and modeling how architectural and design choices influence the ATM system and its various behaviours.

• **Research proposals** may start by characteristics of today’s systems or using a “clean sheet” approach or lessons learnt from other industries. Projects should be careful not to spend time re-doing previous work on architecture done in SESAR or elsewhere.
• **ATM Performance** – will study new effective methodologies and tools for micro and macro modelling of performance in ATM, capable of capturing the interdependencies between different Key Performance Areas (KPAs).

• **Challenges** - to achieve EATMN significant change in the way Air Navigation Services (ANS) are regulated, operated, consumed and financed is now undergoing.

• **Research activities** may also cover the modelling and analysis of the current performance drivers underpinning each and every stakeholder’s business model as well as their interactions. Projects may also propose innovative metrics and indicators for the performance impact of ATM operations on the different stakeholders, as well as the collection and processing of the relevant data.
SESAR 2020 Exploratory Research Call

• SESAR 2020 ER 1st Call launch 25th of March 2015
• SES2020 ER 1st Call closure 25th of June 2015
• H2020 open calls, so not limited to SJU Members
• SESAR Exploratory Research will be the driver behind innovative and disruptive research ideas

SESAR Needs You!

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Thank you for your attention