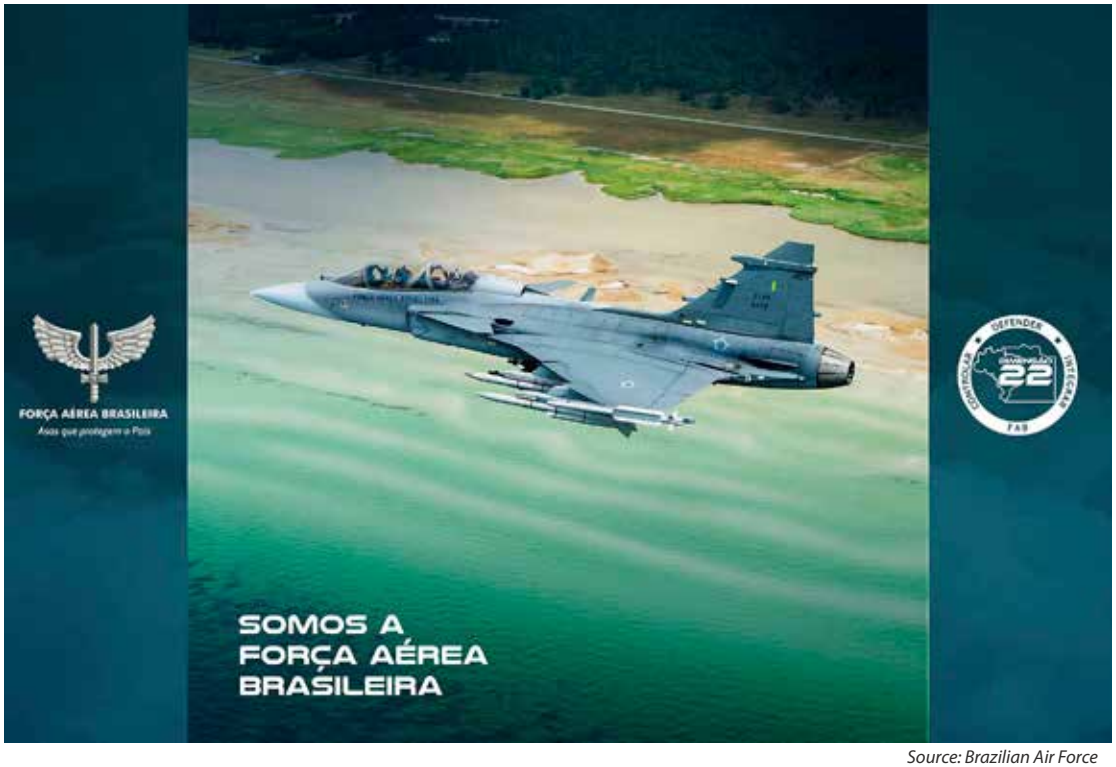
Changes in the Profile of War and Reflections on the Preparation and Use of Brazilian AirPower

Colonel Alexandre Fernandes Ramos, Brazilian Air Force
Dr. Patricia de Oliveira Matos



Source: Brazilian Air Force

Air dominance, according to Giulio Douhet, "means to be in a position to prevent the enemy from flying while retaining the ability to fly oneself."[1]

The perfectioning of aircraft, and the technologies derived from them, has led to the understanding that airpower encompasses a broad spectrum, not just in the aerial environment, but also in space, since space can be exploited "by means of intercontinental ballistic missiles or through the use of space with the deployment of satellites."[2]

Furthermore, the necessity for effective dominance in the air requires that airpower not solely be identified by air and space platforms but also by its essential support elements. These include structures such as aerodromes and maintenance hangars; and organizations to provide surveillance, communications, command and control, research and development (R&D), whether

through the defense industry, or military and civilian higher learning institutions, and civil aviation, all of which contribute to advancements in the field and specialized human resources.[3]

Airpower, in short, is the projection of national power[4] through the use of air and space, whether as an instrument of political and military action or "for social and economic development, with the goal of reaching and maintaining national objectives."[5] However, in order to narrow the scope of this article, airpower will only be considered to consist of the resources needed to project power over an opponent, with the goal of gaining and maintaining dominion over the air environment; i.e., the of military aircraft that compose the Air Force and the aeronautical industry that supports them.

Although many aircraft fulfill the basic tasks[6] required of the Brazilian Air Force (FAB), in its current inventory air superiority[7] is only supported by the F-5E/F Tiger II aircraft (manufactured by the North American firm Northrop) and the A-1 aircraft (joint design and manufacture by Brazil and Italy), due to their operational performance (speed and weaponry), range, penetration, flexibility and versatility,[8] making them the "spearhead" of Brazilian airpower.

The F-5E/F aircraft arrived in Brazil at three different stages: 1975, 1988, and 2008, acquired from the manufacturer (new), from the United States Air Force (used), and from the Jordanian Air Force (used), respectively. The average age of these aircraft is more than 40 years.[9] As for the A-1, they were incorporated into the FAB beginning in 1990, all procured new, and thus have an operational age of 28 years.

Throughout 2024, the FAB will be receiving 36 new Saab Gripen NG airplanes. The Swedish multi-use fighter is a supersonic single-motor model designed for air-air, air-sea, and air-ground missions under any weather condition. According to the FAB, in strategic terms, the Gripen NG opens the possibility of Brazilian participation as a partner in high-tech programs, with repercussions for Brazil's national defense industry.[10]

In considering, therefore, the current stock of FAB aircraft that have the capability to project airpower, as well as the incorporation of new fighter planes in the near future, one questions to what point will this serve to prepare the FAB to be able to confront a profound change in the profile of conflicts we've been experiencing since the end of the Cold War (1947–1991). In this new environment, traditional air platforms (such as the F5E/F and A-1) may possibly need to be replaced with others better adapted to the demands of a new model of war. However, will the Brazilian defense industry, especially its aeronautical industry, have the training or grasp on technology to potentially affect these changes?

The two FAB aircraft cited (F-5 and A-1) underwent a modernization process to improve their operational capabilities. But, did these improvements ready them to be deployed in scenarios in which a new kind of war prevails? Regarding the modernization of the F-5 and some of the A-1 aircraft (modernization program is still in process), a "baroque technical change" was effected, where no major technological break-through focused on future necessity was accomplished, only a technical improvement in performance.[11]

The plans that are currently guiding actions in the aeronautics field (among them the modernization of airplanes) have their sights on the execution of FAB's main constitutional mission and are strategic in nature, comprised of a systematic process of development and implementation of plans to reach desired objectives within feasible scenarios.[12] Planning factors must be considered for the preparation and use of airpower, in particular the definition of the type of future conflict mostly likely to occur. A case can be made that future wars, or derivations (armed conflicts, insurgencies, asymmetrical wars, irregular wars), will occur within parameters totally different from the traditional conflicts of the past, i.e., state versus state, each applying massive application of national power, as took place in World War II.

The glossary of the Brazilian Defense Ministry defines war, in the classic concept, as a "conflict, usually between States, involving the use of their armed forces. It is triggered by declaration and in accordance with International Law."[13] However, the same book includes another 46 types of war,

opening the classic concept to conflicts beyond those of a traditional nature, whether in terms of geographic area, the actors involved, the weapons utilized, the tactics, or even the motives of the belligerants.[14] Thus, in the face of the multiplicity of types of wars that may occur in the future, the challenges of being able to obtain and deploy, in a timely manner, the technology needed to prepare and employ national airpower to conquer and maintain air dominance are already being articulated.

This article's objective is to discuss the transformations occurring in war and its derivatives, as well as their implications for the preparation and use of Brazilian airpower. The article is divided into five parts. After this brief introduction, the second part presents arguments regarding the changes that have occurred in the concepts of war, which, breaking from the paradigm of state against state, point to geographically uncertain armed conflict environments with not readily identifiable opponents, making it difficult for the proper scaling of airpower. The third part will discuss the concept of generational wars as a mechanism for understanding the fourth-generation war. The fourth part presents the generational evolution of military aircraft and their adequacy for future wars. And, finally, the fifth part presents our final considerations.

Modifications in the War Scenario

On 11 September, 2001 the greatest military power at the time was attacked on its own soil, causing the death of 3,071 people, when the Twin Towers of the World Trade Center (civilian target) in New York, the Pentagon (military target) in Washington, and the downing of a commercial Boeing 757 airplane, were strategic targets for terrorists.[15]

In contrast to this attack on North American soil, it should be mentioned that on 7 December, 1941, a United States aircraft squadron in the Pacific was the target of a Japanese attack at the air base at Pearl Harbor in Hawaii, killing 3,303 people and wounding another 1,272, all being targets of military nature.[16]

The difference between the two attacks is that, in the first case, the enemy was not immediately identified, clearly nor objectively, nor his origin known, as both military and civilian targets had been attacked. In the second case, it was immediately confirmed that Japan had committed an act of war, with a typical military target.

In the first case, through analysis by the United States intelligence sector, the enemy was later identified as a nonstate opponent (al–Qaeda terrorists), therefore, diffused and unknown. In the second case, the opponent was identified, of course, as a belligerent state, perfectly defined geographically, acting within a geopolitical concept known at that time, which drew the United States into the WWII.

As a historical framework, after 1945 the world observed a new division of power which redefined the areas of interest of the major international actors (United States, Soviet Union–now Russia, England, France and China). Within this new framework, regional instabilities exploded, leaving doubts that world peace had been achieved with the end of WWII. On the other hand, those new conflicts also came to represent a new nature of war.

In the period after WWII until the beginning of the twenty first century, the occurrence of more than 80 wars of asymmetrical nature were observed; in the 1990s, 96 percent of the conflicts were of asymmetrical nature. In the two-year period between 1999 and 2000, more than 50 incidents of non-conventional war took place.[17]

Have the types of wars changed, or are asymmetrical wars simply displaying different ways of applying firepower in order to win desired objectives (political or ideological, for example)? Taking into account that in any armed conflict there are points in common, further inquiry is in order.

First, we can cite Clausewitz, for whom war was neither art nor science—nor even a chameleon that adapts its nature–but a group of tendencies toward violence, hatred, and animosity.[18] On the other hand, Sun Tzu tried to explain war by its dynamics, emphasizing being careful with the mo-

bility and flexibility of military forces. He compared their movements, for example, with the movement of water. Sun Tzu proposed that forces should exploit the weaknesses of the enemy, while avoiding their strong points.[19]

With regard to classic strategic thought about war, exemplified by the two prior citations, a common point of convergence can be observed regarding their interpretation: combatant forces should structure themselves in order to exploit the weaknesses of the opponent—that is, they should seek in battle an asymmetrical force effect, in order to reach military supremacy.

The term *asymmetrical war* or *asymmetry* of war is associated with irregular warfare, i.e., to use unconventional means of confronting military forces. Asymmetry in war, or asymmetrical war, is not a recent term, or an innovative operational dynamic of military forces, since, to a greater or lesser extent, it has been present throughout conventional wars throughout history.

However, "asymmetrical," as an adjective, has come to mean that which is innovative in terms of obtaining political objectives by force. Thus, asymmetrical conflict, strategy, crisis, or war have been utilized greatly to describe, for example, cyberattacks, or even the combined utilization of paramilitary forces with conventional means.

Taking for example the 11 September, 2001 terrorist attack on the Twin Towers in New York, the fact is that current asymmetrical war is not confined to a defined territory, but it encompasses the whole planet, with repercussions on points of view regarding war, economics, politics and psychology.[20] Historically, the term *asymmetry* or *asymmetrical* conflict received emphasis in the article "Why Big Nations Lose Small Wars" written by Andrew JR Mack, when it established that asymmetrical war would be a conflict with a great disparity of forces, in quantities or qualities of technologies of equipment and weapons utilized, as well as with regard to the economic imbalance of rival powers.[21] In general, the subject of asymmetrical war became more widely used in the framework of military planning in the period after the Cold War, which culminated with the collapse of the Soviet Union, when the United States was considered the only superpower (military, economic, and technological) on the planet.

Since then, there has been no room for large-scale wars and the true power to attain political objectives (internal and external) came to be through states' regional economic power. This explains how regional antagonisms gave origin to the outbreak of limited scope conflicts, between actors with military (or nonmilitary) power, that were economically and/or technologically imbalanced, which made the perfect environment for application of asymmetrical actions. Montgomery Meigs describes *asymmetry* as an "unorthodox way to apply a capability that follows no rules and is disturbingly peculiar".[22]

In Brazilian Armed Forces doctrine, the concept of *asymmetrical war* is a "conflict characterized by the use of non-conventional means against the opponent, usually by the side weaker in combat assets." In other words, "the armed conflict that sets against one another two military powers who have between them marked differences in capacities and possibilities." Such understandings seek to characterize asymmetrical war, in short, as a "confrontation between a certain party and another with crushing superior military power over the first", underscoring, finally, that "the weaker party largely adopts tactics, techniques, and procedures typical of irregular war."[23]

The definition of asymmetrical war merits careful interpretation when facing current conflicts and threats, highlighting the terms: "conflict," "opponent," "combat," "armed conflict," "military power," and "party." This because the concept characterizes asymmetrical war in an operative environment of combat, which, as seen until now, may present itself in diffused environments and outside of an operational military context, within or outside Brazilian borders. It is appropriate to add the reflection of Meigs, regarding idiosyncratic attacks, for which "operational asymmetry is important when it is used for military capacities," but the author adds that "the current threat of terrorism and the types of operations we can expect from terror networks in the future derive from the idiosyncratic use not only of military but also non-military capacities."[24] These changes in war

can be explained from the analysis of the evolution of wars throughout time, incorporating the concept of generational wars.

Generational Wars

Considering the evolution of wars in the modern era, we are witnessing, at the beginning of the twenty first century, fourth-generation wars, which have important similarities with the characteristics of asymmetrical wars. Fourth-generation wars are under the mantle of the information technology and globalized communications era. They present elements that differentiate them from other generations of war and can also be associated with asymmetrical war and terrorism, taking place within or outside the sovereign dominions of a state.

First-generation wars would be those that took place from the end of the Thirty Years' War (1648), up to the Napoleonic wars, in the preindustrial period. Such wars were characterized by linear combats and closed formation of the troops, as if they were military parades. The value of troops was not measured by initiative or the freedom of movements but by discipline and rigid obedience to the orders from superiors. This is because the battle plans, described earlier, were to be faithfully followed, since there was no real-time vision of the battle and communications were precarious, not allowing for coordinated tactical changes.[25]

Second-generation wars would be those marked by the industrial era, in the middle of the nineteenth century, which allowed the use of new and powerful wartime inventions, where "massive destruction became the central principle of the war."[26] The use of the defensive Maginot Line[27] of 1940 and the attack on the allied troops at Monte Cassino[28] in 1944, are examples of this type of war, where they resorted to synchronized firing and rigid discipline of movement.

For third-generation wars, there was a search for the neutralization of the enemy through identification of weak points, with the end goal of cancelling out the enemy's ability to operate, without total physical destruction. An example would be the development of the "lightening war" (Blitzkrieg) by the German army in WWII. It was not based on firepower, but rather on speed and surprise. This generation of war is identified by psychological warfare and infiltration on the enemy's home front, which exploited freedom of action, initiative, flexible thinking, tactical discernment, sense of opportunity, and decision-making capability.[29] The main tactic in third generational wars consisted of "pass and provoke collapse,"[30] in place of "get close and destroy"[31] the enemy; and they were not linear.

Fourth-generation wars, in addition to what has already been mentioned, have as their main characteristics the change in focus from the front line of the enemy army toward the enemy's population; elevated costs for the state to prevent and oppose it; the use of small independent troop formations acting with initiative and freedom; the use of the combat power of the enemy against themselves, and prioritizing psychological manipulations and objectives to the detriment of physical objectives.[32] Fourth-generation wars, present or future, are characterized not by changes in how the enemy fights but rather by who will be in combat in order to achieve the objective.[33]

The current vision of the FAB also confirms a new generation of war, characterized by asymmetrical threats to airpower, stating in the document titled "Strategic Conceptualization, Air Force 100 (DCA 11- 45)," that "traditional threats derived from confrontations between nations are becoming more rare," and underscores the strategic understanding that, for the preparation and use of air power, "the forms of conflict, or even of war have undergone major modifications," taking into account that "new transnational threats, cyber terrorism among others, appear as more palpable challenges in the future we can glimpse."[34]

In a recent publication regarding defense scenarios for the period between 2020 and 2039, the Brazilian Ministry of Defense pointed out that there will be continued conventional conflicts, with an increase in asymmetrical or hybrid conflicts. Insurgent groups, terrorists, or criminal organizations will tend to continue conventional conflicts along the path of irregular war or might change direction,

mainly in urban areas, by mixing with the population, assuring the anonymity of "human shields;" and will try to take advantage of "logistics for the use of the civilian infrastructure" and use of civilian communications such as "mobile devices and the Internet."[35]

Therefore, fourth generation wars emphasize the existence of asymmetrical conflicts, based on the irregularity of their actions. However, it is appropriate to point out Alessandro Visacro's observation on the skepticism among current military professionals about their preparedness to fight in a fourth-generation war. For Visacro, military professionals, in view of their orthodox education and skepticism regarding asymmetrical conflicts, "are soldiers from a second-generation war and in few armies the third-generation mentality predominates, leaving an even lower number of those with the aptitude for a fourth-generation war."[36]

As for the definition of asymmetrical war, we can also state that this is distinguished from conventional conflicts by the types of tactical engagements with the enemy and the strategies used to achieve desired effects. Thus, while a conventional conflict (first-through third- generation wars) seeks a change in the policies and forms of a government's behaviors by coercive action upon its leaders or military victory over its armed forces, asymmetrical war has as its objective the destruction of a group, government, or ideology by the manipulation (psychological) of public opinion, usually adopted as a center of gravity (CG).[37] Unlike conflicts of a conventional nature, the priority of asymmetrical conflict is not direct combat with opposing military forces but rather utilizing the benefits of asymmetry, taking advantage of the capability of counter forces available to engage the enemy's population. We can cite the example, once more, of the terrorist attack on 11 September, 2001 on North American soil.

Asymmetrical (and irregular) conflict presents itself, almost always, as insurgency,[38] counterinsurgency,[39] terrorism,[40] and counterterrorism, possibly coexisting with conventional conflict. This is because the nature of the conflict can transform from conventional to irregular if the armed solution for the crisis expands, giving rise to another kind of irregular conflict, the war of resistance.[41]

Returning to the subject of this article and remembering Meig's words (2004) regarding the unorthodox form in which irregular combatants apply their capabilities: not following the rules, being disturbingly peculiar, and so forth, one can conclude that airpower characteristics (speed, range, flexibility, mobility, penetration and quick response) aligns with possible application in those conflicts. On the other hand, being unable to foresee the enemy's actions in an asymmetrical war, airpower could be used to primarily to obtain data on the opponent, learning their political, social, military, and economic situation in a specific region, in addition to defining relevant populations, which would allow the effectiveness of friendly military operations.

The collection of information, through acts of surveillance and control of air space[42] and the reconnaissance (air[43] or armed[44]), executed by manned or unmanned aircraft, as well as the possibility of obtaining precise locations, gives commanders a huge gain in situational awareness that can be used in the "process of selection of weapon and targets."[45] Due to the geographic environment in which the asymmetrical war would probably unfold (i.e., near a target population), an air offensive would necessitate the use of precision-guided weapons, as collateral damages puts the local population, and consequently the support they may give, at risk. The range of actions of the air force in asymmetrical conflicts essentially encompasses not only air control, but also close air support[46] and interdiction[47], with the possibility of using both manned or unmanned aircraft (ARP)[48] for carrying out such missions.

Unmentioned is the necessity for air superiority in an asymmetrical conflict because, as a general rule, the opponent would have no offensive aircraft, although such capability should not be dismissed. A case in point was the use of civilian aircraft for the terrorist attack on the World Trade Center on the 11 of September of 2001.

Thus, it is evident that aircraft (manned or unmanned) operating alone or in a network, with the capability to carry out multiple activities, such as the collection of information, selection and

ability to reach targets with precision and minimal collateral effects, and ability to provide battlefield interdiction and ground troop support are essential. Therefore, it is important to know the generational evolution of aircraft until now.

Generations of Military Aircraft

Throughout military aviation history, fighter planes have undergone technological advances categorized by generations, according to the classification of the North Atlantic Treaty Organization (NATO).[49] This categorization has applied only to fighter planes, emphasizing generational changes in speed, range, flexibility and versatility, mobility, penetration, and quick response,[50] evolutionary changes motivated by the strategic objectives of the most influential countries after WWII.

In accordance with NATO classification, first-generation aircraft were those used during the Korean War (mid-1950s). Airplanes lacking radar, subsonic speeds, and weapons consisting of freefall bombs and machine guns or guns with front sight, represented this generation of aircraft. Examples of this generation are the MiG-15, 17, and the Gloster Meteore F-86.

Second-generation aircraft are represented by fighters manufactured between 1955 and 1960, having as their main features supersonic flight at great altitudes for interception, equipped with search radar and the first heat-guided missiles. Among the examples figure the F-104, F-105, F-106, MiG-19, Mirage III, MiG-21, and the English Electric Lightning.

Third-generation aircraft entered service at the beginning of the 1960s, improving upon the features of the prior generation with more advanced aerodynamics and incorporating electronic systems. The F-4 Phantom, F-5 Tiger II, MiG-23, MiG-25, Mirage F1, and Saab Viggen are examples.

Fourth-generation aircraft introduced microelectronics available in the 1970s and 1980s, which made advanced avionics possible, such as fly-by-wire controls and cockpit hands on throttle and stick (HOTAS),[52] in the F-14, F-15, F-16, F-18, MiG-29, MiG-31, Su-27, Mirage 2000, Tornado, and Saab Gripen (JAS 39). This generation of aircraft made possible taking combat beyond visual range, having incorporated beyond visual range (BVR) type missiles.[53]

Generation 4.5, which arose at the end of the 1980s and throughout the 1990s, improved radar and introduced digital technology in avionics but few improvements in aerodynamics. Examples of this generation of airplanes include the F/A-18E SuperHornet, Sukhoi Su-30/35, and the Eurofighter Typhoon.[54]

Fifth-generation fighters introduced aerodynamic changes to divert and absorb electromagnetic waves, with weapons stored inside the fuselage, making these aircraft difficult to detect by radar (stealth technology).[55] In this class are the Lockheed Martin F-22 Raptor (USA), the F-35 Lighting (USA), Sukhoi SU-57 PAK FA (Russia), Chengdu J-20 (China), and Shenyang J-31 (China).[56]

According to this classification, we can consider the Brazilian F-5E/F updated airplanes as being fourth-generation. The a forementioned A-1 airplanes can become fourth-generation as well, if their systems are retrofitted with microelectronics and HOTAS technology.

However, Brazilian airpower, especially in asymmetrical conflict scenarios which involves opponents that are abstract, diffuse, and uncertain, within or outside the national territory, must include manned and unmanned aircraft capable of carrying out, alone or in a network, a varied range of missions. That is, they must be capable of identifying, analyzing, designating the appropriate weapons, and eliminating the threat in a single mission, preferably with stealth. Thus, it seems reasonable that the features of airpower enumerated in the basic doctrine of the Brazilian Air Force, should begin to consider stealth as a feature that should be pursued, since it will greatly influence the survival of multimission platforms.

In addition to stealth technology, there is also “furtive technology”. The term “furtive technology” implies the incorporation of “multispectrum discretion” into aircraft platforms, in order to improve evasion of radar detection. Thus, it is important to understand that the technology is not

about "furtiveness," but rather "multispectral discretion." Furtiveness can be attained through synchronized use of technical and operational capabilities, with the objective of hiding the operation of an aircraft in a way that increases its possibility of survival in a mission.

Of note, a 5th-generation aircraft can incorporate multispectral discretion technology (stealth technology), and still not have furtiveness. Case in point is the downing of an American F-117A Nighthawk[57] in the former territory of Yugoslavia, on 27 March, 1999, during the war in Kosovo. In a scenario typical of irregular war, the aircraft, symbol of stealth technology, was attacked by a surface-to-air missile (SAM) SA-3 Goa[58] belonging to the Serbian anti-aircraft defenses.

Among the possibilities by which the F-117A was shot down, the most probable were that "the F-117A were designed to be 'invisible' to modern radar, but not against the old long wave radars, such as the SA-3"; or that "the same route was used various times by the F-117A and could be seen visually."[59] In summary, there was stealth technology on board but not furtiveness in the operation of the airplane.

It would be reasonable to believe that multispectral discretion technology would not be necessary in an asymmetrical war environment, considering that the opponent would not have means of detection that would dictate the the use of stealth aircraft. However, due to the inherent uncertainty of the operational environment and the possibility of an opponent being able to gain access to such technology, multispectral discretion, together with operational intelligence,[60] could represent the difference between succesful or unsuccesful use of airpower in this environment.

It is timely to point out that the Gripen NG fighter plane that will be incorporated in the FAB inventory can be characterized as a fourth-generation plus multimission aircraft, since it incorporates elements typical of that generation, in addition to an increased operational range, a greater capacity for useful cargo (allowing it to be armed with a great variety of weapons) and network-centered war (NCW) capabilities, compatible with Empresa Brasileña de Aeronáutica SA (Embraer) E-99 Erieye[61] aircraft. Despite this, the future Gripen NG will not be considered as fifth-generation since they do not incorporate stealth technology. On the other hand, the Gripen NG[62] can obtain proper furtiveness in their missions by using appropriate tactics. As it stands, the F-5E/F and A-1 aircraft are not multimission airplanes, since the F-5, even after the modernization process, remains a defensive aircraft and the A-1 remains as an attack/reconnaissance aircraft, as defined by FAB doctrine.

In Brazil's case, is important to point out the geographic challenges the F-5 and A-1 aircraft face fulfilling the Brazilian Air Force's mission "to maintain the sovereignty of national air space".[63] The air space for FAB activity comprises 8,538,000 km², with an economic zone of 3,539,919 km² and under international agreements, 9,922,081 km² of ocean, for a total of 22,000,000 km², known as "Dimension 22."[64]

The sophistication of future military aeronautical assets, in the face of future possible scenarios and Brazil's geographical challenges, require an industrial support base aligned with these new challenges, since "air power is the result of technology".[65] Due to the lack of national industrial and logistical support, adapted to meet the future asymmetrical war needs of the FAB, the Brazilian Defense Ministry considers the "technological dependency" on the industrial base to be a threat until 2039. This is because "the pace of Brazilian technological development will not be sufficient to eliminate external dependence" in order to meet the "ability of the Armed Forces to counter intermediate powers, in eventual conflicts."[66]

The "threat" brought by having an external "technological dependence" raises the question as to whether the national aeronautical industry should be able to provide technology independently or autonomously. According to Idelniza Moreira de Miranda, the aeronautical industry, unlike other industries, is not under the complete dominion of any country that manufactures aircraft. Therefore, the national aeronautical industry must often seek technological alliances in various parts of the globe to support multimission aircraft, or, must adapt to provide logistics and technologies via alliances.[67] Antonio Viana Matias, notes that, with regards to supply chain management, the economic scenario

for companies involved in such an endeaver would be a competitive and unstable environment, based on "global markets, very tenuous borders, variable and restricted demand, financial costs and expensive materials, untrustworthy forecasts, shorter product life cycle, constant technological innovations, economic uncertainties, among other variables."[68] Such behavior in alliance dependent logistics and technologies is already evident in Brazil's national aeronautical industry. For example, the future Gripen NG aircraft for the FAB is presented as a "multinational fighter" since it involves the participation of six countries (Brazil, Sweden, Israel, South Africa, United States, and a European provider) in its development, production and acquisition.[69]

The aeronautics industry, therefore, is structured along global supply chains, with the consequential loss of independence in some sectors, in order to achieve better economic efficiencies. This is the case with Embraer, "anchor" firm in the aeronautics industrial segment in Brazil, which, since its privatization in 1994, with its "strategic alliances" has reached third place in the production and commercialization of commercial and military aircraft market.[70]

Thus, it seems more appropriate to understand that the aeronautical industry, especially in the defense sector, both currently and in the future, must pursue obtaining technological and operational autonomy, but not full independence (utopia). It should be autonomous, and be able to decide who to choose as its economic, technical and logistical partners. It is in this multiplicity of partners where the development of future of multimedia platforms resides, with advanced technologies capable of operating in irregular wars.

Final Considerations

This article presented the changes that have occurred in warfare throughout history, the concept of generational wars, the generational evolution of military aircraft, the repercussions posed for Brazilian air power by the transformations that have taken place, the multiplicity of wars that may occur in the future, and the challenges of adapting to new technological requirements. Regarding the generational evolution of military aircraft, specifically fighter planes, this article discussed how the competitive nature of States, striving to achieve their geopolitical objectives, has served to drive innovative technological changes. These changes have driven the development of next-generation, furtive manned and unmanned aircraft with the ability to carry out, alone or within a network, a varied range of missions; and the capability to identify, analyze, select proper weaponry, and eliminate threats.

Although the FAB has not added new fighter planes to its inventory since the acquisition of the F-5 in the 1970s and the A-1 in the 1990s, its new initiative to acquire the Gripen NG will add multi-misson aircraft to its inventory. The Gripen NG, despite not having an effective stealth capability, can attain an appropriate furtive effect if used in networked operations. However, until then, the FAB does not have the multimission aircraft to be the "spearhead" in today's and future modern wars, and is not up to the challenges posed by unidentifiable opponents in an uncertain geographical environment—typical elements of asymmetrical conflicts. This is further aggravated by the immense "Dimension 22" geographical area in which Brazilian national airpower needs to operate.

Another area of concern is the fragile logistical-industrial support base for the FAB's current and future air assets, as the national defense industry is now and may still be dependent on non-native technology until 2039, according to the Brazilian Defense Ministry's threat assessment in the "Defense Scenario" document for the 2020–2039 timeframe. In order to avoid this threat, it is pertinent to seek not full technological independence but rather the autonomy to decide who our economic, technological, and logistical, partners will be. This is evident in current vanguard aeronautics technology, which instead of being attritubuted to any one country, relies on the participation of various companies with specific knowledge in the design and fabrication of multi-mission fifth-generation aircraft.

At the heart of making airpower adequate to face asymmetrical wars, the defense aeronautical industry must take into account presently, and in the future, the development, fabrication, and support

of new aircraft/platforms that meet operational demands and can operate in the vast geopolitical areas that encompasses Brazil. The defense aeronautical industry must take a proactive stance, based on pertinent public policies, taking advantage of R&D of technological advances, as well as the required support for provisioning and maintenance. ❑

Notes

1. DOUHET, Giulio. *O domínio do ar* (Air Dominion). Translation: Escuela de Perfeccionamiento de Oficiales de Aeronáutica. Belo Horizonte. Itatiaia. Rio de Janeiro. INSTITUTO HISTÓRICO CULTURAL DA AERONÁUTICA 1988, p. 48.
2. BOYNE, W.J. *The influence of airpower upon history*. New York: Pelican Publishing Company, 2003, p. 18.
3. BRASIL. Comando de Aeronáutica. *Doutrina Básica da Força Aérea* (DCA 1-1) (Basic Doctrine of the Air Force DCA 1-1). Brasília, 2012, p. 36
4. According to the definition of the Escuela Superior de Guerra (ESG), national power "is the capacity that a group of men or assets have that constitute a nation to reach and maintain the national goals in accordance with national will". (BRAZIL, 2014, p. 34).
5. Basic Doctrine of the Brazilian Air Force (DCA 1-1), p. 35.
6. Basic tasks of the FAB: define the greater purposes of a military campaign or operation, principally strategic and operational. There are six basic FAB tasks: Information exploration, Air Control, Strategic Projection of Airspace Power, Battlefield Interdiction, Force Protection and Combat Support.
7. Air Control: The basic task carried out with the purpose of dominating airspace of interest and impede that the enemy does the same. (BRAZIL, 2012, p. 45)
8. Basic Doctrine of the Brazilian Air Force, p. 31-32
9. BRAZIL. Aeronautic Command. Integrated System of Logistics for Materials and Services (SILOMS). Management Indicators. 2017b. Available at: <https://www.siloms.intraer/indicadores/indicadores.php? did=&start=6>. Accessed 9 May 2017
10. DIMENSIÓN 22. *Projects–Gripen*. Available at: <http://www.fab.mil.br/dimensao22/>. Consulted 30 May 2018.
11. KALDOR, Mary. *The Baroque Arsenal*. London: A Deutsch, 1981, p. 19.
12. BRAZIL. Ministry of Defense. *Sistemática de Planejamento Estratégico Militar* (Systematics of Military Strategic Planning). Brasília, 2005. (MD51-M-01), p. 4. Available at:
<http://www.defesa.gov.br/arquivos/File/legislacao/emcfa/publicacoes/md51_m_01_sist_de_plj_estr_mil_spem_1a_ed2005.pdf>. Consulted 10 August 2017.
13. BRAZIL. Ministry of Defense. *Glossário das Forças Armadas* (Glossary of the Armed Forces) (MD35-G-01). 2007, p. 122 Available at:
<http://www.defesa.gov.br/arquivos/File/legislacao/emcfa/publicacoes/md35_g_01_glossario_fa_4aed2007.pdf>. Consulted 10 November 2016.
14. BRAZIL. Ministério da Defesa. *Glossário das Forças Armadas* (MD35-G-01). 2007, p. 122 – 127. Disponível em:
<http://www.defesa.gov.br/arquivos/File/legislacao/emcfa/publicacoes/md35_g_01_glossario_fa_4aed2007.pdf>. Acesso em 10 nov. 2016.
15. VISACRO, Alessandro. *Guerra irregular:* terrorismo, guerrilha e movimentos de resistência ao longo da história (Irregular War: terrorism, guerilla warfare and resistance movements throughout history. São Paulo: Contexto, 2009, p. 30
16. VISACRO, Alessandro. *Guerra irregular*: terrorismo, guerrilla y movimientos de resistencia a lo largo de la história. (Irregular War: terrorism, guerilla warfare and resistance movements throughout history. São Paulo: Contexto, 2009, p. 29.
17. VISACRO, Alessandro. *Guerra irregular*: terrorismo, guerrilha e movimentos de resistência ao longo da história. (Irregular War: terrorism, guerilla warfare and resistance movements throughout history. São Paulo: Contexto, 2009, p. 7.
18. CLAUSEWITZ, Carl Von. *Da guerra* (On war). São Paulo. Martins Fontes. 1979, p. 89.
19. TZU, Sun. *A arte da guerra* (The Art of War). Adaptation and preface by James Clavell. Translation by José Sanz, 22nd edition. Rio de Janeiro: Record, 1999, p. 42.
20. LESSA, Carlos; COSTA, Darc; EARP, Fábio Sá. After the attempt: News from the asymmetrical war, the international crisis and Brazil. Garamond, 2002, p. 84
21. MACK, Andrew J.R. Why Big Nations Lose Small Wars: the politics of asymmetric conflict. *World Politics*, v. 27, n. 2, p. 175-200, January 1975.
22. MEIGS, Montgomery C. Ideias pouco ortodoxas sobre a guerra assimétrica (Unorthodox ideas regarding asymmetrical war). *Military Review,* 1st trimester. Brazilian Edition, 2004, p. 2.
23. Ministry of Defense. Glossary of the Armed Forces (MD35-G-01). 2007, p. 110. Available at <http://www.defesa.gov.br/arquivos/File/legislacao/emcfa/publicacoes/md35_g_01_glossario_fa_4aed2007.pdf>. Consulted 10 October 2018.

24. MEIGS, Montgomery C. Ideias pouco ortodoxas sobre a guerra assimétrica (Unorthodox ideas regarding asymmetrical war). *Military Review*, 1st trimester. Brazilian Edition, 2004, p. 4.

25. VISACRO, Alessandro. Guerra irregular: terrorismo, guerrilha e movimentos de resistência ao longo da história. (*Irregular War*: terrorism, guerilla warfare and resistance movements throughout history. São Paulo: Contexto, 2009, p. 38.

26. TOFFLER, Alvin. *Guerra e antiguerra*: sobrevivência na aurora do Terceiro Milênio (War and antiwar: Survival at the dawn of the Third Millennium). Translation by Luiz Carlos do Nascimento Silva. 4th edition. Rio de Janeiro: Record, 1998, p. 54.

27. The Maginot Line was structured from the fortifications and the defenses constructed by France along its borders with Germany and Italy after the First World War.

28. The Battle of Monte Cassino was a sequence of four battles during the Second World War, between the Allies and the Germans, with the intention of breaking the Winter Line and conquering Rome.

29. VISACRO, Alessandro. *Guerra irregular*: terrorismo, guerrilha e movimentos de resistência ao longo da história. (Irregular War: terrorism, guerilla warfare and resistance movements throughout history. São Paulo: Contexto, 2009, p. 39.

30. Non-linear war comprises combat actions within the field of battle, using of aircraft operations, armored vehicles, incursions, applications of massive fire and troop infiltrations, seeking to unbalance the enemy's devices, forcing the fighting in one direction and isolating them from their support and reinforcements. (BRAZIL, 2007b, p. 59).

31. LIND, William S. Compreendendo a guerra de quarta geração (Understanding 4th generation war). *Military Review*, Jan-Feb, Brazilian Edition, 2005, p. 13.

32. WILCOX, Greg; WILSON, G. I. Resposta militar à quarta geração de guerra no Afeganistão (Military response to the fourth-generation war in Afghanistan). *Military Review*, 1st trimester, Brazilian Edition, 2004, p. 38-39.

33. LIND, William S. Compreendendo a guerra de quarta geração. (Understanding 4th generation war). *Military Revie* Jan-Feb, Brazilian Edition, 2005, p. 17.

34. BRASIL. Comando de Aeronáutica. *Concepto Estratégico de la Fuerza Aérea 100* (DCA 11-45). Brasília, 2016, p. 14.

35. BRASIL. Ministerio da Defensa. Cenários de Defesa 2020-2039 – sumário executivo/Ministério da Defesa, Assessoria Especial de Planejamento (Escenarios de defensa 2020-2039 – Executive Summary/Ministry of Defense, Special Counsel for Planning). Brasília: A Assessoria, 2017a. 64p, p. 49

36. VISACRO, Alessandro. Guerra irregular: terrorismo, guerrilha e movimentos de resistência ao longo da história. (*Irregular War:* terrorism, guerilla warfare and resistance movements throughout history. São Paulo: Contexto, 2009, p. 39.

37. CENTER OF GRAVITY – 1. Essential point of a nation, military forces or diverse systems, whose functioning is essential for the survival of the group. 2. Point from which a military force (friend or foe), due to its characteristics, capacities or localities, extracts its liberty of action, physical force or will to fight. (BRASIL, 2007, p.48).

38. The term insurgency does not appear in the glossary of the Brazilian Armed Forces, but its meaning can be extracted in the opposite term counter insurgency, as being: movement for upset, rebellion or resistance executed by a society against its government (social authority) to comply by force (armed struggle). It is a movement from within going outward.

39. COUNTER-INSURGENCY – Strategy that seeks to defeat the centers of insurgency by the use of the same tactics as the enemy, normally a guerrilla, with the purpose of eliminating the public support for the guerillas. For this, the strategy includes, if necessary, social, economic and political reforms in the region. (BRASIL, 2007, p. 60).

40. TERRORISM – The form of action that consists of the use of physical or psychological violence, in a premeditated way, by adversarial individuals or groups, supported or not by States, for the purpose of coercing a government, authority, individual, group or even the whole population to adopt a certain behavior. It is motivated and organized by political, ideological, economic, environmental religious or psychological reasons. (BRASIL, 2007, p.227).

41. WAR OF RESISTANCE -Armed conflict in which citizens of a country occupied by another country or coalition of countries, completely or partially, fight against the occupying power to reestablish the former sovereignty and independence. (BRASIL, 2007, p. 112).

42. Surveillance and Control of Airspace (VCEA) is the action that consists in using, from the ground, Air Force assets to detect, identify, accompany and control aircraft in the airspace of interest. The VCEA done from the air is called Control and Alarm in Flight. (BRASIL, 2012, p. 56).

43. Air reconnaissance (RecAe) is the action that consists of the use of Air Force assets to collect specific data about the enemy forces and areas of interest. (BRASIL, 2012, p. 55).

44. Armed reconnaissance (Rec A) is the action that consists of using Air Force assets to detect, identify and neutralize or destroy enemy targets in an area or route selected in advance. (BRASIL, 2012, p. 55).

45. JUNIOR, Hélcio Vieira; KIENITZ, Karl Heinz; BELDERRAIN, Mischel Carmem Neyra. *Metodologia de apoio a decisão para os processos de seleção de alvos e armamentos* (Methodology of support for the decision for the processes of selection of targets and weapons). Symposium of Operational and Logistical Research of the Navy (SPOLM). August 2009, p.2 Available at: <https: //www.marinha.mil.br/spolm/sites/www.marinha.mil.br.spolm/files/005_2.pdf>. Consulted 20 November 2016.

46. Close Air Support (Ap AA) is the action that consists of using Air Force assets to detect, identify and neutralize or destroy enemy ground forces that are in direct contact with friendly ground forces (BRASIL, 2012, p.50).

47. Interdiction involves military actions that seek to affect the organization and function of enemy ground forces. (BRASIL, 2012, p. 47).

48. ARP – Aircraft piloted by remote control.

49. GIORDANI, Evandro. *As gerações de caças em imagens* - parte I, II, III, IV e V. 2015 (The generations of fighter planes in images – parts I, II, III, IV y V 2015). Available at: < http://www.cavok.com.br/blog/as-geracoes-dos-cacas-em-imagens-parte-v/>. Consulted 10 November 2016.

50. Basic Doctrine of the Brazilian Air Force, p. 31-32.

51. FERREIRA, Marcos José Barbieri. Dinâmica da inovação e mudanças estruturais: um estudo de caso da indústria aeronáutica mundial e a inserção brasileira (Dynamics of innovation and structural changes: Case study of the world aeronautical industry and Brazilian participation). 2009. 257 p. Doctoral Thesis - Universidade Estadual de Campinas, Instituto de Economia, Campinas, SP, p. 22. Available at: <http://libdigi.unicamp.br/document/?code=000470653>. Consulted 20 June 2017.

52. HOTAS, acronym for *Hands On Throttle And Stick,* which allows the pilot to have access to the weapons and navigation systems without taking his hands for the power and command controls. In Brazil, the first airplane to utilize said technology was the A-1.

53. *Beyond Visual Range* or BVR are missiles for air to air combat, with a range of more than 20 NM.

54. FERREIRA, Marcos José Barbieri. *Dinâmica da inovação e mudanças estruturais:* um estudo de caso da indústria aeronáutica mundial e a inserção brasileira (Dynamics of innovation and structural changes: Case study of the world aeronautical industry and Brazilian participation). 2009. 257 p. Doctoral thesis) - Universidade Estadual de Campinas, Instituto de Economia, Campinas, SP, p. 26 Available at: <http://libdigi.unicamp.br/document/?code=000470653>. Consulted 20 June 2017.

55. TECHNOLOGY OF FURTIVENESS - Means of non-destructive electronic attack that allows hiding the unit. It is intimately tied to aspects of development and construction of platforms. Their geometry and material are used to build them. It is a multi-spectrum discretion capability (microwaves, infrared and visual) of the platforms. BRASIL. Ministério da Defesa. *Glossário das Forças Armadas* (MD35-G-01). 2007, p. 252. Available at:
<http://www.defesa.gov.br/arquivos/File/legislacao/emcfa/publicacoes/md35_g_01_glossario_fa_4aed2007.pdf>. Consulted 10 October 2018.

56. STROSKI, Pedro Ney. Gerações de caças a jato (Generations of fighter jet planes). 2018. Available at: http://www.electricalelibrary.com/2018/10/01/geracoes-de-cacas-a-jato/. Consulted 23 October de 2018.

57. An F-117A was the first *stealth* airplane that entered combat. *Ficha técnica: Lockheed Martin F-117A Nighthawk*. Available at https://airway.uol.com.br/ficha-tecnica-lockheed-martin-f-117a-nighthawk/. Consulted 20 October 2018.

58. SA-3 GOA (NATO designation), or *S-125 Neva/Pechora* (Russian designation) is a system of ground-to-air missiles, of Russian fabrication, and intermediate altitude. The S-125 launches 5V24 (V-600) missiles that travel at a velocity of Mach 3 to 3.5. This one, like the Soviet models of its type, is guided by radio waves. Available at: https://fas.org/nuke/guide/russia/airdef/s-125.htm. Consulted 23 October 2018.

59.'Stealth' abatido na Iugoslávia (Stealth shot down in Yugoslavia) – Air Power. Available at: https://www.aereo.jor.br/2010/02/03/stealth-abatido-na-iugoslavia/. Consulted 23 October 2018.

60. According to the Doctrine for Use of the Brazilian Air Force, operational intelligence (Intlg Op) is the action of the Air Force that consists in the use of Air Force assets to produce knowledge about the opponent and protect sensitive knowledge of friendly forces. (BRASIL, 2012, pg. 53).

61. *GRIPEN-NG. Principais características* (Principal features) (2013). Available at: <http://www.defesanet.com.br/fx2/noticia/13530/GRIPEN-NG---Principais-Características/>. Consulted 15 January 2016.

62. GRIPEN-NG. Pequeno e letal combatente (Small and lethal combatant) (2014). Available at: <https://aeromagazine.uol.com.br/artigo/pequeno-e-letal-combatente_1340.html>. Consulted 20 October 2018.

63. BRASIL. Comando da Aeronáutica. *Concepção Estratégica Força Aérea* 100 (DCA 11-45). Brasília, 2016, p. 17.

64. DIMENSIÓN 22. Access. Available at <http://www.fab.mil.br/dimensao22/>. Consulted 30 mayo 2018.

65. MEILINGER, Phillip S. *Dez proposições referentes ao poder aéreo* (Ten proposals regarding to air power), 1996. Available at: <http://www.airpower.maxwell.af.mil/apjinternational/apj-p/1996/1tri96/meiling.html>. Consulted 1 August 2015.

66. BRASIL. Ministério da Defesa. *Cenários de Defesa 2020-2039* – sumário executivo/Ministério da Defesa, Assessoria Especial de Planejamento. Brasília: A Assessoria, 2017a. 64p, p. 51

67. MIRANDA, Idenilza Moreira de. *O vôo da Embraer*: a competitividade brasileira na indústria de alta tecnologia (Embraer's flight: Brazilian competitivity in the high-tech industry. 1st ed. São Paulo: Editora Papagaio, 2007.

68. MATIAS, Antonio Viana. *Gestão da cadeia de suprimentos* (Supply chain management). 2012. Available at:
< http://www.castelobranco.br/sistema/novoenfoque/files/08/05.pdf >. Consulted 8 January 2017.

69. CAZA. *Caça multinacional* (Multi-national fighter plane). Available at: <http://militarypower.com.br/Gripen.htm>. Consulted 30 October 2015.

70. To better understand the subject of Embraer's strategic partnerships, see "Strategies in relation to the providers: The Embraer case". Available at: < http://www.scielo.br/pdf/gp/v18n2/01.pdf>. Consulted 20 October 2018.

Colonel Alexandre Fernandes Ramos, is an officer of the Brazilian Air Force Reserve, working since 2010 as part of the docent group at the Escuela de Comando y Estado Mayor de la Aeronáutica (ECEMAR). He holds a masters degree in aerospace sciences from the Universidad de la Fuerza Aérea–UNIFA (Air Force University), specializing in contemporary strategic political thought. He has an MBA–in advanced executive development–with emphasis on strategic institutional management from the Universidade Federal Fluminense and specialization in aerospace policy and strategy from ECEMAR. Colonel Fernandes is an operational pilot in air transport, search and rescue, in-flight refueling and operations in Antarctica.

Dr. Patricia de Oliveira Matos, PhD, Economist, Doctor of Aerospace Sciences from the Air Force University (UNIFA), Master's degree in Applied Economics from the University of São Paulo (Esalq/USP). Since 2006 she has worked as a docent of the postgraduate program in aerospace sciences at the Air Force University, administrating the discipines of defense economics and scientific research methodology. She carries out research regarding the following subjects: defense budget, defense industry, aerospace industry, strategic programs and aerospace projects.