De-Centralized Command and Control in Air Operations: Implications for Air Battle Management and Mission Command

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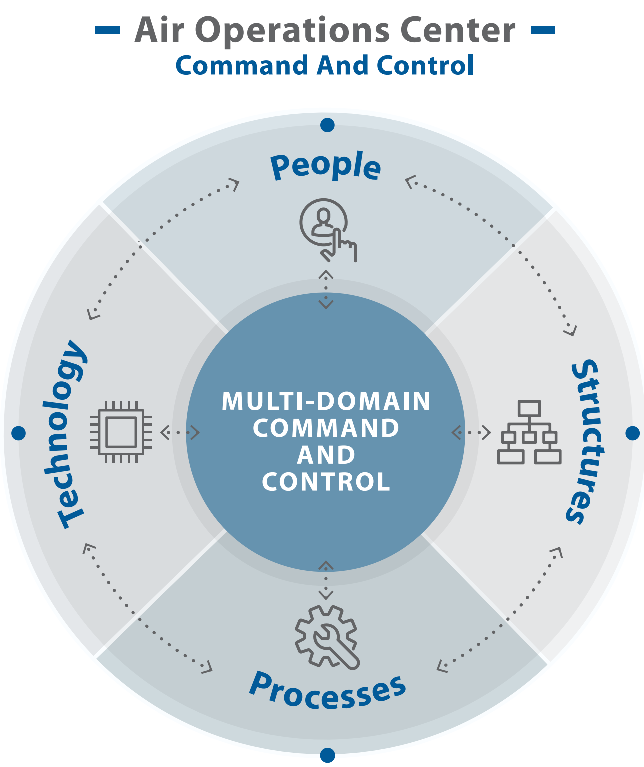
Introduction

Air forces around the world which are focusing on peer or near-peer military competition are increasingly aware of the need to adopt decentralised mission command and control (C2) architectures. However, important cultural and political resistance will need to be overcome to allow this to happen. Decentralised C2 will require a reintroduction of traditional notions of mission command where decision-making authorities and permissions are increasingly delegated to relatively junior combat leaders at the tactical level. Nevertheless, most future C2 architectures are being developed with at least some degree of decentralisation in order to make it harder for opposing forces to find, target and degrade key airborne and ground-based nodes. Leading airpower nations are exploring combinations for distributed orbital assets and unmanned aerial vehicles (UAV) to displace legacy processing, exploitation, and dissemination (PED) and C2 platforms.

The future shape of the orbital domain as part of distributed C2 and ISTAR architectures remains uncertain because rapid advances in space-based sensor capabilities, communications bandwidth and robustness suggest a sharp increase in their role, however, the use of these assets is also likely be highly contested or even denied in the future. UAVs offer potential for long endurance without the same predictable and potentially vulnerable trajectories as satellites in orbit. The viability of fifth generation platforms such as the F-35 and very low observable UAVs as building blocks in a next-generation distributed C2 and ISTAR architecture requires not only secure and inconspicuous datalinks and sensors, but also dynamic edge processing capacity to reduce bandwidth requirements and automatically identify and pass relevant data to other assets. For the foreseeable future, therefore, air forces may well remain reliant on centralised C2 based on obsolescent wide-bodied legacy systems.



The Future Environment

The future combat air environment is characterised by the increasingly ubiquitous development of long-range surface to air missile (SAM) systems (Bronk, 2020a), very long-range air-to-air missiles (VLRAAMs) and very low observable (VLO) fighter and interceptor aircraft (Bronk, 2020b). This new generation of threat systems is steadily increasing the risk level to conventional air operations which rely heavily on centralised command and control assets such as the E-3 AWACS. Long range SAM systems, VLRAAMs and VLO fighter threats will increasingly force traditional command and control (C2) and intelligence, surveillance, target acquisition and reconnaissance (ISTAR) aircraft to operate so far away from hostile territory that their on-board sensors and communications hub capabilities will give greatly reduced operational utility. At the same time, the availability of long-range precision strike systems and offensive cyber tools continue to increase the threat which modern states can pose to each other's centralised ground-based command and control facilities such as combined air operations centres (CAOCs) (Kaushal, Macy and Stickings, 2019). As such, two of the central pillars of early 21st Century Western air power face a potentially existential challenge.

Since the late 1980s, Western air forces have relied heavily on air power to enable joint force operations to be conducted with significantly smaller ground and maritime components than would otherwise have been necessary. The striking success of this model in multiple conflicts during the 1990s and 2000s led to force design across armies and navies which assumed the availability of air support and air-enabled C2 and ISTAR. As such, the ability to provide on-demand ISTAR and fire support from the air is now an essential prerequisite for many Western nations to employ military power. The reliance on coalition operations to generate mass and political legitimacy has also created integration, deconfliction and permissions and oversight requirements as part of everyday air operations. This combination of reliance on air power for joint operations, and coalition integration as a constant requirement, has created an extremely centralised C2 model with the combined air operations centre (CAOC) construct as the focal point.

Legacy Models for C2 and CAOCs

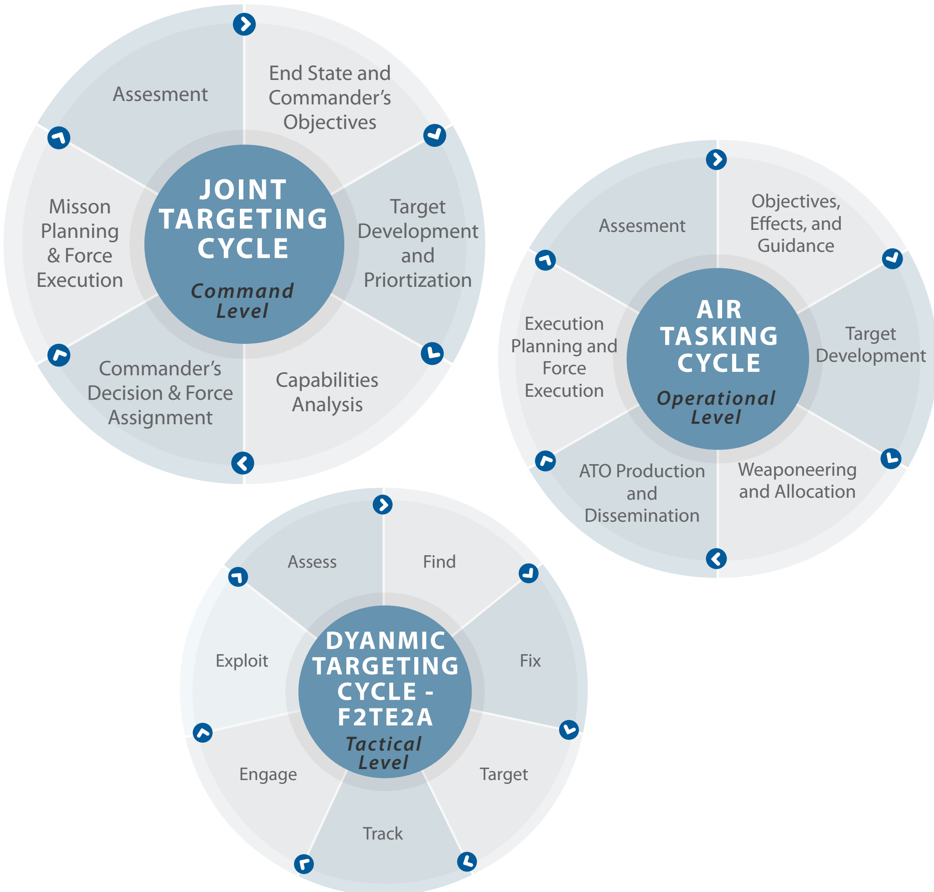
Within a CAOC, the 72-hour Air Tasking Order (ATO) is generated with reference to the various joint force taskings, ISTAR products, multinational contingent permissions processes and enablers such as tankers. This process requires hundreds of specialist professionals, large, fixed facilities and excellent communications links—making CAOCs an extremely valuable and obvious target for hostile states in any major war. The closer a CAOC is to the area of operations, the more potentially vulnerable it becomes to hostile kinetic long range precision strike capabilities. However, the further removed it is, the greater the operational dependence on potentially vulnerable buried, line-of-sight, beyond-line-of-sight and orbital communications links.

Some future concepts feature smaller scale, more distributed air operations centres (AOCs) to reduce the vulnerability of the joint force to decapitation style attacks on its C2. However, relying on more numerous, distributed AOCs rather than large COACs could create duplication of tasks and thereby increase the burden placed on already overstretched intelligence and command staff personnel. C2 distribution could also increase the dependency on assured communications links, since each AOC is only able to perform some functions of a full scale COAC even with a significant automation of necessary processes. Therefore, if kinetic or non-kinetic tools were to sever or even seriously contest these links then both centralised COACs or smaller distributed AOCs may stand to lose the ability to tactically coordinate ISTAR, strike and enabler assets in-theatre.

Furthermore, a habit of senior commanders exerting direct control and supervision over tactical operations has been allowed to emerge during several decades of largely uncontested air operations. This has partially been prompted by the increased availability of real-time full motion video feeds, allowing CAOC commanders the perception of tactical situational awareness. It has also been fed by a significantly curtailed tolerance for risk at the political level during what have often been seen as discretionary and unpopular conflicts. This, in turn, has increased the desire to avoid delegating control and permissions to the tactical level. Such existing command practices further increase centralisation, reduce operational tempo and introduce a range of potential bandwidth bottlenecks and electromagnetic vulnerabilities into air operations. Despite discretionary conflicts being the context within which authorities have been held at higher levels, the move back towards planning for high-end conflicts may be unlikely to produce a natural reversal of this trend. Senior politicians and military leaders in many countries are likely to view the much higher geopolitical stakes involved in a peer conflict as a reason to continue to centrally manage tactical decision-making. However, this approach is almost certain to fail in practice against peer and near peer opponents due to the slow operational tempo it entails, and the beyond-line-of-sight connectivity and bandwidth it requires. To be suitable for future state-on-state conflicts, the tactical air commander culture must change to avoid operational paralysis as kinetic, electromagnetic and cyber attacks on the CAOC construct and its supporting communications links cut off commanders from frontline assets.

Future Architectures for Decentralized C2

It is clear to many air forces that traditional airborne C2 and ISTAR nodes derived from wide-bodied airliners such as the E-3 AWACS and E-8 J-STARS are no longer optimal for future conflict scenarios. These assets have very limited self-defence capabilities and must emit large amounts of easily detectable electromagnetic signals in order to function effectively, which makes them easy to locate and track. Such platforms also represent a serious source of potential casualties, since they carry large, highly trained mission systems crews to carry out the key task of processing, exploitation, and dissemination (PED), as well as air battle management functions. Wide-bodied ISTAR and C2 aircraft must stand off so far from hostile SAM systems and VLRAAMs today as to be largely ineffective in terms of their primary sensor picture in the early stages of a conflict with technologically advanced competitors.



The fifth generation F-35 is significantly less dependent on such C2 and ISTAR enablers due to its own ability to supply its pilots with multi-spectral wide-area situation awareness. This ability to organically build situational awareness inside hostile airspace has led many to plan on exploiting the F-35 as a primary building block in a next-generation distributed C2 and ISTAR network (Bronk, 2020c). However, in its present form the F-35 cannot transmit the full sensor picture which it creates for its pilots to other force elements due to bandwidth, software architecture and emissions-control limitations. Furthermore, as a tactical strike fighter, F-35s have limited endurance compared to traditional ISTAR and

C2 nodes, and the limited numbers of F-35s available are also already committed to strike, SEAD/DEAD and interdiction mission sets. Platforms such as the F35, therefore, offer only a partial solution to the increasing obsolescence of traditional C2 and ISTAR enabler assets and networks.

Decentralised airborne C2 and ISTAR architectures under development require changes in equipment to enable air forces to field a larger number of smaller platforms. Alongside network-enabled combat assets such as the F-35, a range of smaller, crewed C2 and ISTAR platforms may still offer the option to carry a small mission system crew to enable on-board PED and air battle management. However, several leading airpower nations are already exploring combinations of distributed orbital assets and unmanned aerial vehicles (UAV) which would displace the PED and C2 functions to remote ground stations.

The future shape of the orbital domain as part of distributed C2 and ISTAR architectures is currently unclear due to a range of competing trends. On the one hand, rapid advances in sensor capabilities, space/weight/power requirements for equipment, communications bandwidth and robustness through MIMO-type arrays and falling cost of launch capacity all point to a sharp increase in the role orbital assets are able to play in future distributed ISTAR and C2 networks. At the same time however a proliferation of kinetic and soft-kill ASAT capabilities, orbital assets capable of Rendezvous, offensive proximity operations and an increasingly contested electromagnetic spectrum render orbital assets and the uplink/downlink capabilities required to utilise them increasingly likely to be denied or at least highly contested in any future war.

> *The ability to provide on-demand ISTAR and fire support from the air is now an essential prerequisite*

UAVs offer the potential for much longer endurance on station than assets which rely on a human flight and mission system crew, without the same predictable and potentially vulnerable trajectories as satellites in orbit. Large UAVs such as the US Air Force RQ-4 Global Hawk and Chinese Divine Eagle have already demonstrated the ability to fly at very high altitudes for more than 24 hours at a time—a hugely desirable attribute for any decentralised airborne C2 or ISTAR node. To make them better able to persist in the face of peer threats, high-altitude, long endurance (HALE) type UAVs with very-low observable (VLO) shapes and materials offer new potential. The suitability of VLO UAVs for C2 and ISTAR tasks within a decentralised system would depend on the development of cutting-edge datalinks, sensors and SATCOMs which could perform their mission functions without revealing the airframe to hostile passive sensors. To complete such tasks, there are promising technologies on the horizon which exist at various degrees of technological maturity but remain expensive and are held at a high level of classification and security sensitivity by the nations which field them. This means that large scale deployment will be challenging, especially on unmanned platforms close to hostile territory.

Connecting Assets is Not Enough

Whilst uncrewed VLO, HALE airframes could be deployed and persist closer to hostile forces than current generation airliner-derived solutions, their ability to replace traditional airborne C2 and ISTAR nodes depends on automated data-sharing and edge processing technologies. Modern ISTAR assets, especially those with multi-spectral sensor suites such as on the F-35, create huge volumes of data as they construct a wide-area picture of the battlespace around them. During this process, they will collect information that could potentially be of high or even critical value to a wide range of other assets across all domains. However, physics-based bandwidth limitations restrict the ability to offload or share all the data collected, even in a non-contested electromagnetic environment (Watling, 2020). In a state-on-state conflict scenario, where the ISTAR (and C2) platforms will be competing for limited and contested spectrum access and potentially operating under emission-controlled conditions to reduce their vulnerability to detection and attack, edge processing to reduce the data volumes which need to be shared will be essential.

Human mission crews can (subject to mental capacity and workload) make the required subjective and situationally-dependent priority and relevance judgements about what information might or might not be worth passing to other assets. Crucially, however, automated systems cannot currently do this except in specific, rigidly defined circumstances. The same goes for the often reactive and judgement-dependent task of air battle management, which is a core part of the AWACS mission set. Replacing centralised C2 and ISTAR nodes in the air domain with an architecture of datalinks and decentralised network nodes primarily mounted on HALE type UAVs and penetrating combat assets is impossible without a suitable answer to these problems.

The components for a highly automated, decentralised airborne C2 and data-sharing network such as that being pursued under the US Joint All-Domain Command and Control (JADC2) programme are within the reach of airframe designers (Congressional Research Service, 2021). However, this ambition is beyond the capacity of currently viable artificial intelligence and autonomy technology. The requirement for such a system is clear, since the bulk of the combat mass in air forces around the world will still be provided by advanced fourth-generation fighters and standoff munitions until at least the mid-2030s. These weapons systems will not be able to perform the roles required of them in high intensity conflicts without being fed real time situational awareness, targeting and weapons cueing from across the battlespace. However, without the subjective judgement and prioritisation capabilities required to allow automated edge processing to truly replace human mission crews in the air battle management and ISTAR PED tasks, air forces may well remain dependent on centralised airborne architecture based on obsolescent wide-bodied legacy systems.

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