Air Power: The 6th Generation of Aircraft

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Introduction

In addition to the existence of conventional threats, today the geopolitical scenario offers very complex hybrid challenges.

Borders have returned to the centre of world politics, just like a century ago on the eve of the Great War. Moved, cancelled, or contested from the Middle and Far East to Eastern Europe shows how great crises are changing the balance of power and national geography.

Faced with so much instability the military instrument has become increasingly important and air power, the result of the evolution of science and technology, has played a leading role, demonstrating its validity even in an asymmetrical environment. The ability to hit an opponent with extreme precision while minimizing collateral damage has significantly contributed to the achievement of the desired end state in many operations.

NATO's aerospace power provides nations and national political leaders with an unparalleled tool of responsiveness and flexibility. However, there is a significant risk that NATO may not have the right capability, in terms of aerospace power, to address future security challenges. This necessitates a look by NATO and other European nations at ways to accelerate research, development and acquisition of fifth and even sixth-generation systems.

Air Power Today and Tomorrow with Space, Cyber, and Hypersonic Components

In 2014, following the Ukrainian crisis, Russia reminded the United States (US) that it is still a great nuclear power, reversing the agreements reached by Reagan and Gorbachev. China has repeatedly expressed its desire to be the dominant power in the South China Sea and does not want US interference. Russia and China have been working together for some time in both the technological and diplomatic fields and supported countries considered hostile by the US (Iran and North Korea). The two Asian superpowers have been subjected to sanctions of various kinds by the US and this has reinforced the 'sentiment' of working together in an anti-US function. Technology, in today's world, is not to be considered a monopoly. When a country expresses technological superiority, the opposing party will do everything to limit the consequences of such superiority.[1]

During the Cold War, the deterrent power exercised by the two opposing blocs was fundamental and the development of missile systems capable of targeting opposing defence and attack systems was one of the pillars capable of shaping the international balance until recently.[2]

The US developed various anti-ballistic missile systems, considered a threat by Russia for its deterrent capability, especially taking into account the ongoing work to improve Russian missile defence systems.

The research in the field of hypersonics filled the existing gap (Mach 5 or higher). The Russians developed the 'Avangard' hypersonic missile system (Mach 20) to counter US' anti-missile capability, assessed as destabilizing the global balance of power. The system has been in the deployment phase since 2020.

The birth of hypersonic weapons has given rise to the need to develop new defence systems.

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Since the invention of flying, the field of speed applied to aircraft and missile has been a frontier that man is trying to push ever further.

The objective has materialized thanks to the progress made in the study and research of new materials and propulsion systems.

Hypersonic aircraft fly through the atmosphere creating intense friction with the surrounding air as they travel at speeds above Mach 5. Developing structures that can withstand high temperatures and high speeds is a technical challenge, especially for leading edges that bear the weight of the heat.[3]

To address this, Defense Advanced Research Projects Agency (DARPA) announced its Materials Architectures and Characterization for Hypersonics (MACH) programme in early 2019.[4] The programme seeks to develop and demonstrate new design solutions and materials for sharp, stable, and cooled leading edges for hypersonic aircraft.

Regarding propulsion, the creation of the Advanced Full Range Engine (AFRE) programme launched by DARPA includes a hybrid propulsion system paving the way for reusable hypersonic flight. The programme seeks to develop a new aircraft propulsion system that can operate at subsonic, supersonic and hypersonic speeds.

In the decade-long quest to develop reusable aircraft able to reach hypersonic speeds of approximately 5,300 km/h (Mach 5) and above, engineers have faced major challenges. Worth mentioning the maximum speed of traditional turbine engines, a reaction that reaches the limit speed at about 2.5 Mach, or the fact that hypersonic motors, such as scramjets, cannot operate at speeds lower than 3.5 Mach.

AFRE aims to explore the combined cycle turbine engine concept, which would use a turbine engine for low-speed operations and a dual-mode ramjet for high-speed operations. The two components of the hybrid engine would have in common a forward-facing air intake and a rear-facing exhaust nozzle to release thrust.[5]

If on the one hand the US has been constantly committed, the surprise comes from its geopolitical competitors, which now seem to own these new technologies.

In May 2019, China tested the first hypersonic aircraft named Jiageng-1 developed by the Xiamen University after more than ten years of research.[6] The aircraft is capable of reaching speeds between Mach 5 and Mach 7, thus making it invulnerable to the most sophisticated anti-aircraft defence systems in use.

The Jiageng-1 adopts a 'waverider' type design, that improves its supersonic lift-to-drag ratio by using the shock waves generated by its own flight as a lifting surface, a phenomenon known as 'compression lift' similar to that of other prototypes such as the Boeing X-51 (tested from 2010 to 2013 and capable of reaching Mach 5.1, 5,400 km/h). Additionally, it allows improving the lift ratio/resistance by means of the in-flight generated shock waves.

This aircraft outperforms Western competitors for its ability to switch from supersonic to hypersonic flight with ease and lower fuel consumption. These results were possible thanks to the discovery of new materials capable of resisting temperatures above 3,000 °C.

The developments that hypersonic technology may bring in the future, especially in the military field, warrant great innovation.

China is determined to have a leading position in the sector and this has prompted the Pentagon to increase funding dedicated to hypersonic capabilities.

DARPA's Falcon project aircraft are in the making, requiring substantial financial resources of around 320 million USD.

Technological discoveries have been able to relaunch the eternal duel between defence and offence.

The world is now facing a similar situation like the advent of nuclear weapons after the Second World War: weapons based on new technologies that make current defence systems obsolete and inefficient.

Nuclear weapons might be the primary beneficiaries of the hypersonic developments.

Hypersonic speeds undermine traditional decision-making cycles based on the Observe, Orient, Decide, and Act (OODA) loop that currently involve longer response times than the time needed by hypersonic weapons to reach the target. The different types of previous and extant defence weapons might become insufficient. Due to the speed of the hypersonic threat, any enemy target data acquired, regardless of how great the distance, will become inefficient for targeting purposes due to the reactive nature of the weapon. The only efficient observation and reconnaissance capability will be the offered by low-earth orbit satellites.

Therefore, the technological innovation of hypersonic aircraft and weapons is of fundamental importance. It initiates a new form of conflict, which emphasizes the space domain's importance.

Progressions in hypersonic technology bring control over the space domain, leading to inherent advantages in the sister domains of air, land, and sea.[7]

Developing hypersonic technologies implies a considerable economic effort with investments that not all countries are ready to face.

In the light of future technological innovations, it is necessary to look at a sixth-generation of aircraft, capable of detecting hypersonic threats at range, assessing them quickly using Artificial Intelligence (AI) and networked support, and engaging them with weapons designed for the purpose.

The US is working on a replacement for the F-35; United Kingdom (UK), Italy, and Sweden have signed agreements for the new Tempest system; France and Germany are planning the development of the Future Combat Air System (FCAS) and Turkey is planning the TF-X.

The new generation of aircraft will no doubt have to take into account the leaps forward in the speed sector and new hypersonic ballistic systems.

In complex systems, situational awareness built on real-time theatre information is the starting point for the analysis and for the consequent decision-making processes.

With the cyber revolution underway, in order to maintain high situational awareness and rapid decision-making processes, the use of AI generating tasks automation and behaviour prediction is consequential.

The US has already outlined some of the requirements for the sixth-generation aircraft.[8]

In particular, they are developing:

- digital engineering, to accelerate the construction and industrialization processes; *'in the 21st century, at current rates we will not experience 100 years of progress but 20,000 years'*;[9]
- advanced artificial intelligence, which can provide required targeting data in seconds;
- new kinetic and non-kinetic precision weapons;
- an expansion of the network for combat platforms, enabling real-time data exchange to achieve information and intervention dominance;
- new nanotechnologies applied to materials to reduce the radar and infrared signature;
- new engines with the application of the 'third air stream' that provides an extra source of airflow to either improve propulsive efficiency and lower fuel burn or to deliver additional airflow through the core for higher thrust and cooling.

The new platforms will be part of a complex information system made up of many nodal points capable of continuously acquiring and exchanging data and executing decisions. Being nodes of a network will give complexity and resilience to the military system synchronizing forces across domains, with or without direct contact with those forces, providing new capabilities for the application of operational art across air, space, and cyber domains.

Italy, which shares a part of its defence industry with the UK, has worked towards the most logical solution, but has also underlined the need not to fragment the industrial potential as happened with Eurofighter, Gripen, and Rafale programmes.

Having more types of aircraft in the Alliance undermines interoperability and synergy between allies by reducing the integrated logistic support, whose inefficiency will negatively impact the military capabilities available in the operational theatre.

Comparing the Gross Domestic Product (GDP) of the countries participating in the Tempest, FCAS, Tornado and Eurofighter programmes, the following elements can be detected:

- The Tornado counts on Germany, Italy and the UK whose GDPs total approximately 8.2 trillion USD (2017 values).
- Eurofighter with Germany, UK, Italy, and Spain availed of 10.5 trillion USD.
- The FCAS aircraft, on the other hand, will be able to leverage 7.5 trillion USD.
- The Tempest aircraft contemplates a potential of only 5 trillion USD aggregate.[10]

The development of the sixth-generation aircraft might face limitations due to reduced budgets and probably will not have economic repercussions as in the F-35 programme.

Merging the two European projects, Tempest and F-CAS, improvements are to be expected. In this respect, the financial base would be comparable to China's 12.2 trillion USD of comparable GDP. If, on the other hand, the projects were to encompass all the countries of the European Union, it could count on 18.5 trillion USD, close to the US GDP of 19.4 trillion USD.[11] Undoubtedly, the effects of the Covid-19 crisis will have an impact on the projected financial estimates.[12]

Conclusion

A keyword emerges from this picture, namely: fragmentation. An antithetical word to that of 'Union', making Europe a giant with feet of clay on various fronts, from foreign, domestic, industrial and economic policies.

A unity of purpose and a unity of views is required, and perhaps a single European defence industry.

Faced with the uncertainty and insecurity of the future, it is necessary to remain united.

The military instrument is fundamental to guaranteeing security. As history has shown, the aerospace power provides nations and national political leaders with an instrument of unparalleled responsiveness and flexibility, and is always in constant evolution.

Europe now has set the stage for a turnaround through the Next Generation European Union[13] tool that will be implemented through three pillars: helping member states to recover, reviving the economy and supporting private investments focused on research and innovation. European leaders should take advantage of this reset opportunity and find a way to knit Europe's defence industries into a more interconnected system with enough funding and cohesive technical and production capability to tackle the challenges of hypersonic threats and sixth-generation systems.

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