SESAR: PERSPECTIVES ON AUTOMATION

Olivia Nunez (SJU), SIDs 2014
The SESAR Programme


It pools together the knowledge and resources of the entire ATM community through a public-private partnership – the SESAR Joint Undertaking.
Implementing the Single European Sky

5 pillars

Performance
- Performance scheme
- Performance Review Body
- Functional Airspace Blocks
- Network Manager
- National Supervisory Authorities

Safety
- EASA Crisis coord. cell

Technology
- SESAR
- European ATM Master Plan
- SESAR Joint Undertaking
- Common projects

Airports
- Airport observatory

Human factor
- Specific sectoral dialogue Committee
- Consultative expert group on social dimension of the SES

FROM INNOVATION TO SOLUTION
SESAR is Approaching the Deployment Phase

**Development Phase**
- Develop new standards, operational procedures and technologies

**Deployment Phase**
- Implement results of development to meet performance targets

**Definition phase**
- Create European ATM Master Plan

**Timeline**
- **2005-2008**
  - 06/2009 Launch
  - 07/2009 400 contributors, 20 projects
  - 09/2009 Airlines on board
  - 03/2010 1,500 contributors, 300 projects
  - 06/2011 GA&R in the ConOps at a Glance
  - 10/2012 Rotorcraft Operators (EHA) full involvement

- **Today**
  - 3000+ contributors
  - 35+ validation exercises
  - 17 SESAR Solutions

FROM INNOVATION TO SOLUTION
HP SESAR VALIDATION LIFECYCLE

**V1**
- Operational and technical scope
- Potential performance benefits

**V2**
- Feasibility/acceptability
- Detailed task analysis, HMI
- Impact on teamwork, training needs
- Performance Measurement
- V2 Performance assessment

**V3**
- Pre-industrial development and integration
- HP case to support Business Case
- HP into Safety Case (HEA)
The HP assessment process

STEP 1
- Define reference and solution scenarios for validation, as well as assumptions
- Identify related projects
- Review maturity

STEP 2
- Identify relevant HP arguments
- Identify and prioritize HP issues, impacts and benefits. Define HP validation objectives.
- Develop HP assessment plan

STEP 3
- Identification of normal and abnormal operating conditions
- Run validation activities
- Analyse results and improve the concept

STEP 4
- Manage HP recommendations and requirements
- Produce HP assessment report
- Is the concept ready for transition to the next V-phase?
# HP Arguments used in SESAR

<table>
<thead>
<tr>
<th>Arg. 2</th>
<th>Technical systems support the human actors in performing their tasks.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>In order for the technical systems to support the human in carrying out their tasks, the usability of the technical system must be assured. Usability is the extent to which a system allows people to achieve goals (tasks) in an effective, efficient and satisfactory way (HF Case v2.0).</td>
</tr>
<tr>
<td>Arg. 2.1</td>
<td>There is an appropriate allocation of tasks between the human and machine (i.e. level of automation).</td>
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<td>Allocation of tasks between the human and machine relates to the level of automation introduced, i.e. the extent to which tasks are controlled/performed by the human operator or the machine.</td>
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<tr>
<td>Arg. 2.1.1</td>
<td>The task allocation between the human and the machine is consistent with automation principles.</td>
</tr>
<tr>
<td></td>
<td>The level of automation/distribution of tasks between the human and machine must be consistent with HF automation principles. Relevant HF automation principles are mentioned in the list of HP activities and required evidence.</td>
</tr>
<tr>
<td>Arg. 2.1.2</td>
<td>Changes to the task allocation between human and machine support human performance.</td>
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<td></td>
<td>The proposed changes to task allocation must not negatively affect human performance and hence the ability of the human actor to achieve their tasks. The impact of the changes in the task on situational awareness, workload, human error/ performance must be considered.</td>
</tr>
<tr>
<td>Arg. 2.1.3</td>
<td>Transition from automatic to manual modes and vice versa, human-intended or failure induced, can be performed by the human actors in a timely, efficient and accurate manner. [not applicable in V1]</td>
</tr>
<tr>
<td></td>
<td>The change in mode of operations from automatic to manual and vice versa must be clear to the human actor (to ensure that mode errors are mitigated). Also, the actions required by the human actor in response to the mode change must be easy to perform.</td>
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<tr>
<td>Arg. 2.1.4</td>
<td>The level of workload (induced by the allocation of tasks between the human and the machine) is acceptable.</td>
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<td></td>
<td>Subjective workload relates to an individual’s perception of the effort expended to perform a task/set of tasks. Subjective workload is induced by cognitive and physical task demand</td>
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</tbody>
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SESAR HP assessment process in practice

Three examples of how human/automation interaction is assessed in SESAR:

- Remote Tower
- Time Based Separation (TBS)
- i4D operations
SESAR SOLUTION: Remote Tower for Single Airport

The Remote Tower concept enables Air Traffic Control services (ATCS) and Aerodrome Flight Information Services (AFIS) to be provided at aerodromes where such services are either currently unavailable, or where it is difficult or too expensive to implement and staff a conventional manned facility.

Benefits
What is a “Remote Tower”? 

• Aim of Remote Tower Research in SESAR:
  • Development and assessment of an operational concept that enables the cost effective provision of Air Traffic Services (ATS) at one or more airports from a control facility that is not located in the local ATS Tower.

• Validation Targets:
  • It is feasible to provide ATS from a remote facility;
  • Human Performance is not negatively impacted and is at least as good as with current operations (from a local Tower). Any instances of Human Performance degradation are either mitigated or acceptably offset by improvements in other areas;
  • Safety levels are maintained; and
  • The airspace and runway capacity for the target candidate environments is not negatively impacted by the Remote Provision of ATS under normal conditions, and may be positively impacted.
Remote Tower Classification

- Remote Tower ATC services (single tower)
- Remote TWR Airport Flight Information Services
- Contingency Tower services
- Remote Tower ATC services (multiple tower)
HP Arguments for Single Airport Remote Tower (1/2)

Role of the human is consistent with human capabilities/limitations

How does the human role change:
- visual separation (basic vs. advanced RT),
- degree of focus on radar rather than visual,
- MET observations,
- workload,
- abnormal conditions: what if screen freezes?,
- trust

Technical systems support to human actors

Latency, how auto-identification and tracking would help (re-locate aircraft after attention had been focused elsewhere) + allow for visual separation,

Pixilation and picture freeing at dawn/dusk (need IR), which MET information needs to be provided,

Controller Working Position (CWP), cameras must work in rain and other met conditions and be able to be automatically cleaned remotely,

Pan Tilt Zoom (PTZ) cameras instead of binoculars,

Limit number of screens (integrated CWP), auditory information and SA, how distances are judged on screen,

Set-up/viewing angle to avoid eyestrain,
Effect on team structures and communication

Need for maintenance technicians for new equipment, allocation of certain tasks (e.g. METOBS) to airport staff rather than ATCOS, phraseology, impact on perception of ATC authority, relationship and communication between RT and airport

HP-related transition factors

State tower is RT on first contact, need for ATCOs to remain tower controllers (rather than radar/simulator controllers), need to maintain ATCOS knowledge of the local environment/aerodrome as if they worked there, how professionally stimulating new setting is, staffing levels
RT Single Airport Standardization

- EUROCAE WG-100 kicked-off summer 2014
- MASPS related to visual presentation are expected to be published summer 2016:
  - Resolution
  - Glare
  - Latency
  - Blur effect
  - Etc.
Time Based Separation (TBS) provides a consistent time spacing between arriving aircraft in order to maintain runway approach capacity, no matter the headwind conditions.
Time-Based Separation (TBS)

Aircraft land against the wind

Wind dissipates wake vortex faster

Ground speed (GS) = TAS – Headwind

Higher headwind (HW) = Lower GS

2.5NM wake vortex separation LM-LM

60 seconds 150 KT no HW (GS = 150 KT)

70 seconds 150 KT and 20 KT HW (GS = 130 KT)

With HW, less wake vortex danger, but we separate more!
TBS: Controller Support Tools

Extended Runway Centre-Line Distance Markings

Separation Indicators to Support Turn Decisions on to Final Approach

Requires updated AMAN sequence

Additional applications: Support for implementation of variable separation targets for additional purposes (06.08.04 AMAN/DMAN integration)
Role of the human is consistent with human capabilities/limitations

Need for pilots to be briefed on TBS, TWR/APP role allocation (in particular supervisory roles), reversion to Distance Based Separation (DBS) if situation becomes abnormal, need for ATCOs to increase speed monitoring,

Technical systems support to human actors

HMI to clearly differentiate between TBS and DBS (avoid mode error), need to look at TCAS/TBS interaction, time when TBS indicator should be removed (extend from threshold to touchdown?), SA and workload levels are maintained, separation for wake-pairs is more accurate, how clutter on screen may be reduced (selectively eliminate mile marker?), adequate level of trust, possibility to incorporate compression factor into future evolutions of the TBS tool.
Effect on team structures and communication

RT usage remains the same, phraseology needs to be adapted to support TBS

HP-related transition factors

Need for ATCOS to maintain DBS skills, training needs, transition: first implement DBS with indicators and then gradually reduce distance between indicators to TBS minima
i4D and Controlled Time of Arrival (CTA)

Advisories to ground

- TTL/TTG
- Speed advisory
- Route advisory

Airborne solution

AMAN generates planned time

Why not send aircraft the time and let them self-manage?
I estimate the metering point at 15:04, but I could adjust my flight to be there between 15:00 and 15:06.

Desirable equipage:
- RTA (+-10 sec 95% confidence)
- ADS-C
- CPDLC
i4D: Operational Use of EPP

Lateral discrepancy to be resolved by ATCO:
- Uplink (CPDLC) ground route (only dct possible in VP-463, more to come...) or more likely...
- Update ground trajectory to match EPP

Ground Trajectory Prediction (TP)

Route discrepancy indicator (2D)

EPP downlink (FMS trajectory)
- Estimates according to FMS horizontal speed schedule
- Altitudes / flight levels according to FMS vertical speed schedule

Source: 04.03 D64 draft (MUAC RTS)
Role of the human is consistent with human capabilities/limitations

New tasks for air crew and controllers, increased use of airborne managed mode, cockpit workload increase: wind/temp update, trajectory and RTA insertion into FMS, need for controllers to monitor separation between aircraft that may be self-managing speed/descent profile, workload in the event of CTA cancellation

Technical systems support human actors

Controller HMI, display of EPP route, 2D route discrepancy indicator, how CTA operations are to be displayed, avoid controllers to focus only on CTA aircraft, mixed equipage
Effect on team structures and communication

RT vs. CPDLC usage, air crew task allocation for new tasks (between PF and PNF), ATCO task allocation (planning controller/executive controller),

HP-related transition factors

Training needs, mixed equipage
## i4D + CTA HP LOG (in progress)

<table>
<thead>
<tr>
<th>Arg.</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Arg. 1.2.5:</td>
<td></td>
<td>Operating methods can be followed in an accurate, efficient and timely manner.</td>
<td>Not satisfied</td>
<td>Open</td>
<td>Air/Ground</td>
<td></td>
<td>Evaluate adequacy of recovery procedure in case of CPDLC failure while ADS-C remains operational</td>
</tr>
<tr>
<td>12</td>
<td>Arg. 3.3.3: Changes in communication means &amp; modalities are identified and acceptable.</td>
<td></td>
<td>4D operations require a lot of Controllers-Pilots communications - for RTA and route negotiation. The use of DataLink as communication mode would contribute to maintain workload at an acceptable level and to ensure a good level of communications reliability, making 4D operations acceptable.</td>
<td>Not satisfied</td>
<td>Open</td>
<td>Airborne</td>
<td>High</td>
<td>Safety: Assess the impact of the CPDL communication mode (including load function) on communication workload</td>
</tr>
<tr>
<td>13</td>
<td>Arg. 3.3.3: Changes in communication means &amp; modalities are identified and acceptable.</td>
<td></td>
<td>The use of ADS-C as means of synchronisation of air and ground trajectory predictions would contribute to reduce the number of radio communications and therefore to maintain workload at an acceptable level.</td>
<td>Not satisfied</td>
<td>Open</td>
<td>Airborne</td>
<td>High</td>
<td>Safety: Assess the impact of route synchronisation via ADS-C or workload</td>
</tr>
<tr>
<td>15</td>
<td>Arg. 3.3.3: Changes in communication means &amp; modalities are identified and acceptable.</td>
<td></td>
<td>Voice is the primary communication medium between pilots and ATCOs, and CPDLC is used for non time critical communications and 4D negotiation. The conditions of voice reversion could be difficult to understand (after RTA refusal, or RTA missed). The crew and ATCO may use inappropriate communication means: - if they use CPDLC instead of voice, thus the information may arrive too late and/or the workload may increase. - on the contrary, if they use voice instead of CPDLC, it may block the frequency and affect more critical voice exchanges.</td>
<td>Not satisfied</td>
<td>16</td>
<td>Open</td>
<td>Air/Ground</td>
<td>Low</td>
</tr>
</tbody>
</table>
Human Error Analysis in SESAR

• Errors are classified according to error type:
  – Detection error
  – Interpretation error
  – Planning error
  – Execution error

• HEA is performed **qualitatively**

• Use of quantitative error analysis has been discussed, but not adopted

• NexGen uses qualitative error analysis, but probability of error is used in some cases
Conclusions

• A good HP assessment process is needed to prevent that tools are deployed and end up not being used
• There is a need to balance the need for strategic control (where automated tools thrive) with the need to retain flexibility in the system (to account for uncertainty)
• Transition factors are key to ensure success
Thanks for your attention