VAUBAN
SESSIONS

#7 HOW CLOUD COMPUTING SUPPORTS C2:
BALANCING COLLABORATIVE TECHNOLOGY
AND COMMAND PERFORMANCE?

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The Vauban Papers are a series of publications dedicated to the impact of digital transformation on the Armed Forces and the conduct of operations, published by Forward Global in partnership with VMware.

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FOREWORD

The art of command in its main principles has not fundamentally changed since Sun Tzu expressed it clearly in his "Art of War". Thus, anticipation, preparation and training, knowledge and intelligence, distribution of responsibilities and delegation of authority, and resilience, to name but a few of his commands, remain particularly relevant in crisis management, the conduct of modern operations, and especially in the context of the war in Ukraine. Today, in each of these fields, man holds more than ever an essential place, even if the rapid evolution of the technical means at his disposal, in particular in the digital domain, can give the illusion of a possible automation of the decision-making and even execution processes.

On the contrary, the digital transformation of the armed forces, in order to bring all its benefits, must intimately involve all the players in the operational chain, as the series of "Vauban Papers" published to date has emphasised. The Command and Control (C2) functions, which constitute the real nervous system of this chain, are at the heart of this operational digital transformation. They can now benefit from massive and continuous data flows that need to be managed, filtered, classified, exploited, exchanged and stored. Thanks to its potential for remote access and processing, cloud computing is a solution that has already been tried and tested in the civilian world and in companies, and some armies have already adopted it, adapting it to their needs. In this area, the sharing of experience and best practices constitutes both an axis of progress and interoperability. Indeed, the adoption of cloud computing within operational chains offers a remarkable potential for accelerating the decision/action loop by allowing access to relevant data at each level, from decision to execution, and by offering everyone a common vision of the operational situation. Cloud computing is therefore an integral part of the multi-domain collaborative battle. The implementation of the cloud in Command and Control structures must first of all lead to a comprehensive analysis of the pre-existing processes of exchange and storage of operational data. This must lead in particular to a new approach to the levels of confidentiality of these data, as mentioned in the "Vauban Paper 6: Taking to the Cloud: challenges to military uses of cloud computing" to ensure the best possible fluidity of exchanges throughout the chain of operations, whether purely national, inter-allied (NATO, EU) or within an ad hoc coalition. The adoption of the Cloud should in fact open the way to a new dynamic in the Command and Control of operations. This is not to question the need for a centralised level of command capable of implementing coherent and effective military strategies. On the contrary, the objective is to enable operational decision-makers to delegate the authority to engage to the most appropriate level in the chain, ensuring that the latter has the most relevant information to assume this responsibility. Thus, while accelerating the Observe-Orient-Decide-Act (OODA) decision loop, the combat cloud also aims to make all the data that contributes to its effectiveness reliable and organised in real time.

The control of operational data is more than ever a strategic, operational and tactical issue. The Cloud has an exceptional potential in this field, but it should not replace the experience and competence of the different actors of the operational chain. On the contrary, it should enable the art of command and execution to be enhanced in a very dynamic vision of modern operations, which is the whole point of this 7th "Vauban Paper".

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NATO defines Command and Control (C2) as "the functions of commanders, staffs, and other Command and Control bodies in maintaining the combat readiness of their forces, preparing operations, and directing troops in the performance of their tasks". C2 designates the decision-making process, the ability to lead, and information and communication systems. It enables the planning, programming and conduct of operations from the strategic to the tactical level, taking into account developments in the theatre.

Developments in communications greatly influence on C2. The military's ongoing digitalisation generates a massive volume of operational and technical data. In this context, the performance of C2 depends on the permanent capacity to acquire, communicate, process and synthesise information at the relevant level. This capacity is itself based on the means to produce, receive, store and transmit information and orders faster than the adversary.

The operational benefits of a digitalised C2 - which can be summarised as a condensation of the decision-making loop or OODA (Observe-Orient-Decide-Act) - are widely recognised and identified, from increased intelligence capacities to decision support, giving the commander greater freedom of action and manœuvre.

A horizontal tool to serve the verticality of command

By offering increased means of storage, access and remote processing of data, cloud computing serves the performance of C2. In concrete terms, cloud computing translates into the command and control of operations through:

→ An infrastructure which allows all units and staffs to access information remotely, thus limiting the volume of communication and information systems (CIS) in command posts and allowing, for example, mobility gains.

→ The sharing of a common operational picture at all levels, based on improved information sharing. This common picture is no longer only centralised at the highest C2 level, but information can be shared across all echelons, which can increase autonomy and initiative at the lowest tactical levels.

→ Data replication and synchronisation capabilities with an architecture comprising "mini-Clouds" in theatre interacting with a more central Cloud at the strategic level. This allows for greater resilience of the chain of command in the event of loss of contact with one of the echelons.

Cloud computing will therefore contribute to a strengthening and acceleration of decision-making by improving access to information (upward flow from the tactical to the strategic level) and the transmission and coordination of orders (downward flow from the strategic to the theatre level). In theatre, orders reach subordinate units more quickly and can even go directly to the weapon systems without human intermediaries (automatic fire control, missile guidance, etc.).

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An increased risk of weakening the chain of command

By its very nature, cloud-based operation generates a great deal of information exchange between different levels of decision-making and results in a certain horizontality between C2 players, as expressed by the term "collaborative combat." These developments amplify certain challenges and constraints impacting the verticality of the chain of command, where each level must have the right and necessary information quality to guarantee its freedom of decision and action. For example, in the case of a tank squadron, a generalised access to the squadron's network "allows each of the tank commanders to understand his place in the system. It does not mean that the network is no longer directed and that the links of subordination between elements are not clearly established."[1]

For commanders, at the operative or even strategic level, access to a massive amount of information in real time can lead to micro-management, a term borrowed from the business world. The opportunity to follow the live evolution of a section or even a combat group, with great precision can lead to a "tunnel effect", locking in the decision- maker. This perception bias may be detrimental to the distance required to command large combat units. The hierarchical chain is broken by the upper level, which bypasses or crushes the intermediate echelons. Mirroring the concept of the "strategic corporal", i.e. how individual action of tactical significance can lead to a real strategic turnaround, this would lead to a "tactical general." Initial feedback from the war in Ukraine shows the operational consequences of reduced room for initiative at tactical level, due to an overly strict control by the higher echelons. The Russian army's highly vertical chain of command, which includes few non-commissioned officers, grants little autonomy to tactical units; the latter tends to be reduced to reaction only. In contrast, Ukrainian doctrine encourages tactical initiative, leading to unpredictability and much more reactive attitudes.

Facilitated by cloud computing, the potential abundance of information, sometimes accessible in real-time and remotely, can also interfere with the decision-making process by exposing the decision-maker to:

→ An "**information avalanche**" which can lead to an **information overload**[2] where the data feedback is too dense to be processed efficiently. This overload can be explained by technical faults on the one hand, when the computing capacity is not sufficient to exploit the mass of data that is fed back and stored; and by human limitations on the other hand, when operators are exposed to cognitive overload and unable to extract useful information from the mass of data available. In April 2012, this led Regional Command East in Afghanistan to ban video feeds from Predator UAVs to Joint Operations Command, as these distracted operators from their missions[3]. This "infobesity" can divert attention from information which is essential to the conduct of operations.

→ **The blocking of the chain of command by the permanent expectation of additional information**. The appropriate response to overabundance of data could be to voluntarily limit the flow of incoming data. Instead, individuals often seek to have increasing amounts of information to make better-informed choices. However, a decision can only be considered appropriate in a specific context and according to the time frame in which it is made. By constantly trying to reduce uncertainty, decision- making becomes paralysed. For military leaders, the risk is to reduce their capacity for initiative and to place themselves in a reactive position. Maintaining the capacity to decide in conditions of uncertainty is essential as information will always be incomplete and imperfect: enemy action or theatre conditions may lead to a loss of connection with certain units.

1. CES Martin Pinel, "*La subsidiarité au combat : de quoi s'agit-il ?*", Fondation Maréchal Leclerc, 18/12/2020, URL: https://www.fondation-marechal-leclerc.fr/wp-content/uploads/2017/08/CES-PINEL_Subsidiarite-au-combat.pdf

2. Caroline Sauvajol-Rialland, "*La surcharge d'emails, nouveau vecteur de la souffrance au travail*", Huffington Post, 31/08/2012, URL: https://www.huffingtonpost.fr/actualites/article/la-surcharge-d-emails-nouveau-vecteur-de-la-souffrance-au-travail_8843.html

3. Serge Caplain, "*Les 10 pièges de la numérisation des forces terrestres*", Linkedin, 15/01/2018 URL: https://www.linkedin.com/pulse/les-10-pièges-de-la-numérisation-des-forces-serge-caplain/?originalSubdomain=fr

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In a context of increased dependence of the C2 on networks, these risks to the chain of command highlight the importance of:

→ Strictly maintaining the principle of subsidiarity of command;

→ Maintaining the responsiveness of decision-making, especially in a degraded environment where access to data may be limited or even cut off;

→ Managing the growing influx of data at the various levels of the chain of command while avoiding paralysis of decision-making;

→ Facilitating the processing of heterogeneous data from multiple sources;

→ Making information more accessible at all levels through ergonomic tools and interfaces.

These requirements are met first and foremost by managing information feedback and orders via each link in the chain, adapted to instantaneous data flows for all the players connected to the network. This implies that there

be a progressive upwards processing of information, but also an adjustment of the orders given downwards at each hierarchical level. Cloud computing can contribute to this organisation by enabling optimal distribution of data between "local storage" (up to the combatant level) and "network storage" (up to the strategic level). Its corollary for the distribution of computing capacity (Edge Computing) also allows data to be processed "locally" on platforms and terminals. Artificial intelligence, another technology closely linked to cloud computing, enables the automation of data processing and the extraction of useful information from the mass of data to guide - rather than automate or replace - decision-making.

Combined, these tools reduce the flow of data and therefore of information between the various levels of the chain of command. Once the data has been stored and processed at the relevant level, only useful information is transmitted onwards. In addition to reducing the volume of data flowing through the networks - and thus meeting the constraints of limited connectivity - they improve decision-making by on the one hand storing, and on the other transmitting

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Evolution of command with the emergence of "collaborative" technologies

As Asma Mhalla[4], a specialist in political and geopolitical issues of Tech, points out, the year 2022 will have been marked by the entry of cyberspace into the public debate. Whether through cyberattacks, disinformation campaigns on social networks, or the destruction or takeover of network infrastructures, cyberspace offers states new tools for power, subversion and coercion.

The year 2022 will also have been marked by the Russian invasion of Ukraine and the war that has been going on there ever since. Against all odds, the Russian army failed to achieve its main strategic or operational objectives, as it came up against a well-prepared, well-organised and highly resistant Ukrainian army. One of the notable differences between the two armies at war was in C2 (Command and Control). Where the Russian army remained organised according to the Soviet model based on excessive centralisation of command, the Ukrainian army has been able to evolve since 2014 and the loss of Crimea and part of the Donbass by making an effort on a decentralised C2 relying on small, mobile and underground command posts.

As C2 is recognised as the main factor of superiority, it is therefore vital for armies to take a determined look at so-called collaborative digital technologies to evolve their command in terms of its organisation and implementation and thus remain capable of winning the war.

On the one hand, one of the challenges of cloud computing lies in the ability to acquire more and more information, to be able to analyse, store, exploit, transmit and monitor it. The army that is able to do this will retain its freedom of action in the digital and data fields. It will be able to gain the upper hand over its competitors or adversaries by being one step ahead and by anticipating thanks to more powerful and more efficient decision support tools.

On the other hand, technologies in the fields of space, satellite, imagery, robotics, etc., contribute directly to the transparency of the battlefield, which is a particularly important factor in today's conflicts. Even if it is not absolute, it must be taken into account in the different operational phases of the strategic campaign. The direct consequence of this transparency applies to C2, which can hardly remain established on an organisation based on plethoric, sedentary staffs weighed down by ever more cumbersome digital tools. Today, a chain of command must be based on an organisation offering reactivity and pragmatism. It is therefore necessary for each level (strategic, operational and tactical) to know how to operate on small, agile and mobile HQs or CPs. A modular organisation in distributed PCs is already a relevant response. Furthermore, the principle of subsidiarity is an imperative. It is more applicable with access to the cloud. Any command entity must be able to connect to it and find the common operational picture (COP). Such an organisation allows for autonomy of the CPs down to the lowest level, which should not be seen as a permanent command, but as an opportunity to be exploited according to the manœuvre and the situation of the moment.

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4. Asma Mhalla teaches at Sciences-Po Paris and Ecole Polytechnique

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However, although they represent a major technological development, cloud computing, with its various applications (storage, messaging, collaborative tools, etc.), should not be considered as a panacea in the field of information exchange. Indeed, although it can bring real added value in terms of speed in the collection of information, data processing cannot be fully exploited without the contribution of artificial intelligence. Given the ever-increasing massification of information, whether operational or technical, humans are already no longer able to see everything, analyse everything and exploit the right data at the right time. Information overload will only increase in the operation of cloud computing, developing real cognitive risks.

Yes, and this is a reality, the difficulties and even risks associated with the emergence of new collaborative technologies exist, but given the challenges of cognitive superiority, of accelerating the decision-making process through decision support tools capable of automated or predictive analysis, militaries have little choice but to pursue with determination their understanding of a constantly evolving C2 and to consolidate the resilience of the chain of command. Therefore, not only will the chain of command need to be protected from cyber threats and jamming of all kinds, but it will also need to work continuously to increase its stealth, reduce its electromagnetic signature and thermal footprint, while promoting an operational level organisation based on a system of replicating parts of the strategic cloud.

The digital transformation of our armies has been underway for many years. Collaborative technologies will become increasingly important, as will virtual reality and other immersive solutions. It is therefore vital that we continue to keep up with the advances in high-tech and continue to evolve our chains of command. The complexity of the battlefield or the fog of war will not disappear, but it can be more understandable. The country that does not make the necessary efforts and investments has already lost the war.

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Adopting agile to avert becoming fragile

Modern warfare is the embodiment of variety. It is conducted in the multi-domains of land, sea, air and cyber - often simultaneously. While it often involves several nations acting in a coalition with troops operating with various equipment, using multiple languages and conducting operations in all conceivable types of environments. The potential scenarios are almost limitless.

It means that the basis of success for all armed forces is agility. But given the size and scope of the work militaries are faced with, the difference between wanting to be agile and actually being so, is vast.

No singular road map to agile

The obvious question is, "what is required to enable forces to be more agile" ? For all the bullets fired in this sector, there is no silver one. It is precisely because of the variations involved that no singular road map to agile exists. Yet there is a common denominator that differentiates the forces that are agile and those that are not. That is infrastructure.

The best and most agile militaries have the necessary infrastructure to allow coordination across coalition members, regardless of mission objective or geography. It is the backbone that supports data propagation to all the different command levels and is the key to delivering the right information, at the right tempo to the right individual so that initiative can be taken in the field by the mission commanders.

Changing chain of command

The dispersal of forces in the field are evidence enough that a monolithic chain of command no longer works. The requirement to enable initiatives in the field at a commander-level has not just fractured the traditional chain but obliterated it entirely. This is the 21st Century, Western approach to warfare and something we're seeing today in the conflict in Ukraine.

The Ukrainians, supported by leaders of other European states, are adopting this approach. It is a key strategy in aiding the fluidity of their operations both in attack and defense and why we continually hear reports of mission successes, no matter how small. The reason this is brought into such sharp focus, is because the Russian forces continue to operate with a very rigid command structure, which does not allow for flexibility or the agility to respond or prepare in enough time. This piece[6] of detailed analysis on the subject makes for interesting reading.

Federation of clouds

The next question is, 'what is infrastructure'? What do we mean and what is involved? To be clear, we're talking about a federation of clouds. That is a collection of clouds coming together to create a multi-cloud architecture. This ensures the right data is hosted, stored and shared in the appropriate place, capitalizing on the unique benefits of public, private or edge, without an over-reliance on one particular option. Aside from that, it allows for interoperability between nations and coalition members.

5. Major General (rtd.) Mick Ryan "*A tale of three generals - how the Ukrainian military turned the tide*", Engelsberg Ideas, 14/10/2022, URL: https://engelsbergideas.com/essays/a-tale-of-two-generals-how-the-ukrainian-military-turned-the-tide/

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This type of cloud architecture enables nations or forces to plug into the overall scheme or command infrastructure for information and data while offering the autonomy to scale activity up or down accordingly. This is where multi-cloud architecture is bringing value. It is cycle of processing information from the backend to the front in a federated mode and the basis for agility in the armed forces.

Multi-cloud in a coalition

Take, for instance, a coalition between Portugal, Spain and the UK. The UK would be the lead country with its own cloud architecture. But this same architecture would enable Portugal to plug-in with its own cloud and Spain to do likewise. This is a multi-cloud and it allows information to flow from the Portuguese or Spanish source into the UK control and command system as the lead country. This information can be processed at the back-end and delivered into actionable intelligence in the field almost in real-time. At the end of the operation, Portugal and Spain can disconnect with their security, intelligence and information intact.

Bringing multi-cloud to life

We only need to look back a few weeks to see an example of how this journey to multi- cloud is being brought to life. In December 2022, the U.S. The Defense Department (DOD) awarded the Joint Warfighting Cloud Capability[7] (JWCC) contract - the Department's enterprise-level acquisition vehicle - which allows the DOD to directly acquire commercial cloud offerings at all classification levels to serve missions from headquarters to the tactical edge.

The JWCC contract allows the DOD to have direct access to the four main cloud providers - AWS, Google, Microsoft and Oracle - of which VMware is the glue that binds them together. It means that warfighters will have the opportunity to, under one contract, acquire capabilities such as global accessibility; available and resilient services; centralized management and distributed control; ease of use; commercial parity; elastic computing, storage and network infrastructure; advanced data analytics; fortified security; and tactical edge devices.

Military leaders need not be afraid of integrating legacy systems or embracing multi- cloud architecture. The best and most agile forces are already doing this successfully. Without embracing this approach, there is no doubt that, in time, military operations will become fragile and unwittingly restrict progress. Or, even worse, put missions and lives at risk.

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6. AUS Department of Defense "*Department of Defense Announces Joint Warfighting Cloud Capability Procurement*", 07/12/2022, URL: https://www.defense.gov/News/Releases/Release/Article/3239378/department-of-defense-announces-joint-warfighting-cloud-capability-procurement/

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