Feasibility Studies on the Integration of Military Ground and Aircraft Systems in the SESAR Concept and Architecture

“Capability Gaps between Military Systems and SESAR”

Executive Summary
Feasibility Studies on the Integration of Military Ground and Aircraft Systems in the SESAR Concept and Architecture

1 Background

EUROCONTROL, through the Directorate Civil-Military ATM Co-ordination (DCMAC), sponsored two external studies (ground and aircraft systems) aiming at determining Capability Gaps between Military ATM/CNS Systems and the SESAR Concept and Architecture. These tasks have been commissioned to ALTRAN SUD-OUEST.

The ALTRAN Group is composed of a wide network of companies which makes accessible sound knowledge and expertise in a large variety of domains. ALTRAN SUD-OUEST was invited to provide an independent expert judgement on the best options to consider military systems integration in SESAR thus guaranteeing the objectivity, impartiality and transparency of the recommendations.

The methodology applied by ALTRAN in both ground and airborne systems studies comprised a description of the current situation (including interviews with relevant Stakeholders), the assessment of SESAR requirements and identification of areas with insufficient levels of interoperability between civil and military systems. This was the basis to propose potential R&D efforts and rationalisation options.

To a large extent the conclusions and recommendations of these studies are based on the interviews (and responses to questionnaires) that ALTRAN conducted with the German Armed Forces ATS Office, French Air Force, Italian Air Force, Royal Netherlands Air Force, NATO and industry.

Subsequent consultation took place within the EUROCONTROL Civil-Military CNS Focus Group (CNS FG). Without prejudice to further analysis and consultation it was found useful to disseminate the findings of these studies to provide to the SESAR Joint Undertaking, ATM planners and military organisations a better picture of the challenges ahead in the context of SESAR.

2 Objective

The objective of these studies is to have a clear overview of the impact on ground and aircraft system infrastructure aspects supporting civil-military coordination by listing the capability gaps and:

- Promoting performance-based solutions.
- Proposing civil-military ATM/CNS system interoperability and longer-term technology convergence.

Military ground and aircraft systems ATM/CNS capabilities are mapped against SESAR architecture and technology requirements to identify existing infrastructure mismatches and assess potential technology solutions.

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1 Single European Sky ATM Research - the European ATM infrastructure modernisation programme.
2 Air Traffic Management/Communications Navigation Surveillance.
## 3 Capability Gaps

### 3.1 Main Capability Gaps - Ground Systems

<table>
<thead>
<tr>
<th>SESAR concept or architecture element</th>
<th>Capability Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 SWIM – Net-Centric Architecture</td>
<td>Limitation of military ground systems (including ATC and AD/C2 (e.g. NATO Air Command and Control System – ACCS)) to be able to exchange services with SWIM. This requires update of inconsistent information formats and models (e.g. harmonisation of Flight Plans and Aeronautical Information).</td>
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<tr>
<td>2 SWIM and Ground COM Technology</td>
<td>Selected military ground systems lack the required level of interoperability to provide connectivity and exchange services with the IP-based ground communications Pan-European Network Services (PENS).</td>
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<tr>
<td>3 SWIM and Ground COM Technology</td>
<td>Military Message Handling Systems (MMHS) are not configured to have some level of exchange with the emerging Aeronautical Message Handling Systems (AMHS). Gateway-based solutions may provide transitional capability and security aspects need to be tackled.</td>
</tr>
<tr>
<td>4 SWIM and Air-Ground COM Technology</td>
<td>The data link capabilities of military aircraft might not include, in time and for all aircraft types, a VDL Mode 2 or a Future COM capability. Ground systems and interfaces to enable equivalent support (accommodating MIDS/Link 16) should be envisaged.</td>
</tr>
<tr>
<td>5 SWIM - Aeronautical Information and Meteo</td>
<td>Military Aeronautical Information Management (AIM) and meteorology systems might not be fully compatible with SESAR requirements if to be used as contributors to the overall (civil) AIM and meteo services.</td>
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<tr>
<td>6 4D Trajectory Management</td>
<td>Conceptual detail and validation is not yet done on how Military Mission Trajectories will interact with Business Trajectories and how military Wing Operations Centres (WOC) and Command and Control (C2) systems will process the associated information.</td>
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<tr>
<td>7 4D Trajectory Management</td>
<td>Data management capabilities of military ground systems will need to evolve to support 4D Trajectory instances in terms of Shared, Reference, and Ground-Predicted Mission Trajectory functions.</td>
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<tr>
<td>8 4D Trajectory Management</td>
<td>For military aircraft without FMS, equivalent capability might have to be provided to process Reference Mission Trajectory from supplementary support from WOC ground systems.</td>
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<tr>
<td>9 Technology Assessment - Rationalization of CNS Infrastructure</td>
<td>Military systems contribution to the overall rationalisation of SESAR infrastructure to be maximized, for example, through radar data sharing or utilisation of TACAN stations to improve DME coverage supporting DME/DME navigation application used as backup of GNSS.</td>
</tr>
<tr>
<td>10 Technology Assessment - Surveillance</td>
<td>SESAR predicts a mixed surveillance environment comprising MSPSR, SSR Mode S, WAM, Surface Movement Radar, Airport Multilateration (A-SMGCS), ADS-B and Enhanced Visual Systems. Current military surveillance infrastructure includes PSR and SSR. Capability gaps might exist when military SUR systems have to support civil traffic.</td>
</tr>
<tr>
<td>11 Aerodrome Systems</td>
<td>Military ATC systems performance and capabilities used on military aerodromes might not be sufficient to support service provision to commercial traffic.</td>
</tr>
<tr>
<td>12 Approach Systems</td>
<td>Military ATC systems performance and capabilities used on military TMA/Control Zones (CTR) might not be adequate to support service provision to commercial traffic (e.g. availability of approach and lauding Navaids).</td>
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</table>
### 3.2 Main Capability Gaps – Aircraft Systems

<table>
<thead>
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<tr>
<td>Technology Assessment – Air-Ground Voice</td>
<td>Air-ground voice communication capability requires equipage with VHF 8.33 kHz radios. Many military aircraft will not be retrofitted in time and will have to be accommodated in UHF or VHF 25 kHz.</td>
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<tr>
<td>Technology Assessment – Air-Ground Data Link</td>
<td>Air-ground data link capability onboard military aircraft is limited or inexistent in relation with ATM applications (e.g. VDL Mode 2 supporting CPDLC). An interoperable air ground data link is required to support trajectory management, air-ground SWIM, ADS-B ASAS, CPDLC and other applications. Possible equipage with civil data links, re-use of military data links (e.g. MIDS/Link 16) and convergence to Future COM data links should be considered.</td>
</tr>
<tr>
<td>Technology Assessment – Air-Air Data Link</td>
<td>The same gap exists in terms of air-air data link capability useable for ATM exchanges (e.g. ADS-B In). Again the use of military data link might be envisaged.</td>
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<tr>
<td>Technology Assessment – ADS-B</td>
<td>Military aircraft ADS-B capability is not yet planned but can easily be achieved using Mode S Extended Squitter or other data link, at least for ADS-B Out capability.</td>
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<tr>
<td>Technology Assessment – Navigation Positioning</td>
<td>Military aircraft have NAV positioning capabilities in many cases with higher performance levels than civil aircraft but possibly not fully compliant with configurations foreseen in SESAR (e.g. ABAS with RAIM, RNAV computer supporting DME/DME). When migrating to GNSS environment specific military systems (e.g. GPS/PPS, GALILEO PRS, TACAN) might be re-used if capable of providing equivalent NAV performance.</td>
</tr>
<tr>
<td>Technology Assessment – Navigation Positioning</td>
<td>Some military aircraft might be considered as compliant with vertical performance navigation requirements (RVSM capability) if, in addition to barometric height monitoring, GNSS vertical positioning would be used.</td>
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<tr>
<td>Technology Assessment – Approach and Landing</td>
<td>Many military aircraft are equipped with Multi Mode Receivers (MMR) that may have a Differential GPS capability. It remains to be confirmed whether all DGPS configurations available onboard military aircraft are interoperable with GBAS stations. SBAS capability is not widely available in military airframes but its introduction could be advantageous for some aircraft types.</td>
</tr>
<tr>
<td>Technology Assessment – Trajectory Management</td>
<td>Most military aircraft are not equipped with civil Flight Management Systems (FMS). This capability is required in SESAR to support advanced 4D trajectory management/4D contract and specific approaches (e.g. CDA). However, Military Mission Systems (MMS) or Mission Computers are available in many military airframes and could provide equivalent trajectory management or flight control functionalities. Alternative fall back might be supplementary support from ground systems.</td>
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<tr>
<td>Architecture – Airborne integration</td>
<td>To ensure that civil and military avionics can co-exist in military aircraft where there is a lack of cockpit space, multi-mode avionics solutions have to be developed through the use of software defined radio technology and possibly military POD systems.</td>
</tr>
<tr>
<td>Standardisation and Certification</td>
<td>A key gap is the lack of mechanisms and processes to ensure that the certification of military systems can be recognised by civil regulators as equivalent certified through equivalent verification of compliance. Aviation standards supporting certification should cover military requirements.</td>
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4 Outline of Conclusions

Ground Systems

Concerning Ground Systems the studies emphasised that the military ATC services organisational model differs considerably from State to State. This explains the current lack of military systems harmonisation and interoperability and justifies procurement and deployment decisions mainly taken at State level. Therefore, the conclusions presented in the study have to be considered in the framework of the local organization in each State.

The typical interactions between civil and military ground units (ATC and Command and Control/Air Defence) and the CNS infrastructure in place have been taken as the basis for further analysis. The diagram below shows examples of interactions, in many cases unidirectional.

The Ground Systems study has identified particular existing or planned military ground system capabilities or technologies that could support the abovementioned interactions and offer equivalent functional capability and performance in line with the requirements identified in SESAR.

Based on the identified ground system capability gaps the need for specific SESAR Research & Development (R&D) activities can easily be determined.
The main recommendations for R&D concerning ground systems are related to the need for a seamless interaction between military ground systems and SESAR structures and functions. Examples are: net-centric System Wide Information Management (SWIM), Trajectory Management, rationalisation of underlying CNS infrastructure and need to accommodate aircraft with capability mismatch through ground systems support.

A key aspect to be further investigated, as presented hereafter in the aircraft systems study conclusions, is the utilization of military data link capabilities for ATC purposes that will have, to a certain extent, to be supported by a ground infrastructure probably including military Link 16 ground transceivers. Trajectory management exchanges might also have to be supported by specific ground systems to provide the required service to military users when interconnected with SWIM.

In summary, the proposals for Ground Systems R&D include:

- Investigation of options to interface military systems with SWIM with particular focus on security aspects and interoperability with NATO ACCS.
- Study of solutions for ground systems support of Military Mission Trajectory exchanges including SWIM air-ground data link connectivity.
- Assessment of options for military approach/aerodrome connectivity with SWIM structures.

**Aircraft Systems**

In terms of Aircraft Systems, the study summarises the capabilities of military aircraft and, starting from known capability gaps, discusses how to achieve the required levels of interoperability or technology convergence between civil and military ATM/CNS enablers.
It concluded that there is a lack of interoperability between military avionics and SESAR infrastructure due to the fact that military combat aircraft are essentially weapons platforms whose equipage priorities are decided in accordance with specific military mission requirements. The consequence is an evident capability mismatch that needs to be overtaken by retrofitting or by following a performance-based approach that enables available military systems to be re-used to support SESAR ATM functions.

The study took also into account that capability gaps and possible solutions may vary depending on the type of military aircraft.

In terms of communications capabilities, two main technological domains have to be addressed: air-ground voice and data link.

It has been recognized that an important effort is underway concerning VHF 8.33 kHz equipage for aircraft flying above FL195. However, the evolution of voice communication regulations requirements and technologies should be monitored to assess the impact of plans for VHF 8.33 kHz usage below FL195 and investigations of new digital voice technologies.
Civil-military data link interoperability, both for the air-ground and air-air segments, should be put in place in order to support new applications (e.g. 4D trajectory) in SESAR. This may be achieved through reusing existing military data link technologies and converge with civil Future Communication Infrastructure in the longer term.

Military aircraft navigation capabilities (incl. the use of military avionics for horizontal and vertical positioning (RVSM) and timing/flight control) will have to be reassessed in a trajectory based operation context, to demonstrate the compliance to SESAR performance levels. In parallel, real-time trajectory execution will require some improved Flight Management System (FMS) (equivalent) functionalities onboard military aircraft.

Most of the current technologies required by SESAR in the surveillance domain are becoming available (e.g. Mode S Elementary Surveillance - ELS) or are already onboard military aircraft (SSR). Emerging SUR technologies may become critical to support SESAR applications in particular for air-air surveillance purposes (e.g. ADS-B).

An overarching requirement to implement these the civil-military interoperability solutions is to ensure that mechanisms and processes are put in place to develop aviation standards that take into account military requirements facilitating the equivalent certification/verification of compliance of military aircraft systems.

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Disclaimer:
The positions and views expressed in the ALTRAN studies shall be seen as expert-level advice.
5 List of Acronyms

A-SMGCS Advanced Surface Movement Guidance and Control System
ABAS Aircraft-Based Augmentation System
ACCS Air Command and Control System (NATO)
AD Air Defence
ADS Automatic Dependent Surveillance (C - Contract, B – Broadcast)
AIM Aeronautical Information Management
AMHS Aeronautical Message Handling System
ASAS Aircraft Separation Assurance System
ATC Air Traffic Control
ATM Air Traffic Management
CDA Continuous Descent Approach
CNS Communications, Navigation and Surveillance
C2 Command and Control
CPDLC Controller-Pilot Data Link Communications
DCMAC Directorate Civil-Military ATM Co-ordination
DGPS Differential GPS
DME Distance Measuring Equipment
FMS Flight Management System
GNSS Global Navigation Satellite System
GPS Global Positioning System
MMS Military Mission System (FMS-alike)
MSPSR Multi-Static Primary Surveillance Radar
PENS Pan-European Network Services
POD Bay/pod hard mounted to points on the outside of the aircraft, typically located on the wing
PPS Precise Positioning Service
PRS Public Restricted Service (GALILEO)
PSR Primary Surveillance Radar
RAIM Receiver Autonomous Integrity Monitoring
RNAV Area Navigation
RVSM Reduced Vertical Separation Minima
SBAS Space-Based Augmentation System
SSR Secondary Surveillance Radar
SWIM System Wide Information Management
TACAN (UHF) Tactical Air Navigation Aid
TIS-B Traffic Information System – Broadcast
TMA Terminal Manoeuvring Area
VDL VHF Data Link
WAM Wide Area Multilateration
WOC Wing Operations Center