EUROCONTROL
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Dual-use CNS: The Civil-Military Interoperability Multiplier

The Russian invasion of Ukraine in February 2022 kicked Europe's defence spending into higher gear, accelerating plans to introduce a new generation of weapon systems. A huge number of leading-edge military assets, such as the 5th generation F-35 Joint Strike Fighter, will soon be operational in Europe, which bring with them additional airspace and infrastructure requirements. And the defence industry is lining up to introduce many other advanced weapon systems. Civil-military interoperability, therefore, has become increasingly important.

In parallel, civil aviation's communications, navigation and surveillance (CNS) infrastructure is being digitally transformed. This offers a unique opportunity to develop and deploy a dual-use CNS system that is capable of seamlessly accommodating and integrating military air operations. Such a system can only be accomplished through a new blend of innovative civil-military interoperability solutions that are tailored to the data-centric nature of modern air traffic services – and solve the avionics mismatch that many military aircraft face.

Summary

This Think Paper argues that the time has come to define a dual-use CNS system, taking advantage of new civil-military interoperability opportunities such as emerging performance-based concepts, enhanced data sharing, virtual and remote service provision, and increasing ATM/CNS avionics predominance, coupled with software-intensive technical approaches.

Main findings

- Aviation's future CNS infrastructure must have a dual-use nature to sustain particular requirements from various airspace users.
- Civil-military CNS interoperability must benefit from enhanced data sharing/ "big data", emerging ICAO performance-based CNS concepts, and cutting-edge software-based avionics.
- Innovative interoperability solutions need to be developed through pragmatic industrial research initiatives (SESAR 3 JU and others).
- A performance-based approach must be favoured to allow the military to use their own available CNS equipment when seeking compliance with civil requirements.
- The new dual-use system needs to be resilient and mitigate against security vulnerabilities, addressing data encryption, jamming protection, GNSS outages and concealment of surveillance parameters.
- Particular attention needs to be paid to the emergence of disruptive technologies and to new challenges related to spectrum efficiency and sharing.
- CNS provision must be aligned with sustainability objectives through improved flight efficiency.

Setting the scene

A new interoperability approach

Russia's aggression to Ukraine has confirmed the vital role of Europe's armed forces in protecting national security and defence interests. This relies heavily on ensuring military assets across Europe are highly mobile – with unrestricted access to airspace and aerodromes crucial in this regard.

Every year, the European aviation network managed by EUROCONTROL processes around 200,000 State military flights under General Air Traffic (GAT) status. These flights are enabled by a communication, navigation and surveillance (CNS) infrastructure that is frequently owned/operated by civil air traffic service providers.

Many of these flights are conducted by military aircraft that are non-equipped or evidence a mismatch with the required civil ATM/CNS capabilities. Hence, accommodation is based on equipage exemptions. As connectivity and automation increase, there is additional pressure for industrial research to deliver civil-military interoperability solutions that are adapted to the rapidly evolving technology context.

Civil aviation requirements are becoming technology-agnostic. There is increasing net-centricity, and modern military avionics are part of "functional integrative architectures", leveraging a full glass cockpit (Figure 1), enhanced visual systems, electronically scanned array multi-function radars, onboard data fusion, smart antennae and software-defined radios. Cyber vulnerabilities however grow exponentially every day.

This technology context offers opportunities for new and inventive engineering solutions that support civil-military interoperability, building on the power of "big data" and performance-based approaches. Interoperability options based on the traditional "equipment-based approach" will not work anymore.

Key guidance in this regard will be offered by the CNS Evolution Plan, which is to be developed on the basis of the recommendations and action plan from the CNS Advisory Group of the High Level Group on SES, led by the European Commission.

Figure 1: F-35 JSF cockpit

A related "Military CNS Strategy" is being coordinated by the European Defence Agency (EDA), with contributions from EUROCONTROL, NATO and States, which is intended to be a fundamental source of military requirements.

A true civil-military dual-use system needs to be developed, building on work done via the SESAR 3 Joint Undertaking or other research initiatives, where EUROCONTROL will provide a substantial technical-level contribution within dedicated industry partnerships. **The focus must be to raise interoperability, avoid cumbersome retrofitting, address security vulnerabilities, face radio spectrum congestion, respect sustainability targets and respond to requirements identified by national authorities.**

Addressing infrastructure evolution

Across Europe, the civil aviation CNS infrastructure has begun a transformational journey that will bring an exponential increase in the levels of automation, interconnectivity and data-sharing – all of which however pose new safety and security challenges.

A fully digitalised, high-bandwidth and low-latency infrastructure as per Figure 2 is expected to emerge, featuring:

- a network-centric and distributed data sharing environment
- strong reliance on satellite technologies
- a new generation of datalink-style air-ground communication technologies
- an evolution from conventional to area navigation (performance-based navigation, PBN)
- an optimal mix" of surveillance technologies (SSR Mode S, WAM and ADS-B).

Future CNS systems must be radio frequency (RF) spectrum-efficient, performance-based, highly integrated and rationalised. Performance monitoring mechanisms will be paramount.

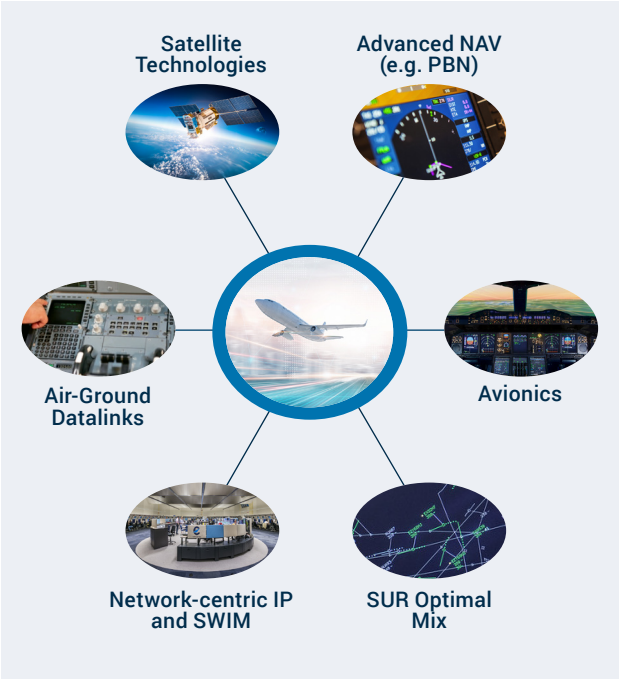

Figure 2: New Technologies

Any interoperability initiatives need to be consistent with related national decisions with a focus on harmonisation, de-fragmentation and cost reduction.

A layer of existing technologies will be retained, designated as minimum operational networks (MON), to complement the deployment of new technologies and to make the overall ATM system more resilient.

Electromagnetic RF spectrum coordination and sharing represents a major interoperability challenge, and ensuring RF spectrum efficiency is vital whenever new systems are planned.

Technical studies are needed to address RF spectrum sharing and compatibility; to assess radio frequency interference, technical CNS performance and quality of service, surveillance detection, NAVAID coverage and integrity; as well as to ensure interfacing solutions and put in place technical security measures.

Performance-based CNS to boost civil-military interoperability

Benefits of performance-based CNS

The ICAO performance-based CNS concepts allow an evolution from prescriptive equipment-based operations to the delivery of technology-agnostic performance-based services, tailored to meet operational requirements, and treating CNS as a fully integrated system (see Figure 3).

This paradigm shift will enable airspace users to rationalise airborne systems by customising the required airborne equipage, allowing potential synergies across COM, NAV and SUR.

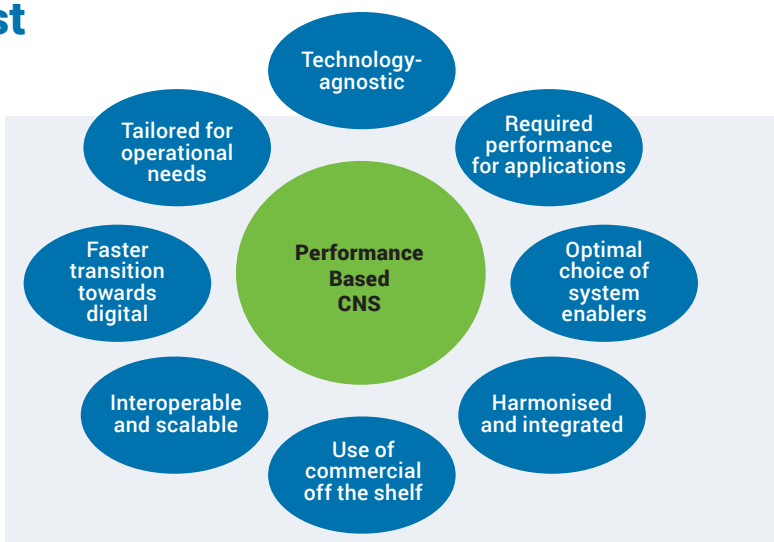

Figure 3: Performance-based CNS

Performance-based CNS metrics

The performance indicators to be met must be selected in accordance with the specific operational environment.

ICAO's PBN concept specifies that aircraft navigation system performance requirements should be defined in terms of accuracy, integrity, continuity and functionality, all of which are needed for operations in the context of a particular airspace concept.

Similar metric targets have been defined under the concept of performance-based communications and surveillance (PBCS).

Performance-based CNS applied to civil-military interoperability

To overcome equipage mismatches, national authorities may decide to apply alternative performance-based processes, which would allow the use of available military equipment to comply with civil-derived ATM/CNS requirements based on performance metrics.

Research efforts must deliver technical solutions and methodologies that demonstrate the feasibility of equipment re-use and performance-based approaches for civil-military interoperability. The decision to implement resides with national authorities.

Data-sharing as a civil-military interoperability multiplier

Data context

Future aviation developments will be driven by enhanced data-sharing. Network-centricity will be another essential asset. Future air and ground systems, including those at airports, are expected to evolve into a single integrated infrastructure, enabling the network to accommodate the growth of air traffic, and raise system performance in an intermodal environment.

At the core of this integrated infrastructure will be the new EUROCONTROL Network Manager system, iNM (integrated Network Management). The iNM digital transformation programme, part of EUROCONTROL's Network Transformation 2030 roadmap, will accelerate the transition towards a digital information-rich environment supporting the full range of aviation functions.

Such data-intensive operations will rely on high speed and low latency communication systems that are highly interconnected, taking advantage of Internet Protocol technologies and air-ground connectivity. Aircraft avionics will access ground data repositories updated in near-real-time.

Enhanced data-sharing will decisively stimulate greater military operations integration into the overall aviation system.

The ADaaS is fed by remote flight data processing system services from MUAC.

Remote service provision

The extensive sharing of flight data is also the basis for ATS virtualisation and remote operations. Correlated flight plans, safety nets, Flight Data Processing System (FDPS) functionalities and other ATC information resources may be shared remotely, contributing to improved coordination, safety and infrastructure rationalisation.

Virtualisation of air navigation services, the use of common FDPS and the remote processing of operational data can be a major civil-military integration multiplier.

One example from recent years of remote service benefits for civil-military interoperability was the Shared ATS System (SAS) initiative, when the air traffic control system of EUROCONTROL's Maastricht Upper Area Control Centre (MUAC) became fully operational at the Royal Netherlands Air Force (RNLAF) Air Operations Control Station at Nieuw Milligen, and at seven air bases. In the meantime, the RNLAF has been relocated to LVNL Schiphol, as part of an integration project, and has stopped using SAS. This valuable experience can offer benefits for other organisations willing to follow similar synergies.

MUAC has been a pioneer in this domain through the development of ATM Data as a Service (ADaaS). The ADaaS project has investigated the extent to which ATM data services can be provided by the interoperable ATM system of an ATM data service provider (ADSP) to one or more civil air traffic service units (ATSUs), all of which moves closer to the concept of data centres.

The ADaaS demonstrator used local radars, tracking and safety net services, but is fed by remote flight data processing system services from MUAC. This project demonstrated how a state-of-the-art data centre could

be deployed from which an ADSP can deliver services to remote ATSUs.

If national authorities so decide, military operations can benefit from "big data" repositories, centralised common FDPS and remote provision to support air picture compilation, flight identification, surveillance data sharing, access to up-to-date flight data and aeronautical information, as well as support to airspace management, meteorological data, etc.

Intensive data-sharing does however carry some risks, which calls for a sound security policy to be in place each time sensitive data are to be exchanged, or systems are to be interconnected.

Commercial off-the-shelf and software-based innovative solutions uplift interoperability

Interoperability reliant on commercial off-the-shelf and software-based approaches

As an extremely safety-centric environment, aviation relies strongly on highly standardised technologies – with the necessarily prescriptive standards to some degree constraining the use of cutting-edge commercial off-the-shelf (COTS) technologies, and resulting in longer procurement cycles.

Nevertheless, civil-military interoperability approaches taking advantage of COTS and software-based solutions can be important, comprising, for example:

- application programming interfaces (API), which enable compatibility with integrated modular avionics (IMA)
- reuse of legacy hardware leveraged with enhanced components
- reutilisation (rewriting) of legacy software functionalities to adapt to new processing environments
- use of software emulation to mitigate obsolete hardware
- use of model-driven architectures to allow for modular and incremental certification.

Such approaches may be crucial when adapting military avionics to emerging concepts like trajectory management, PBN and advanced surveillance.

One potential example is the future multilink environment as part of the air-ground data communications evolution. This calls for a flexible aviation radio based on software-defined radio (SDR) technology, which will drastically rationalise airborne avionics.

Greater focus on SDR technologies would facilitate military adherence to civil datalink requirements, possibly on the basis of waveform accommodation and performance-based options for compliance.

The most recent, i.e. 5th generation of fighters, like the F35 Joint Strike Fighter Lightning II, carry communication, navigation and identification (CNI) avionics suites supported by SDR technology, with conformal and adaptive (multi-frequency band) antenna arrays, which use reconfigurable FPGA (field programmable gate arrays)/RF hardware and computer processors to run software which produces the desired/selected waveform(s).

Flexible aviation radios based on SDR (as per Figure 4) could help to overcome military aircraft integration constraints by using reprogrammable software to facilitate the implementation of future communication infrastructure (FCI) datalink capabilities defined as waveforms.

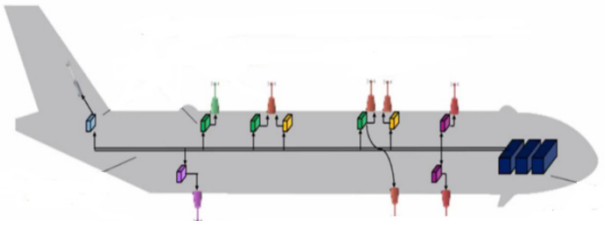

Figure 4: Flexible Software Defined Radios

This would also facilitate co-existence with other military capabilities. A flexible radio solution for military aircraft based on SDR would avoid cumbersome military aircraft retrofits, eliminating duplicated equipage and senseless architecture configurations. Again, in this interoperability domain a research gap persists.