Introduction to the SESAR Concept of Operations

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The SESAR Concept of Operations

- SESAR performances objectives
- SESAR Concept Highlights
- The next steps
Current status of the SESAR concept

The SESAR Concept of Operations is not finalised

This presentation is an overview of the current situation

What is left to be done:

• Issues to be solved
• SESAR Stakeholders buy-in and approval
• Ensure feasibility by:
  – architecture, technologies
  – CBAs and institutional enablers
The performance objectives of the SESAR concept

D2 has delivered performances objectives and targets

Main Concept design drivers:

- **Capacity x 3** for traffic increase + headroom for flexibility
- **Safety x10**
- **Users Costs -50%** per flight
- **Environmental impact -10%** ATM impact per flight

Efficient **Gate-to-Gate** and **Enroute-to-Enroute**\(^{(1)}\) operations that accommodate the **user’s requirements** and priorities:

- Maximise capacity and minimise constraints.
- Minimise uncertainties/maximise economic performance for all stakeholders

\(^{(1)}\) Relating to TMA entry to TMA exit on next flight. Encompasses airport air-side and ground-side operations.
Concept Highlights
Focus: the SESAR concept paradigms ...

At the heart of the SESAR concept of operations:

• **trajectory-based operations** respecting the airspace user’s individual business cases

• **Improved conflict management**
  • Shifting from tactical intervention to strategic deconfliction
  • Redistribution of tasks between ATM partners
  • Improved system automation support
  • The human remains the most flexible and creative element to:
    – achieve the performance of the overall ATM System
    – manage the threats, errors and unpredictable events
The Human in the SESAR Concept

**AOC/Mil**
- Active role in all phases of the planning processes.
- Ensures the users business objectives for a flight are met.
- More direct impact on ATM decisions - communicates company preferences.

**Pilots**
- Ultimate responsibility for the safety of the aircraft.
- Ensure the aircraft operates in accordance with ATC clearances and Air-Ground trajectory negotiations.
- May be assigned separation tasks or responsibility.
- Supported by automation: for separation tasks and performance and conformance monitoring.

**ATC Civ/Mil**
- Strategic conflict reduction through precision planning: lower level of tactical intervention.
- Active separation role but may assign separation tasks or responsibility in defined circumstances.
- Supported by automation: for conflict tasks and system performance and conformance monitoring.

**LANDSIDE**
- Active role in all phases of the planning processes. Ensures the users business objectives for a flight are met.
- More direct impact on ATM decisions - communicates company preferences.
The Twin Pillars of the Concept

SESAR Concept of Operations

TRAJECTORY MANAGEMENT
- Business Trajectory
- 4D Trajectory Management
- Trajectory Ownership
- Advanced Acti Capabilities
- Collaborative Planning

CONFLICT MANAGEMENT
- Collision Avoidance
- Separation Provision
- Automation Support
- Queue Management
- Airspace Organisation/Mgt.

Demand/Capacity Balancing
- Airport Operations

Airspace Organisation/Mgt.

TRAJECTORY MANAGEMENT

System Wide Information Management/Collaborative Decision Making
Trajectory-based operations
Why Trajectory Based Operations

The Trajectory Management concept:
- entails the systematic exchange of aircraft trajectory data between various participants in the ATM process
- ensures that all participants share a common view of a flight and have access to the most accurate data available to perform their tasks.

4D trajectory supports:
- Collaborative Decision Making,
- Planning and analysis
- System automation

4D Trajectory Management supports a degree of pre-deconfliction of traffic flows
- resulting in less tactical interventions during flight execution.
The Business Trajectory

4D Trajectory expresses the Business/Mission intention of the airspace user

Fully owned by the airspace user:
- Changes only via CDM processes involving user (does not interfere with ATC/Pilot tactical decision processes)
- When constraints are needed the solution is chosen by the user whenever possible

Based on most timely and accurate data available
- Sources: AOC, Airborne Automation, ANSP, 3rd Party on behalf user.
- Normally the relevant ANSP will compute trajectory for Military or non-capable users during flight.

Exists throughout all phases of the ATM process
Business Trajectory Lifecycle

EXECUTION PHASE
- Executed BT
- Predicted Trajectory (PT)

ATM Network System Wide Information Sharing
- Network awareness
- Constraints Shared BT
- Constraints Ref. BT
- Cleared RBT

PLANNING
- Developing BDT
  - historic perf. data, new perf. targets
- Optimising SBT
  - may or may not contain constraints
- Updating RBT
  - network constraints

BUSINESS DEVELOPMENT
- Sufficiently Stabilized
- Most up to date data
- Accurate take-off time

Years ➔ Months ➔ Hours/Minutes ➔ Take-off

Airspace User Domain

Network constraints

Ref. BT

RBT

Predicted Trajectory (PT)

Cleared RBT
Reference Business Trajectory (RBT)

Trajectory that airspace user agrees to fly and the service provider agrees to facilitate.

RBT executed by the flight crew unless there is intervention for the purposes of separation provision, other safety related needs or queue management.

Aircraft guided by Airborne Automation from take-off to landing. Taxi out/in executed by the crew supported by advanced tools to increase adherence to the agreed taxi routes and times.

RBT_\text{A}: the CLEARED part

RBT_\text{P}: segments from the limit of authorisation to trajectory end.

PLANNED RBT_\text{P}

Cleared RBT_\text{A}

EXECUTED RBT_\text{X}
Two Key Separation Concepts

The High Complexity Operations:
- Used in the most complex airspace (TMA and high density en route Airspace),
- Priority is to maximise capacity so that the TMA airports can operate at their full capacity.
- This capacity can only be achieved at the cost of some constraint on the Reference Business Trajectory (RBT).

The Medium Complexity Operations:
- Used in almost throughout all En Route Europe (above a TBD level, FL200?).
- Priority is to allow flights to operate as near as possible to their business trajectory whilst eliminating all en-route capacity constraints.

Separation concept is defined in space but possibly also in time
Progressive exploitation of the dimensions of Control:

- **2D-RNP routes** are being designed/deployed now that allow ‘deconflicted’ routes to be more closely spaced laterally.
  - This will enable more SID and STAR routes to be introduced whilst reducing the need for tactical intervention.

- Design and deploy **3D-PNR routes** (tubes and funnels) which more tightly constrain the vertical dimension
  - Allow more deconflicted routes to exist within the complex airspace
  - The 3D routes closest to RBT will be allocated as far as practicable

- **4D separation** along the 3D routes by using time/speed control, ASAS-SM
The High Complexity TMA Concept

Concept Elements:

- Dynamic allocation of ‘best available’ departure and/or arrival route.
- Clearance conformance monitored independently on ground and in the air.
- MTCD continuously monitoring for separation infringements.
- Conventional (less efficient) SIDs and STARs for non-equipped flights
- No tactical intervention for 3D flights (provided they are in conformance)

Transition:

- Operates with any mix of 2D/3D/4D capable flights. The higher the overall capability level the higher the resultant capacity.
- Flights that equip early can benefit immediately in TMAs that have reorganised and re-equipped to utilise the capability.
The Medium Complexity Operation Concept
Driver: Optimise Efficiency, Flexibility, Treble Capacity

Techniques evolve towards 4D control/4D Contracts

- 4D Trajectory management and improvements in Trajectory Prediction provide more accurate conflict detection and conformance/intent monitoring
- Aircraft operate as far as possible on user preferred routes
- Continuous update of the RBT by the Aircraft (Trajectory Management Requirement)
- Strategically de-conflict 4D capable flights (by 4D-Contract clearances) to further reduce the need for tactical intervention.
  - Provide priority to 4D contract flights to encourage equipage.
- Concept allows for flights on ASAS self-separation but implementation will be at the limits of the SESAR timeframe:
  - In managed airspace the decision on authorising ASAS self-separation is with the ANSP/ATC.
  - Self-separating aircraft in managed airspace will be fully participating in the 4D process i.e. are known to the system.
The Medium Complexity En-Route Concept

Concept Elements:

- RBT is the basis for separation
- Arrival constraints (when within AMAN horizon) incorporated in RBT
- Clearance conformance monitored independently on ground and in the air.
- MTCD continuously monitoring for separation infringements.
- Minimising of the traffic complexity
- Priority and No tactical intervention for 4D contract flights
- Conventional control techniques used to control non 4D contract capable Aircrafts.
- Pre-requisite is improved upper wind data (from down-linked data)

Transition:

- Concept operates with any mix of 2D/3D/4D capable flights. The higher the overall capability level the higher the resultant capacity.
- Flights that equip early can benefit immediately in UIR/FAB that have reorganised and re-equipped to utilise the capability.
## Separation Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Detection</th>
<th>Separator</th>
<th>Separation Minima</th>
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<tbody>
<tr>
<td>Conventional</td>
<td>Ground</td>
<td>Ground</td>
<td>Conventional</td>
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<tr>
<td>Task Allocation to flight crew</td>
<td>Ground</td>
<td>Air</td>
<td>Airborne (TBD) or Visual</td>
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<tr>
<td>(Includes ASAS and Visual methods)</td>
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<tr>
<td>Dynamic Allocation of 2D Routes</td>
<td>Ground</td>
<td>Ground</td>
<td>Lateral</td>
</tr>
<tr>
<td>Dynamic Allocation of 3D Routes</td>
<td>Ground</td>
<td>Ground</td>
<td>Lateral/vertical</td>
</tr>
<tr>
<td>4D Contract</td>
<td>Ground</td>
<td>Ground</td>
<td>Lateral/vertical/time</td>
</tr>
<tr>
<td>ASAS Self-Separation</td>
<td>Air</td>
<td>Air</td>
<td>Airborne (TBD)</td>
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"Conventional" includes a known and up-to-date 4D trajectory, communicated within a SWIM environment e.g. via data link supporting controller automation tools.
The defining characteristic of 4D contract flights versus other 4D-capable flights is that the 4D contract flight will stay inside its containment. This allows to use 4D contracts as separation method and reduces workload drastically.

- 4D contracts will be segmented with the likely optimum segment length being in the order of 20-30 minutes (or FIR/FAB transit)

4D contracts are issued on the basis of the RBT if conflict free.

- If not, a conflict-free alternative will be negotiated.

4D contract flights will be treated as ‘non-deviating’ and will therefore have priority over other flights.

- ATC will separate conventional flights from 4D contract flights by tactical intervention applied to the conventional flight.
- Self-separating flights (if any) will manoeuvre to avoid 4D contract flights.

All tactical actors must know which flights are on 4D contracts
ASAS Applications

Many ASAS applications can be utilised within either or both these concepts:

- **Situation Awareness** – On the airfield and in the air
- **Sequencing and Merging** – In TMA for merging and longitudinal spacing of the arrival stream and for longitudinal spacing of ‘same route’ departures. Also for en-route spacing if airspeeds are compatible
- **Crossing and Passing** - In en-route delegated separation task/responsibility to resolve specific conflict situations, potentially reducing controller workload.
- **Self-Separation** – the aircraft is responsible for separation from all other traffic

All of these applications provide a measure of Air/Ground redundancy significantly extending the current SNET overlap between ACAS and STCA.
Continuous Collaborative Refinement (2)

UNCERTAINTY ABOUT TRAJECTORY REDUCES THROUGH TIME
Demand and Capacity Balancing

The goals are:

• More flexible capacity and adapted to match predicted demand in order to never jeopardize the safety
• The constraints on the demand are minimized and the Reference Business Trajectory (RBT) is as close as possible to the initial Shared Business Trajectory
• To make the best use of the available resources

Network management function:

• Central and regional components,
• Actions mediated by CDM
• Independent of Users and Service Providers

Links to User Assisted Delay Management (UADM)
User Assisted Delay Management

Airspace will have sufficient capacity to cope with demand in normal circumstances.

There will be more (c 50?) airports which are working at capacity for significant periods of the day:

- Most delay allocation will be the result of shortfalls in capacity at airports already running full.

Once runway slots are known, delay will be allocated by users working collaboratively according to their own priorities (UODM):

- The process is dynamic: real-time CDM,
- The process is opaque as far as ATM is concerned: only the outputs are needed (but economic and legal regulators will be interested),
- This process answers the commercial/mission needs of the users and maximises capacity by being reactive,
- The Network Management Function may act as an ‘Honest Broker’.
Airspace Organisation

**UNMANAGED**
- Low Density
  - ‘Free’ routes

**MANAGED**
- Mid-High Complexity/Density: Sustained Throughput
  - User Preferred Routes and 3D/2D Routes (route structure for TMA transition)
  - 4D Contracts: ANSP Sep – Priority When Cleared
  - Conventional ATC: ANSP separates from 4D Contracts
  - ASAS-SS: Authorised by ANSP: ‘Give Way’

**MANAGED**
- Low-Mid Complexity/Density
  - 2D Routes
  - ANSP Sep (ASAS-SS)
  - ‘Like today’: More efficient

**UNMANAGED**
- Low Density
  - ‘Free’ and fixed Routes
  - FIS and On-Demand services
  - Aircraft Self Separation
  - Similar to current ‘Class G airspace’

**MANAGED**
- Very High Complexity/Density
  - 3D-PNR Tubes; 2D-RNP SID/STAR
  - Closely spaced, separated routes
  - All Operations - ANSP Sep
  - ASAS-SA/SM

Introduction     Concept Highlights     Open Issue
Reconciliation of the needs for diverse airspace use
(Civil - military airspace management)

- More flexible and more real-time allocation of reservations for military needs according to military mission profiles (FUA concept).
- Created in a way that the reservations are the least hindrance to civil airspace users’ business trajectories while ensuring the successful completion of the missions of the relevant users.
- This comprises a planning process taking into account the business trajectories and the mission needs by AMC.
- Military Variable Profile Areas (MVPA) will be restricted and tailored to the airspace dimensions needed for the mission.
- The dynamic variable profile and mobility trajectory exclusion (DVMTE) allows for properly equipped aircraft to avoid the temporary trajectory exclusion volumes with a minimum business trajectory disruption.
Airports
Operating Principles

Enroute-to-Enroute Concept: Linking the arrival and departure segments with turnaround management, effectively managing flight as a single continuous event.

Advanced CDM processes improve common situational awareness involving the entire ground turnaround process.

Airport operational planning is based upon the Business Trajectory planning process:

- Information on landing time, constraints, turnaround time, airport capacity and taxiing time.

The “UODM” approach aimed at achieving the business objectives of the airspace users

- When demand exceeds capacity, net system benefit may override individual benefits.

Airports are full participants in the ATM process
Runway Operations

Capacity and Throughput:
- Use of airports linked by high-speed train connections ("Clustered runways") to increase regional capacity
- Use of technologies like MLS, GLS, Synthetic Vision could mitigate effects of Low Visibility - also environmental benefits of curved approaches
- Closely Spaced Parallel Runways: independent operations down to 300 m from WV perspective, has to be linked with other future applications.
  - Offset approaches with 1.5NM diagonal separation could be an alternative

Separation:
- Reduction of separation on final approach and on departure using ASAS tools and time based final approach spacing
- Wake Vortex: better classification of aircraft and vortex detection and prediction to minimise separation

Runway Occupancy:
- Use of "brake to vacate"-technology
- Interlaced Take-off and Landing (mixed mode operation) for optimum runway utilisation.
**Surface Movement and Environment**

**Surface Movement Operations**
- Better situational awareness for controllers and pilots by A-SMGCS and its link to Cockpit Display technology
- The taxiing process considered as an integral part of the process chain from arrival to departure
- Use of these technologies on a broad basis not only addresses capacity issues, but also enhances safety

**Environment**
- Definition of the operational procedures that best minimise the environmental impacts of airport activities
- Specific flight paths such as curved approach and continuous descent procedures.
- Ensuring that environmental assessments are carried out by considering the trade-offs among the different effects (e.g. noise vs. gaseous emissions).
- Reduction of both ground and airborne queues
SESAR Concept of Operations

The next steps
The next steps

Mid-March 07: Identification of a recommended Concept

Mid-May 07: Definition of the SESAR ATM concept

30 Jun 07: Delivery of D3

30 Nov 07: Delivery of D4: the transition
End
Meeting SESAR goals for capacity, environment and cost-effectiveness while ...

**CAPACITY**
- 4D Trajectory Mgt.
- 3D Routes/4D Contracts/ASAS
- Advanced Automation-Air/Ground
- Advanced Aircraft Capabilities
- New Airport Capabilities

**ENVIRONMENT**
- Optimal Profiles
- Minimise Holding
- Eliminate Ground Queues

**COST EFFECTIVENESS**
- Business Trajectory
- Optimal Profiles
- Maintain Throughput
- Minimise Holding
- Eliminate Ground Queues

In the real world it is a trade-off
... Enhancing Safety.

Accuracy, predictability, conformance: (1)(2)(4)
De-conflicted DEP/ARR routes: (1)(2)(3)
Reduced tactical intervention: (2)(3)
Assimilate, analyse, act in a timely manner: (4)
Improved situational awareness: (4)(5)

ENROUTE

De-conflicted DEP/ARR routes: (1)(2)(3)
Reduced tactical intervention: (2)(3)
Assimilate, analyse, act in a timely manner: (4)
Improved situational awareness: (4)(5)
Enhanced tactical separation assurance: (4)(5)

TMA/ETMA

Accuracy, predictability, conformance: (1)(2)(4)
Reduced tactical intervention: (2)(3)
Assimilate, analyse, act in a timely manner: (4)
Improved situational awareness: (4)(5)
Enhanced tactical separation assurance: (4)(5)

1. Advanced aircraft capabilities
2. 4D Trajectory Mgt & 3D/4D route concepts
3. Strategic deconfliction
4. Advanced automation support
5. ASAS capabilities

AIRPORT