Preparing an initial Assessment of the SESAR Concept of Operations
“EP3: Single European Sky Implementation Support through Validation”

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European Context

The ATM validation business is changing due to the need to move promising concepts quickly from research into deployment. In Europe, the focus is on SESAR, the Single European Sky ATM programme launched by EUROCONTROL and the European Commission in 2006. SESAR, which is recognised as the technological arm of the Single European Sky (SES), aims to achieve a high-performance European air traffic control infrastructure by 2020 which will enable the safe, environmentally friendly and sustainable development of air transport.

A major objective and significant challenge of SESAR is to integrate and coordinate research and development activities which were previously undertaken in a dispersed and uncoordinated manner in Europe. SESAR is currently in its definition phase, where the focus is on agreeing the future European ATM system performance goals, concept and associated research-to-implementation master plan.

SESAR will set system performance objectives that will help research organisations align their businesses. With that in mind EUROCONTROL together with 26 mostly SESAR stakeholders have developed a European Commission funded Project to undertake a first assessment of the SESAR concept of operation.
Through its 6th Framework Research Programme, the European Commission initiated EP3 (Episode 3), a €35M three year project, to undertake a detailed first assessment of SESAR, building on the SESAR Definition Phase initial conclusions.

EP3, together with the EUROCONTROL Mid-Term Concept Validation programme (MTV) will assess the SESAR gate to gate operational ATM concept aspects during a three year period. Their common goal is to deliver validated Operational Services and Environment Definitions (OSEDs) together with the associated performance justification, to SESAR stakeholders. During their lifecycle, these activities will be fully integrated into the SESAR, programme’s development phase (2007-2013), governed by the SESAR Joint Undertaking1,

**Constraints to Growth**

The Air Transport industry is a major pillar of the European economy with a predicted growth of 5 percent within Europe2, employing over 2 million people and contributing more than €130 Billion to European GDP (predicted to grow by 2.1% annually to 2020) with around 500 million passengers transported yearly by European airlines.

However, growth of Air Transport in Europe is heavily constrained by traffic congestion and delays. Considering the 5% annual traffic growth forecast by ICAO, at least a two-fold growth of Air Traffic in Europe is anticipated up to 2020.

European ATM Service provision is fragmented which has a direct influence on a number of Key Performance Areas including cost, efficiency, predictability and more importantly safety. The resulting impact is estimated at up to €1.4Bn3 annually in direct costs of en-route ATM operations alone.

Recognising the challenges facing Air Traffic Management, the European Transport Commissioner (Mr. Barrot) set the following stretch goals for SESAR:

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<tr>
<td>Safety</td>
<td>Increase 10 times</td>
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<tr>
<td>Capacity</td>
<td>Increase 3 times</td>
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<tr>
<td>ATM costs</td>
<td>Divided by 2</td>
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<tr>
<td>Environment impact</td>
<td>Reduce by 10%</td>
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1 The SESAR Joint Undertaking is an initiative of the European Commission established by a Council Regulation under Article 171 of the Treaty establishing the European Community and is co-founded with EUROCONTROL.
2 ACARE CERMAS report 2003
3 Performance Review Report 2005. EUROCONTROL.
In its first deliverable\(^4\) SESAR confirmed stakeholders’ concerns, underlining that Airports are a major capacity limiting factor whilst fragmentation and limited system integration severely impacts on ATM’s ability to support commercial schedules.

SESAR highlighted lack of common architecture and expressed concern that operators would be unable to cope with future complexity and traffic levels. SESAR recommended that the future system should be built on a common Network Plan and a comprehensive performance framework where system design treats airborne and ground systems as one.

**EP3’s Objectives and Coherency**

SESAR will deliver its concept of operations covering strategic and tactical planning phases, Air Traffic Control, Airport and Airspace User Operations, in 2007. EP3’s scientific and technical objectives are directed toward assuring that the resulting concept satisfies the required levels of performance of the future European ATM system.

This overall goal has been broken down into the following major objectives:

- Provide evidence, or otherwise:
  - That the SESAR target concept is “safe in principle”;
  - Of the performance of the SESAR target concept;
  - Of the operational viability of the SESAR target concept;
  - Of the technical viability of the SESAR target concept.
- Deliver a consolidated and detailed SESAR operational concept in accordance with assessment results.

But how can we ensure a comprehensive assessment covering such a large and complex topic? Clearly, system wide assessment is a new domain of activity which is in many ways contrary to traditional practices. One of the first considerations is that of the richness offered by the European diversity and how this must be balanced with the constraints that fragmentation brings in the European research domain.

To address diversity, the validation will be performed within the framework of the European Operational Concept Validation Methodology (E-OCVM)\(^5\). Consistent application of the E-OCVM validation methodology by EP3’s 26 partners will ensure a coherent approach to all validation activities irrespective of partner or platform.

Methodologies followed by the project will be compliant with EUROCAE ED78A and EUROCONTROL Safety Assessment methodology ensuring that EP3 can contribute to the Single European Sky Interoperability Regulation, which aims, inter alia, at expediting the introduction of new operational concepts and technology.

\(^4\) SESAR Definition Phase D1 : Air Transport Framework The Current Situation

\(^5\) [http://www.eurocontrol.int/valug/public/subsite_homepage/homepage.html](http://www.eurocontrol.int/valug/public/subsite_homepage/homepage.html)
The project deliverables, validated OSEDs, Safety and Human Factor Assessments, will serve as a strong foundation for further development by industry of means of compliance (Community Specifications) to the implementing rules supporting the regulation.

Several areas for development of Community specifications can be foreseen through the standardisation of avionics, ground systems and operational procedures.

**Performance Assessment Framework**

EP3 will support the safety, political, social, economic and environmental expectations of SESAR’s stakeholder community by addressing today’s system bottlenecks in a performance based approach. Assessments will be structured into Key Performance Areas (KPA) defined by SESAR and aligned with ICAO’s 11 top level KPA:

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<tr>
<th>KPA 01 Access and Equity.</th>
<th>KPA 07 Global Interoperability.</th>
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<td>KPA 02 Capacity.</td>
<td>KPA 08 Participation by the ATM community.</td>
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<tr>
<td>KPA 03 Cost Effectiveness.</td>
<td>KPA 09 Predictability.</td>
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<tr>
<td>KPA 04 Efficiency.</td>
<td>KPA 10 Safety.</td>
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<tr>
<td>KPA 05 Environment.</td>
<td>KPA 11 Security (not specifically addressed).</td>
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<tr>
<td>KPA 06 Flexibility.</td>
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</table>

Many of these KPA correspond to current day system performance indicators measured on an annual basis by the Performance Review Commission and published in their Annual Report\(^6\). Furthermore, they are addressed by SESAR and are increasingly recognised as a standard way of expressing ATM system performance.

The project will operate within an agreed performance assessment framework based on the performance objectives identified in SESAR, whilst current day data will be extracted from the Performance Review Report as the baseline. Through the application of KPAs, Target Levels of Performance will be allocated to each of the identified key processes of the SESAR Concept. These will be further detailed to provide descriptions matching SESAR’s “specific and measurable” performance objectives to performance indicators which will then be allocated to individual concept components.

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\(^6\) [http://www.eurocontrol.int/prc/public/subsite_homepage/homepage.html](http://www.eurocontrol.int/prc/public/subsite_homepage/homepage.html)
Clearly this will be a complex process! One approach to reducing the complexity (or increasing it?) would be to organise the KPAs as a series of sets that define how the KPA can relate to each other. This approach is proposed by Kinchin and suggests that a top level or threshold KPA (set1: Safety, Environment, Security and Access) provide targets in their own right which are supported by enabler KPA (set 2: Predictability and Flexibility). A third set represent the solution space (Interoperability; Participation ..).

Kinchin suggests that sustainability “the holy grail” is the “balance between the threshold variables, the need to deliver capacity and the trade-off with the composite costs and environment”.

Performance Trade-off

The diversity of business objectives amongst the ATM stakeholders will inevitably necessitate an equitable balance in the assessment of the results and the orientations these may suggest.

EP3 will organise trade-off to agree indicators-to-concept and then of results, to achieve an equitable consensus.

The trade-off approach has been defined using current business methodologies laid down in a nine step approach to multi criteria decision making. This has been adapted and developed by the London Business School and EUROCONTROL for System Performance Trade-Offs.

Influence Analysis techniques will have to be developed by EP3 and will form part of achieving consensus in trade-offs to take account of the interdependencies between performance objectives and associated metrics and stakeholder expectations.

Performance and Operability Assessment - Approach

EP3 applies a top-down validation and assessment strategy directed toward key concept processes through a two cycle “double V” validation strategy. This is underpinned by a Work Breakdown structure focusing on system consistency and specialised poles.

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7 The Performance of Medium Term Concepts of Operation, ICON/EUROCONTROL, January 2006
8 System Performance Trade-Offs: Application of Methods and Tools. EUROCONTROL
At the highest level, System Consistency ensures a coherent validation approach, developing the project operational and validation requirements and experimental plan and consolidating results, whilst the technical assessment is built across the specialist poles to provide the technical assessment of the concept elements.

The three specialist poles include:
- Collaborative Planning Processes which aims to refine and validate the key processes that occur during the strategic and pre-tactical phases of ATM operations (from 18 months to the day of operation);
- Traffic Management/Synchronisation Processes which aims to refine and validate identified processes corresponding to the tactical phase;
- Conflict Management Processes which aims to refine and validate the identified processes corresponding to the management of separation.

In Cycle one, process validation activities will focus on solving generic concept issues whilst Cycle two will undertake detailed assessments in regional and local environments from the most constraining areas of Europe. This philosophy ensures that the reality of implementing the future concept is assessed under local conditions whilst still ensuring an integrated concept approach.

EP3 has constructed 19 Validation Areas that serve to group SESAR Concept Elements for assessment through a sequence of classical and innovative assessment tools including:
- Expert Groups providing initial qualitative assessment against selected KPA in relation to operability, safety and human factors whilst also developing validation scenarios;
- Gaming exercises providing human assessment of strategic decision making processes feeding fast-time simulation and analytical modelling;
• Fast-time modelling performance assessment and a scalable set of analytical performance models: macroscopic\(^9\) mesoscopic\(^{10}\) and microscopic\(^{11}\); based on different types of analysis techniques (e.g. Queuing, Analytic, Dynamic and Stochastic) filtering scenarios and options for real-time simulation and trade-off activities, and
• Real time air and ground based simulation providing qualitative operational assessments valuable for developing the concept and common understanding.

A comprehensive assessment environment will be developed for both cycles with a generic environment for cycle 1 whilst cycle 2 will further focus assessment activities which will be conducted on specific local validation environments, including:
• En-route and Extended TMA/Approach real time simulation environments for Maastricht, United Kingdom, Spain, France, and Italy, Germany and the Netherlands local airspace and TMA conditions;
• Tower/Airport in Sweden and the Netherlands;
• Human in the Loop collaborative decision making environments adapted to cover collaborative process validations, specifically in collaborative planning and dynamic traffic management involving ATFCM, ATC, Airlines and airport processes, and
• The top level system operability model, iteratively revised to reflect the findings of local level assessments ensuring continued operability, coherency and robustness of the groupings of SESAR services and processes at a system view, over the ECAC area.

Technology Assessment

A set of validation facilities will be developed by European manufacturing industry partners to undertake a technical validation of key concept aspects including impact of 4D trajectory on FMS and FDPS plus ASAS applications on avionics. At this detailed engineering level significant platform structures such as test benches and test harnesses will be used to verify and validate individual and integrated system components.

European Validation Infrastructure

Assessment activity will exploit the partners’ validation capabilities throughout Europe in a developing European Validation Infrastructure framework during the two validation cycles. This is the first instantiation of a European Validation Infrastructure (EVI) which will target common architecture and design for real time simulation platforms and tool

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\(^9\) A Macroscopic model describes entities and their activities and interactions at an aggregated level of detail, usually based upon mathematical equations.

\(^{10}\) Mesoscopic models generally represents most entities at a high level of detail but describes their activities and interactions at a much higher level of detail than a microscopic model would, and some elements and/or activities are aggregated.

\(^{11}\) A Microscopic model describes both the system entities and their interactions, and each element or activity is completely separated from the others.
sets and a harmonised approach to model requirement capture. EVI will ensure common procurement of model enhancements bringing cost efficiency into R&D.

**Deliverables**

Operational Services and Environment Definition documents (OSED) that detail the SESAR Concept of Operation and are validated by the assessment process described above are the key deliverables of this 3 year programme. Associated to the OSED will be the performance and operability output that will justify the OSEDs.

OSEDs are a deliberate choice to ensure that industry standards are applied to deliverables to integrate the strategy of expediting research-to-implementation and to assure continuity and comprehension between the manufacturer of systems and the architects of the next generation European ATM system.

The graphic depicts the current air system process for achieving standards and certification. The same requirements are being developed under Single European Sky legislation for ground systems and it may therefore be expected that a similar process be adopted by ground system manufacturers and applied by the SESAR JU.

A final delivery will involve education and dissemination to cover the many stakeholders not directly involved in SESAR but who need its output for implementation decisions.

**Conclusions**

The success of EP3 is largely dependant upon the ability to assemble the correct balance of representative “stakeholders”. Their needs, expectations and requirements will be the drivers in establishing the validation strategy and evolutions to the concept, taking into account the inevitable trade-offs that must occur between the major performance axis, i.e. Safety, Security, Efficiency, Capacity, Environment and Sustainability.

Through EP3, Europe is initiating specific, focused performance and delivery driven research in accordance with the European ATM Master Plan driven from SESAR, assembling the European research community around common goals and reducing many of the inefficiencies generated through diverse National interests and programmes.