The armed forces' current and future needs of radio frequencies: A strategic issue for France

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Abstract:
To remain competitive in dealing with an enemy that taps digital technology's potential, armies are modernizing and procuring innovative equipment to implement the concept of "collaborative warfare" based on more connectivity and a broader use of the radio-frequency spectrum. Such is the case of major programs in France (*e.g.*, Scorpion for the army or SCAF for the air force). Characterized by a quest for high speeds and very low latency (required for air/naval combat), this trend relies on all types of radio support and on satellite constellations. Obtaining a real-time view of a tactical situation, thanks to this connectivity, requires sensors for collecting information, satellites for observations, drones, interplatform connections for handling data, and better means of detection (like the radar systems to be installed on ships under the FDI, a completely digital program capable of guiding missiles in a hostile environment). Decision-making will thus be shortened when dealing with threats, including the menace of high-speed missiles. Dependent on using an ever more limited radio-frequency spectrum, the armed forces must foster resilience to cope with interferences and jamming, a sensitive but highly strategic maneuver.

Like the world, which is undergoing perpetual innovation while coping with menaces by relying on the most recent forms of technology, the French armed forces are undergoing modernization by procuring equipment with an ever improved performance thanks to advanced, innovative forms of technology. This situation calls for a conception of how to use this equipment in an ever more integrative way. Preparedness is a task to be done now but with a major drawback: how to make decisions by balancing the procurement of material for the next twenty or thirty years with forms of technology that evolve faster, normally every two or three years?[1]

This modernization is mainly intended to implement the concept of "collaborative warfare". The party that masters this concept is sure to have the capability of coordinated maneuvers thanks to a sharing of not only information but also objectives. The architecture for this relies on increased connectivity, which, in turn, depends on a broader use of the radio-frequency spectrum, so that descriptions of tactical situations can be shared in real time, thus shortening the decision-making process. The French army, navy and air force each has expressed the need for new military capacities, genuine "systems of systems" capable of sharing information in various environments and in synergy with our allies.

[1] This article, including quotations from French sources, has been translated from French by Noal Mellott (Omaha Beach, France).

For these reasons, the optimized use of the radio-frequency spectrum, the major means for conveying data from sensors and between information and communication systems, is the solution for increasing connectivity. It promises descriptions of the military situation in real time along with ever improved means of detection so as to shorten the decision-making process, but with a negative effect: a heavier dependency, which requires, as a consequence, even more resilience.

Frequencies for more connectivity

In current scenarios, military equipment and even weapon systems will be used ever less in isolation. Instead, they must fit into the model of collaborative warfare, based on platforms that, cooperating with each other thanks to more connectivity, hold the promise of a global system that outperforms the sum of each platform's own performance.

For instance, Scorpion, one of the French army's major weapons programs, is intended to modernize the median combat capacity of units at the level of the regiment by renovating or developing equipment and, especially, by improving exchanges between commanders thanks to a new information system. Since the end of 2018, Scorpion is trying to reinvigorate contact combat capability thanks to the value of information ("infovalue") — by interconnecting the major pieces of existing but modernized equipment (*e.g.*, Leclerc tanks) and two new platforms: VBMR Griffon, a multi-role armored vehicle, and EBRC Jaguar, an armored reconnaissance and combat vehicle.

Figure 1: The VBMR Griffon, a multi-role armored vehicle.
Source: P. Segrette ©DICOD.

Figure 2: The EBRC Jaguar, an armored reconnaissance and combat vehicle.
Source: A. Thomas-Trophime ©DICOD.

To protect the population and neutralize the enemy, mobile, agile forces have to be deployed with an effective capability of observation and action, whether maneuvers are performed in large zones or, on the contrary, in very small (even urban) areas. By networking forces, Scorpion makes it possible to oversee territorial units and share the information necessary for controlling the situation. It also directs the ability to strike at the place and time wanted and with an adapted intensity. The "effector", which produces the expected effect, is not necessarily a sensor that captures information.

This "infovalued" combat is based on SICS (Scorpion Combat Information System) coupled with CONTACT radios (Communications Numériques Tactiques et de Théâtre, a new generation of radios that is the successor of PR4G radios with frequency hopping) and with the ground station of Syracuse IV satellites. The latter will place at the disposal of our armed forces better satellite communications in terms of throughput, availability and resistance to threats.

CONTACT radio will offer to our forces software-defined radios that operate on VHF and UHF. Since operating them will be transparent for users, these radios will be more efficiently used than the current generation of radios. Having a radio core in common, the tactical CONTACT radios used for ground, air and naval operations will provide better throughput, security and interoperability. Unlike cellular networks and PMR (private mobile radiocommunications), the CONTACT radio system does not use a fixed communications infrastructure, since each radio set can automatically relay information in a resilient, self-adapting network.

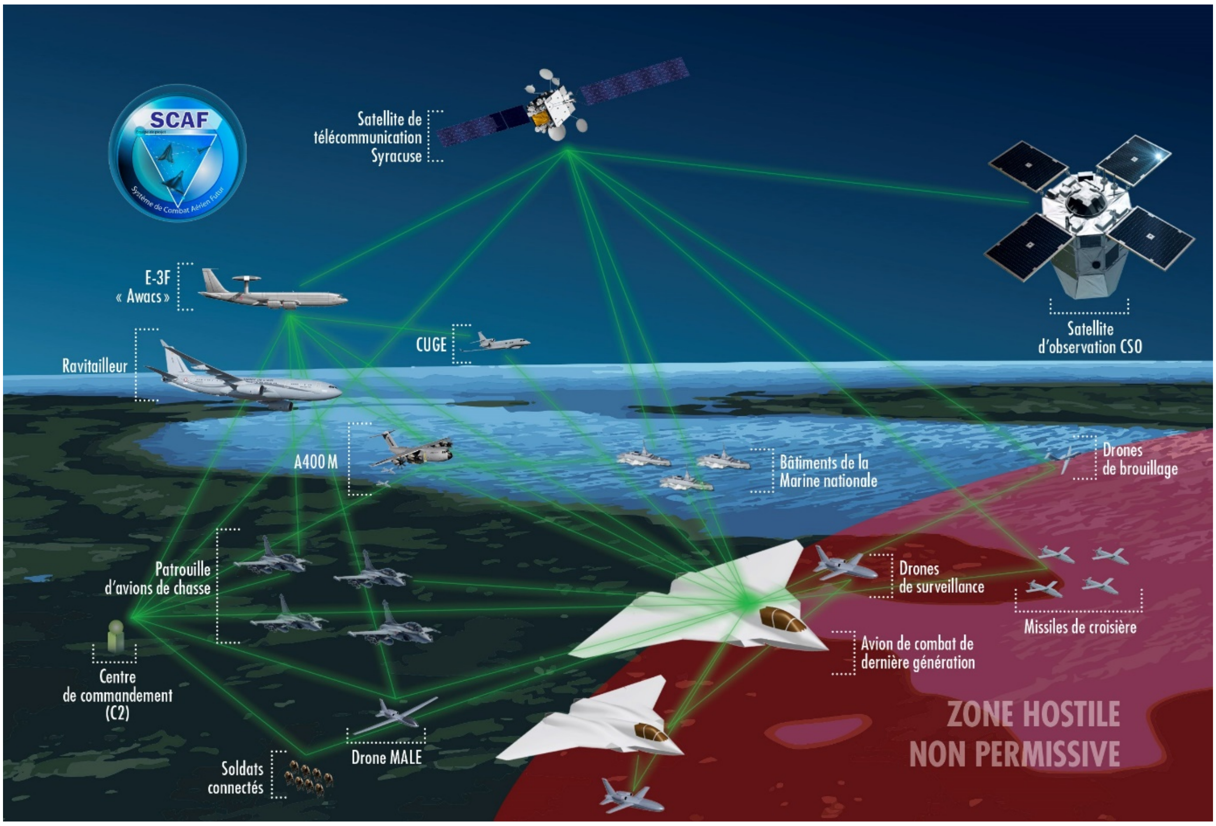
Coupled with SICS, the new CONTACT radio sets will speed up exchanges of tactical data, allow for blue force tracking, and enhance the capacity for commanding all units. Naval networks will necessarily be interconnected with SICS.

Already interoperable with standardized radio protocols and based on an open radio architecture, CONTACT will also decisively improve interallied deployments, thanks, in particular, to the future standard ESSOR (European secured software-defined radio). In this baseline architecture, which is compatible with the American SCA standard (software communications architecture), a specific waveform with a high bit rate has been worked up into a new standard. Software-defined radio and the waveforms developed for it will respond to the new needs with a very high operational value that the armed forces have expressed in matters related to the digitization of the battlefield, the increasing utility of applications (such as C4I: computerized command, control, communications and intelligence), the transmission of images and videos, etc.

The armed forces will also use Syracuse IV, the fourth-generation program of satellite communication. In 2019, the Directorate-General of Armaments (DGA) notified the contract for designing and building installations for this program, and the first deliveries are planned for 2021. Long-distance communications between headquarters in France and the theaters of operations (or even within these theaters) have to be secure and resist interference. They are the key to evaluating situations, making plans and commanding forces in operation. The Syracuse IV system comprises the space segment (geostationary satellites) and ground equipment for users (terminals) and network operators (stations for connections with terrestrial networks, centers of management). Designed to handle cyberthreats, interference, electromagnetic interceptions and pulses, this equipment can be reconfigured in flight and increase the bit rate available on the K_a and X bands. This program will endow the armed forces with improved communications: data rates, connection speed, and resistance against threats.

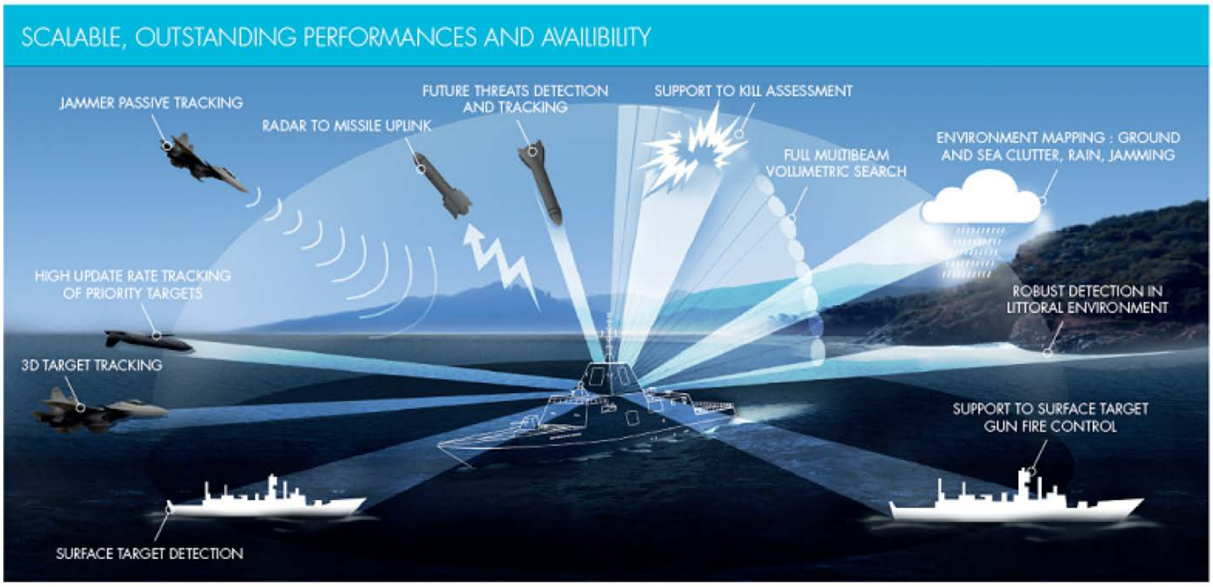
Having the same need for permanent connectivity, the air force has launched CONNECT@AERO for collaboratively using equipment more effectively than do eventual enemies. The goals are to adapt the system of aerial combat to menaces in the years 2025-2035, prepare SCAF (a system of air combat of the future: 2040) and propose a coherent, incremental approach to improving the air force’s capabilities.

Figure 3: The conception of SCAF, a future air combat system.
Source: ©SIRPA Air.



As for the navy, the rapidity of air-ship combat in the future calls for overhauling the connectivity of naval forces too. Like Scorpion and CONNECT@AERO for ground and air forces, the AXON@V roadmap lays the basis for long-term planning with the ambitious goal of connectivity for carrier battle groups. These plans take into account the growing threats from space and the menaces arising because reaction times are shorter. For this purpose, collaborative warfare will require very high throughput and low latency. It will also be necessary to explore the potential of constellations of medium and low Earth orbit satellites (MEO/LEO) or of high altitude platform stations (HAPS for services with less resilience in combat). For lower bit rates, the HF wideband will provide a resilient C2 service (command and control). Clearly, the objective is to eliminate earth-sea discontinuities and differences in connectivity between big ultraconnected carriers and small ships with a lesser capacity.

Figure 4: Collaborative air-ship combat
Source: ©Thalès.



Connectivity for real-time descriptions

In low- or high-intensity combat, controlling "space" (in the digital realm too) is a key factor for preserving a freedom of action and initiative, and therefore a superiority over the enemy.

As seen, SICS is useful for collaborative warfare, since it shares the data gathered by all Scorpion platforms nearly instantaneously (via HF/VHF/UHF and X/K_a in communication satellites: SATCOMs).

Furthermore, soldiers of the future will rely on robots for reconnaissance and the defense of their perimeter (rocket attacks, etc.). Given this, the Ministry of the Armed Forces has already experimented with an autonomous motorized system for autonomous movements (without supervision by an operator). Such a system activates sensors and other devices; but it also requires radio frequencies (*e.g.*, control/command or vehicle radar in the S and W bands).

Benefitting from the convergence of military and civilian technology, the logistics of support to soldiers will be based on real-time descriptions of stocks, equipment and consumption patterns (munitions, outfits, etc.) thanks to sensors of radio-frequency identification (RFID).

Figure 5: FELIN (Integrated Infantryman Equipment and Communications)
Source: J.J. Chatard ©DICOD.

Like satellites for observations, drones, which heavily use the radio-frequency spectrum, have become essential for obtaining real-time reports. To their advantage, they can accomplish missions in tough environments, when air supremacy is not assured, or when facing a nuclear, bacteriological or chemical threat. What characterizes drones is: their mission, autonomy, flight altitude and range of action. The missions for French military drones will be: surveillance and reconnaissance, as well as relaying communications, designating targets and (tomorrow) firing. In many areas, drones have to abide by the rules for civilian air traffic, which are based on the regulations laid down by the International Civil Aviation Organization (ICAO). Drones use radio frequencies not just to steer, but also for altimeters, transponders and, potentially for an automatic system of assisted landings and takeoffs, radio to air control communications, and soon for an anticollision system. Drones also need liaisons for their payload: radar, sensors, the system for relaying communications, etc. Access to the spectrum, eventually on all bands, is essential for drones.

Figure 6: The SDT Patroller
Source: P. de Poulpiquet ©DICOD.

Independently of technical limitations, flight security requires reliable connections between the control center and drones. The spectrum is, therefore, extremely important, since connections must be available at a sufficient bit rate, regardless of the range, and the system has to resist interference. Studies on a future European system (MAME: Medium Altitude and Long Endurance) based on the K_a and/or K_u bands are being conducted in cooperation between France, Germany, Italy and Spain.

The size of the mobile platforms necessary for providing real-time reports on tactical situations is shrinking. The Agency of Innovation for Defense (AID) has a plan for a SATCOM antenna that, 3-5 cm thick, will be "*agile, intelligent, electronically reconfigurable*" without being too expensive. By covering a wall with "metasurfaces", it will be possible "*to block the waves reflecting from it, concentrate or orient them in a precise direction in a given situation*". This means controlling an electromagnetic field in a small, semi-open, chaotic cavity. Work is under way to coat one or several parts of the cavity's internal surface with an electronically controlled metasurface. According to AID, "*the goal is to control conditions at the limits in the cavity and distribute the fields in the cavity's opening so as to point directly toward the satellite.*"

Figure 7: Future Combat Air System (FCAS) model at the Paris Air Show at Bourget in 2019
Source: J.-L. Brunet ©Armée de l'Air.

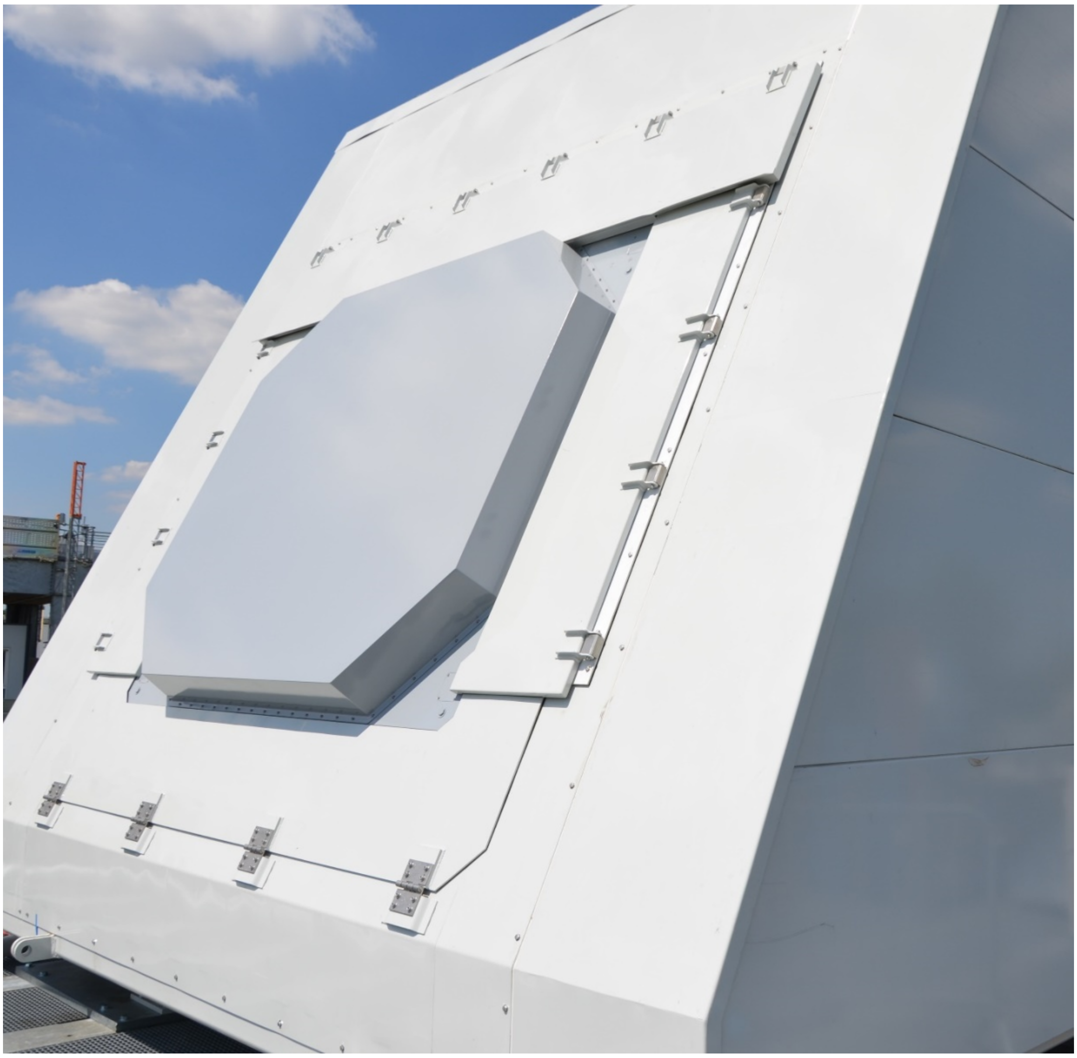
The Future Combat Air System (SCAF) will rely on the HF/VHF/UHF ranges and SATCOM (K_a and/or K_u). The liaison of interplatform data (furtive intraflight of the Next Generation Weapon System, NGWS) will probably rely on a waveform high on the band.

Sharing information in real time also requires powerful sensors.

Connectivity for improved detection

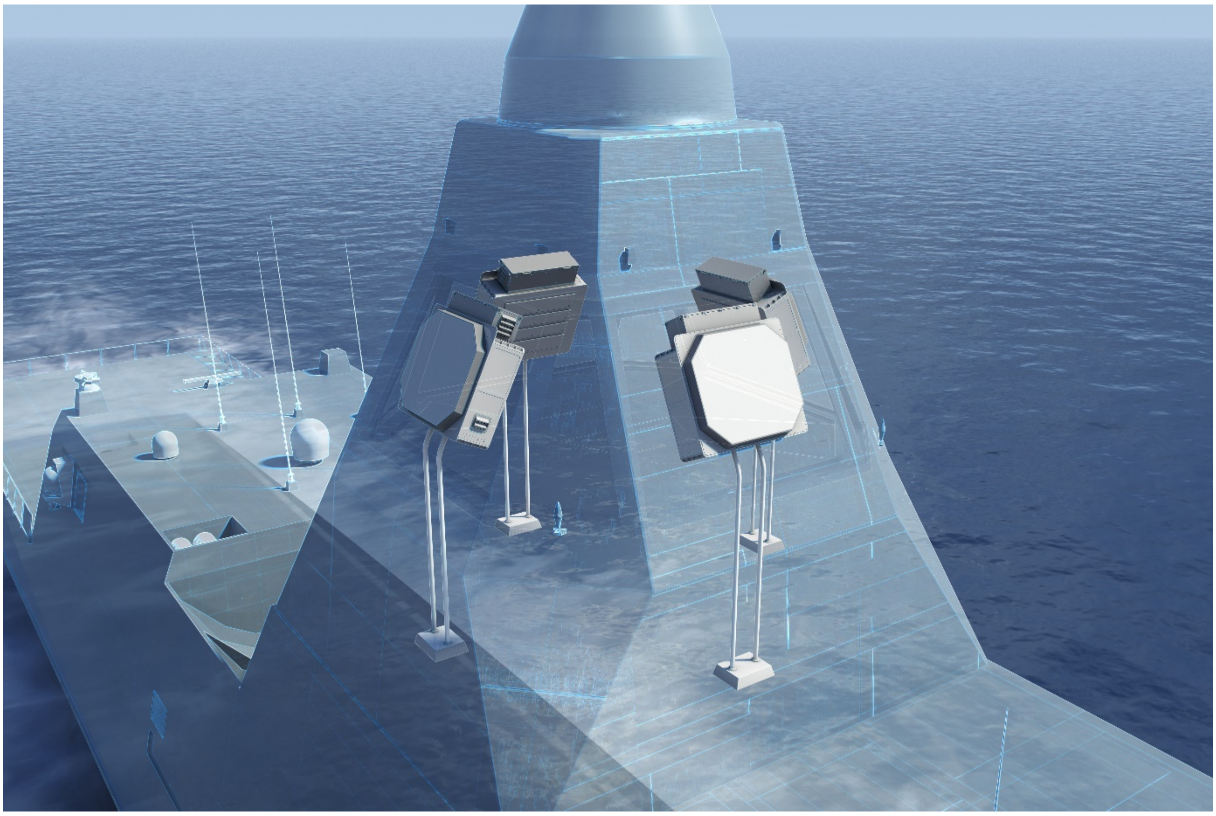
The armed forces are pursuing the modernization of sensors. For example, air defense is to integrate not only a new generation of drones but also new radars from the Ground Fire family (band S) while continuing to use large radar panels (on the L, C, X and K_u bands). The fully electronic Ground Fire family offers an unprecedented performance in missions of surveillance and air defense, including anti-missile ballistics, with the capability of guiding missiles of the Aster family in a hostile environment (due to clutter, congestion, rainfall, interference, etc.). Deployable in fewer than fifteen minutes, Ground Fire radars are very compact, extremely mobile and transportable by air. The panel includes a mobile antenna on a truck and will be able to operate on any terrain. The Ground Fire family is identical to Sea Fire, the naval version (also on the S band) that will equip frigates of intermediate size for defense and interventions (FDI).

Figure 8: Sea Fire 500 radar panel
Source: ©Thalès.



Sea Fire will also be able to fire missiles if a threat arises on the sea or in the air. This radar is not at all like the rotating systems enthroned on French warships. Sea Fire is a fixed component installed in the radar mast. On each of its four panels are sensors for analyzing the environment in 3D so as to detect anything that floats, flies or runs. Sea Fire is designed to detect and target ultra fast aircraft. But above all, this radar is designed to be adaptable to changes in the technology of military equipment. This “software radar” has capabilities that can be updated without having to modify the hardware.

Figure 9: SF500 installed on a frigate
Source: ©Thalès.



For interventions at sea to protect shipping or fight against the drug trade or human trafficking, the weapons program AVSIMAR foresees using air drones for the navy (SDAM) or tactical operations: light vertical take-off and landing aircraft (VTOL), light drones on POM patrol boats (Patrouilleurs Outre-Mer) and light/heavy drones on patrol boats on the high sea.

With this stronger capacity for detection, which requires major efforts in research and development, the cycle of the processes that enable commanders to decide and act — the decision-making loop — will be shortened.

Connnectivity for shortening decision-making… on condition of more resilience

During the ceremony for the delivery of the first such vehicles to Nexter in Satory on 4 July 2019, Florence Parly declared, "*The new Griffons are capable of collecting data from their environment and turning them into combat information. They are equipped to assist decision-making for responding to menaces. They are the spearhead of collaborative warfare.*"

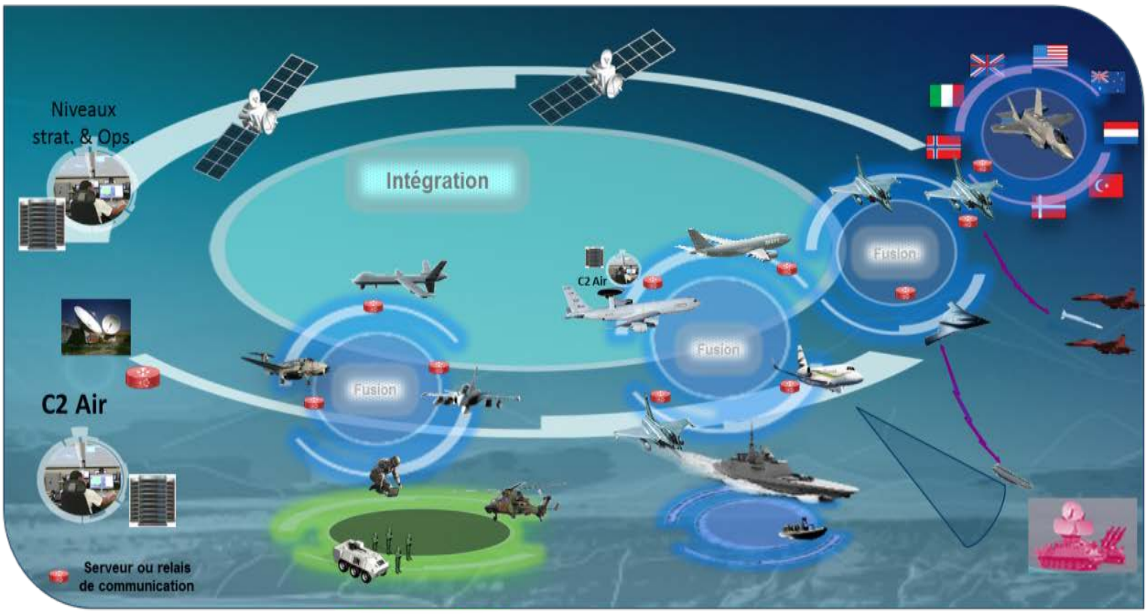
To cope with issues related to stealth and the upgrading of enemy forces in the air, the principal axes for shortening the decision-making process are:

- collaborative detection (refinement of the Common Operational Picture through a coordinated distribution and orientation of passive sensors, radars, optronics).
- collaborative engagement (missile guidance through a coordinated distribution and orientation of sensors and effectors).
- collaborative combat for defense and survival (maneuvers, interference, baiting, fire power).

This optimized decision-making process requires:

● the debunkerizing of the uses of sensors and effectors;
● an autonomous local, discreet and robust, network;
● local real-time supervision of means (adapted interaction between people and the system); and
● a high degree of interoperability.

Figure 10: Connect@aero
Source: Faury & Ledoux ©Bureau des Plans de l'Armée de l'Air.



Thanks to a centralized and distributed command and control (C2), the conception of maneuvers will be shared; and our strike capability, accelerated. High-intensity combat will benefit from radio sets with very high data rates and directional antennas and from the support of drones. The harmonized NATO band (225-400 MHz), which is heavily used for UHF communications and applications (aerospace, maritime and satellite), in particular for the control of air space, will have a major place in this sort of combat.

In ever more disputed spaces, where threats are growing (due to very high velocity missiles, for example), the French Navy is developing a polymorphous strategy for shortening the decision-making process in order to preserve its freedom of action and initiative. This supposes a technological breakthrough in the performance of sensors, the extension of the capacity of the chain of command for engaging missiles, and collaborative naval combat so as to reduce reaction times for "detection, classification, engagement".

Time is a multifaceted factor in naval connectivity. Compatible forms of technology should render services as expected in terms of bit rates, latency and resilience:

● the immediacy of collaborative warfare against a hypervelocity menace: very low latency, a very high bit rate, and a high degree of resilience. Line Of Sight (LOS): very high bit rates, directional antennas, a naval increment of high-frequency radio programs and relays (drone/airplane/HAPS).

- the timing of operations: air-sea C2 in real-time or nearly real-time. SATCOM has high bit rates, and MEO/LEO satellites are to be equipped for optical transmissions toward geostationary satellites (GEO).
- a longer perspective (non-real-time). The capability of a more usual SATCOM GEO with high bit rates but more latency.

Let us not overlook HF, an awesome means of resilience for SATCOM and the diversification of constellations of satellites (MEO or LEO). Despite the saturation of the spectrum, the new HF XL technology will provide IP access on a broad band (instant messaging or on-line conversations) by simultaneously using several separate HF channels, thus ensuring transmission at a high bit rate.

The decision-making process will, therefore, be shorter thanks to a harmonization of: communication systems, standards for exchanges, and the necessary waveforms. The development of a dynamic, adaptive control of the radio-frequency spectrum will favor these changes.

The Ministry of the Armed Forces is the public authority with the most primary or priority services on radio frequencies registered in the national table of frequency allocations (TNRBF). Nonetheless, the number of assignments has been constantly dwindling under pressure from new forms of technology (such as mobile telephones) and interests unrelated to the exercise of national sovereignty. At stake for the armed forces is to have enough of the spectrum in both quantity and quality to maintain coherency between its operational means and the assigned missions.

Given this increasing dependency on radio frequencies, jamming devices represent a tangible, permanent threat. Operating a jammer is a voluntary action intended to neutralize radio systems in a sector. For example, a drone with 3G/4G connectivity and WiFi is vulnerable on a theater of operations owing to these two types of connectivity. To cope, the armed forces use resilient systems for scrambling or frequency hopping. When a system is developed, its resistance to jamming is evaluated. In addition, the armed forces now undergo training in unfriendly electromagnetic environments. In turn, jammers can be used to protect our forces against improvised explosive devices (IED), for example. A coordination procedure exists in France for the operational use of jammers for defensive purposes, especially in the fight against enemy drones.

In conclusion, the Ministry of the Armed Forces is definitely conducting a sensitive maneuver: obtain future weapon systems that are collaborative, agile and resilient but while thus making the armed forces ever more dependent on radio frequencies, even though the spectrum is under ever more pressure! To satisfy its growing needs for bandwidth, the Ministry will have to wager on innovation to help better manage the spectrum and improve the efficiency of radio systems.

The key to success obviously lies in the capability of the national regulatory authority (ANFR) to satisfy as best possible the demand for frequencies from the Ministry of the Armed Forces. The spectrum thus turns out to be an immaterial but highly strategic good.