Integration and Interoperability for Multi-Domain Operations in the Coalition Environment: Challenges for European Air Combat Fleets

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Multi-Domain Operations and Interoperability between Air Forces

Strategic thinking in the airpower community is evolving dramatically under the influence of the multi-domain operations (MDO) concept. Until the 1990s, armed forces were broadly engaged in 'transformation' efforts with the aim of improving coordination between military services. By the 2000s, the goal and objectives of transformation efforts evolved and the desire for improved coordination gave way to efforts for deeper operational integration between military services and coalition partners. MDO advances the transformation objective towards an eventual fusion of capabilities among the operational domains in order to be able to deliver simultaneous effects at a much faster pace of operations (Jamieson and Calabrese, 2015). However not all countries are clear on how precisely to adopt the American vision for MDO into their own doctrines and concept of operations or how to resolve the likely integration and interoperability challenges which are generated (Townsend, 2019).

The intended goal of MDO is to accelerate the pace of military operations and allow a more synergistic coordination of effects to be produced in the operational environment. Multi-domain integration promises to optimize operational advantages in order to pressure the decision-making loops of opposing forces. At the same time MDO also implies a considerable evolution of and necessary changes in approaches to joint operations so its impact will readily affect friendly forces just as profoundly. As noted by Major General Louis Pena, Deputy Commander of the French Air Defense and Air Operations Command (CDAOA), MDO represents "an opportunity to think about how air forces will plan and conduct air operations in the future" (Pena, 2020). It is certain that MDO will be a powerful factor in shaping the future concept of operations for air combat and transformation efforts however there are complex conceptual, technical and strategic challenges that will need to be overcome.

Connectivity and Future Air Combat

Future combat aircraft are envisioned to function and perform as 'connectivity centers' and 'airborne data fusion servers,' linked with a combat cloud providing real-time multi-domain information to distributed elements of joint or coalition forces. These next generation combat aircraft are prepositioned to assume the same roles currently assigned by air forces to airborne warning and control (AWAC) aircraft. AWACS have become a key nodal function in air operations since the arrival of Link 16 which has proven instrumental for Western air superiority in recent decades by enabling radically improved situational awareness and command, control and communications (C3) capabilities in joint and coalition campaigns.

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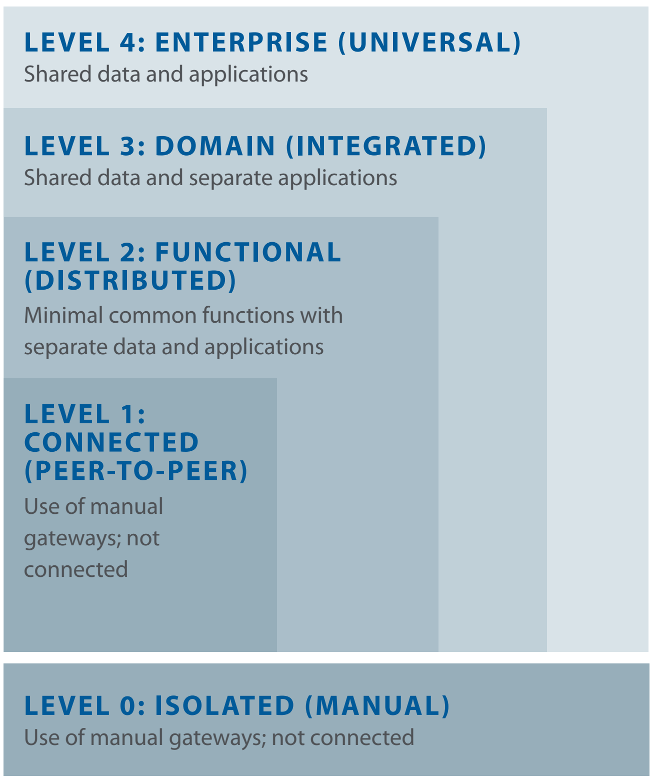
In the future, data fusion and relay functions will become more distributed and increasingly transferred to combat aircraft themselves, which will be able to orchestrate drone swarms to, for example, penetrate enemy air defenses or deliver kinetic effects. Empowered by new tools and faster decision-making through next generation data and communication networks, combat aircraft will operate in a multi-domain space as key command and control (C2) nodes themselves. Air combat operations will therefore no longer correlate to a set of sequenced tasks but rather to a single continuum of de-compartmentalized maneuvers and effects based on and highly responsive to activity by opposing forces.

Level of Information System Interoperability (LISI) Model



Air combat will feature a more informed and intelligent application of economy of force to overwhelm opposing forces using a combination of velocity, saturation and stealth ("V2S"—velocity, saturation, stealth) to achieve battlespace superiority. These future concepts rely on a system-of-systems approach with a command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISTAR) core and where each individual force vector functions both as a sensor and as an effector at the same time. Capabilities relating to data fusion, automation, robotics and artificial intelligence (AI) will be critical to realizing 'Spectrum Dominance'—superiority across the operational spectrum.

Air combat will progressively become more dependent on multi-domain awareness and information dominance. The prospect of a singular, overarching combat cloud functioning as central library or brain however presents complex issues in a coalition environment: Permanent connectivity to such a combat cloud generates obvious vulnerabilities for coalition force components. While offering advantages in terms of force concentration and efficiency, the same concentration of power and reliance towards one central cloud generates the prospects of a catastrophic loss in freedom of action. Opposing forces will be aim to hinder communications and employ decoys against sensor networks and in such a context of benign cyberspace and electromagnetic warfare a "One Ring" combat cloud may lead to operational paralysis across its subscribed user base.

In considering such risks, there are serious questions around the maturity of key enabling technologies for the notion of the combat cloud. Information systems and technologies that collect, analyze, store and transmit data are all subject to intrusive threats and replication by opposing forces in order to advance the effectiveness of their anti-access/area denial(A2AD) (Orlin, 2021). 'Big data,' a fundamental requisite for any Common Recognized Operational Picture (CROP) between distributed C2 elements, cannot be properly exploited without AI, the use of which remains problematic given its susceptibility to manipulation and deception.

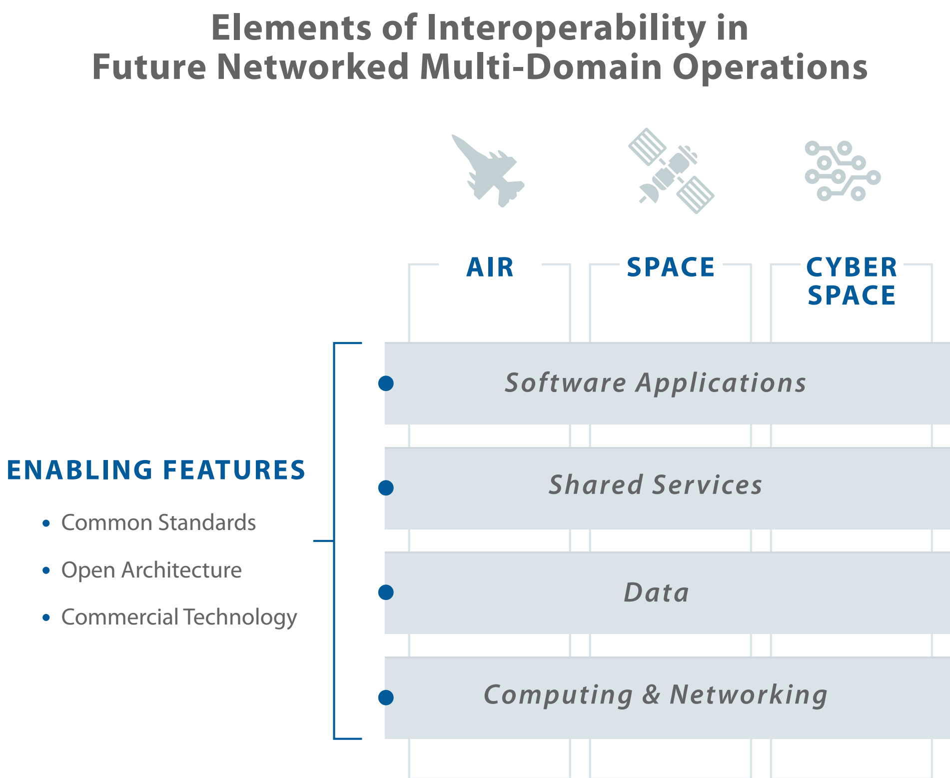
Predictive maintenance, which is native to future air combat platforms and will be continuously communicated over the network, offers a new attack vulnerability in the warfare space and is likely to be heavily targeted (Hitchens, 2020). The exploitation of potential software flaws and limitations will create opportunities for opposing forces in terms of deception, circumvention and surprise operations. Advanced jamming targeting communications and sensor networks, offensive cyber warfare operations directed at the combat cloud (Gros, 2019), and dependence on space assets presents serious risks in scenarios where ground-based or space assets are destroyed or critical data-links become compromised (French Defense and National Security Strategic Review, 2017).

The proliferation of drone technology and digitization of combat systems is already compelling air forces and their sister services Europe to focus investments in cyberspace countermeasures and to 'harden' platforms, assets and operations infrastructure to ensure communications nodes and transmitters are not compromised. Such efforts will accelerate and intensify as military competitors target data and data connectivity capabilities across a wider attack surface that extends the coalition or allied force which are all connected to the same cloud. Such inherent risks to multi-domain combat grids therefore emphasize needs to consider the development of future combat clouds for MDO in coalition environments outside a 'One Ring' design.

Europe's Combat Air Fleets: The Current and Future Landscape

In Europe, operational integration between air forces has been progressing steadily—the NATO factor has been an important one but is by no means the only driver for the progress achieved in enhancing interoperability between European air forces. Yet the European airpower landscape remains marked by considerable diversity, as illustrated by the diverse typology of the more than 1,900 combat aircraft currently in service.

The American-led F-35 program has brought together a number of European nations including the United Kingdom, the Netherlands, Denmark, Norway, Belgium and Italy. The F-35 as a fifth-generation combat aircraft introduces a new model and standard for interoperability for Europe which will, together with its operators, play a powerful role in shaping interoperability efforts and programs across European air forces over the coming years. However, most F-35 users continue to maintain wider combat fleets—the Eurofighter Typhoon for example is likely to remain indispensable to the United Kingdom because of the F-35's limitations in air superiority missions. For similar reasons, the Typhoon will likely continue to be operated by Italy, Germany and Spain and similar considerations may extend to F-16 operators such as Belgium, Denmark, Greece, the Netherlands, Norway, Portugal and Turkey.



Other European air forces have acquired combat aircraft such as the Gripen-E and Rafale which, with its AESA radar and data fusion capabilities, could be considered as the de facto future European standard for interoperability. Finland is pursuing its HX Fighter program with five combat aircraft platforms actively involved in the competition. Looking out to 2040 and beyond, Europe is likely to continue seeing the indigenous development of next generation combat aircraft and, with them, new standards for interoperability being inserted into both the acquisition and operational planning frames. Consider the development of the FCAS (Future Combat Air System) and the British Tempest as cases in example—both platforms will be coupled with remotely operated and autonomous systems and relays, and operate inside cloud-based multi-domain data exchange networks.

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The existing and likely future diversity of European air combat fleets may prima facie suggest an unnecessary duplication of capabilities however these same differences in approaches and capabilities also provide greater resilience at the operational and strategic levels. In the coalition environment, it is unclear to what extent Europe's air combat fleets will be interoperable with, for example, F35s entering operational service in Europe now. The same questions will theoretically apply to the FCAS or Tempest and these questions around compatibility and interoperability will extend into the future particularly in relation to MDO.

The challenge of interoperability in coalition environments is being reframed and will take a new direction with the introduction of new combat aircraft and platforms but there are no clear or readily available solutions to bridge differences in doctrine and concept of operations on the one hand, or for technical integration in a coalition environment where constituent air forces each bring their own set of capabilities, tools and platforms to the fight. The irony is that the basic premise and purpose of multi-domain integration is to resolve the lack of or low compatibility and synergies between different types of platforms, across different domains, which are developed using different technical standards and systems engineering approaches.

The Political Dimensions of Integration and Interoperability

The evolution towards MDO implies new challenges for the air force by introducing new sets of dynamics into and for joint parallel planning in the coalition environment. It also presents a need to adapt or replace existing mechanisms which have been developed to enable the necessary levels of integration and interoperability between coalition partners which allow them to operate together effectively. As the movement towards MDO accelerates, it begs the basic question: Is interoperability possible when air forces belonging to coalitions and alliances have adopted different standards in systems and network design owing to contrasting industrial and political considerations?

This question highlights uncertainties related to interoperability in the future timeframe looking out to 2040 and beyond as well as to current air combat fleets which, in the European landscape, already face similar challenges. European air forces will need to contend with requirements for joint integration and fusion at an operational level which will need to be balanced against higher level policy considerations that extend into the realm of national strategy, to include freedom of action and strategic autonomy. In this context, European air forces will need to interact with and plan capability programs and interoperability goals in line with national or European policy directions which are shaped by a complex milieu of institutional factors and agendas.

It is a reasonable argument that the likely benefits of distributivity and data fusion between air forces in coalition environments outweighs the associated risks created by shared combat clouds or the likelihood of operational paralysis occurring. However, beyond purely operational considerations, there are important policy issues which are shaped by grand strategy and political outlooks. Even between allies and partners that share similar worldviews and which frequently operate or cooperate closely in coalition and joint operations, national policies can diverge—particularly with regards to military activity in crisis situations.

There are compelling and historical justifications for continuing to work towards achieving interoperability between coalition and allied partners, including however that would be implied in the context of combat clouds. These efforts however must be balanced with the need to preserve strategic autonomy and the ability to make independent assessments or military activity (Binnendjik and Vershbow, 2021). Diverging approaches which are sometimes viewed as leading to "capability duplication" and a wastage of financial resources in another way offer advantages through the creation of natural firewalls and resilience for joint national and joint coalition operations.

In view of current and future developments in coalition air combat models, preserving a level of autonomy may be as important as securing emerging combat clouds themselves. This will be particularly true in the European context where the combined combat fleet will likely be comprised of a range of platform types, each developed according to different systems engineering, technical and interoperability standards, which link to industrial and political considerations. The same baseline challenges may be transposable to other parts of the world, such as the Middle East or Asia. Rather than attempting to segment air combat fleets into "first" and "second" tier capabilities, coalition and allied partners will need to focus attention towards overcoming challenges and generating the integration enablers and interoperability solutions for MDO in traditional coalition environments (Binnendjik et al, 2021).

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