Dual Use CNS Concept for Military
Research approach and opportunities for civil-military ATM/CNS interoperability
EXECUTIVE SUMMARY

The European ATM Master Plan (Edition 2015 – Military Executive Summary) identified the need for SESAR to seek “Infrastructure interoperability on the basis of solutions/synergies that enable the maximum level of reutilisation of existing military capabilities.”

Military operators permanently strive for the recognition that the capabilities available onboard modern military aircraft can sustain civil Air Traffic Management/Communications, Navigation and Surveillance (ATM/CNS) requirements. A Dual Use CNS approach is paramount to optimise equipage and to drastically reduce the technical impact and cost upon military from civil aviation infrastructure modernisation initiatives.

The civil-military technical solutions defined and validated within SESAR follow, in many cases, such Dual Use CNS concept. Dual Use represents simply the optimal use of military capabilities to sustain civil requirements. Nevertheless, it is important to underline that the equipage priorities of military platforms will always be determined from their primary military mission requirements.

The present leaflet is partially derived from a EUROCONTROL paper awarded at the 2018 Integrated Communications Navigation and Surveillance (I-CNS) Conference in Washington U.S. on 10-12 April 2018. It describes the EUROCONTROL understanding of the Dual Use CNS concept for Military, as it is usually applied in SESAR research, and identifies potential interoperability opportunities for future research, notably SESAR, in that domain.
Military operators permanently strive for the recognition that the capabilities available onboard modern military aircraft can sustain civil Air Traffic Management/Communications, Navigation and Surveillance (ATM/CNS) requirements.

The reutilization of military avionics to support ATM functions can drastically reduce retrofits and integration costs. Specific military operations and training require a segregated environment. Nevertheless, an increasing number of military flights needs to be accommodated in common airspace volumes, shared with civil traffic, relying on a common underlying ATM/CNS infrastructure. More than 150,000 military General Air Traffic (GAT) flights have been carried out in the European Civil Aviation Conference (ECAC) region annually in the recent years1.

As the ATM/CNS infrastructure is improved and modernised, civil-military interoperability, instead of equipage exemptions, becomes a fundamental enabler to ensure the required levels of military connectivity and performance in a globally interoperable context.

That is valid in particular when there is a need to cope with modernised ATC systems, new network centric data exchange structures, advanced satellite-based navigation and aircraft avionics that need to be more cooperative with the underlying surveillance and data communications infrastructure.

Military aircraft are essentially weapon systems. Consequently, military aircraft compliance with civil ATM/CNS requirements is very difficult to achieve due to numerous constraints, including the size of the military fleet, its multiple aircraft types and variants, budget constraints, technical integration difficulties, unsynchronised procurement cycles and lack of recognized certification processes.

Civil-military interoperability solutions for the optimal re-use of military capabilities are to be subject of focused industrial research considering the following CNS evolution trends:

- increasing connectivity and higher automation levels (sometimes referred as "digitalization")
- combined satellite-based, airborne and ground-based CNS
- more performance-based CNS
- aircraft-centric concepts and modular avionics architectures
- more secure and resilient infrastructure
- focus on efficient use and increased sharing of radio spectrum aviation bands
- more focus on services and applications than on physical equipment and remote/virtual provision.

The Dual Use CNS concept is one of the options for military to face such civil ATM/CNS evolution opening the door to huge benefits by enabling seamless operational handling of military flights, increasing interoperability, avoiding duplicated equipage and drastically reducing investments on CNS retrofits. Research initiatives are crucial for such objectives.

---

1 EUROCONTROL CNS Dashboard tool
Focused research is a fundamental step to define and validate technical solutions to enable the reutilization of military capabilities to cope with civil ATM/CNS requirements taking into account their identified performance levels.

The Dual Use CNS approach (illustrated in Fig 1), was recognized in the European ATM Master Plan and to large extent followed in the Single European Sky Research (SESAR) Programme in respect to civil-military R&D initiatives. It is in line with the principles and good practices described in the EUROCONTROL Roadmap on Enhanced Civil-Military CNS Interoperability and Technology Convergence (Edition 2.0) endorsed by the Military ATM Directors on 17 October 2013. This document states that:

- the need for an exemption for State aircraft should be based on compelling technical or military imperative reasons and only used as a last resort;
- instead of implementing special procedures, the first approach should be to enhance interoperability;
- there is a need to consider performance-based approaches minimising retrofit efforts by meeting compliance on the basis of enabler-independent options;
- new requirements should be introduced, preferably as forward fits, and agile capability approaches should be maximised, including the reutilization of avionics, multi-mode capabilities and appropriate obsolescence management.

Dual Use CNS can bring significant benefits to military operators when facing the modernization of civil aviation infrastructure even if it represents only one of the options to cope with such technology evolution challenges. The required research steps to define and validate technical solutions must be seen as independent of subsequent efforts to produce alternative technical standardization materials, safety assurance cases and optional certification processes that will be also required before industrialization and deployment.

Between 2009 and 2015 a particular SESAR 1 research project defined and validated a specific solution for Automatic Dependent Surveillance – Broadcast (ADS-B) to be enabled on board military aircraft using existing military transponders.

This work included the assessment of interoperability opportunities offered by the re-utilisation of different types of military Identification Friend or Foe (IFF) equipment.

This project culminated with a series of live flight trials, in September 2014, using airborne prototypes that provided unprecedented evidence that modern military aircraft can be interoperable within a civil ADS-B environment in a cost-effective way. These successful validations indicated that military aircraft compliance with civil ATM/CNS requirements, in a cost effective manner, must be progressed by decoupling equipage from performance and making use of low-cost adaptations and interfaces for avionics already in operation. Truly collaborative industry partnerships such as SESAR are crucial to progress such Dual Use CNS approaches.
DUAL USE CNS OPPORTUNITIES

Avionics Modularity

The following diagram (Fig 2) depicts the functional breakdown of a generic avionics suite which must be used as a reference for the information provided in this section:

![Generic Avionics Suite Diagram](image)

There is a wide variety of military aircraft types, models, variants and upgrades and their specific roles or missions require dissimilar architecture configurations. Nevertheless, the functional architectures of some military aircraft can be compared with civil mainline aircraft as far as ATM/CNS components are concerned. Additional functions fulfilled by military aircraft, specific to their mission, are not of interest for ATM/CNS.

Although it is difficult to identify common architecture principles for multiple platforms, it is important to highlight that the state-of-the-art Integrated Modular Avionics (IMA) architecture, used for civil mainline aircraft, derive from military programmes. IMA was first developed in the context of a modern fighter programme in the U.S. IMA is now widely used by Airbus and Boeing and for multiple civil and military aircraft. IMA became the most important architecture principle for aircraft avionics.

The IMA Core System relies on a set of standard modules communicating across a common backbone bus/network. The IMA Core System receives its inputs from the platform’s sensors. The digital processing that occurs within the IMA Core System includes all the typical functional applications normally associated with avionics platforms: vehicle management, mission management, stores management, communications, navigation and identification, target detection & tracking, head up displays, etc.

In the IMA Core System, the functional application software is available in mass memory-storage devices and it is downloadable to the modules upon which they are to execute as part of the system initialisation and configuration processes.

![Integrated Modular Architecture (IMA) Diagram](image)
In summary, the IMA Core System can be viewed as a single entity comprising many integrated processing resources that may be used to build any avionics system function regardless of its size and complexity. Therefore, IMA offers an excellent basis to enable dual use of particular aircraft functions, as multiple systems can be architected and overlaid on the partitioned platform resources to form a highly integrated system with full isolation and independence of each individual system.

Consideration of IMA to support Dual Use CNS may require additional research but it surely offers a promising option to address the challenges put by the increasing avionics predominance and functional allocation principles of 5th generation fighter aircraft due to its modularity and multimode avionics principles of the relevant AoR.

Flight Management System

Military aircraft are typically equipped with a Mission Computer (MC) or Military Mission System (MMS) that are to some extent different from civil Flight Management Systems (FMS). The MC enables the crew to create, retrieve, modify and store flight plans. Once a particular flight plan is to be executed, the MC calculates the parameters, and provides estimated times along the route with estimated fuel burn rates. The flight plan and data are displayed on the control panel display.

A typical transport-type military aircraft MC is able to store about 200 waypoints. Operator-selected identifiers can be inserted for waypoints other than the reference database waypoints. Once an active flight plan has been entered, the MC provides the capability to make special edits to the flight plan, to add various attributes to waypoints, and to perform a variety of functions.

The Mission Computer provides the capability to store navigation data to or load data from the navigation database generating displays of navigational solutions for selectable navigation modes. The MC is also able to calculate and provide navigation guidance e.g. during non-precision approaches. In summary, the Mission Computer processes and provides guidance information relating to the active waypoint in the active flight plan.

The MC provides also an interface for the pilot/co-pilot flight instruments and the auto-pilot/flight director. The MC provides selectable solutions for guidance and signals to drive the pilot and co-pilot flight directors and flight instruments.

When implementing 4D trajectory management functions, eventually deemed to be implemented in military aircraft, it may be required the support by MC/MMS, similar to FMS, or emulated by ground systems. This is an aspect that should warrant the fullest attention in future research.

When existing as an independent component, the FMS provides electrical interfaces, interface control and flight...
Communications Equipment

Radio communications between aircraft and ground receiver sites, supporting voice communications between pilots and air traffic controllers, is ensured through VHF radios (HF and SATCOM used in oceanic regions). For similar air-ground voice requirements the military rely on UHF radio communications, which are also provided by certain civil ANSPs when handling State aircraft operating GAT without VHF 8.33 kHz channel spacing capability.

Civil aviation is presently introducing new concepts that rely on air-ground data exchanges, instead of voice, namely Controller Pilot Data link Communications (CPDLC) and Trajectory Management. Currently, such data link communications are supported by VHF data link radios, namely the ICAO-compliant VDL Mode 2 protocols.

The definition, validation and standardisation of the next generation of air-ground data link technologies is underway in the context of SESAR and ICAO. Such higher capacity technologies comprise a terrestrial segment (LDACS), satellite communications (SATCOM) and airport data link (AeroMACS). It is collectively designated Future COM Infrastructure (FCI). FCI and its related multi-link concept offers significant opportunities for civil-military interoperability.

Knowing that the available military air-ground data communication technologies are not useable in the ATM context and that present communications requirements are not (yet) fully defined as performance statements, there are no substantial dual use opportunities in this domain. Conversely, the ongoing research developments to define the next generation of data link technologies for ATM (Future COM Infrastructure) must be influenced for relevant civil-military requirements to be adequately considered.

Sensor Equipment

Sensors are the equipment able to provide data to onboard computational equipment (i.e. MC/MMS and FMS) and to communication systems (i.e. VDL Mode 2 radio). Sensors are for example:

- INS (Inertial Navigation System) with gyros and accelerometers
- GPS (Global Positioning System) also used to fix INS drift errors
- TACAN (Tactical Air Navigation Aid)
- VOR (VHF Omnidirectional Radio Range)
- DME (Distance Measurement Equipment)
- Radar Altimeter
- TCAS (Traffic Alert and Collision Avoidance System)
- TAWS (Terrain Avoidance Warning System)
- ILS/MLS (Instrumental Landing System/Microwave Landing System)

These sensors are able to provide information about position, velocities and accelerations (angular and linear). This data is generated for the purpose of navigational performance and guidance.

The eligibility of sensors available in military aircraft is usually one of the important constraints for military systems compliance with civil ATM/CNS requirements. This is particularly evident in the case of compliance with PBN navigation specifications.

In fact, today’s satellite-based navigation services used by military are predominantly based on restricted signals like GPS/PPS (and possibly in the future Galileo/PRS). Usually, military inertial systems get updates from this restricted signal and not from DME/DME thus preventing Inertial Reference Unit (IRU) from eligibility. Other navigation fixing means could be used, particularly on combat aircraft, such as data link, radar, TACAN or terrain correlation in some cases.

The dual use of satellite restricted signals, e.g. GPS PPS, is an important subject to be considered for research efforts. Research investigations must focus on the determination of performance levels to compare with civil navigation requirements, in respect to GPS SPS receivers and hence GNSS, and the need for specific signal processing modes, which may increase the complexity and cost of the receivers.

Civil developments on advanced navigation concepts relying on GNSS augmented signals (e.g. EGNOS/ SBAS), area navigation and the development of multifrequency/multiconstellation receiver architectures will raise more complex civil-military interoperability challenges.

For military sensors in general, tactical aircraft with airborne architecture constraints could be handled by addressing the equivalence of military TACAN, GPS PPS, GALILEO PRS and INS performances. The determination of military sensors eligibility shall consider existing integration architectures e.g. Multimode Receivers (MMR) and GPS/GNSS coupling. For demanding requirements that imply reliance on augmented GNSS signals, the availability of multifrequency/multiconstellation and multi-tracking capabilities, other specific technical solutions are still to be defined and validated.

Control Panels and Displays

There are various Multi-Function Displays (MFD) located on the main instrument panel of military aircraft. Typically, there are two Primary Flight Displays (PFD) and two Navigation Displays (pilot and co-pilot), as well as two central system displays where aircraft status parameters are showed. All displays are multipurpose and so the pilot can decide the information to be shown in each display.

The Multipurpose Control Display Units (MCDUs) provide the primary operator interface via an alphanumeric keyboard, mode select keys, line select keys, annunciators, and a flat panel display. The two MCDUs are redundant to each other, and both MCDUs can communicate with either MC. The crew may operate any MCDU at any time, call up different pages on the MCDUs without affecting what appears on the other, and override the default operation. Synchronization of data between the MCDUs is handled by the MC.

All avionic systems are interconnected to allow access and control of nearly all flight plan management parameters, as long as one MC and one MCDU are available. The communication radio management function acts through MCDU as the control for the VHF/UHF and HF radios. The navigation radio management function acts also through MCDU as the control for the TACAN, VOR, and ADF navigation radios. MCDUs are also used to control the IFF transponder and to select SAR functions.

![Figure 5 - Displays and Control Panels](image-url)
The Communication Management Display (CMD) is used to reduce the pilot workload associated with the MCDU, and to provide pilots with a head up means of using the radios. CMD provides the pilots with an alternative way of tuning the communications and navigation radios. The CMD is also capable of using the FMS database to tune navigation radios. The CMD can also control the IFF modes.

CMD provides the possibility of controlling the VDL Mode 2 Radio. ADS-C contracts are managed with this control panel as well as the uplink and downlink CPDLC messages which are visualized in association with CMD.

IFF Control Panel consists of a control panel identical to the CMD but dedicated only to IFF. IFF Control Panel can be used as an alternative way of controlling CMD. The IFF control panel provides the pilot with power control, mode control, mode test control, code selection, and zeroize control. Available civil surveillance transponder modes are: 3/A, C, S ELS/EHS. Military IFF Modes are: 1, 2, 4, 5.

The Digital Autopilot/Flight Director (DA/FD) system interfaces with the autopilot system control panels as well as the other components of the avionics system. Two identical and interchangeable DA/FD Automatic Flight Control Processors (AFCPs) are connected to the aircraft avionics data buses.

Adaptation of airborne displays and integration with multiple avionics is a key constraint to the potential military compliance with civil ATM/CNS functions. Dual Use initiatives in this domain require innovative approaches at the level of software applications and overarching architecture modules. For the particular case of PBN, this matter needs to be subject of in-depth studies to propose mitigations.

Other Dual Use CNS Opportunities

In the communications domain, as civil requirements start to be defined on the basis of performance levels, it is important to continue research efforts on how Future Communications Infrastructure (Future COM) technologies, (e.g. new terrestrial data links, SATCOM and airport data links) can be enabled and used by military aircraft to sustain potential interoperability requirements in terms of air-ground CPDLC and Trajectory Management.

In terms of advanced navigation, the implementation of Performance-Based Navigation offers substantial opportunities to apply a Dual Use CNS approach as described before but technical solutions are still to be defined and validated in the context of European research. Re-drafting of PBN specifications may also be envisaged for more extreme cases if still in line with operational needs.

In the context of surveillance, the main interoperability area relates to ADS-B implementation in military aircraft which must be adequately coordinated with the equipage efforts in relation to IFF Mode 5. In this respect, the future research efforts must complement the work conducted in SESAR 1 to conclude the validation of the feasibility of using military transponders (Mode S component) to support ADS-B.

Other areas that remain open for research initiatives are the eventual use of multi-mode avionics relying on software defined radios and reliance on enhanced visual systems and airborne surveillance to mitigate airborne collision functions.

The advent of Unmanned Aircraft Systems (UAS) / Remote Piloted Aerial Systems (RPAS) represents a huge challenge for aviation. Accommodating UAS/RPAS in non-segregated airspace, without any increase in risk to other airspace users, calls for focused research on the technologies supporting the incremental integration of UAS/RPAS in European airspace. UAS/RPAS research must be at the leading edge of pioneering aviation technology progress and could also catalyse next research steps in finding advanced data link solutions, new collision avoidance alternatives, and low-cost navigation-related technical solutions, as well as determining parameters for autonomous flying operations.

The compliance of the core system software to the civil standards for software design assurance level can be anticipated as crucial for equipment approval. Some aspects of those research domains would require strong involvement of National Authorities to address the specific security and institutional constraints.
In a nutshell, the essential civil ATM/CNS requirements, applicable in European continental airspace, that impact military aircraft,\(^2\),\(^3\) (it must be understood that State aircraft in general face the same challenges) of different types that need to conduct operations in mixed controlled airspace (e.g. as GAT/IFR) comprise:

- Air-ground voice relying on VHF 8.33 channel spacing
- Air-ground data link for CPDLC and Trajectory Management (ADS-C)
- Navigation applications including defined PBN specifications and functionalities for en-route, terminal and approach & landing flight phases
- Reduce Vertical Separation Minima (RVSM)
- FM Immunity of VHF receivers
- SSR Mode S ELS and EHS
- Automatic Dependent Surveillance – Broadcast (ADS-B)
- Aircraft Collision Avoidance System (ACAS)
- Enhanced Ground Proximity Warning Systems (EGPWS) /Terrain Awareness warning Systems (TAWS)

To comply with those requirements, a significant number of transport military type aircraft may simply be forward fitted as civil mainline. In fact, modern military large transport-type aircraft will be expected to feature equipage solutions that cope simultaneously with civil and military requirements. As there are no significant limitations in terms of cockpit space and aircraft integration, this type of aircraft will increasingly be equipped in line with civil requirements.

Nevertheless, Dual Use CNS technical solutions have to be defined for those aircraft types, validated and industrialised to avoid overlapping equipage fittings through avionics rationalisation and by taking advantage of multi-mode performance-based solutions.

Combat aircraft are war-fighting platforms that have limited cockpit space for additional avionics fit. For this particular type of aircraft, the integration of civil ATM/CNS onboard equipment is often problematic. For fighters, the preferred approach to attain the desired levels of civil-military interoperability should be on the basis of maximum reutilisation of available capabilities, performance-level solutions and multi-mode avionics.

This approach must be also applicable to face the upcoming introduction of 5th generation fighter aircraft with its increasing avionics complexity and functional allocation principles. In this case, Dual Use CNS research must place a particular focus on technical challenges related with system integration, modularity and software-defined avionics architectures.

In line with the Dual Use CNS opportunities described above, the immediate research needs that would respond to the identified performance-based ATM/CNS requirements can be summarised as follows:

- Consideration of IMA modularity to implement ATM/CNS functions in military aircraft
- Suitability of Mission Computer (MC) / Military Mission Systems (MMS) to support key 4D functions and advanced navigation (including Flight Path Definition / NAV Data Processing relying on ARINC 424) (follow up of SESAR 1 project 9.3)
- Military Sensor Eligibility / Alternative Fixing Means for PBN (e.g. TACAN, GNSS Restricted Signals, Military INS, etc.) (follow up of SESAR 1 project 9.3 and 9.27)
- Avionics Suite Integration, Display Adaptation and Software Assurance for PBN and Key 4D functions (follow up of SESAR 1 project 9.3)
- Validation of ADS-B for Military Aircraft based on Re-Use of Military IFF (complete validation in the sequence of SESAR 1 project 9.24).

The technical challenges described above must be understood in a context where military operations and training need to be accommodated with an adequate level of priority. However, civil and military aviation activities are tightly interlinked and the provision of air navigation services for civil and military aviation is driven by the need to ensure the highest level of safety.

For that purpose, it is crucial for security and defence that any development in air traffic modernization takes civil-military requirements fully into account, in order to avoid any adverse impact on national and collective defence capabilities. The changes brought about by technological solutions in terms of procedures, regulations, equipment and organisation need to be considered at the earliest possible stage and on the basis of a systemic approach, by relevant military organisations.

This leaflet contributes to raise awareness by identifying future prospective research directions in respect to State/military aircraft compliance with civil ATM/CNS requirements.

For low capability military aircraft, transitional periods to handle legacy aircraft may need to be envisaged (e.g. for aircraft reaching the end of their life span).

\(^2\) It must be understood that all State aircraft, including military, police and customs aircraft, face the same challenges and in general are expected to benefit from the same solutions.

\(^3\) A summary of such requirements can be found here: [http://www.eurocontrol.int/articles/avionics-requirements](http://www.eurocontrol.int/articles/avionics-requirements)
Dual Use CNS can bring significant benefits to military operators when facing the modernization of civil aviation infrastructure even if it represents only one of the options to face such technology evolution challenges. The required research steps to define and validate technical solutions must be seen as independent of subsequent efforts to define alternative standardization, safety assurance and certification processes that will be also required before industrialization and deployment.

In the past, some studies quantified the potential impact of SESAR upon military as very substantial. With the emergence of PBN, trajectory based operations and other concepts and technology evolution trends, with clear impact on certain military operations, it can be inferred that cost benefits of Dual Use CNS approaches allowing maximum reutilization of available military aircraft capabilities may need to be measured in the same order of magnitude. Limitation of technical impacts as well as enhanced interoperability and safety benefits will be certainly paramount to justify future research initiatives.
<table>
<thead>
<tr>
<th>ACRONYMS AND ABBREVIATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADS-B</strong></td>
</tr>
<tr>
<td><strong>ARINC</strong></td>
</tr>
<tr>
<td><strong>ATC</strong></td>
</tr>
<tr>
<td><strong>ATM</strong></td>
</tr>
<tr>
<td><strong>CNS</strong></td>
</tr>
<tr>
<td><strong>DA/FD</strong></td>
</tr>
<tr>
<td><strong>DME</strong></td>
</tr>
<tr>
<td><strong>EGNOS</strong></td>
</tr>
<tr>
<td><strong>FMS</strong></td>
</tr>
<tr>
<td><strong>GNSS</strong></td>
</tr>
<tr>
<td><strong>GPS</strong></td>
</tr>
<tr>
<td><strong>ICAO</strong></td>
</tr>
<tr>
<td><strong>IFF</strong></td>
</tr>
<tr>
<td><strong>ILS</strong></td>
</tr>
<tr>
<td><strong>IMA</strong></td>
</tr>
<tr>
<td><strong>INS</strong></td>
</tr>
<tr>
<td><strong>MCDU</strong></td>
</tr>
<tr>
<td><strong>MFD</strong></td>
</tr>
<tr>
<td><strong>MLS</strong></td>
</tr>
<tr>
<td><strong>MMR</strong></td>
</tr>
<tr>
<td><strong>MMS</strong></td>
</tr>
<tr>
<td><strong>PFD</strong></td>
</tr>
<tr>
<td><strong>PPS</strong></td>
</tr>
<tr>
<td><strong>PRS</strong></td>
</tr>
<tr>
<td><strong>R&amp;D</strong></td>
</tr>
<tr>
<td><strong>RNAV</strong></td>
</tr>
<tr>
<td><strong>SAR</strong></td>
</tr>
<tr>
<td><strong>SBAS</strong></td>
</tr>
<tr>
<td><strong>SESAR</strong></td>
</tr>
<tr>
<td><strong>TACAN</strong></td>
</tr>
<tr>
<td><strong>TAWS</strong></td>
</tr>
<tr>
<td><strong>TCAS</strong></td>
</tr>
<tr>
<td><strong>UAS</strong></td>
</tr>
<tr>
<td><strong>VDL2</strong></td>
</tr>
<tr>
<td><strong>VHF</strong></td>
</tr>
<tr>
<td><strong>VOR</strong></td>
</tr>
</tbody>
</table>
Author:
Jorge PEREIRA (DECMA/CMC/CNS)

Reviewers:
Ricardo OLIVEIRA (DECMA/CMC/CNS)
Thomas OSTER (DECMA/CMC/CNS)