Artificial Intelligence Serving Airmen, or How Human Intelligence is the Future of AI

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Artificial intelligence (AI) is one of the four technologies at the heart of digital transformation of the Air Force as the Future combat air system (FCAS, *Système de combat aérien du futur*—SCAF) is being developed, in parallel with its use in the massive amount of analysis of data (big data analytics), in connectivity and in cyber-security. By combining the calculating and storage capacity of computers with the ability of human intelligence to adapt itself, this transformation is aiming to create a truly cognitive air combat management system.(1)

In the world of AI, connectionism and machine learning have progressed markedly as a result of huge increases in calculating power.(2) The ability to handle vast quantities of information in a very short time is now excellent, and compensates for human limitations such as memory, attention, calculating ability and anticipation in situations where there is an excess of information (*infobesity*!) and where speeding-up of decisional processes is necessary. And yet these digital technologies remain limited to effecting specific, identified tasks: the notion of AI being able to perform better than its creator is a complete myth, as is the much vaunted technological *Singularity* from which it is derived.(3)

For that reason, the planned cognitive air combat system neither breaks with humanism nor leads to the semantic dead end of anthropomorphism. Since AI does not have the human ability for lateral thinking, questioning whether machines can think is about as relevant as asking whether aeroplanes know how to fly.(4) On the contrary, AI needs to allow the airmen to concentrate on his main tactical and operational combat tasks, which gives rise to a counter-intuitive paradox: the more we advance in AI, the more man is able to fulfil his potential, given that he is relieved of the simplest analytical tasks. Since he is able to understand both context and higher-level issues, the airmen will always bring good sense, intuition and the ability

(1) Ferrari Vincent, *Prise de décision et numérisation de l'espace de bataille : l'exemple du C2*, French Air Force Research Centre, May 2017.

(2) They represent the most remarkable progress yet in supervised learning by networks of neurones fed with vast quantities of data.

(3) Ganascia J.-G., *Le mythe de la singularité : faut-il craindre l'intelligence artificielle ?*, Éditions du Seuil, 2017, 144 pages.

(4) This paraphrases the mathematician Edsger W. Dijkstra, whose comparison was whether submarines can swim.

to adapt when faced with the unknown. Man is very much the future of AI within the cognitive air combat system of the future.

The Air Force is therefore moving ahead with great determination on the road to developing AI, whose numerous fields of application range from predictive maintenance to the management of multi-agent systems within the Man-Machine Teaming project.

AI and the Performance of Maintenance in Operational Condition

In the short term AI and big data analytics together offer decisive opportunities on the economic, industrial and practical levels to increase the availability of fleets and, in fine, the overall performance of maintenance in operational condition (*Maintien en condition opérationnelle*—MCO). Three channels of effort have been identified within the Air Force—predictive maintenance, its corollary *logistique 4.0*, and robotisation of maintenance operations.

Digital technologies will allow optimisation in the planning of maintenance tasks with regard to operational requirements by substituting the conventional, correctional approach with one that is diverse and predictive, intended to 'make danger predictable'.[5] This will be achieved by aggregating and correlating data from different sources: from the maintenance and service units of the Air Force, from industrial concerns in general (integrators, builders and sub-contractors, among others), and also the data coming directly from the digital twins of connected aircraft. These virtual twins, taken from the Internet of things, should allow data analysis in real time through the use of AI machine learning techniques and its ergonomic presentation on a three-dimensional, enhanced-reality display. Such projects are being studied for natively connected aircraft for use from around 2030. The principal purpose of this value-added data is to improve the management of fleets and to anticipate maintenance operations including the pre-positioning of spare parts.

Optimisation of logistic support is a natural corollary of predictive maintenance. AI and big data should lead in the short term to optimisation of logistic flows through use of better real-time capability for anticipation of demands, stock levels, state of materiel and driving replenishment pipelines.

Robotics and additive manufacture are progressively modifying line maintenance of aircraft. For example, automated drones are currently under study for inspection of areas of aircraft that are difficult to access—from above or even within the airframe. Furthermore, 3D printers will in time allow some parts to be manufactured within the country or in the theatre of operations, where the logistic flow is often limited.

Management of the Mass of Operational and Intelligence Data

Apart from MCO, the strategy for adoption of AI must start with control of data. From intelligence to planning and conduct of operations, insertion of AI must

(5) Choain Christophe, *La course au numérique est en marche*, *Epidosis* No. 48 by Cesa, July 2015.

of necessity respond to the problem of the information deluge. In particular the amount of information available (the *infobesity* mentioned above), the multitude of players involved and the improvement in performance in general all pose a number of challenges to the command. Faced with this problem, the real question concerns the data rather than the algorithm. Digital technologies have become essential for the analysis of vast quantities of data, to consolidate the information extracted and then to distribute the knowledge acquired in order to decide and act with clarity.

IA and Sensors

The first step is to integrate AI into the sensors of the different weapons systems in a 'data and services' approach. Current effort is on the tools to help handling and exploitation of information in order to achieve better discrimination and identification of potential targets through use of automatic target detection and recognition algorithms.

For example, the Rafale F4 standard will integrate this type of algorithm into its TALIOS targeting pod(6) for optronics, its RBE2 radar(7) for radar imagery and, in the longer term, into SPECTRA(8) for electronic warfare. Similarly, work is in hand to improve terrain interpretation and detection of anomalies arising from wide-field surveillance of medium altitude, long endurance (MALE) drones—the Wide Area Motion Imagery (WAMI) System.

Allocation of importance to the transmitted data is also of great importance in an operational environment constrained by the techniques used—for example, a given pass band is finite, so data rates remain limited and are never as high as those of fibre-optics—and also by the threat of contest within the EM spectrum.

If initially identified by AI, priority information could be transmitted as rapidly as possible whilst that of lesser importance or criticality could be stored, indexed and archived for later exploitation.

The Problem of **Infobesity** *in Intelligence*

The second step acknowledges the problem of *infobesity* in intelligence, where issues of criticality, integrity, validity and sensitivity of information are exacerbated. The challenge, then, is to exploit more effectively and independently a great, and greatly increasing, mass of data with ever-limited human resources. The use of AI and big data analytics is therefore needed to automate the most common types of data handling and to optimise the collation of data coming from multiple directions and sources. The final objective is to refocus human endeavour onto high added-value functions of expertise such as decision-making, high-level analysis, creation and conceptualisation.

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(6) Targeting Long-range Identification Optronic System.

(7) RBE2: *Radar à balayage électronique 2 plans* (Two-dimensional electronically scanned radar).

(8) SPECTRA: *Système de protection et d'évitement des conduites de tir du Rafale* (System for protection and avoidance of enemy fire control for Rafale – in short, the advanced EW suite).

Digitisation of Operational Command and Control (C2) Structures

Lastly here, the ability to put AI into effect efficiently is a major challenge in the management of an increasing flow of data in air operational command and control structures. Management of combat space will therefore need ever more efficient real-time coordination and sharing of information—the notion of the Common Relevant Operational Picture (CROP). To have success in operations in distant theatres and over long periods, forces will need digital assets that are compatible with real-time transmission of information so that the entire command chain can operate at the required tempo.

The Air Force is making such moves towards digitisation of its command structures, supported by the technologies associated with AI—the e-JFAC concept.(9) Progress in digital technology should enable C2 Air to:

- **Automate general tasks** of airspace management and coordination.
- **Have available dynamic, resilient and connected databases.** Resilience comes from spreading of data (between aircraft, air bases and command centres), from its transmission and from functional applications with or without connectivity.
- **Give sense to data** by optimisation of man-machine interfaces, to redirect human effort onto the most useful information, which means the human will remain in the loop, or in close supervision of it (on the loop), as required and as a function of context and operational tempo.
- **Assist manoeuvre planning** by offering relevant modes of action. AI will then be able to enhance the traditional techniques of serious game by increasing the available possibilities, anticipating the probable behaviour of the adversary and increasing the chances of facing him with a dilemma.
- **Assist conduct of a manoeuvre**, by following divergences from the plan and by proposing reactive changes in the face of contingencies.

Thereafter, the involvement of AI in C2 Air should lead to shortening the OODA loop, particularly in air operations evolving well away from decisional centres.

Connected, Collaborative Air Combat and Virtual Cognitive Assistance(10)

In the face of growing anti access/area denial (A2AD) strategies, conducted in and from airspace will increasingly be regarded from a multi-domain point of view, within which its collaborative dimension will be one of the measures of freedom of military action.

Networking of different airborne weapons systems centred on the Rafale and the future Next Generation Fighter (NGF) will make new modes of collaborative

(9) JFAC being Joint Force Air Command.
(10) Faury Étienne and Pappalardo David, *L'intelligence artificielle dans l'Armée de l'air*, Special edition of *Défense & Sécurité Internationale* (DSI) No 65 (*Intelligence artificielle – Vers une révolution militaire ?*), April 2019.

combat possible, which will in turn increase the intrinsic fighting strength of the platforms. But there again, connected, collaborative air combat will also necessitate piloting of ever more complex systems. AI has therefore to allow the creation of a genuine virtual cognitive assistant to the aircrew, whose double aim is aiding decision-making and piloting of complex systems.

Aids to Decision-Making

Within the Man Machine Teaming (MMT) study programme, co-directed by Dassault and Thales, the aim of studying this virtual assistant is to make it proactive, by suggesting changes in the operational states of objects, and also reactive, by continually choosing the best function or the best resource to obtain the desired change of state. It will have to interact and work in an intuitive and natural manner with the aircrew if it is to help them in their missions. This means capabilities to adapt displays and alerts to the tactical situation and to the cognitive workload of pilots, assist the reconfiguration of systems following breakdowns and faults, improve prediction of the chance of success of a weapon firing, adapt navigation as the tactical scenario develops and more yet.

Management of complex systems and autonomy[11]

Connected, collaborative air combat will go hand-in-hand with strengthened partnership between human operators (whether embarked or not) and the autonomous functions within a system of systems. This partnership must improve the effectiveness of the mission above that which the traditional manned craft could achieve by itself. To achieve this, the virtual cognitive assistant must be in a position to respond to demands placed upon it, to anticipate needs and to act autonomously, though in coordination with the overall system.

For example, combat in numbers (packs of manned platforms, combat drones or remote carriers) will offer the effects of saturation, which will make neutralisation of ground-air defences of an A2AD network easier. Collaborative autonomy will in this case allow overall coherence of flight trajectories—avoidance of collision and assessing the performance of the saturation effect—in particular for stealthy elements and in a Navwar context.[12] Besides that, it will improve the survivability of the overall unit by assigning designated tasks to certain consumable elements to the benefit of the whole pack. This approach is to wear down the opponent, as distinct from the classical duel in the sky, which very often needs more expensive technology and which is difficult to guarantee over the long term.

The arrival of cognitive virtual assistants and the collaboration within a system of systems that goes with it will, in short, empower air strategy with ubiquity through

(11) Pappalardo David, *Combat collaboratif aérien connecté, autonomie et hybridation Homme-Machine : vers un "Guerrier Centaure" ailé ?*, *DSI* No 139, Jan-Feb 2019, p. 70-75.
(12) Navigational warfare, which incorporates PNT, meaning Position-Navigation-Time.

recreation of the mass that is essential to open the spatial and temporal doors to air superiority in the face of enemy defences.(13)

Protection: the Sole Solution to Counter Adverse AI

The advent of AI is not only a source of opportunities, it is also harbinger of new threats. No longer can anyone claim to beat AI at chess or *Go*. If strategy is, according to Coutau-Bégarie, a debate between opposing forces in a conflictual environment, the armed forces have to be in a position to face the adversary with a higher intelligence, able to operate at a higher speed over a broader spectrum.(14)(15) The Air Force, itself facing growth of this new form of conflict, needs to be in a position to counter massive, synchronised, sudden and autonomous attacks, be that in cyberspace, for the analysis of weak signals, or in the face of a saturating swarm attack of mini drones or cruise missiles. In particular, the threat of a swarm of hostile mini drones against an air base or other sensitive site poses a real challenge to national ground-air defence capabilities: the miniaturisation of these technologies and their easy availability is making the threat from Low, Slow, Small (LSS) drones ever more credible and dangerous.

At the other end of the spectrum the emergence of a hypervelocity threat by its very nature means we have to possess defence systems that are more and more automated and reactive, given the short reaction times afforded.

Education and Training

As a final point, AI must play a key role in transforming and improving the training of airmen in all their operational functions. On the individual level, AI will be able to stimulate active and interactive learning through personalisation of syllabi, hence creating a sort of virtual coach. Regarding virtual operational preparation, AI will facilitate generation in the various simulation tools of representative, threatening virtual opponents.

On the level of the Air Force as a whole, AI collation of data from doctrine, training and operational feedback should lead to better performance evaluation, and short-cycle identification of channels for improvement. AI and massive, coordinated data handling will then help the Mont-de-Marsan Air Warfare Center (*Centre d'expertise aérienne militaire*—CEAM) to become a creditable battle lab, capable of developing tactics, techniques, procedures and doctrine and being in a position to advise the operational chief and the staff headquarters.

(13) Malis Christian, *Horizon 2030 : réflexions prospectives sur le combat terrestre*, *Revue Défense Nationale* No 778 March 2015, p. 105-112.
(14) Coutau-Bégarie Hervé, *Traité de stratégie* (7th edition), Economica, 2017.
(15) Pappalardo David, *DSI*, *op. cit*.

The airmen shall not be the subject of the algorithm

In conclusion, and following in the footsteps of one philosopher and expert in autonomy, to see robots as mirror images of what we should be is an error. The manner in which we program them or the information that we 'teach' them will reflect our prejudices, our cognitive biases and all that ought to change in our societies. Robots will not create a perfect world for us.(16) AI and robots will not create a perfect world for the Air Force either. They bring us many promising things but do not announce the end of the airmen within the FCAS. To this end, the Air Force is developing a voluntarist strategy with neither false modesty nor excessive hope but always with responsibility. Its main factors are:

- **Critical acknowledgement of data as the basis of AI**: it is essential to store, archive, structure and add value to data by setting up adapted infrastructure and rationalising our processes.

- **Acceleration of application and adoption of AI**, not only with regard to the technology, but also organisation and human resources, so we are not left behind. For the Air Force and air operations to take full part in the AI age, future systems architectures will need to be designed to cater for continuous digital development throughout their long lives (30 years for a Rafale). We must be able with ease to improve software and on-board data storage and calculating capacity, without having to requalify the entire aircraft. That will mean separation of flight and combat systems and dissociating hardware, software and data. That is in itself a revolution.

- **Hardening against the increasing cyber threat**: hence the need to retain non-connected modes of action and the ability to use fallback modes to maintain a certain level of resilience.

- **Strict ethical rules**. A machine can never be moral or ethical. But as Louis Colin indicated, ethics remains pertinent in consideration of risk and in good governance of robotics for aggressive use.(17) Ethical action has to be made in consideration of the precepts of utilitarian ethics, in which an action is good when it produces the best possible consequences for the individuals or enterprises affected, and the ethics of responsibility, in which 'I respond to the consequences of my actions'.

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Given the stakes involved, the rationale of the air combat system must be shaped by three essential conditions: that the association of man with machine benefits from accuracy and speed of automation to increase many-fold the agility and creativity of human intelligence; that AI will not abolish human responsibility and will not remove the man from the decision process when committing to lethal force; and that engineers' ideas in design will not replace those of the airmen in the decision-making process. Man must never be subjected to the algorithm, but use it to improve his own performance. ◆

(16) See: Ruffo de Calabre Marie-des-Neiges, *Itinéraire d'un Robot tueur*, Éditions Le Pommier, 2018, p.180.
(17) See: Colin Louis, *Éthique des systèmes d'armes autonomes (dissertation)*, University of Cergy-Pointoise, 2018.