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STRATEGY FOR HIGHER AIRSPACE OPERATIONS

In an international environment undergoing profound transformation, the trends identified in the 2022 National Strategic Review are accelerating. Power rivalries are hardening: the return of the nuclear factor, the uninhibited use of force, and the generalization of hybrid strategies. The proliferation of anti-access strategies, along with the spread of deep-strike systems, has now become a reality.

New and significant challenges are emerging—or re-emerging—notably through the diversification of pressures exerted on our interests by potential adversaries. In this complex strategic context, where all domains and environments are mobilized, Higher Airspace Operations (HAO) appears both as a source of opportunities and as a theater of growing conflict. France must therefore position itself credibly in this domain and, in time, be able to exercise a form of operational superiority through HAO.

With threats ranging from intelligence-gathering balloons to hypervelocity weapons, HAO is an environment particularly difficult to control. France possesses historic and technological assets enabling it to invest in this space: on the one hand, as a nuclear power and a Spacefaring nation, it enjoys unparalleled technical and operational experience in Europe, with the ability to master rapid and maneuverable vectors in this environment; on the other hand, building on the heritage of pioneering expertise in balloons, France is especially well placed to address the challenges posed by slow and persistent objects operating at these altitudes.

Our vision is to invest in HAO in order to protect our population by extending our sovereignty into this domain, to preserve our strategic autonomy and freedom of action, and to shape strategic balances as a respected aerospace power across the full continuum from the ground to space.

Our first ambition is to extend our Air sovereignty into HAO. To do so, it is firstly necessary to deter potential adversaries through full mastery of all layers of the third dimension above our territory. Inability to act in HAO would expose France to vulnerabilities exploitable by competitors who control this environment. To exercise credible sovereignty and demonstrate our determination, we intend, in the short term, to possess national means of situational awareness and action in this space: namely, the ability to detect in time and, if necessary, to counter the maneuvers of potential adversaries operating in HAO over French territory.

Our second ambition is to harness this new domain to achieve operational superiority, safeguarding the freedom of action of our armed forces in other environments, and thereby shaping strategic balances. In this regard, and despite the challenges involved, HAO can serve as a true force multiplier: mastering this environment—characterized, depending on the vector, by persistence or extreme velocity—provides tactical advantages across other domains. Theater surveillance and communications relays from HAO, as well as the use of strike assets maneuvering at these altitudes, can contribute to securing operational superiority over a potential adversary. Enhanced situational understanding and credible action capabilities across the entirety of the third dimension are instruments for influencing strategic balances. At the same time, the capabilities developed for HAO will provide complementary solutions to missions currently carried out by Space or Air assets, thereby strengthening the overall resilience of our force system. At both the national and European levels, close attention must be paid to civil-military coordination and the integration of HAO-capable vectors.

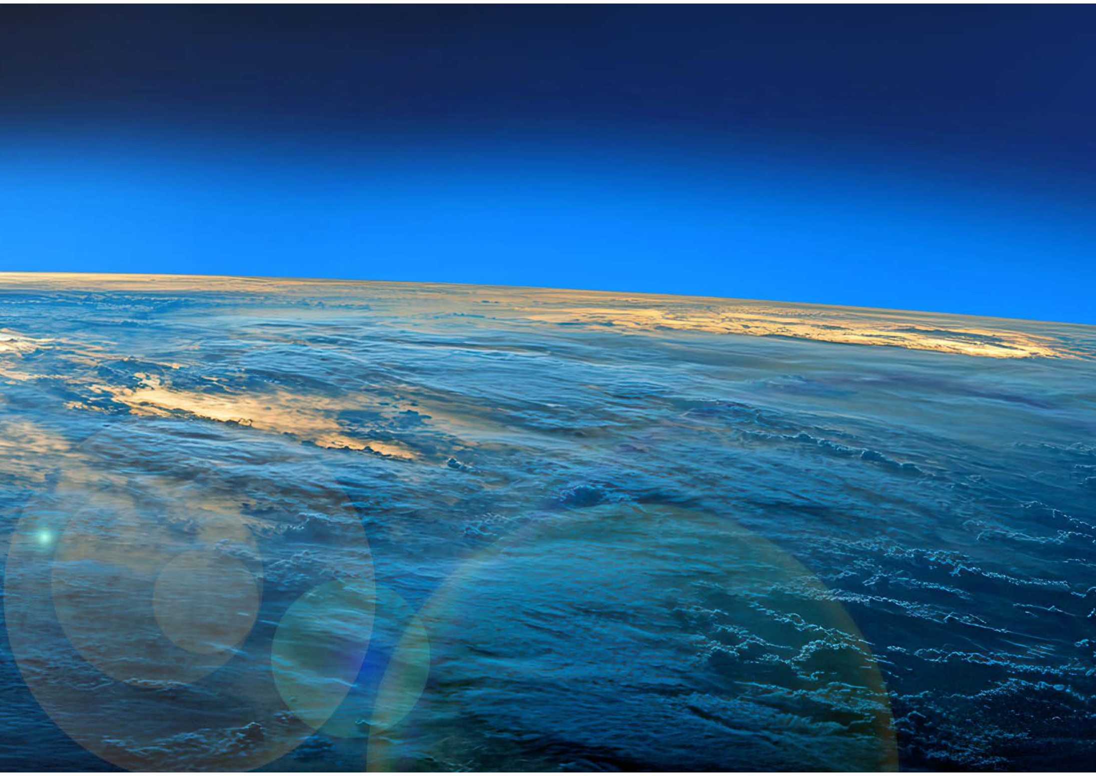
Finally, we aim to rally European nations willing to engage around HAO. This is a complex and demanding domain, difficult to access. Its mastery would significantly reinforce the standing of our forces within NATO, the EU, or ad hoc coalitions. At a time when the durability of Euro-Atlantic solidarity is in question, and when cases of strategic solitude could affect us, the HAO domain offers an opportunity to cooperate with our European partners and potentially to federate them around our operational and industrial centers of excellence, while promoting the European defense industrial and technological base. Such cooperation will be essential for initiating collective reflection on regulatory aspects of HAO within European institutions.

The use of HAO is a necessity for our nation. We must seize the opportunities it presents, and France possesses all the assets required for success. I am counting on all our airmen, and more broadly on all our armed forces, to rise to this new challenge!

Sébastien Lecornu

FRENCH ARMED FORCES STRATEGY FOR HIGHER AIRSPACE OPERATIONS

Working Group Report



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ABSTRACT

As the geostrategic landscape continues to harden, the trends identified following the invasion of Ukraine are being confirmed—and are accelerating. At the same time, new structural challenges are emerging, driven by competitors seeking to diversify the tools of coercion targeting the interests of France and its allies. In this regard, Higher Airspace Operations (HAO) (or *Très Haute Altitude*, THA) offers them a range of opportunities and is increasingly establishing itself, day by day, as an additional domain of conflict. France must therefore respond credibly to these new power dynamics and be capable of asserting operational superiority in this domain.

As there is no universally agreed definition of the upper boundary of airspace, HAO — though not officially delimited — is generally understood to cover the upper portion of the atmosphere, roughly between 20 km[1] and 100 km[2] in altitude. It is a realm of extremes, whether in altitude or speed, and is particularly difficult to control. The objects operating there fall into two main categories: high altitude permanent systems (HAPS), currently primarily balloons, and hypervelocity[3] vectors (weapons and aircraft). More broadly, numerous military capabilities are involved in detecting, intercepting, or even neutralizing these objects (radars, satellites, fighter jets, surface-to-air systems, lasers, etc.). HAO therefore engages the full scope of the third dimension, where Command and Control (C2[4]) is a key capability, in a multi-domain[5] logic based on a multi-sensor, multi-effector network architecture.

Three major strategic stakes arise from the challenge of HAO. The first concerns sovereignty: the objective is to protect French citizens from threats emanating from the Air domain, including HAO. However, neither the 1944 Chicago Convention on international civil aviation nor the 1967 Outer Space Treaty have defined a vertical boundary between national (sovereign) airspace and outer space (non-sovereign), leaving room for interpretation[6]. Additionally, the difficulty in accessing HAO raises a core question: the ability to enforce sovereignty at such altitudes. Due to its ambiguity, the challenges of its control, and its military relevance, HAO thus becomes a "grey zone" ripe for hybrid strategies—a new Wild West, a contested space.

1 Altitude close to the Karman limit (aŕound 86 km), above which the aircraft cannot fly anymore. At 86km, air is so rare that an aircraft must fly at 28 000 km/h. That speed is in fact the speed of orbiting objects at this altitude.
2 In that document hypervelocity refers to objects capable to reach very high speeds (at least supersonic) and with significant maneuverability.
3 Refers to the capability to coordinate and synchronize actions and military effects in different domains (land, sea, air, Cyber and Space) and areas of operations (informational and electromagnetic).
4 France has adopted a functional approach based on the technical characteristics of the vehicle (aircraft or spacecraft) and the purpose of the activity concerned.
5 Refers to the capability to coordinate and synchronize actions and military effects in different domains (land, sea, air, Cyber and Space) and areas of operations (informational and electromagnetic).
6 France has adopted a functional approach based on the technical characteristics of the vehicle (aircraft or spacecraft) and the purpose of the activity concerned.

The second issue lies in our ability to leverage HAO and the advantages it provides in order to achieve a new level of **operational superiority**. Although inherently difficult to access, recent technological advancements are opening new perspectives. HAO allows for exploiting altitude and speed—two historically decisive factors in military operations. These offer increased range, extended persistence[7] , and enhanced survivability[8] to operating platforms in HAO. With competitors already investing in the domain, HAO reaffirms the age-old principle of the advantage held by "those who control the heights." As such, it presents both new opportunities and emerging threats. The increased use of hypersonic missiles by Russia in Ukraine from 2022, the so-called "Chinese balloon incident" in 2023, and Israeli raids in 2024 have all accelerated awareness of the strategic relevance of HAO. Mastering this new environment will be decisive in preserving the freedom of action of French armed forces and will directly contribute to France's strategic autonomy. This also requires effective integration of HAO vectors into shared airspace—both civil and military—and coordination with our partners.

In light of these findings, the Ministry of Armed Forces has chosen to invest decisively in the HAO domain, not only to counter developing threats but also to gain operational advantage. This effort will focus offensively on HAPS, a field in which France has long been a pioneer[9], while continuing development in conventional hypervelocity, where it benefits from unmatched technical and operational experience as a nuclear-armed and spacefaring nation. The defensive corollary, a prerequisite to asserting sovereignty, must ensure the capability to detect, intercept, and if necessary destroy any object operating in this altitude range.

The third challenge is that of broad-based cooperation, with the goal of building cohesion around the HAO domain. Much like the Space sector, the complexity inherent to HAO argues for a dual approach: on the one side, relying on DTIB[10] partners through dual-use innovation, and on the other, working with our allies through the European Union, NATO, or existing bilateral agreements—particularly with neighbouring countries. It is only together—industrial partners and allied nations—that our armed forces will be able to operate effectively in the full third dimension, with the shared imperative to be among the first: "faster, higher, stronger[11]."

7 In particular for the benefit of intelligence, electronic warfare, and telecommunications missions.
8 Due to the flight altitude of the HAPS, above the air traffic, or to the speed and maneuverability of the hypervelocity weapons.
9 The hot air balloon was invented in 1783 by the Montgolfier brothers, and the airship by Henri Giffard in 1852. Since its creation, CNES has also played a major role in developing and maintaining expertise in the operation of stratospheric balloons.
10 Defense technological and industrial base.
11 Motto devised by Pierre de Coubertin for the modern Olympic Games in 1896.

Accordingly, HAO mastery will now be integrated into France's Defense Strategy, enabling it to promote its vision for the domain and to provide a framework allowing armed forces to preserve freedom of access and action. This will involve participating in the development of regulatory frameworks for air traffic extended into HAO, as well as their operational translation (airspace classification, flight planning, procedures), within national and international civil-military coordination bodies.

Beyond that, a roadmap towards 2030 will outline France's ambition, with initial capabilities coming up as early as 2025 to demonstrate its determination. In an era marked by the uninhibited use of force—from aggressive deterrence strategies to hybrid actions cloaked in "plausible deniability"—a comprehensive understanding and controlled action across the full aerospace continuum—from ground to outer space, via HAO—will be key to shaping strategic balances.

FRENCH ARMED FORCES STRATEGY FOR HIGHER AIRSPACE OPERATIONS

1. INTRODUCTION

Interest in Higher Airspace Operations (HAO) has long remained limited, mainly for technical reasons. The higher the altitude, the more complex[12] the solutions to be mastered, differing from those applied to commonly used airspace. Today, however, the analysis of the various activities taking place there—whether military, economic, or scientific—highlights an increasingly strong desire to gain control of this domain. But what exactly does it consist of, given that the altitude band under consideration covers an immense range ?

1.1 Defining HAO

In order to delineate its boundaries, two main types of considerations are required: some physical and technical, others regulatory and legal. Vertically, the physical reality is one of continuity and gradual transition, from the lower layers of the atmosphere to outer space, with HAO in between.

The lower limit of HAO is not physically defined, as there is no atmospheric or aerodynamic rupture. Rather, it reflects a level of technical mastery in lift, propulsion, or onboard survival. It could thus be set around 12 km (the maximum cruising altitude of commercial aviation) or 18 km (the ceiling of most modern interceptor fighters and the Concorde's cruising altitude).

From a regulatory standpoint, there is no universally agreed upper limit to controlled airspace that could serve as the boundary of HAO. Depending on regions and national choices, air traffic rules become minimalist, vague, or non-existent above altitudes ranging between 17 km (flight level 550) and 20 km (flight level 660[13]).

Ultimately, choosing **20 km**—the upper limit of controlled airspace in France—as the lower boundary represents a good compromise between physical reality, regulation, and simplicity.

12 For instance, challenges regarding lift, control of low and high temperatures, resistance to the ionizing nature of the ionosphere, etc.
13 In France, airspace is regulated regardless of altitude. Above flight level 660 (66,000 feet), airspace is no longer controlled but classified as class "G," offering very limited services to users (alerts and flight information).

The question of HAO's upper limit is more complex. A first approach is to consider the so-called Kármán[14] line, which corresponds to the theoretical altitude above which air density is so low that the flight speed required to sustain an aircraft equals orbital velocity.

Calculated at 83.6 km in standard atmosphere, but often conventionally set at 100 km, this limit has been adopted by several institutions, including the FAI[15], the FAA[16], and NASA[17]. We will retain this altitude as the indicative upper boundary of HAO.

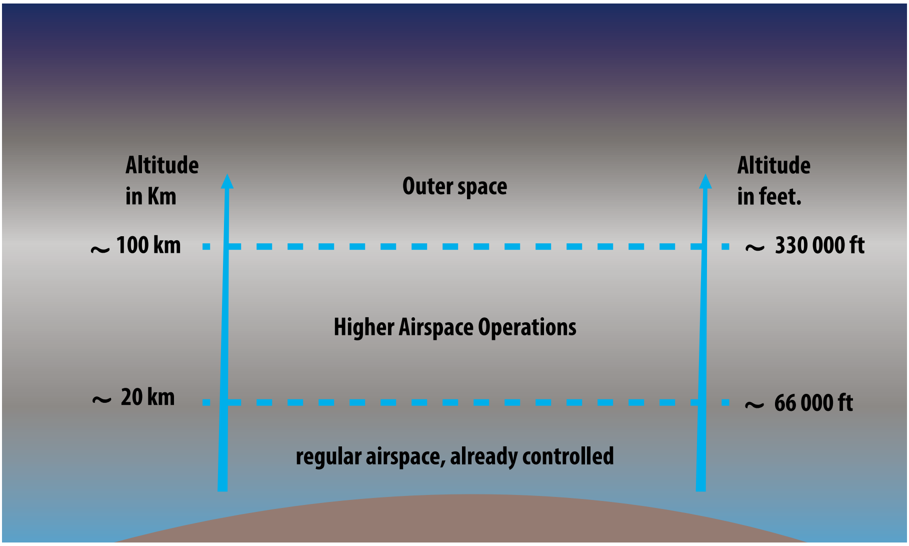
However, no value has been enshrined as a legal reference in binding texts for States, such as the 1944 Chicago Convention[18] , which establishes the foundations of sovereignty in airspace but only provides a horizontal limit, in line with maritime law. The 1967 Outer Space Treaty[19] also refrains from setting a lower limit, even though it defines outer space as a common domain where notions of borders and territoriality do not apply.

Still, even if the demarcation with outer space remains difficult to set precisely, it is clear that HAO belongs to the aerial domain and is subject to air law, given the flight technologies and characteristics of the objects evolving within it. Consequently, like regular airspace, it is subject to State sovereignty.

Furthermore, considering on the one hand the simplicity and flexibility of horizontal airspace boundaries for Air defense, and on the other their consistency with international law regarding borders, the French Ministry of Armed Forces supports the current regime of horizontal airspace limits without imposing a vertical ceiling.

Thus, HAO is considered an integral part of airspace, approximately spanning altitudes between 20 and 100 kilometers. It is neither timely nor necessary to define a precise border with outer space. Moreover, the alignment of HAO's lateral boundaries with those of lower-altitude airspace remains relevant.

14 Theodore von Kármán was a Hungarian-American engineer and physicist specializing in aeronautics
15 Fédération Aéronautique Internationale - World Air Sports Federation.
16 Federal Aviation Administration
17 National Aeronautics and Space Administration.
18 The Convention on International Civil Aviation, signed on December 7, 1944, in Chicago, also known as the Chicago Convention, established the International Civil Aviation Organization (ICAO), a specialized agency of the United Nations responsible for coordinating and regulating international air transport.
19 The Outer Space Treaty, or Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, is an international treaty ratified in 1967 relating to the exploration and use of outer space.



1.2 Understanding maneuvering objects in HAO

The use of HAO, including for military purposes, is already a reality, though still limited in volume. The novelty lies mainly in the proliferation and variety of activities and projects, driven by the civil sector. The spectrum of objects to consider will only broaden in the future.

At one end of the spectrum lies a first category of slow and persistent objects known as **HAPS** (High Altitude Permanent Systems): stratospheric balloons, airships, or solar-powered aircraft. Generally operating between 18 km and 28 km, they take advantage of weak and variable winds at those altitudes to move. Positioned "above the fray," their altitude grants them a certain survivability, especially since current radars and weapons are optimized to detect fast, not slow, objects.

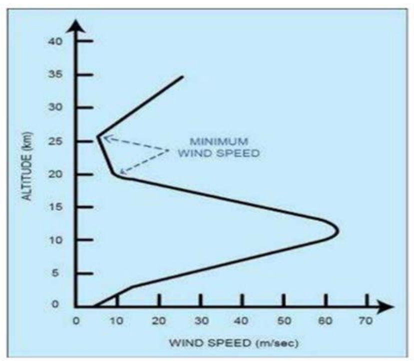
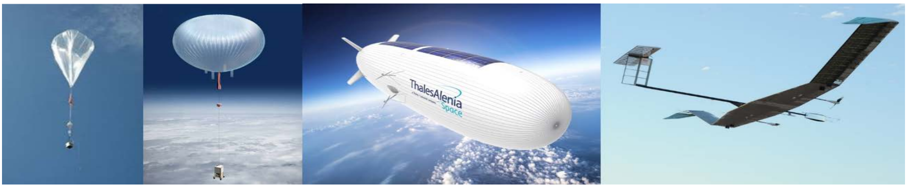


Diagram 2 – Wind speeds as a function of altitude (source: ONERA)

There are mainly four types of HAPS with potential military uses. The simplest are open **stratospheric balloons** (OSB). Filled with helium or hydrogen[20] , their technical simplicity enables them to lift several tons to altitudes of up to 40 km, depending on size. CNES scientific balloons are a good example. However, being open and made of lower-performance materials (more porous), they remain airborne only for a few hours to a few days, drifting with the winds.

Next are **pressurized stratospheric balloons** (PSB). Thanks to pressurization and superior (but heavier) envelopes, they can last several months at heights of up to 30 km, though at the cost of much-reduced payloads. **They can maneuver in two ways**: by adjusting altitude to ride different winds, as hot-air balloons[21] do (though altitude-control devices further reduce payload to only a few dozen kilograms), or by using solar-powered electric engines to propel objects commonly called **airships**[22] at speeds of up to 80 km/h. Larger and more stable, these can carry several hundred kilograms.

Finally, **solar-powered aircrafts** are also part of HAPS. Although heavier-than-air, their light weight and aerodynamics allow them to reach HAO, though with limited payloads at this **stage**[23] . Also solar-powered, they can fly at speeds up to 100 km/h.



Example photos of HAPS types

At the other end of the spectrum is a second category of very fast objects (up to hypersonic speeds, Mach 5+). By exploiting HAO, they benefit from altitude and speed to increase range (thousands of kilometers for the most advanced systems) and use maneuverability for survivability against advanced surface-to-air systems (e.g., S-400), which they can potentially neutralize thanks to precise terminal guidance.

Currently, three main types of weapons coexist, ranked by technological complexity. First, MaRV (**maneuverable reentry vehicles**) ballistic missiles, which initially follow ballistic trajectories but perform maneuvers (bounces, spirals) in their final phase (from ~30 km) to alter impact points and evade defenses. The Russian Kinzhal, launched from a MiG-31, and the Iranian Fatah, launched from the ground, are examples. Next are **hypervelocity glide vehicles** (HGVs), operating between 30 and 90 km after a ballistic launch, such as China's DF-17. Finally, there are **hypervelocity cruise missiles**, flying at altitudes between 20 and 40 km.

20 Less expensive and easier to produce, it has the disadvantage of being flammable.
21 This is the case, for example, for the Balman project from Hemeria.
22 As the Stratobus project from TAS.
23 Airbus is developing the Zephyr, which completed a record-breaking 64-day flight in 2022.

These weapons increasingly exploit HAO: staying maneuverable thanks to remaining atmosphere, while avoiding adversary tracking radars due to Earth's curvature, thus enhancing survivability and surprise.

More marginal at this stage is the segment of high-speed aircraft, such as the U.S. SR-71 reconnaissance plane, which may be replaced in coming years. Very high speed is also of interest to the private sector for commercial transport projects.

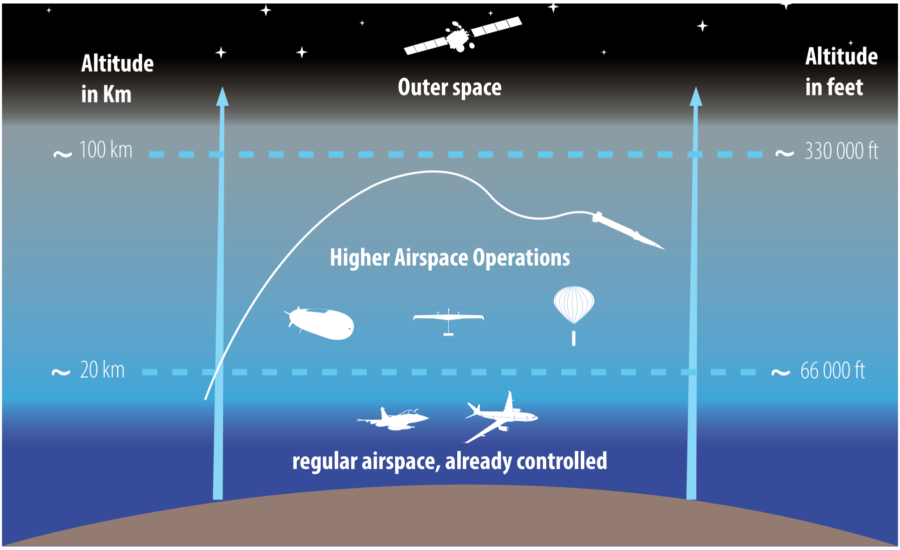


Diagram 3 – Types of vectors in HAO

As technology advances in both HAPS and hypersonic domains, HAO emerges as an additional factor of operational superiority. An "arms and counter-arms" dynamic is underway, pushing actors to develop both defensive and offensive capabilities in this altitude range[24].

This document therefore focuses mainly on objects capable of significant maneuvers in HAO, rather than those merely transiting through it, which are addressed in the context of Space operations[25]. While the distinction between operating and transiting objects can sometimes be thin, it is crucial, for clarity, to focus on what makes HAO a distinct—though not isolated—environment. This choice does not preclude analysing the articulation of military operations below, within, and above HAO.

1.3 Accounting for its stakes

Beyond maneuvering objects in HAO—whether HAPS or hypersonic weapons—a wide range of military systems are concerned, whether for detection, identification, interception, or neutralization. Some examples :

24 Cf. Russian president's speech of March 1, 2018.
25 Nor those relating to deterrence, which are particularly sensitive in nature.

DETECTION AND IDENTIFICATION:


Early warning radars


Over-the-horizon radars


Tracking radars


Frigate radars


Satellites

INTERCEPTION AND NEUTRALIZATION:


Fighters


Air-to-air missiles


SCAF


Surface to air systems


Lasers

Thus, HAO involves three major stakes:

1. **Sovereignty** (since it overlies States): it raises legal ambiguities due to the absence of a physical boundary between Air and Space, as well as practical challenges of exercising sovereignty.

2. **Operational superiority**: altitude and speed provide decisive military advantages: extended range; persistence for HAPS; survivability and stealth for HAPS (through altitude and discretion) or for hypervelocity vectors (through speed and maneuverability).

3. **Cooperation**: both with national and European defense industries, and with allies—whether neighbouring States offering depth of detection/intervention, or European/NATO partners. The challenges of HAO—technological, regulatory, doctrinal, and capability-related—are such that they can only be met collectively.

Mastery of HAO, given the operational advantages it provides, is a key issue for the French Armed Forces: both for detection, identification, and interception of objects, and for optimizing its use to their benefit. If uncontrolled, HAO could become a strategic vulnerability. It is also a force multiplier, being a high vantage point and next to outer space. The objectives are to preserve freedom of access, situational awareness, and freedom of action, to guarantee strategic autonomy, to influence global balances as an aerospace power, and to position France in Europe as a pioneer and unifier.

2. ENSURING NATIONAL SOVEREIGNTY IN HAO

Among the three major challenges related to HAO[26] , the ability to ensure national sovereignty within it comes first. Protecting our citizens and our territory from the threats posed by HAPS and hypervelocity weapons is not easily achieved, for the two main reasons previously discussed: the ambiguity surrounding HAO's boundaries and, above all, the difficulty of accessing and mastering it.

The absence of a clearly defined boundary between Air and Space domains is a deliberate choice in both the Chicago Convention and the Outer Space Treaty. Indeed, the air thins continuously, from the ground up to around 800 km altitude, where atmospheric drag becomes negligible[27]. Yet, as technologies evolve, there will be more satellites orbiting near 100 km[28], more hypervelocity objects oscillating around that altitude, and more aircraft and spaceplanes maneuvering both in Space and in Air. In the future, it will therefore become increasingly difficult to determine whether an activity is aerial or spatial in nature.

Some might be tempted to close the debate by arbitrarily setting 100 km as the border between sovereign airspace and non-sovereign outer space. But this would have a double disadvantage. Not only would we be almost alone in drawing a clear frontier[29] , with the associated legal weakness, but it would also create an opportunity for competitors to exploit this limit by bypassing our sovereignty "from above." A functionalist approach must therefore be retained, based on the dichotomy between "space object" and "aircraft," and maintaining a form of "constructive ambiguity," similar to "vital interests" in nuclear deterrence. In all cases, it remains established that HAO is considered part of the Air domain, and thus falls under State sovereignty whenever applicable.

Beyond the issue of HAO's physical delimitation, the primary concern is capability: our means to act within HAO and enforce our sovereignty there. This is not simple, given the difficulty of reaching such altitudes and high speeds. Ensuring sovereignty necessarily involves: first knowing, understanding, and anticipating potential threats; then being able to detect and identify them; and finally acquiring the means to intercept and neutralize them.

2.1 Knowing, understanding, and anticipating this new domain

The application of the strategic function "knowledge and anticipation" to very high altitude relies on the full range of intelligence sources already available or under development in the multi-domain environment. It will probably not require specific sensors. However, it may be necessary to adapt certain ones so that, in addition to their other functions, they can direct their intelligence operations toward HAO, potentially with new analytical tools. A typical example could be

26 Sovereighnty, operational superiority and cooperation.
27 It takes around 100 years for a satellite orbiting at 800 km to fall back to Earth.
28 The first VLEO (very low Earth orbit) and ELEO (extremely low earth orbit) are emerging.
29 Australia, Canada and Danemark are the only countries to have set the boundary between Air and Space at 100km.

monitoring balloon launch sites or using artificial intelligence to analyse data for detecting and identifying such objects in flight.

The emergence of new activities in HAO—and thus new current and future threats—should not overshadow the activities already taking place there and their strategic and military implications, particularly with regard to competitor powers employing them. For instance, the United States still operates its U-2 reconnaissance aircraft above 20 km, and Russia continues to field fighters theoretically capable of very high altitudes (over 26 km for the MiG-25, then the MiG-31). Moreover, scientific exploitation of HAO by balloons has long been routine, and military or dual use of such objects is already likely.

What is new is the proliferation of activities and projects in HAO, as well as the variety of objects involved. The threat spectrum to be addressed continues to expand.

Intelligence efforts must be therefore reinforced on the two disruptive technologies associated with HAO: HAPS and hypervelocity systems.

2.2 Detecting and identifying aircrafts in HAO

Some existing assets can already detect HAPS-like objects, though with limitations, particularly for airborne radars. In reality, the issue lies less in raw signal detection than in the velocity filters applied, or in how processors interpret signals and discriminate between real and false tracks. Ultimately, the objective is to maintain usable detection both in "conventional" airspace and in HAO, in order to build a comprehensive Air picture. Detecting targets at very high altitude—whether very slow, with low radar cross-section[30] (RCS), or at long range for fast vectors—thus represents a first technical challenge.

Beyond detection, target identification and attribution remain difficult. At lower altitudes, this is often achieved through interceptor aircraft. In HAO, this may still be possible in certain cases but will likely require improvements to existing assets, particularly their optronic sensors.

After initial identification, the ability to attribute (to a competitor, an operator) and maintain long-term tracking of a persistent object, despite challenges such as detection losses or range, is critical to avoid "plausible deniability"[31] . This will require coordination with allies on procedures and data sharing, and the combined exploitation of multiple detection sources—from the ground, from the air, and from space.

The detection of hypervelocity objects is a distinct challenge, closely tied to long-range early warning. Traditionally in France, this has been approached through ballistic missile launch detection within the BMD (ballistic missile defense) framework. It is now essential to also address early detection of future hypersonics aircrafts.

30 Radar cross section (RCS), expressed in squared meters, measures the intensity of reflection from an object that has received an incident electromagnetic beam
31 For example, China stated in 2023 that its balloons where scientific and not military.

UHF and HF over-the-horizon[32] radar technologies show promising potential.

In a comprehensive, multi-domain approach, the goal—through integrated C2[33] —is to establish a real-time operational picture by sharing relevant data, both from the contiguous Air and Space domains and from other domains impacted by HAO. The European Defense Industrial Development Programme (EDIDP) project Odin's Eye (multinational initiative for a space-based missile early warning architecture) contributes to this effort. For this, a connection between Air and Space C2 systems is necessary.

Building a coherent detection capability, both on national territory and in theaters of operations, will require striking the right balance among three complementary approaches:

• Leveraging, with adaptations[34] , if necessary, detection assets primarily designed for conventional Air operations or surface-to-air defense: AWACS[35] , fighter radars and optronic sensors, and ground-based radars.

• Repurposing space-oriented technologies, such as early warning satellites, electronic intelligence satellites, or imaging satellites.

• Developing new solutions tailored to extended Air defense, including surface-to-air systems, which could also benefit HAO defense (e.g., over-the-horizon HF or UHF radars for long-range detection).

• Exploiting artificial intelligence, which will be a major enabler for both detection and C2.

The ability to establish an Air picture in HAO constitutes the essential foundation upon which an effective Command & Control (C2) of operations can be built. For sovereign spaces, it is necessary to achieve maximum understanding and control of activities occurring there, both civil and military.

2.3 Intercepting and neutralizing potential threats in HAO

Air defense is exercised within territorial limits consistent with international law, but not necessarily aligned with the performance of certain aerial vectors operating in HAO, which pose threats very different from conventional aviation due to their speed, altitude, or persistence.

By their speed, which gives Air defenses very little reaction time and renders late coercion attempts useless, hypervelocity platforms present two main difficulties: first, the issue of warning time, tied to the depth of space required for effective

32 HF waves bounce off the ionospheric layer, allowing detection beyond the horizon, despite the curvature of the Earth.
33 Command and control.
34 The benefit will be assessed by value analyses.
35 Airborne Warning and Control System.

Air defense operations (detection, identification, classification, safety measures); second, uncertainty about the impact zone, which is resolved only at the last moment given the speed and maneuverability of these vectors.

Persistent platforms—some of which can already remain aloft for weeks or even months—can maintain positions near national territory for extended periods. Deploying military payloads (optical sensors, electromagnetic sensors, or active effectors) over long durations at such short distances from sovereign airspace (12 nautical miles) poses a threat essentially equivalent to direct, permanent overflight.

Thus arises the issue of freedom of action and legitimacy of intervention beyond current sovereign airspace limits. While international law recognizes each State's sovereignty over its territory, territorial waters, and by extension its "territorial" airspace, it does not forbid interventions beyond borders as long as these comply with international law[36].

In addition to air law, some States establish Air Defense Identification Zones (ADIZ) in international airspace, by unilateral declaration. Within these zones, civilian and military aircraft must comply with identification rules set by the declaring State. While defense considerations can sometimes justify such zones (as per Annex 15 of the Chicago Convention), ADIZs cannot under any circumstances be considered sovereign airspace.

Beyond these legal considerations, true sovereignty in HAO requires that a State equip itself with the physical means to enforce it.

For HAPS, both surface-to-air systems and fighter aircraft with their weapons face altitude limitations. Nevertheless, in the short term, current French air-to-air interception capabilities will be extended to provide initial solutions for neutralizing such threats, through upgrades enabling better detection and targeting or excursions beyond currently authorized flight envelopes. From 2025 onwards, simulations, trials and experiments will be conducted by the French Defense Procurement Agency (DGA) and the Air and Space Force, using Mirage 2000 and Rafale aircrafts, to identify priority improvements needed for missiles and sensors to achieve HAPS interceptions.

In the medium term, an arms race appears to be emerging, with the clear objective of ensuring interceptor effectiveness up to 28 km—the typical altitude of HAPS operations. In this context, laser and jamming capabilities, developed as part of Space control, offer opportunities with cost-effective synergies. If a ground-based laser can dazzle or disable a satellite's sensors hundreds of kilometers away, it will be certainly effective in HAO.

36 In particular, in the context of self-defense as provided for in Article 51 of the United Nations Charter.

Other, more innovative and complementary interception means must also be envisioned to address this new conflict domain. One possibility could be the use of mini-launchers in reactive launch mode. To explore the range of options, the Defense Innovation Agency (AID) will launch a hackathon in early 2026 on interception capabilities in HAO.

Regarding hypervelocity weapons, their speed combined with the maneuverability afforded by HAO makes them difficult to intercept. Effective defense requires deep detection assets[37] and interceptors adapted to different phases of their flight: the high endo-atmospheric[38] trajectory and the final penetration phase, where they are most maneuverable (low endo-atmosphere[39]). Russia's use of such weapons in Ukraine provides valuable operational feedback[40] .

In this domain, the Ministry of Armed Forces has deemed it necessary to modernize SAMP-T surface-to-air systems, with the first successful test firing of the ASTER 30 B1NT missile in late 2024, as well as to upgrade air-defense frigates with B1NT capability. Likewise, the Ministry is engaged in the Permanent structured cooperation (PESCO)project TWISTER, which addresses the hypervelocity threat (cruise missiles and glide vehicles) and covers both space-based early warning (via the European Defense Fund project ODIN's EYE) and interception (via the European Defense Fund project HYDIS[41]).

Thus, while HAO brings increasing operational value, it also presents a sovereignty challenge: on the one hand because its associated law is open to interpretation, and on the other hand because enforcing sovereignty requires developing interception and neutralization capabilities, from both ground and airborne[42] platforms. France is therefore firmly committed to mastering HAO by applying the general principles of air safety implemented by the Air Defense Supreme Authority.

In a broader defensive approach, the ability to enforce France's sovereignty over its territory will also benefit its armed forces' operations in theaters, by reinforcing Air superiority. While it may not currently be feasible to provide such defense capabilities across an entire theater of operations, it is at minimum necessary to consider localized Air defense bubbles over particularly sensitive areas.

37 Early warning systems : Hypersonic Ballistic Tracking Space Sensor (HBTSS) satellites in LEO and very long range radar (3000 km).
38 Between 30 km and 100 km altitude.
39 Below 30 km.
40 Open source feedback from general Syrskyi on August 21st, 2024.
41 Hypersonic defense interceptor System.
42 For the New Generation Fighter (NGF), the multiplicity of its sensors, as well as its effectors (missiles and remote carriers) will be decisive.

3. ENHANCING OPERATIONAL SUPERIORITY THROUGH HAO

Beyond the defensive mastery of HAO through the triptych — intelligence, detection, and neutralization — the armed forces intend to focus, with an offensive mindset, on HAPS, while continuing developments on conventional applications of hypervelocity[43] . The objective is to leverage HAO and its advantages (range, persistence, and survivability) to achieve operational gains. In this regard, mastering vectors maneuvering within HAO sends a strong and clear signal to our competitors, with the aim of shaping strategic balances as an aerospace power.

3.1 Investing in HAPS

HAPS offer a number of advantages, the foremost being persistence over a designated area, which is far superior to that of HALE or MALE[44] -type drones, or satellites whose inherent transience may be offset either by constellations or by geostationary orbit — albeit at significant cost. No other type of aircraft today can remain in flight for several months, or even a year, largely immune to weather once deployed.

Another advantage lies in their extended reach: due to persistence, they are capable of traveling around the globe. For HAPS flying at particularly high altitudes, their altitude provides a degree of survivability. Their cost, especially for open stratospheric balloons (OSB) or pressurized stratospheric balloons (PSB), remains controlled, as these rely on relatively simple technologies. Furthermore, PSB and solar-powered aircraft are potentially stealthy, due both to their small size combined with altitude, their reduced radar cross section (RCS), and their ability to be deployed far from the area of operation. In fact, it is likely that the first "sensor" to spot them could well be commercial airline pilots — more than 10,000 overfly metropolitan France daily.

Lastly, despite their slowness, some HAPS provide a degree of reactivity through various means. The limited logistical footprint of maneuverable balloons allows pre-deployment in overseas territories or aboard major French Navy vessels. They may also be air-transported into a theater of interest prior to deployment. Moreover, given their persistence, low cost per flight hour, and limited carbon footprint, it is conceivable to pre-deploy a number of them in flight over areas of interest, ready to act when necessary.

43 Hypervelocity has always been of interest for deterrence.
44 MALE : Medium Altitude Low Endurance (eg. Reaper) – HALE : High Altitude Low Endurance (eg. RQ4).

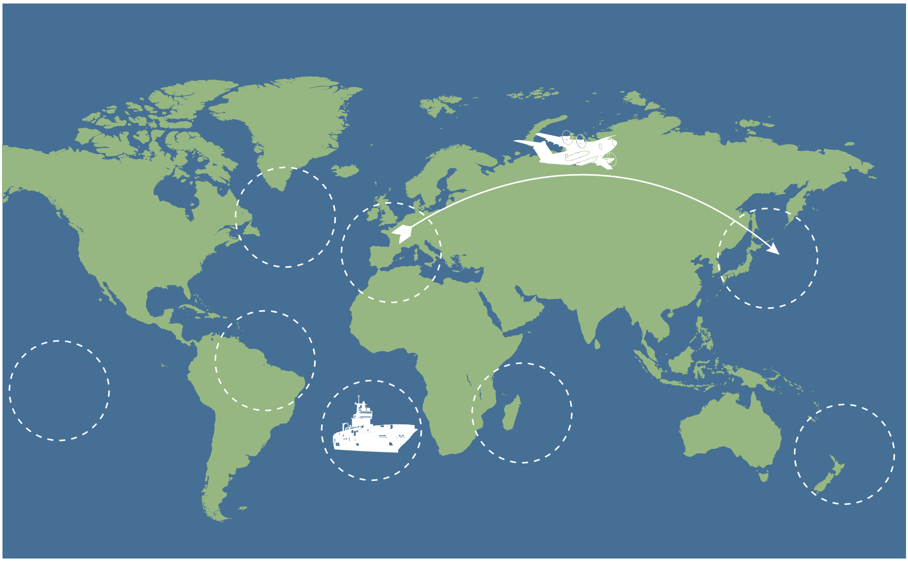


Diagram 4 — Potential HAPS deployment zones within a few days, based on overseas footholds, French Navy vessels, or rapid pre-deployment via A400M

These intrinsic qualities make HAPS suitable for telecommunications relay missions (V/UHF, 4G, 5G, laser, Link 16, etc.), thereby creating connectivity bubbles in coverage gaps or areas requiring high data rates to support operations. They are equally suited to all types of intelligence missions — signals, radar, or optical. In this last regard, their ability to fly above cloud cover makes them partly weather-dependent. Conversely, their proximity to the ground (20 km) compared to observation satellites (around 500 km) allows them to provide optical resolution comparable to satellites, while using simpler and therefore less costly systems. Their persistence also makes it possible to envision continuous video capture, transmitted in real time via line-of-sight (LOS) or satellite relay (beyond line of sight - BLOS).

Beyond their role in C4ISR (Command, Control, Communication, Compute, Intelligence, Surveillance, Reconnaissance), HAPS could represent disruptive innovation and a paradigm shift in Air combat and air-to-ground strikes. Air-to-ground weapons release and/or offensive electronic warfare effectors launched from HAO could provide a complementary and cost-effective option for deep strikes, contributing for instance to fighter or weapon penetration raids. Certain foreign developments suggest the concept's viability — for example, Canadian company Landing Zone Canada has developed the Eagle system to deliver payloads from stratospheric balloons.

On the other hand, HAPS also have drawbacks. Open stratospheric balloons fly at most a few days and are entirely dependent on winds. Maneuverable balloons have limited payloads and relatively imprecise navigation, often requiring ten days to deploy and reach an area of interest, with difficulty maintaining precise station-keeping. Airships require dedicated infrastructure ("strato-ports") for deployment, and their technology and size imply higher acquisition costs.

Their large volume also makes them less discreet. Moreover, unless they are massive, their altitude is limited (around 20 km), reducing survivability. Solar aircraft, meanwhile, have very limited payloads, are fragile, weather-sensitive, and can only be deployed in favorable regions and periods. Finally, all HAPS face constraints linked to latitude of employment: solar panel illumination must be sufficient to power propulsion and onboard systems. Regulatory navigability requirements also remain challenging, especially for drones.

Thus, it is precisely their complementarity that makes HAPS relevant:

- **Among themselves**, depending on the mission objectives (persistence, range, payload, cost, survivability, reactivity, or discretion).
- **With conventional aircrafts**, which offer greater payload capacity and speed.
- **With satellites**, which provide global and permanent coverage, with freedom of movement acquired under international law, unlike HAPS, and retain survivability — though increasingly contested as Space becomes a warfighting domain.

Ultimately, conventional air platforms, HAO assets, and space-based systems complement one another, enhancing resilience across all domains if these were to be contested.

HAPS employed in HAO therefore provide operational advantages (persistence, range, survivability, cost-effectiveness, ease of deployment, discretion, and some reactivity) to complement the capabilities of conventional aircraft and satellites within a holistic vision of the third dimension — forming an aerospace continuum combining operational superiority and resilience. They could also constitute a disruptive technology for offensive capabilities, particularly for deep-strike missions.

While some of these capabilities may, in the medium term, be acquired as services from defense industry providers, it is already necessary to plan, for certain systems and in the longer term, for sovereign acquisition and the creation of a dedicated HAPS unit by around 2030, stationed on an air base suited to their characteristics. This site should ideally be located on national territory to ensure high protection levels and specialized support (including technologies closely related to Space). It must also provide favorable meteorological conditions, integration into air traffic, and logistical/industrial support.

3.2 Continuing Developments in hypervelocity

Hypervelocity vectors exploit their extreme speed and maneuverability to **achieve greater range and survivability.** While the American SR-71-type aircraft remains out of reach due to prohibitive costs, weapons remain accessible — particularly since the French defense industry benefits from extensive experience drawn from deterrence programs.

These weapons become strategic assets when striking deep within adversary territory defended by advanced surface-to-air systems, notably for Suppression of Enemy Air Defense (SEAD[45]) missions or high-value targets. Operating within HAO enables strike options against — or through — adversary anti-access/area denial (A2AD[46]) networks, or against heavily defended fleets, provided accurate guidance[47] is available.

Such weapons impose geographically expansive threats, compelling adversaries to establish multi-layers[48] defenses with long-range detection capabilities — thereby complicating defense. In practice, while cutting-edge surface-to-air and ballistic missile defense systems may protect specific high-value sites, they can no longer shield vast areas such as entire theaters.

To enhance survivability, the last decade has seen a shift from traditional ballistic missiles[49] (with apogees well above 100 km) and subsonic cruise missiles toward weapons increasingly exploiting HAO. Such systems derive threefold advantage from remaining as long as possible at very high altitudes rather than transiting through space or staying at low altitude:

- They retain maneuverability thanks to residual atmosphere and velocity.
- They remain longer concealed from early warning radars, hidden by Earth's curvature.
- At altitudes above 30 km, they avoid engagement by standard surface-to-air systems, including S-300s.

Only so-called "high endo-atmospheric" interceptors (30–80 km) can counter them — at significant cost[50]. The ongoing development of hypersonic air-breathing cruise missiles best illustrates this trend. Operating between roughly 20 and 40 km, they perform maneuvers while maintaining considerable range (on the order of 500–1000 km).

The effectiveness of such weapons has been demonstrated by both Russia in Ukraine from 2022 and Israel during its 2024 raids on Iran. According to Ukrainian open sources, among approximately 12,000 Russian missiles launched (hypervelocity and non-hypervelocity), fewer than 5% of hypervelocity weapons[51] were intercepted, compared to over 70% of conventional ones.

On the Israeli side, April and October 2024 raids were notable in many respects. By employing maneuverable reentry vehicles (MaRV[52]) , launched from fighters

45 This capability covers both weapons guided by ground-to-air tracking radar emissions and those that have more conventional terminal guidance, combining kinetic and non-kinetic capabilities.
46 The concept of A2AD describes the actions taken by an actor controlling a territory to deny access to the adversary, as well as the means used to hinder the adversary's freedom of maneuver.
47 It should be noted that mixed HAPS/glider systems, such as those developed previously, could complement SEAD hypervelocity strike capabilities at low cost, for example by deploying a swarm in advance, deep behind enemy lines, in order to saturate the opponent's air defenses.
48 0-30 km, 30-100 km and extra-atmospheric.
49 Non maneuverable.
50 This is the case of the US THAAD (Terminal High Altitude Area Defense) system.
51 Tsirkon, Oniks and Iskander-M.
52 Missile propulsion stages were found, and photos released by the Iraqi authorities suggest that they were potentially from IS02 Rocks, Golden Horizon or Air LORA (LOng Range Artillery) in Blue Sparrow or Silver Sparrow aerial version.

(primarily F-15s), Israel successfully neutralized much of Iran's surface-to-air defense, including long-range systems. Destroying such systems protecting sensitive sites sent a strategic message — Iran is now vulnerable to renewed airstrikes.

This capability serves as a powerful military lever for political authorities, both to deter and to weaken adversaries while managing attrition risks. These raids highlight how SEAD missions remain crucial precursors to deep-strike campaigns.

China and the United States have developed wide-ranging hypervelocity arsenals[53], fully aware of their strategic role in high-intensity conflict. Europe, for its part, is organizing around the ELSA (European Long-Range Strike Approach) initiative, driven notably by France, with the goal of strengthening Europe's deep precision-strike capabilities via hypersonic or maneuverable ballistic missiles — especially against adversaries equipped with advanced Air defense.

Blue Sparrow (Israël) | HACM (USA) | LRHW Dark Eagle | Programme IRCPS

Examples of Israeli and American hyper-velocity weapons

The French armed forces intend to continue hypervelocity developments operating within HAO, whose extended range and survivability allow them to counter growing A2AD strategies and deliver a strategic signal against any attempted fait accompli.

3.3 Adapting the Command & Control (C2) Chain to HAO Challenges

HAO presents specific C2 challenges, both within the Air domain and in terms of cross-domain and allied coordination.

For Air-domain C2 — the first impacted by emerging HAO operations — **several challenges arise**:

- The greatly expanded range of speeds and altitudes of objects to be managed.
- The difficulty of consolidating essential intelligence and detection data to build a coherent Air picture within a dynamic intelligence-sharing framework.
- The complexity of active air security measures (interception/boarding), given the access difficulties at such altitudes.

While the fundamental functions of Air defense (detect, identify, classify, intervene) remain valid, their application will require new C2 approaches.

Given the extended range of hypervelocity weapons and HAPS, an Air C2 adapted to HAO — akin to France's integrated model — must account for vast geographic

53 For example: DF-17 and DF-21 for China and AGM-183A-Arrow, LRHW Dark Eagle for the United States.

areas, exceeding the immediate operational theater[54], whether national territory or overseas deployments. In fact, the distinction between geographical theaters may blur under hypervelocity threat. Real-time coordination between Air C2 in the sovereign space, between Air C2 in different theatres , or with other domain C2s and allied C2, will be paramount[55].

HAO operations will drive a reconfiguration of airpower employment, enabled by increased altitude bands, extended range, and persistence. Decision-making and engagement processes for Land, Sea, Air, and Space assets must also be integrated, given that certain space-based sensors and effectors may prove valuable for HAO operations. In this respect, interfacing with early warning systems is crucial.

Beyond the convergence of Air and Space C2, **integration with other domain C2s is also necessary** to ensure seamless continuity and avoid fragmentation. Extending this logic — already applied in integrated air and missile defense (IAMD) architectures within "traditional" airspace, such as NATO's Coordinated Air-Sea Procedures[56] (CASP) — will ensure the Air defense mission extends into the highest atmospheric layers.

In targeting, the use of hypervelocity weapons offers new opportunities to neutralize mobile high-value assets (e.g., surface-to-air batteries or warships), provided adapted targeting loops are implemented.

Finally, delegation of responsibilities must be adapted so each threat type is handled at the right level of subsidiarity and reactivity, given detection and identification occur with minimal warning. This challenge is compounded by the speed and maneuverability of HAO objects — and by the likely emergence of civilian hypersonic vehicles by 2030, which may create confusion.

Considering the vast operational areas, short reaction times inherent to hypervelocity, the need to accelerate targeting cycles, the multiplicity of multi-domain/multi-spectrum sensors involved, and the imperative of real-time cooperation with allies and partners, all make effective articulation of operations C2 with Air C2 — based on multi-sensor, multi-effector networked architectures — a key success factor for mastering HAO.

54 Dynamic intelligence sharing, interfacing (or integration) of the various information systems contributing to Air C2 in order to ensure identification, classification and intervention functions, interfacing with early warning systems.
55 The merger of CNOA and CAPCO within the CAPCODA – Air Planning and Operations Command Center for Air Defense (4 colocalised JFAC) permit it.
56 Coordinated Air Sea Procedures enable naval vessels' sensors and weapons to be used for surface-based air defense with varying levels of integration.

4. EXTENDING COOPERATION

When it comes to mastering HAO, cooperation has been identified as a key issue. Much like the Space domain, which remains highly technical and difficult to access, the complexity inherent to HAO argues for the armed forces to rely both on the industrial and technological base of the French defense industry, in a dual-use logic, and on France's allies, through the European Union, NATO, or existing bilateral agreements, particularly with neighbouring countries. The relative novelty of HAO, coupled with France's lead in the domain, positions the country as both a leader and a convener.

4.1 Leveraging civilian expertise and dynamism

For the Ministry, the first step is to deepen knowledge of the domain in partnership. Theoretical scientific understanding is essential to exploit HAO effectively. The armed forces must therefore directly benefit from the collection and sharing of scientific knowledge (winds, sunlight levels, radiation, etc.), which will not only improve understanding of this environment's intrinsic characteristics but also help identify possible technological options. They must also play a role in orienting scientific research in this zone so that defense interests are accounted for. It is therefore necessary to establish a network of national and international expertise. Organizations such as CNES[57] , ONERA[58] , Météo-France, and the Paris Observatory — and more broadly, the companies within the industrial and technological base of the French defense industry already active in the fields of balloons or hypervelocity — are natural and privileged interlocutors for the French Defense Procurement Agency (DGA) and the armed forces.

In terms of innovation, HAO is already part of commercial sectors undergoing promising technological and industrial developments, many of which could yield dual-use applications.

The use of HAPS for scientific research has been one driver of this development. This is why CNES has been working on balloons for more than 60 years. Projects vary, ranging from the use of mature technologies such as sounding balloons[59] , to those in active development such as solar-powered stratospheric aircraft[60] or long-endurance airships[61]. Commercial services for Earth observation and communications are already beginning to emerge.

To these can be added projects for supersonic and hypersonic aircraft[62] — both cargo and passenger — aimed at cruise speeds of around Mach 5 and altitudes

57 Centre National des Etudes spatiales: French space agency.
58 Office National d'Études et de Recherches Aérospatiales : French aeronautics, space and defense research lab.
59 CNES area of expertise.
60 Such as the Zephyr from Airbus Defence and Space.
61 Such as the Stratobus project from Thales Alenia Space, Hale-D from Lockheed Martin or Skyrider from Stratosyst.
62 Such as projects Boom Supersonic, Exosonic or Destinus.

between 18 and 50 km, depending on the configuration. Some of these projects target commercial operation by the end of the decade. Beyond this, work on spaceplanes capable of maneuvering in HAO could ultimately open the door to military applications.

"Space tourism"[63] also contributes to this momentum. Several models and technologies coexist, including suborbital flights[64] and stratospheric balloon experiences[65]. While most of these companies have not yet launched commercial operations, they anticipate an imminent start and already plan for high flight cadence[66].

All **these projects present opportunities for military applications.** The industrial and technological base of the French and European defense industries are among the most dynamic in the domain and offer several promising examples: Héméria's *Balman* maneuverable balloon, TAS's *Stratobus* airship, Airbus's solar-powered *Zephyr*, SAFRAN/CILAS and ONERA's laser systems, Thales's UHF radars, ONERA's over-the-horizon radar, Dassault's spaceplane project, Zephalto's stratospheric capsule, ANS-E's balloons, and hypervelocity programs at MBDA and ArianeGroup, along with various payloads for detection or communications. Depending on their maturity, military applications could be pursued — at least in the short term — via "off-the-shelf" service contracts with so-called "trusted operators," as is already the case in space. Notably, the specificities of HAO (cold, heat, radiation, lightweight design) strongly resemble those in Space, further encouraging duality between the two sectors. Payloads designed for Space[67] could also be studied for use in HAO, given that the industrial bases for the two domains are currently very similar.

Conversely, some projects are only in their infancy, offering an opportunity to conduct early, proactive technology watch. Areas of particular focus should include propulsion, energy, sensors, and connectivity.

For ground infrastructure, close cooperation with civilian actors should be considered — especially regarding "strato-port" projects (such as the one under construction in the Canary Islands), whose facilities will share strong similarities with those required for military HAO operations (e.g., payload production and maintenance stations).

Finally, in the event of a crisis or major engagement, HAO capabilities must be able to draw upon the duality of civilian assets and their support, in order to diversify modes of action quickly and flexibly. The French Defense Procurement Agency (DGA) will therefore include HAO within the scope of capabilities eligible for reinforcement by civilian industry in the event of high-intensity conflict. Expanding communication networks and rapidly increasing the number of optical sensors are examples of actions that could be implemented swiftly, subject to legal adjustments (requisition, mobilization, etc.).

63 Even if it doesn't really have anything to do with space.
64 Such as the projects led by Blue Origin or Virgin Galactic. A suborbital flight refers to the trajectory. of a spacecraft travelling at a speed lower than the one required to remain in orbit.
65 Such as the projects led by Space Perspective or World View Zephalto.
66 For example, Virgin Galactic is planning to operate 200 flights per year.
67 Adapted to operate in the extreme conditions of space.

The technological challenges of mastering HAO, combined with the dynamism of the civilian sector, argue strongly for the Ministry to cooperate extensively, in a structured and trusted manner, with scientific agencies and private companies. Applications in HAO are inherently dual and hold significant potential for technological and operational innovation — offering numerous opportunities for the armed forces.

4.2 Strengthening bilateral operation

France's national Air defense system has long relied on bilateral operational cooperation with neighboring countries (United Kingdom, BENELUX, Germany, Switzerland, Italy, and Spain) to ensure airspace security and anticipate threats.

In Europe, these cross-border agreements complement the broader NATO Integrated Air and missile Defense System (NATINAMDS) framework, ensuring continuity in handling Air threats. Such agreements allow state assets to intervene in another state's airspace — for its benefit and under its operational control — within a clearly defined framework.

The emergence of HAO operations, particularly hypersonic platforms and HAPS, with their challenges in detection and coercive response, calls for adaptation and strengthening of existing agreements, as well as extension of such operational and technical links to a broader set of neighboring states.

Two points are especially critical and could be greatly facilitated by pre-negotiated agreements:

- Early detection of objects and sustained tracking to provide predictive trajectory data and, potentially, determine their origin.
- Establishment of security zones under time constraints to prevent collateral damage on the ground and in airspace in the event of a decision to neutralize the threat[68].

Given the global nature of potential threats[69], privileged partnerships could be established with:

- The United States — for western coverage of metropolitan France, as well as the Antilles and French Guiana.
- Northern South American and Central American countries, especially Brazil — to strengthen defenses around French Guiana.
- Israel, Djibouti, the UAE, and Qatar — in relation to French deployments (bases H5, UAE, and Djibouti).
- South Africa and Madagascar — concerning the defense of La Réunion and Mayotte.
- Australia and New Zealand — regarding New Caledonia.

68 Growing problematic related to the speed of vectors involving hypersonic objects.
69 For example, with current technology, a solar powered aircraft flying at an altitude of 20 kilometers could potentially reach any point on the globe in 10 to 15 days.

Bilateral agreements should primarily focus on real-time intelligence exchange and sharing of a Recognized Air Picture (RAP) on HAO threats, thereby enhancing threat anticipation and assessment. They should also include the sharing of technical data (notably detection data and physical characteristics of observed objects).

HAO thus requires a broader approach to bilateral cooperation in Air defense, particularly across French overseas territories.

4.3 Promoting these issues within NATO and the EU

France's national Air defense system, with regard to military aerial threats, is closely tied to NATO through NATINAMDS, to which it contributes and from which it benefits greatly. Participation in this network significantly improves threat anticipation and response thanks to interconnection of national and NATO systems, composed of sensors, C2 assets, and weapons systems. Notably, this network gives metropolitan France extended depth in aerial threat detection, strengthening national Air defense.

Currently, NATINAMDS relies mainly on member states' detection and action capabilities, and only marginally on NATO's own assets (NAEW&C[70]), which are technically limited to lower layers of HAO, except for ballistic missile defense (BMD). France must therefore advocate within NATO, the EU, and among member nations:

- The adoption of France's vision of HAO's vertical and horizontal boundaries within the Alliance, ensuring homogeneous coverage of threats at continental scale and centralized management for more effective operational responses.
- The development or progressive adaptation of C2 tools to handle hypersonic threats, and improved synergies between Air C2 and Space C2 given their interdependencies.
- Enhanced detection capabilities above 20 km.
- Improved continuity of detection and tracking of targets from Space, ground, and airborne assets, to counter threats operating at the HAO / space boundary.
- The development of action capabilities (neutralization, destruction) suited to HAO constraints, as well as tools to analyze ground-level fallout.

Several NATO and EU initiatives are noteworthy in this regard: NATINAMDS, European projects such as ELSA, TWISTER[71], ODIN'S EYE[72], HYDIS, EuroHAPS, and IFurther[73], ECHO[74] .

Beyond this, France organized the Conference on European Air and Missile Defense[75] in Paris on 19 June 2023, aimed at strengthening European cooperation in Air defense against contemporary threats, particularly those revealed by the

70 NATO Airborne Early Warning and Control Force.
71 Timely Warning and Interception with Space-based TheateR surveillance.
72 Multinational development initiative for a Space-based missile early-warning architecture.
73 High frequency over the horizon sensors' cognitive network.
74 European Concept of Operations for Higher Airspace Operations.
75 Initiative reiterated by the Italians in Rome on 17 September 2024.

war in Ukraine. The Minister of Armed Forces emphasized the importance of Europe developing an autonomous strategy for defending its airspace, building on existing European industrial solutions.

Protection against threats evolving in HAO will undoubtedly be integrated into a broader strategic reflection at the European Union, NATO, and bilateral levels. More broadly, the armed forces' strategy for HAO must enable France to consolidate its strategic autonomy by seizing the technological, industrial, and cooperative opportunities linked to this new domain.

5. FRAMING THE ACTION OF THE ARMED FORCES IN HAO

While this strategy sets out the Ministry of Armed Forces' overarching vision of HAO, it must naturally be followed by a doctrinal framework guiding military action in this domain.

5.1 Integrating Mastery of HAO into Our Defense Strategy

In the future, HAO must be **explicitly addressed within the broader military strategy.** This will lead to doctrinal reflection, initially through forward-looking analyses that examine the potential consequences and uses for the armed forces, building in particular on expertise in operations planning, early warning, detection, Air-Space integration, intelligence, connectivity, electronic warfare, hypervelocity weapons, directed-energy weapons, and more.

It must then be integrated into joint-level doctrines and publications where relevant. Naturally, HAO should also feature in exercise scenarios, particularly from 2026 onward with ORION, which provides a framework for joint training in multi-domain and multi-spectrum operations.

The creation of a Threat and Foresight Assessment Group (GEMP), tasked with monitoring the evolution of both military and civilian activities in HAO, will make it possible to characterize each threat and its timeline with precision, feeding into operational and capability reflections.

In the medium term, HAO specificities will need to be incorporated into various Air defense operational plans and, if necessary, confronted with the current Defense Code and regulatory framework, so as to ensure effective action against any type of threat evolving in high or very high altitude — whether under the Permanent Air Security Posture (PPS-Air) or territorial defense.

Similarly, dual-use and military technologies linked to HAO exploitation must be included in **export-control** frameworks for dual-use goods and military equipment.

More broadly, national and European reflection on HAO should be stimulated through think tanks, as well as through the work of armed forces institutions responsible for strategic thought (CESA, CICDE, CCF, CESM) and scientific research (IRSEM, CREA, etc.).

Ultimately, the entire doctrinal, regulatory, and training framework must be revised and expanded to fully integrate HAO into armed forces operations and to address the specificities of this new battlespace.

5.2 Relying on the current operational and capability organization

From an operational standpoint, the Permanent Air Security Posture (PPS-Air) provides a robust and responsive framework. As a historic and ongoing mission of the French Air and Space Force, its purpose is to guarantee national sovereignty in French airspace extended to HAO, and to defend the territory against all threats. It serves at all times as the first line of defense against aerial military aggression and provides the foundation for activating the Military Air Defense Plan.

Under the authority of the Chief of Staff of the Air and Space Force, advisor to the Chief of the Defense Staff on Air defense, the Air Defense and Air Operations Commander (CDAOA) relies on a national operational command structure: the Air Planning and Operations Command Center for Air Defense in Lyon-Mont Verdun (CAPCODA). This structure is supported by extended detection and control centers (including early warning), surveillance assets (ground-based radar, airborne detection and control aircraft), and intervention means (fighter aircraft and surface-to-air systems). Beyond national Permanent Air Security Posture responsibilities, the Air Planning and Operations Command Center for Air Defense is also responsible for the conduct of Air operations more broadly, including in HAO.

On the capability side, organization is governed by Ministerial Instruction 1618, which defines objectives and principles for investments, governance, and the management and monitoring of programs, especially armament programs. It helps build coherent force packages composed of personnel and weapon systems, trained and supported under a doctrine. Within this framework, the Ministry will develop a capability vision incorporating HAO as an extension of the Air domain, and may, if required, launch new armament programs to fill gaps revealed by this comprehensive analysis.

Beyond that, the creation of a dedicated major armament program could be studied — focused specifically on HAO or otherwise. Its goals would be to consolidate capabilities not yet addressed (such as HAPS) and ensure overall coherence by linking adjacent programs (radars, C2, fighters, frigates, etc.) essential to monitoring HAO challenges.

Since HAO is essentially an extension of the Air domain to its extreme limits of altitude and speed, it is coherent to apply the current organizational model — operationally and capability-wise — to this new environment.

5.3 Supporting regulatory work to preserve armed forces' freedom of access and action in HAO

It will be essential to continue defending national defense interests in the work and decisions of national, European, and international[76] regulatory bodies, while remaining within a controlled security framework. Preserving freedom of action in HAO requires military considerations to be fully integrated into future civil regulations — whether concerning air traffic, aircraft operation, or airworthiness.

In this respect, the European Union launched in 2020 the European Concept of Operations for Higher Airspace Operations (ECHO) research project. Recognizing the increasing and diversified use of this altitude band, its aim is to integrate HAO operations into air traffic management. Similar work is being conducted in

76 OACI, the Committee on the Peaceful Uses of Outer Space (COPUOS) of the United Nations, European Commission, AESA, NATO, etc.

the United States. European and American regulators (EASA[77] and FAA) broadly converge toward an upcoming regulatory framework for HAO traffic, based on proactive and cooperative coordination between operators using this domain.

Additionally, the Ministry of Armed Forces may support industry players in securing airworthiness certification for their developing platforms, most of which are drones. This will require adapting the regulatory framework for HAPS in particular. Access to information from HAO operators must be guaranteed for Air defense missions (including Permanent Air Security Posture), without delay or conditions. Rules must also guarantee military access to sovereign HAO without delay or need for flight plans. Airspace organization must be quickly adaptable to military operations.

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As for "high-speed" objects, supersonic and hypersonic aircraft or drones must be addressed at very short notice. Their speeds mean extremely limited time for detection, analysis, and response, combined with distances covered on continental scales. This requires rethinking the role of the armed forces in managing and monitoring traffic and airspace.

To preserve freedom of access and action in HAO, the armed forces must participate in designing the regulatory framework for air traffic extended to higher airspace operations, and in its operational adaptations (airspace, flight planning, procedures) within civil-military coordination bodies, both nationally and internationally.

Given the now undeniable extension of conflict into HAO, this strategy sets forth renewed ambition proportionate to the challenge. It can be implemented through a roadmap guiding and supporting the armed forces' ability to master HAO, following a logic of operational effectiveness and proportional need. **While the strategy provides the Ministry's vision and a framework for military action, this roadmap will chart the ambition through to 2030. By then, several demonstrations — starting as early as 2025 — will illustrate France's determination.**

77 European Union Aviation Safety Agency.

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