Work Package Final Report

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Abstract

WP-E managed a portfolio of long-term and innovative research activities that fell outside the main SESAR industrial work programme. It operated through open calls, not restricted to SJU members, for projects and research networks. Evaluation and selection of tenders was done by independent review in line with standard EC practice. In total WP-E managed two research networks, 40 projects and 20 PhDs. Around 75 organisations (mainly academia and research centres) received funding. In addition WP-E initiated and managed the SESAR Innovation Days with, so far, five highly successful events completed. WPE was managed by Eurocontrol on behalf of SESAR.

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This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ABM	Agent-based Modelling
AOC	Airport Operations Centre
AOM	Airspace Organization and Management Centre
ATM	Air Traffic Management
CDR	Conflict Detection and Resolution
CSE	Cognitive Systems Engineering
DCI	Dynamic Cost Indexing
EA	Enterprise Architecture
EID	Ecological Interface Design
EPS	Ensemble Prediction System
EWF	Ensemble Weather Forecast
GA	General Aviation
RE	Resilience Engineering
SESAR	Single European Sky ATM Research
SMC	Secure Multiparty Computation
SJU	SESAR Joint Undertaking
SRK	Skills, Rules, Knowledge
TBO	Trajectory-based Operations
TP	Trajectory Prediction
TRL	Technology Readiness Level
WP	Work Package
WPE	Work Package E - Long-term and innovative research

1 Work Package Overview

SESAR WPE managed a portfolio of long-term and innovative research activities that fell outside the main SESAR industrial work programme. It operated through open calls, not restricted to SJU members, for projects and research networks. Evaluation and selection of tenders was done by independent review in line with standard EC practice. In total WPE managed two research networks, 40 projects and 20 PhDs. Around 75 organisations (mainly academia and research centres) received funding. In addition WP-E initiated and managed the SESAR Innovation Days with, so far, five highly successful events completed.

There were two sub-workpackages:

E.1: Networks. These were designed to provide a structured way to build research knowledge, competence and capability to serve the industry in the long term. Each network comprised members and participants from academia, research centres, industry and SMEs that shared a common expertise and interest in a particular air traffic management or transportation domain. Part of the networks' activities was to manage a portfolio of PhDs.

E.2: Projects. These research projects were oriented towards a specific research question or challenge and were hence much more focussed than networks. Projects explored new ideas oriented to the long term but also produced innovative solutions applicable in short- and mid-terms. Interdisciplinary approaches were explicitly encouraged to help enrich projects with innovative solutions.

In addition WPE organised the SESAR Innovation Days (SIDs), a major annual event that gathered around 200 researchers for exchange of information and results. Since 2010 the SIDs have become a key focus for the community resulting in many strong and enduring connections across European organisations.

This report briefly summarises each network and project and then provides some overall indications of WPE performance.

1.1 Work Package contribution to the Master Plan

The nature of WPE, long-term and innovative research, means that direct contributions from projects to the Master Plan are difficult to document. In some cases output from individual projects will have fed into discussion and definition of S2020 industrial research. However, the connection between WPE projects and the rest of the SESAR programme was an ongoing weakness that is documented below and elsewhere. This is a clear lesson to be learned for S2020. Some indications of follow-up that may have influenced S2020 may be found in the final reports of each project.

More evident is that the outcomes of WPE influenced the 2015 ER call. This has happened in three ways.

First, the content of the call borrowed heavily from successful themes developed and expanded in WPE. This is particularly true in the case of economic and institutional studies, complexity, big data and parts of advanced automation and human factors.

Second, the projects were asked in their final reports to specifically identify, in their publishable summary, topics and gaps to be addressed in future research.

Third, many of the consortia that bid for projects were brought together from interactions born in WPE, often through the SIDs or though workshops done by HALA! and ComplexWorld.

1.2 Work Package achievements

From the beginning the objectives of WPE were twofold: one the one hand to generate and publish research results and thus contribute to the growing body of knowledge in air traffic management and related areas; and on the other hand to create a thriving community and network of young researchers persisting beyond the duration of and financing through the work package, seeking careers in air traffic management.

Due to the limited budget it was clear from the outset that WPE could only sponsor research in selected areas. For the main project calls WPE developed a Thematic Programme which set out the research themes to be explored. The four themes for the first project call were: Legal aspects of paradigm shift; Towards higher levels of automation in ATM; Mastering complex systems safely and Economics and performance. For the second project call these were slightly modified, the five new themes being: Towards higher levels of automation in ATM; Mastering complex systems safely; System architecture and system design; Information management, uncertainty and optimisation and Enabling change in ATM.

The degree of innovation of project proposals was an important selection criterion. The proportion of research projects in a given portfolio that generate results leading, directly or indirectly, to a 'product' may be considered a metric of success. But new ideas may or may not work, and some will, after investigation, be judged unworthy of further investment. Amongst the forty projects sponsored through WPE, it is subjectively estimated that around one in three are in this situation. That is, they have investigated concepts and knowledge that has, for the moment at least, no future in ATM.

All projects have documented their research results in scientific publications such as conference proceedings and in many cases scientific journals. This includes the proceedings of the SESAR Innovation Days (SIDs) where we made it a requirement for all projects to submit articles subject to a peer review-based selection process. All SIDs articles are listed in Elsevier's Scopus database and are available for free download on the conference website www.sesarinnovationdays.eu

A special edition of Elsevier's Journal of Air Traffic Management entitled 'Long-term and Innovative Research in ATM' has recently been published. The edition includes seven articles from the second wave of SESAR WPE projects.

Research networks functioned for the duration of WPE as groupings of academics and researchers with a common interest in a given topic. They organised activities such as conferences, workshops, summer universities and publication of position papers. The networks also hosted a total of 20 PhD projects completed over the duration of WPE.

WPE provided a number of occasions for researchers to meet and discuss, most notably of course the SESAR Innovation Days but also the network conferences, workshops and summer universities as well as workshops organized by some of the projects. Attendance to these events demonstrated a very 'loyal' community with links grown and reinforced over the years but also that WPE had been successful in attracting new players into the community, in many cases leading to very fruitful cooperation and common projects. All material related to the SIDs can be found at www.sesarinnovationdays.eu.

Note (since the template doesn't allow me to write it in the following section) that projects and networks produced a very large number of deliverables which are accessible through the SESAR extranet and also on most project- and network-specific web sites. It is not the purpose of this document to list them all, rather we give a high-level view of each activity below.

1.3 Work Package Deliverables

The following table presents the relevant deliverables that have been produced by the Work Package management team (if any).

Reference	Title	Description
E.01.01	ComplexWorld	A scientific network with an interest in the application of complexity science in air traffic management. Research threads included

		- Uncertainty; - Emergent behaviour; - Complex data analysis; - Non-classical, complex performance metrics; - Resilience. The network was led by Innaxis and further involved the University of Seville, DLR, NLR, the University of Palermo, and the University of Westminster. Network activities included workshops, a position paper, a book [ref. 5] and the management of seven PhD research projects. For more information see the network website at http://www.complexworld.eu
E.01.02	HALA! - Higher Automation Levels in ATM	A scientific network focussed on increased levels of automation in ATM; research threads included: - Trajectory management - Human factors - Decision Support Systems - Seamless UAS Test Bed for innovation - Control System Techniques The network was led by Universidad Politécnica de Madrid and further involved Imperial College London, KTH Royal institute of Technology, TU Braunschweig, TU Dresden, University of Toulouse, University of Naples, CRIDA, NLR, Boeing, R&TE, Deep Blue, EADS Innovation Works, GMV SKY, Pildo Labs. Network activities included the annual conference ATACCS, annual summer university courses and 13 PhD research projects. See www.hala-sesar.net for more information.
E.02.01	SUPEROPT - Supervision of route optimisers	Numerical trajectory optimization is well-studied, and with SESAR's focus on trajectory-based operations, it is logical to investigate what role trajectory optimizers might play in future ATM. However, existing trajectory optimizers tend to ignore any human role and offer interfaces only in awkward mathematical terms, for developer tuning. SUPEROPT (Supervision of Route Optimizers) looked at translations between the mathematical forms needed for optimizers and more usable human forms of behaviour and information, to see if optimizers could be exploited at lower levels of information. Project leader: University of Bristol
E.02.02	NEWO - Emerging network-wide effects of inventive operational	NEWO (emerging NEtwork-Wide Effects of inventive Operational approaches in ATM) explored

	approaches in ATM	network-wide performance and delay propagation phenomena in the air transport network linked to specific prioritisation rules applied to departure flights at airports. Project leader: ISDEFE
E.02.03	STREAM - Strategic trajectory deconfliction to enable seamless aircraft conflict management	STREAM explored innovative trajectory de-confliction algorithms supporting the concept of a rolling conflict management process that bridges the gap between strategic pre-departure flow management and conflict detection and resolution during flight execution. The STREAM concept of operations considered pre-departure and dynamic Conflict Management as part of a future, hypothetical, enhanced Network Management function. Project leader: ALG-INDRA Consortium: Boeing RTE, University of Barcelona
E.02.04	ONBOARD - Probabilistic network-based operations ATM R&D	The goal of ONBOARD was to see if improvements could be made in ATFM performance by explicitly incorporating information about uncertainty within the optimization in the Network Management planning and execution phases. ONBOARD also focused on addressing the two factors that jointly account nowadays for two thirds of the total ATFM delay in Europe: weather and knock-on effects. Project leader: GMV Consortium: Skysoft, University of Bristol
E.02.05	ASHiCS - Automating the search for hazards in complex systems	To help analysts discover hazards in complex systems, ASHiCS created a proof-of-concept tool that used evolutionary search and fast-time air traffic control (ATC) simulation to uncover airspace hazards that might otherwise be missed using traditional manual safety analysis. Project leader: University of York
E.02.06	POEM - Passenger-oriented enhanced metrics	Social and political priorities in Europe are continuing to shift in further support of passenger rights in transportation; to better measure progress in reaching such objectives, passenger-centric metrics are needed. POEM built the first full European network simulation model with explicit passenger itineraries and delay cost estimations. At the core of the project were the design of insightful, new air transport performance metrics, and their evaluation under novel flight and passenger prioritisation scenarios. Project leader: University of Westminster Consortium: INNAXIS
E.02.07	TESA - Trajectory prediction and conflict resolution for en-route to	The aim of TESA was to develop reliable Trajectory Prediction (TP) and Conflict Detection and

	en-route seamless air traffic management	Resolution (CDR) capabilities, with the specific objectives to address the sources of error (uncertainty) in TP and to use the improved TP to optimise CDR (thereby enhancing safety). The TP and CDR models were validated with real operational aircraft data and sensitivity analysis undertaken to evaluate performance. Project leader: Imperial College London
E.02.08	MUFASA - Multi-dimensional framework for advanced SESAR automation	MUFASA laid out an initial predictive framework for automation usage and acceptance, and set out to explore how these would be impacted by the possibly interactive effects of three factors: (a) traffic complexity; (b) automation level; and (c) strategic conformance, i.e. the degree to which automation's behaviour and apparent underlying operations match those of the human. Simulations were performed in which controllers were presented with conflict resolutions advisories in simplified ATC tasks; these advisories, controllers were told, were generated by a colleague or automation respectively. Project leader: Lockheed Martin Consortium: TU Delft, CHPR, IAA
E.02.09	ADAHR - Assessment of degree of automation on human roles	ADAHR carried out serious gaming sessions to assess the impact of increasing Levels of Automation (LoAs) on roles and responsibilities of ATM actors in the long-term future. The Airspace Organization and Management (AOM) and Airport Operations Centre (AOC) environments were chosen for the analysis which involved a series of paper-based and platform-based gaming sessions. Project leader: ISDEFE Consortium: CRIDA, DLR, NLR
E.02.10	MAREA - Mathematical approach towards resilience engineering in ATM	Unlike more traditional safety analysis based on human error, resilience engineering recognised the performance variance of human operators and how they deal with nominal and non-nominal conditions in their effort to support safety The objective of MAREA was to develop a mathematical modelling and analysis approach for prospective analysis of resilience in ATM. This was done by evaluating the implications of potential hazards on operator and system performance using an agent-based modelling (ABM) approach. Project leader: NLR Consortium: University of l'Aquila, VU Amsterdam
E.02.11	C-SHARE - Joint ATM cognition through shared representations	C-SHARE aimed at creating a Joint-Cognitive System, a representation of the air traffic control task in which automation would be transparent, i.e. the rational underlying its conflict detection and

		resolution advisories visible to the human operator. It was argued that such a shared representation would benefit controller acceptance and allow testing varying degrees of automation. C-SAHRE was rooted in the Cognitive Systems Engineering (CSE) and Ecological Interface Design (EID) frameworks. Project leader: TU Delft Consortium: NLR, Thales NL
E.02.12	COMPASS - Safety management in complex ATM system of systems using ICT approaches	COMPASS investigated the degree to which safety patterns extracted from historical data can be used to classify and prioritise future safety-related events (e.g. conflicts). The objectives of COMPASS were to extract such safety patterns by mining historical data, to provide an environment that can visualise the traffic crossing ATM en-route sectors and detect instances of these patterns in this traffic. To this end the history of flights, i.e. the behaviour of the same flight across different days was considered, and whenever a repetitive pattern was found, deviations from that pattern were expected to significantly impact the likelihood of safety relevant events. Project leader: Thales IS Consortium: University of York, INNAXIS, University of Aachen
E.02.13	ALIAS - Addressing liability impact on automated systems	ALIAS addressed the implications that increased levels of automation in air traffic management will have on legal liabilities, e.g. the apportionment of liability on operators, service providers and system manufacturers. ALIAS did so by developing a legal case methodology which includes a variety of supporting tools, such as (a) tables to specify levels of automation and identify tasks and duties, (b) flow diagrams to guide the assessment process, (c) maps to classify failures, identify possible liabilities and analyse their legal grounds, (d) tables and reports to embed the produced results. ALIAS also initiated an interactive network on legal issues in ATM. Although different in nature from the two main WPE networks this was a valuable additional 'mini-network' of expertise. Project leader: EU Institute Consortium: Deep Blue
E.02.14	CASSIOPEIA - Complex adaptive systems for optimisation of performance in ATM	CASSIOPEIA developed a software platform which can be used to analyse the impact of policy making and changes in operational scenarios in the aeronautical field based on Agent Based Modelling. Three case studies were developed. Case study 1 (local environmental restrictions limiting airport and terminal airspace capacity)

		considered the application of night bans in major European airports; case study 2 (en-route slot exchanges through CDM) analysed the benefits of slot exchange and slot trading between aircraft operators; and case study 3 (use of variable aircraft speeds to optimise delay cost recovery) analysed the impact of an increased use of dynamic cost indexing and different delay recovery strategies. Project leader: INNAXIS Consortium: Polytechnic University of Madrid, University of Westminster
E.02.15	UTOPIA - Universal trajectory synchronisation for highly predictable arrivals enabled by full automation	UTOPIA was motivated by the need to integrate new types of airspace users with more highly automated systems. Its objective was to provide a better understanding of trajectory management functions to efficiently manage heterogeneous traffic, specifically by studying uncertainty sources and their propagation including the potential of system disruptions; advanced trajectory management algorithms; and the use of formal language for trajectory data transmission and trajectory synchronization protocols. Project leader: TU Dresden Consortium: Boeing RTE, Barco
E.02.16	ZeFMaP - Zero failure management at maximum productivity in safety critical control rooms	ZeFMaP investigated if and how process improvement methods and tools coming from other domains can be used in the context of tower control rooms. It developed a four-step method for productivity improvement which was applied and tested at Hamburg airport tower. Project leader: SINTEF Consortium: Frequentis
E.02.17	SPAD - System performance under automation degradation	SPAD investigated the effects that higher dependence on automation and closely-coupled systems would have on the propagation of failures and the degradation of the overall system performance. It also aimed to support an effective intervention for the containment of automation degradation. To this end a federation of three different models was employed to model and understand propagation of automation degradation and its performance implications. Project leader: Deep Blue Consortium: ARMINES, University of Toulouse III
E.02.18	ELSA - Empirically grounded agent-based models for the future ATM scenario	The objective of ELSA was to analyse, describe and model the dynamics of the ATM system, especially those concerning the propagation of disturbances (performance and safety related) based on historical data. This was done through (a) an extensive analysis of data of the ATM system

		with complex systems theory techniques in order to characterize statistical regularities; (b) the development of an agent-based model of increasing complexity and degree of realism; and (c) the design of a prototype of a decision support tool, based on and informed by the results of the two other strands. The prototype mostly focused on visualising and interacting with some of the phenomena analysed by ELSA, e.g. disturbances to predictability. Project leader: Deep Blue Consortium: University of Palermo, University of Pisa
E.02.19	RobustATM - Robust Optimisation of ATM Planning Processes by Modelling of Uncertainty Impact	The efficient use of runways as the ultimate capacity bottleneck in the aviation system motivates planning yet uncertainty, inaccuracy and non-determinism almost always lead to deviations from the actual plan or schedule hence schedules are frequently re-computed and updated after the actual change in the data has occurred. A novel approach is to incorporate uncertainty into the initial computation of the plans so that these plans are made robust with respect to changes in the data, leading to a better utilization of resources and more stable plans. RobustATM developed and evaluated different techniques for 'robustification' and the trade-off between robustness and efficiency (in the nominal scenario). Project leader: FAU Nürnberg Consortium: DLR
E.02.20	AGATHA - Assessment of General Aviation & Small Airport Technology Innovation & Adaptations for Harmonisation of the ATM System	AGATHA addressed the better integration of General Aviation (GA) with commercial aviation from an equipment point of view, specifically using wireless technology in support of CNS/ATM applications and concepts to allow aircraft to safely operate in a “connected” mode. Three types of systems were studied in particular: (a) a system based on direct link and derived from the well-known LTE system, currently in deployment for ground mobile telecommunication; (b) a system based on AANET (Aeronautical Ad Hoc NETworks). This system can be considered as a multi hop air-ground communication system with each aircraft acting as a router; and (c) a system based on the VHF network as a fall back option. Project leader: ALTYS Consortium: ENAC, M3 Systems
E.02.21	SAFECORAM - Sharing of Authority in Failure/Emergency Condition for Resilience of Air Traffic Management	SAFECORAM developed a structured approach to quantify and increase the resilience of the ATM system by reallocating functions and authorities. A resilience metric was proposed based on a set of KPIs in relevant Key Performance Areas of the

		SESAR Performance Framework. A total of 12 failure mode scenarios with nominal and alternative flows were developed and resilience in each flow quantified. Project leader: CIRA
E.02.22	NINA - Neurometrics Indicators for ATM	NINA investigated the use of neurophysiological indicators (i.e. brain activity, eye blink, heart rate) to assess air traffic controllers' mental state, measuring in real time mental workload, level of training and type of cognitive control on tasks. A link with Rasmussen's SRK (Skills, Rules, Knowledge) typology was established and the model based on EEG measures was able to distinguish operator SRK states. A second project objective was to generate a set of automation solutions that use the information on the air traffic controllers' mental state to automatically adapt their behaviour, with the end goal of enhancing system performance and safety through adaptive automation. A number of innovative solutions were developed and implemented in mock-ups. Project leader: Deep Blue Consortium: Sapienza University of Roma, ENAC
E.02.23	ALIAS II - Addressing Liability Issues of Automated Systems	ALIAS II continued the work of ALIAS project (see E.02.13) with the specific objectives to extend the role of The Network of Legal Research in ATM within SESAR and to validate and consolidate the Legal Case methodology through test applications and expert interviews, in order to release, at the end of the project, a self-standing and ready-to-use methodology. It also developed digital training on the Legal Case to educate the European CNS/ATM Community to the use of the methodology. Project leader: Deep Blue Consortium: EU Institute
E.02.24	MoTa - Exploring a Gradual Transition towards Modern Taxiing	MoTa developed a tool for ground controllers to help with managing increased traffic and taking advantage of modern aircraft taxiing techniques. The tool consisted of an integrated ground control interface for use with future taxiing technologies such as datalink. In addition to the new integrated ground control interface, autonomous taxiing tugs (inspired by the TaxiBot system) were simulated. The concept is to use the tugs to continue towing the aircraft after pushback, along the taxiways until the runway holding point, thus saving fuel since aircraft engines would be started later in the taxiing sequence. Project leader: ENAC Consortium: EADS, Airbus

E.02.25	6th Sense - Increasing Fault Tolerance of Human Machine Interfaces through Sensor Fusion	6th Sense investigated to which degree interactions of the operator through a range of sensors (such as eye tracking, voice recognition and gesture control) improve the fault tolerance of a user interface. The hypothesis was that the user's intentions might be detectable through observation of his actions and by comparison with his/her inputs the quality of the decisions could be improved. An experimental set-up was implemented and simulations based on Hamburg airport control were performed. Project leader: Fraunhofer Consortium: Frequentis
E.02.26	FLITE - Future Long-term ATM Concept, Infrastructure, Technologies and Operational Environment	FLITE developed a concept of a future air traffic environment characterised by a greater diversity of vehicles and operators and reviewed the degree to which the SESAR ConOps was able to accommodate such diversity. The focus was mainly on automation technologies, which are expected to become the primary drivers of air travel efficiency and safety by 2050, especially in an environment with what is expected to be a very diverse set of air vehicles. Project leader: Imperial College London Consortium: ISA Software
E.02.27	SecureDataCloud	SecureDataCloud evaluated the feasibility and usefulness of the application of Secure Multiparty Computation (SMC) techniques to air transport problems. SMC allows parties to perform a computation on a distributed dataset without disclosing all data points in the dataset. A number of air transport scenarios were defined to facilitate sharing of confidential or competitive information between different stakeholders. The project also created a prototype allowing the execution of secure computations in two Case Studies, namely slot trading and the analysis of delay reports. Project leader: Innaxis Consortium: Telenium, TU Istanbul, DHMI
E.02.28	TREE - Data-driven Modelling of Network-wide Extension of the Tree of Reactionary Delays in ECAC Area	TREE investigated the occurrence of secondary delay in the ATM network, i.e. the mechanisms through which delay propagates through the network; connectivity is not limited to aircraft (i.e. an aircraft arriving late causes delay on the subsequent flight operated with the same airframe) but also concerns passengers (outgoing flights waiting for connecting passengers arriving late) or crew connectivity. The TREE model is data-driven in the sense that historical traffic data was used in a simplified network model.

		Project leader: ISDEFE Consortium: UIB (IFISC)
E.02.29	ACCESS - Application of Agent-based Computational Economics to Strategic Slot Allocation	The goal of ACCESS was to develop an agent-based modelling framework for the evaluation of market-based airport slot allocation mechanisms, allowing the assessment of their impact on network performance as well as on each of the involved stakeholders. Different possible designs for market-based approaches to airport slot allocation and a set of performance areas and indicators for a sound comparative evaluation of different slot allocation mechanisms were proposed. The performance framework and the modelling assumptions were refined based on two stakeholder consultation workshops. Finally the newly developed models and tools were used to assess the impact of market-based slot allocation and compare it to the performance of the current system. Project leader: Nommon Consortium: ALG, University of Valladolid, University of Trieste
E.02.30	SCALES - Resilience Potential and Early Warnings for Air Traffic Management in case of System Degradation through Enterprise Architecture	SCALES aimed to identify measurable indicators as early warnings signs of the resilience of the ATM system. The approach involved combining techniques from Enterprise Architecture (EA) and Resilience Engineering (RE) in a cyclic development process involving operational experts. The SCALES framework was a conceptual or functional prototype about what is useful for operators (what makes systems work). The framework was tested in a set of case studies from the ATM domain. Project leader: SINTEF Consortium: Deep Blue
E.02.31	ACCHANGE - Accelerating Change by Regional Forerunners	ACCHANGE analysed whether vertical institutional integration through contracts between Air Traffic Control (ATC) providers, airports and airlines in a regional context could facilitate change from within the sector in support SESAR deployment. To this end an economic public utility model to analyse the effects of SES regulations on ATC performance was developed and used to investigate incentive schemes for air navigation service providers. The economic model provided insight into the mechanisms through which regulation can drive ATM performance, as well as its limitations. The identified effects were quantified for a single, representative ANSP in Europe. Project leader: TML Consortium: HU Jerusalem, Core-Invest, ADSE

E.02.32	EMFASE - Empirical Framework for Security Design and Economic Trade-off	EMFASE started on the premise that there are no accepted methods to evaluate and compare the effectiveness of security risk assessment practices. The project addressed this gap by developing a framework to compare and evaluate risk assessment methods for security in ATM in a qualitative and quantitative manner, evaluating security benefit on the basis of trade-offs in safety, human factors or economic costs. The overall goal was to provide stakeholders with techniques to select the risk assessment methods best suited for the task at hand, e.g., security assessment in relation to introduction of a particular new system, or the need for security assessment carried out by non-security expert with tight time constraints. Project leader: University of Trento Consortium: SINTEF, Deep Blue
E.02.33	SATURN - Strategic Allocation of Traffic Using Redistribution in the Network	The objective of SATURN was to make novel and credible use of market-based demand-management mechanisms to redistribute air traffic in the European airspace. Traditional ways of dealing with capacity-demand imbalances in ATM mainly concern strategic and tactical capacity-side interventions, such as re-sectorisation and splitting sectors which results in substantial additional costs. Another approach to improve capacity-demand balancing, and capacity usage is the use of economic measures such as pricing mechanisms. Based on learning from other industries SATURN developed a set of performance areas and indicators for their evaluation and proposed three pricing mechanisms: peak-load pricing, rewarding predictability and a tradable flight permit system. Project leader: University of Trieste Consortium: Free University of Brussels, University of Belgrade, University of Westminster
E.02.34	ERAINT - Evaluation of the RPAS-ATM Interaction in Non-segregated Airspace	ERAINT performed an extensive set of real-time simulations with both an RPAS and ATC controllers in order to analyse specific aspects related to the introduction of civil RPAS in non-segregated airspace and the impact of their operations from an ATM perspective. A concept of operation was proposed to provide guidance on the safe integration of civil RPAS into the European aviation system. ERAINT specifically addressed separation provision, response to RPAS contingencies, lost link procedures, and the modification of the RPAS reference trajectory while in execution, due to mission requirements. Project leader: Polytechnic University of Catalonia

		Consortium: LevelCo, Perez Mir
E.02.35	ComplexityCosts	ComplexityCosts targeted better understanding of ATM network performance trade-offs for different stakeholder investment mechanisms in the context of uncertainty. A variety of investment mechanisms for affording network resilience and robustness were considered and the project analysed how the stakeholders' interacting tactical and strategic cost structures affect system performance. The project developed a dynamic, stochastic, multi-layered complex network model including interacting (stakeholder) elements (i.e. the behaviour of some modelled elements will be driven by others) and feedback loops, and, in so doing, giving the model a hysteresis character after multiple simulations. Project leader: University of Westminster Consortium: Innaxis, DLR
E.02.36	ProGA - Probabilistic 4D Trajectories of Light General Aviation Operations	In EASA Member States there are about 30 mid-air collisions involving a General Aviation (GA) aircraft for every mid-air collision involving a commercial aircraft. ProGA aimed at improving safety performance in this area by enabling better traffic awareness for GA pilots and alleviating their workload. One of the key elements of the ProGA concept was the derivation of GA recurring patterns based on historical traffic data. An algorithm was developed that used the GA recurring pattern information - together with shared flight intent - to estimate the flight corridor of an aircraft of which position and ground speed are known. A Human Machine Interface (HMI) was developed to present this information to a pilot using a tablet. Project leader: NLR Consortium: Deep Blue; ONERA
E.02.37	AEROGAME - Serious Gaming in ATM	AeroGame investigated how serious games can support change in ATM; it developed a hybrid game, combining a board game with an electronic score board for 4 players. Each player represents its own organization and can choose one out of six roles (ANSP, airport, low fare airline, legacy airline, government or military). Players have a combination of zero-sum and non zero-sum objectives: whilst the collaborative goal of the game is to jointly build an air traffic system capable of supporting 4D trajectory based operations each player tries to win by accumulating benefits for his/her organization. Project leader: NLR Consortium: Thales NL, University of Twente

E.02.38	ACF - Airport Capacity Forecast	ACF developed a model to estimate the operational capacity of runways based on probabilistic inputs with a lead time of up to two days. Inputs from meteorological services (wind speed, wind direction and visibility) are the major factors for determining which runways to use. Other inputs were runway availability, operational procedures and demand. The runway configuration of Amsterdam Airport Schiphol, with a complex layout of six runways, was chosen for the evaluation. A large dataset, covering runway use of 2012 and half 2013, was used to evaluate the model, which forecasts runway configurations first and then calculates capacity forecasts. Project leader: NLR Consortium: GESAC, ENAC
E.02.39	EMERGIA - Powerful Emergent Behaviour in ATM	EMERGIA evaluated the feasibility and benefits of extending airborne self-separation concepts under trajectory-based operations (TBO). In particular complexity science techniques were applied to evaluate whether certain positive emergent behaviours indicative of synergies observed in the airborne phase would also manifest itself in the ground phase of the flight. Project leader: NLR
E.02.40	IMET - Investigating the Optimal Approach for Future Trajectory Prediction Systems to use Meteorological Uncertainty Information	Uncertainties, especially in met forecasting, limit the accuracy of trajectory predictor (TP); at present TPs are mostly based on deterministic meteorological forecasts. The objective of IMET was to improve the quality of trajectory predictions by using a set of probabilistic weather predictions generated by Ensemble Prediction System (EPS). A probabilistic trajectory predictor was developed that generated an ensemble of trajectories, one of each member of the EWF. This provided uncertainty information on flight parameters such as flight duration, and trip fuel cost. The information can be used to support decision making regarding the predicted trajectory. Project leader: NLR Consortium: UK Met Office, Meteo France

1.4 Contribution to Standards and Reference Material

n/a

1.5 Work Package Conclusion and Recommendations

SESAR long-term and innovative research was different from most other work packages in a number of ways. Many lessons have been learned during the course of WPE. Each project final report (of which there are 42) includes a section, as required by the template, on lessons learned. In addition the SESAR Scientific Committee made its own observations in a report produced early 2016. These will not be repeated here. However, a few high-level recommendations are developed below and these should be taken into account for future SESAR exploratory research.

Whilst most work packages and projects in SESAR tried to bring concepts and tools to successful implementation that had themselves been subject to research at an earlier stage, WPE aimed to 'fill the research pipeline' with new ideas and concepts, producing an output that was at a much lower technology readiness level (TRL). Such research may sometimes produce innovative concepts to address known ATM problems; it may also produce promising new approaches the potential and limitations of which have yet to be better understood; and it may often explore avenues that, although initially promising, turn out to be dead ends. Such is the nature of innovative and long-term research and trying to harness it too tightly towards existing ATM challenges may deprive it of the liberty it requires to explore uncharted territory. That doesn't mean that long-term and innovative research should be disconnected from the rest of the programme, quite on the contrary: the potential of WPE and similar future research projects should be systematically assessed and transferred to other parts of the programme.

Recommendation 1: Strengthen the transfer of long-term and innovative research results to work packages at higher maturity level.

Not all long-term and innovative ('blue-sky') research projects will lead to solutions that are directly applicable and hence a relatively large portfolio of projects is desirable. On the other hand this type of research is significantly less expensive than research at higher maturity levels which often require complex software and hardware implementations (instead of mock-ups) and high-fidelity validation exercises (instead of simple experiments). As a consequence the ideal size of a long-term and innovative research project is much smaller than that of other research projects. The choices made in WPE (300 k€ co-funding for single entity projects; 600 k€ for consortia) have worked relatively well and seem to constitute the right order of magnitude. Much larger projects are likely to generate larger consortia with obvious disadvantages in flexibility and efficiency.

Recommendation 2: Maintain a portfolio with a large number of relatively small research projects, aiming at 2-4 entities and maximum funding of 1M€ or less.

Long-term and innovative research calls will mainly attract interest from academia and research centres, sometimes teaming up with industry and ANPS. Attracting researchers from new disciplines and application areas other than ATM is very desirable and should be encouraged. However not all project teams will be equally familiar with ATM and in these cases it is vital to invest effort to help them learn about the sector. In these cases projects cannot simply be kicked off and then ignored until (probably useless) documents are delivered.

Recommendation 3: Provide full, active and ongoing support to projects new to ATM to ensure their work is relevant. Provide ATM familiarisation for research project team members on a request basis, e.g. ATM initiation training.

To ensure relevance and test the applicability of concepts the vast majority of long-term and innovative research projects is driven by real data, both in the exploration and concept evaluation phase. This includes flight plan data, radar tracks, aircraft performance data, delay, etc. Accessing such data is often cumbersome and time-consuming; in some cases expensive data purchases were necessary. Ways of redressing this situation would be very worthwhile, not only because presently project effort and sometimes budget is dedicated to obtaining data, but also because the quality of the research results themselves depends on the quality of the data used.

Recommendation 4: Facilitate access to data for research purposes (e.g. flight plan data, radar tracks, aircraft performance data, delay data etc.). This includes ready access to current SESAR documentation.

2 References

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