SESAR WP-E
Review of current networks, projects and PhDs

Dirk Schaefer
WP-E second call for projects information day
Brussels, 12th June 2012
Ongoing WP-E Activities

WP-E Networks

- HALA! – Higher Automation Levels in ATM led by UP Madrid
- ComplexWorld – Mastering Complex Systems Safely led by Innaxis
- ALIAS - Addressing the Liability Impact of Automated Systems (mini-network)

WP-E Projects

- 9 related to Higher Automation Levels in ATM
- 8 related to Mastering Complex Systems Safely
- 1 related to Addressing the Liability Impact of Automated Systems

WP-E PhDs

- 13 related to Higher Automation Levels in ATM
- 7 related to Mastering Complex Systems Safely
WP-E Network ComplexWorld

Coordinator: INNAXIS

Scientific lead: University of Sevilla

Other members: University of Palermo, DLR, NLR, University of Westminster

40+ participants

Main activities:
  • Position Paper
  • Parallel session/tutorials at conferences (ATOS, ECCS)

7 PhDs

http://www.ComplexWorld.eu
WP-E Network HALA!

Coordinator and scientific lead: UP Madrid

Other members: TU Dresden, Imperial College, KTH Stockholm, Boeing R&TE, CRIDA, Deep Blue, TU Braunschweig, NLR, University of Toulouse, GMV, Pildo, EADS, University of Naples

80+ participants

13 PhDs

Main activities:
- Position Paper
- ATACCS
- HALA! Summer School

http://www.hala-sesar.net/
**Executor:** U Bristol

**Objective:** Make numerical trajectory optimizers more suitable for human supervision by eliciting input from the supervisor. Provide meaningful feedback from the optimizer about its results.

**Approach:** Investigate and compare a variety of ways for the supervisor to influence the optimizer's decision-making, balancing responsiveness, overall performance and workload. As well as mechanisms for input to the process the project will investigate what output can be provided from the optimizer to support informed interventions. The objective is to provide the rationale behind the optimizer's output without information overload.

**Expected results:** This research will not develop new trajectory optimizers nor HMI's, but rather find routes for information into and out of trajectory optimizers, identifying best choices for human supervision and interaction. This is crucial to enable future human-centred, highly automated, trajectory-based ATM systems.
NEWO

www.newo-sju.eu

Network-Wide effects of inventive Operational approaches in ATM

SESAR WP-E Info Day
Carlos Regidor, cregidor@isdefe.es
Isdefe, Spain

June 12th 2012
OBJECTIVES

To explore the potential network-wide benefits and/or adverse effects of the application of different local operational approaches in ATM

Further develop & explore the potential of innovative modelling and simulation techniques

APPROACH

- Modelling Air Transport as a complex system: dynamic graphs, propagation of noise; non-determinism, inter-relationships between structure and dynamics, modelling uncertainty...
- Capture out-of-the-box ideas for managing complex networks;
- Scenarios selection and simulation
  - Workshop, questionnaires, literature review;
  - Selection of most promising ideas;
  - Select and define scenarios;
  - Model adaptation and development.
- Simulate and check benefits of strategies...
ADAHR in a nutshell

Objectives:
- To assess the impact of increasing Levels of Automation (LoA) in ATM environments on the behaviour of human roles and human interactions.

Approach:
- Current State:
  - Paper-based Games ENV1 are completed, resulting in a preliminary assessment and in useful recommendations for the Platform-based Games.
  - Preparation Platform-based Games ENV1 is practically finished (Gaming sessions on 27-29 June)
Technical presentation of the project

STREAM – Strategic Trajectory de-confliction to Enable seamless Aircraft conflict Management

Small project: March 2011 - March 2013

<table>
<thead>
<tr>
<th>PARTNERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SESAR WPE LONG TERM AND INNOVATIVE RESEARCH</td>
</tr>
<tr>
<td>HALA! RESEARCH NETWORK</td>
</tr>
<tr>
<td>Advanced Logistics</td>
</tr>
<tr>
<td>Boeing Research &amp; Technology</td>
</tr>
<tr>
<td>University Autònoma de Barcelona</td>
</tr>
</tbody>
</table>

Objective:

To perform **conflict detection at pre-departure phase**, allowing resolution maneuvers into the first RBT

- **a)** To develop **time-efficient algorithms** $O(n)$ for the strategic detection and resolution of traffic conflicts
  - CD through **Spatial Data Structures** + CR through **Causal Modelling**
- **b)** To explore the requirements on the reliability and robustness of **traffic predictions**
- **c)** To define **metrics** for assessing the fairness and equity of the proposed algorithms
- **d)** To perform **simulations** in a common environment in order to validate the proposed algorithms and metrics

<table>
<thead>
<tr>
<th>WP0 Project management and planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
</tr>
<tr>
<td>WP1 Concept Definition</td>
</tr>
<tr>
<td>WP 2 development of the basic algorithms</td>
</tr>
<tr>
<td>WP 3 development of the preliminary metrics</td>
</tr>
<tr>
<td>WP 4 Analysis &amp; evaluation</td>
</tr>
<tr>
<td>WP 2 development of enhanced algorithms</td>
</tr>
<tr>
<td>WP 3 development of the assessment framework</td>
</tr>
<tr>
<td>WP 4 Analysis &amp; evaluation</td>
</tr>
<tr>
<td>Phase II</td>
</tr>
</tbody>
</table>

Basic solution

Advanced solution
ASHICS: Automating the search for hazards in complex systems

Consortium: U York

Objective: Refining the description of ATM and its components as a large system of systems simulation model in order to analyse the impact of changes on the overall systems behaviour

Approach: Investigate how to use meta-heuristic search to manipulate and configure system of systems simulation models, so that a huge number of pathways and subsystem combinations within ATM scenarios can be explored without the need for manual intervention. The output of these simulations will build up a picture of the critical system parameters in a given scenario, even when a direct casual link between system entities is not immediately obvious

Expected results: A systematic method for instrumenting risk within simulation models; an analysis of how meta-heuristic search could provide automated hazard discovery; A prototype software relevant to the aims of SESAR that demonstrates the approach in practice
**ONBOARD**

- **Goal**: to enhance the ATM performances (e.g. predictability) of the Network by addressing the two factors that account for 2/3 of the delay (weather, knock-on effects) and the underlying uncertainty

- **Expected outcome**: to develop a R/T closed loop simulation platform integrating an AOC and a sub-regional NM and carry out validation exercises to measure the KPI improvements with the new algorithms

- **Current status and next steps**: first version of stand-alone components and brand-new algorithms available. Final version of algorithms and integrated platform ready by December 2012

- **Lessons learned**: address a real operational problem; ensure you have access to key data; involve operational experts; review thoroughly R&D literature; align with SESAR ConOps; make simplifications and try alternative methods; set long term R&D goals
TESA: Trajectory prediction and conflict resolution for en-route to en-route seamless air traffic management

**Executor:** Imperial College

**Objective:** Develop an accurate and reliable 4D trajectory prediction tool capable of predicting from departure to arrival gate including terminal and surface manoeuvring. Based on this a robust strategic conflict detection and resolution tool will be developed.

**Approach:** Uncertainty will be an explicit and central consideration. For CD&R the project will consider aircraft status and navigation capabilities. The work will particularly focus on terminal manoeuvring areas.

**Expected results:** A robust and reliable deterministic methodology for an efficient and safe TP model. An analytical conflict risk model focussed on TMA and airport environments together with robust conflict resolution methodology.
**MUFASA**  
*Multivariate Framework for Advanced SESAR Automation*

- Level of Automation  
- Complexity  
- Strategic Conformance

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**Will controllers accept automation that matches their own strategy?**

- Partners  
- HALA links  
- 27 months  
- 3 real time sims: 3 populations  
  - Closed loop LOA trigger  
  - Online administration?

→ **Refine a multivariate model of automation acceptance and usage**
MAREA: Mathematical approach towards resilience engineering in ATM

Consortium: NLR, VU Amsterdam, U L’Aquila

Objective: Improve resilience engineering in ATM through a mathematical modelling and analysis approach and demonstrate its usability through application to SESAR 2020 scenarios

Approach: The project will enhance the set of psychological and organizational sub-models currently used in safety analysis and resilience engineering by a systematic inventory of new types of models in artificial intelligence and agent-based modelling with their capability to describe a wider variety of uncertainties and non-nominal behaviour in ATM. These models will be integrated in a formal mathematical framework which will be applied to safety criticality modelling and analysis of 4D trajectory-based SESAR 2020 scenarios

Expected results: More effective resilient design due to the ability to identify and analyse a large variety of emergent non-nominal conditions using mathematical power
C-SHARE: Joint ATM cognition through shared representations

Consortium: TU Delft, NLR, Thales NL

Objective: (a) obtain a description of 4D trajectory management independent of the chosen level of automation and (b) explore the implications of varying degrees of automation in a 4D trajectory management task.

Approach: Analyse the task and work domain of 4D trajectory management using the technique of Work Domain Analysis, implementing the results in a ‘Joint Cognitive System’ for trajectory management which allows various degrees of automation / task allocation. Evaluating the implications of different degrees of automation in experiments.

Expected results: A complete representation for tactical and strategic manipulation of four-dimensional trajectories, a framework that can act as a basis for designing both HMI and automation in the air and on the ground. In addition, a support tool will be developed to provide conflict resolution options depending on the desired degree of automation.
Zero Failure process at Maximum Productivity in Safety Critical Environment

- Can ATM be seen as production process?
- Can the ATCOs' decisions be defined as value adding production steps?
- Which process tools are best suited for managing the dependencies between decisions and productivity?

- **Experiment 19-20 June**
  - 5 positions, Hamburg airport
  - Smartstrips, USGB –NAVSIM
  - One hour recorded traffic scenario
COMPASS: Safety management in complex ATM system of systems using ICT approaches

Consortium: Thales IS, U York, Innaxis, TU Aachen

Objective: provide powerful and more automated safety management support to human operators of complex ATM systems

Approach: taking a pattern-based approach and by combining state-of-the-art technology from data mining, intelligent modelling and complex event processing. The combination will allow engineers to mine safety patterns from past data, filter and enrich these patterns using their expertise and domain knowledge, and then use the patterns to monitor running ATM systems in an automated manner

Expected results: Novel automated safety warning technology and techniques that offer substantial promise in reducing the amount of human intervention in identifying potentially hazardous situations and generating warnings to ATM experts. Bring within the scope of SESAR several novel technologies and theories from the ICT community specifically targeted at management of complex systems. Novel intelligent modelling techniques and languages for safety management in ATM systems
ALIAS: Addressing liability impact on automated systems

Consortium: EU Institute, DeepBlue

Objective: address the liability impact of automated systems via two key questions:
1. To what extent may the use of new automatic tools shift liability for accidents from operators to those who develop the technology?
2. Are current liability regimes at national and international levels suited to accommodate the introduction of new technologies?

Approach: A methodological tool know as a 'Legal Case' will be developed. This will offer a systematic approach for evaluation of legal considerations when developing automation.

Expected results:
A 'Legal Case': a systematic approach and toolset for the evaluation of legal considerations when developing automation.

A (mini-)network on 'Legal Research in ATM' to provide a forum for academia, researchers, industry and others to develop the issues and to establish an archive of relevant documentation.
CASSIOPEIA
(Innaxis & University of Westminster & UPM)

• **Purpose**
  Advance the state of the art in performance and policy assessment tools in future operational scenarios where high number of agents take autonomous decisions impacting the network.

• **Objectives**
  • Define how ABM-tools are to be specified in ATM context
  • Design specific ABM simulation methodology and toolset
  • Look into new metrics for specific Case Studies
  • CS1 - Local capacity restrictions and impact in the network
  • CS2 - ATFM slot trading
  • CS3 - Dynamic cost indexing

• **Scope**
  • Simulation of specific scenarios for each Case Study
POEM (University of Westminster & Innaxis)

• **Purpose**
  Advance the state of the art, which currently focuses heavily on metrics based on single-flight legs, to give better insights into ATM disruption and better alignment with established EU policy

• **Objectives**
  • Design new passenger-centric metrics
  • Design metrics for delay propagation (network resilience)
  • Incorporate full costs (which are not linear with delay minutes)
  • Move metric focus away from averages (etc), and towards network
  • Explore new ATM rules/scenarios – lessons for flight prioritisation
  • Disseminate and consult; include PRB, airlines and ANSPs

• **Scope**
  • Simulation of European airspace : 200 airports (plus 50 non-ECAC)
  • Will cover August and September, 2009 and 2010 (i.e. four periods)
  • Unique combination of full pax itineraries & a/c mvt data
UTOPIA: Universal trajectory synchronisation for highly predictable arrivals enabled by full automation

Consortium: TU Dresden, Boeing R&TE, Barco

Objective: Research the technologies, flight modelling and information required to achieve higher levels of automation in and around airports with particular focus on non-homogeneous aircraft and systems.

Approach: Develop formal models of trajectory data and synchronisation protocols for heterogeneous systems in an automated environment. Sources of uncertainty and their propagation, together with system disruptions, will be considered. Finally the project will produce advanced trajectory management algorithms and ground synchronisation functions based on the formal n-dimensional trajectory data and uncertainty models.

Expected results: An air-ground n-dimensional trajectory synchronisation concept based on formal languages together with the required synchronisation patterns and protocols applicable to a highly automated ATM system. An analysis of uncertainty and the impact of disruption and a full evaluation of the potential added value.
SPAD - System Performances under Automation Degradation

WHAT

• Study and model how automation degradation can propagate through the different ATM components and affect system performances (resilience, capacity)
• Deep Blue; Univ. Paul Sabatier (IRIT); ARMINES
• From May 2011 till November 2013

HOW

• Identify a federation of models able to deal with the different aspect of interest of the ATM system with different levels of granularity
• Tune and validate the model through a set of Case Studies (systems at different levels of automation and degradations of different severity)
• Demonstrate the potential of the approach with a tool monitoring the propagation of degradation (and related reduction of performances).
ELSA: Empirically grounded agent-based models for the future ATM scenario

Consortium: DeepBlue, U Palermo, U Pisa

Objective: To analyze, describe and model the dynamics of the ATM system, especially those concerning complexity, resilience, and safety

Approach: First, an extensive statistical analysis of data of the ATM system with complex systems theory techniques in order to characterize statistical regularities. Thereafter, the development of an agent-based model of increasing complexity and degree of realism, to simulate the emergent properties of the trajectory-based SESAR scenario. And finally, the design and implementation of a prototype decision support tool to monitor, predict (based on the agent-based model) and intervene on the airspace

Expected results: Methods to characterize geographical areas in terms of (i) level of complexity and/or resilience, (ii) dynamics by which these characteristics are engendered and by which they propagate in space/time. Construction, calibration, and validation of an agent-based model, that will be used to simulate realistic ATM scenarios. Design and implementation of the prototype of a decision support tool
ComplexWorld PhDs

1. **Uncertainty Models for Optimal and Robust ATM Schedules** - Alexander University Erlangen-Nuremberg (FAU)

2. **Identification and Analysis of Hidden Safety Patterns** - Universidad Polytechnica de Madrid (UPM)

3. **Using a Complex Systems Approach to Assess Airspace Performance** - TU Delft (TUD)

4. **Analysis of Air Transport using Complex Networks** - IFISC

5. **Assessment of Critical Delay Pattern and Avalanche Dynamics in the ATM System** - Sapienza University of Rome

6. **Modelling Interlevel Relations within ATM** - Vrije Universiteit Amsterdam (VUA)

7. **Intelligent Modelling the Impact of Unpredictable Adverse Weather on ATM Performance** - University of Hannover
HALA! PhDs – First Call

1. *A framework to assess the ability of automation to deliver capacity targets in European airspace* - Imperial College London

2. *Application of the Theory of Formal Languages to the Modeling of Trajectory Uncertainty and the Analysis of its Impact in Future Trajectory-Based Operations* - Boeing R&TE and Glasgow University


4. *Turnaround modeling* - Technische Universitaet Dresden

5. *Uncertainty reduction by an ATS inherent aircraft state vector modeling and estimation* - Technische Universitaet Braunschweig

6. *Exploiting Innovative Sensor Data Fusion Strategies for Sense and Avoid Units to be Installed onboard Unmanned Aerial Systems* - University of Naples Federico II
HALA! PhDs – Second Call

1. **Context-Aware Adaptive Automation for Air Traffic Control** - Delft University of Technology.


3. **Managing information needs in the design of highly automated systems and human-computer interfaces** - University of Roma 3.

4. **Development of an autonomous knowledge-based system state evaluation for an enhanced decision making process** - Technische Universität Braunschweig.

5. **Robust data fusion for 4D conflict-free optimal trajectories in a highly automated ATM system** - Technical University of Catalonia.

6. **Making decisions on human automation allocations resilient by using a virtual safety advisor for ATM** - University Kassel.