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BRAZILIAN AIR FORCE FIGHTER PILOTS THREATS PERCEPTION ON DEPTH AND PERIPHERAL DEFENSE STRATEGIES

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ABSTRACT: *Countries use defense systems as a component of conventional deterrent to avoid conflicts, and aerospace defense collaborates in a relevant way for this purpose. Among the peripheral and in depth defense strategies, some rulers chose to employ the latest. Through a qualitative interview with Brazilian fighter pilots, this work aims to verify if the view about the conventional deterrence of a country's top management is aligned with that of pilots who are exposed to threats from peripheral and in depth aerospace defense, and which generates greater threat perception among them. According to the different aerospace defense strategies, surface-to-air weapons that vary in position, acquisition range radar and weapons system engagement were deployed in hypothetical scenarios. The pilots analyzed such scenarios and presented their perceptions of threats related to the likelihood of being engaged and fulfilling their missions. The results showed a higher perception of threat in the aerospace defense in depth concerning peripheral aerospace defense. The combatants' perception of threats can be a relevant fact, possibly capable of influencing the propensity of these strategies to generate conventional deterrence in potential opponents. Thus, the knowledge obtained here can contribute relevantly to more in depth analysis in the field of conventional deterrence by countries that want to improve their defense capacity. Discussion on the subject and recommendations for future studies complement this work. The research is helpful for scholars and professionals involved in politics, strategy, defense, and overall practitioners.*

KEYWORDS: conventional deterrence, strategy, ground-based air defense, peripheral air defense, air defense in depth.

INTRODUCTION

The specialized literature has shown the relevance of conventional deterrence in conflict prevention. The ground-based air defense has been used as a component of aerospace defense to generate a potential impact on the probability of attack by an adversary (Sotoriva et al., 2021a). During the elaboration and implementation of their aerospace defense strategies in the Cold War period, the United

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States and Russian governments used defense in depth to organize their ground-based air defense. This stance continues to date (Sotoriva et al., 2021b). However, there is a concern: among peripheral and in depth defense strategies, which generates greater threat perception in operational teams of military fighter pilots who may come to operate in opposition to ground-based air defenses deployed according to such strategies, that is, the view about the system that generates more dissuasion of senior management is aligned with that of those who may be exposed to face the weapons unfolded according to such a strategy? Seeking the answer to this question is the objective of this work because it is understood that such perception of threats can influence the propensity of these strategies to generate deterrence in potential opponents. Thus, the knowledge obtained here can contribute to more in depth analysis in the field of conventional deterrence by countries that aim to improve their defense capacity.

THEORETICAL FRAMEWORK ON STRATEGY, CONVENTIONAL DETERRENCE, GROUND-BASED AIR DEFENCE, ANTI-ACCESS, AND AREA DENIAL

Studies on dissuasion linked to the conventional use of force, have been intensely debated since the 1960s. The models were not limited only to nuclear weapons to communicate the defensive capabilities and discourage aggression. Sotoriva et al. (2021a) indicated that: The strategy should guide the acquisition of means; it is necessary to participate in the country's senior management in strategic definitions; dissuasion is linked to capacity, credibility, communication, and uncertainty; the opponent analyzes the cost-benefit ratio and probability of success before initiating an aggression; conventional deterrence and ground-based air defense are relevant in conflict prevention.

From the Cold War to the present day, the United States and Russia have used aerospace defense in depth. Armaments have increasing ranges and capabilities complementary to the previous generations. It is also worth noting that the Russians are using anti-access and area denial (A2/AD) to generate conventional deterrence. The ground-based defense is a fundamental element. Thus, the present study had as an epistemological foundation the thought of classical and contemporary theorists who evidenced surface-to-air weapon systems as an alternative of conventional deterrence (Sotoriva et al., 2021b)

METHODOLOGY

This study is qualitative research that deepens the concepts on the epistemology on dissuasion. The primary data was obtained through a case study within the Brazilian Air Force (FAB). Interviews were conducted with fighter pilots with considerable experience in the universe of the Brazilian Air Force, all Air Unit Commanders or Operations Officers. The application of the questionnaire model occurred so that pilots could express their opinion as to the greater or lesser perception of a threat after encountering different scenarios of aerospace defense, but that was somehow framed in the two predominant types of defense aerospace strategy: In depth or Peripheral. They would need to choose

which of the two dominant types of defense would have a more significant threat than the other and present the reasons for their choices, in order to outline decision-making from a cost/benefit perspective in infiltration to use their armaments and fulfill an assigned mission. The research was carried out focusing on ground-based air defense, disregarding other aspects, such as naval or ground defense strategy. Therefore, it was not considered necessary to submit the work to the research ethics committee. Instead, existing approaches to the proposed theme are presented. The case has civil, political, strategic, academic, and military implications.

AEROSPACE DEFENSE IN DEPTH AND PERIPHERAL AEROSPACE DEFENSE

For the perfect understanding of the theme under study, it is necessary to distinguish the difference between the two strategies for the distribution of aerospace defense systems (Brasil & Ministry of Defense, 2015; the United States & Congress, 1957):

a) Aerospace Defense In depth - assets are deployed in consecutive defensive lines in the direction perpendicular to the attacker's penetration, parallel to the border. These lines reach the sensitive points, which become "fortresses" when given reinforced means of defense. The combination of these elements increases the overall effectiveness of the protection system;

b) Peripheral Aerospace Defense – the means, especially the long-range ones, capable of covering large areas, are concentrated on the periphery of sensitive areas, distant from the sensitive areas and relevant points that are intended to be defended. That is, the means are arranged in a place without specific connection with such areas and points, in a range of airspace transverse to the probable route of the incursions.

STRUCTURING THE INTERVIEW TO PILOTS

In order to obtain information that contributes to the definition of how the aerospace defense strategy influences the perception of threat, considering the deployment of ground-based air defense means in peripheral or in depth aerospace defense strategies, structured interviews were conducted with fighter pilots Brazilians, hypothetically describing that they have been assigned to attack an environment defended by ground-based air arranged in the manner stipulated in these two strategies.

The current Commanders and/or Operations Officers of all six jet fighter aircraft Squadrons, that is, operating the F-5M and A-1M aircraft, were interviewed. In total, eight officers were heard, whose units are based on the primary mission to carry out attack missions, tactical reconnaissance and/or air defense. They all have full operational training and knowledge about ground-based air defense.

Military conceptual scenarios representing peripheral and in depth strategies were presented to these

militaries, asking them to choose those they understood to represent the greatest and least probability of being engaged in ground-based air defense weaponry and the greater and least likely to accomplish their mission.

Relevant aspects of dissuasion concepts and aerospace defense strategies presented in previous works (Sotoriva et al., 2021a, 2021b), served as the basis for the preparation of this script. For example, the importance of uncertainty to dissuasion was explored by informing the interviewee that it had not been possible to determine the precise position of the deployed ground-based air defense deployed on the ground that he would be flying over, nor whether the aircraft's defensive systems would be effective against such surface-to-air armament.

Initially, four scenarios were presented based on selected excerpts from reality, elaborated and elaborated in order to allow the analysis of the choices in face of the presented options. Therefore, such cutouts do not necessarily reflect situations that would be found in the exercise of operational activity. These scenarios can be seen briefly in Table 1 and Figure 1, where the border between Blue (pilots' country) and Red (ground-based air defense country) is represented. The first two represented peripheral defense strategy, while the last two showed defenses in depth.

TABLE 1 - Description of the main aspects of scenarios in the first part of the interview.

Scenario	Number of ground-based air defense batteries	SAM range (horizontal/vertical radius)	Radar range
1	1	300 km/25,000 m	450 km
2	3	120 km/20,000 m	300 km
3	1	120 km/20,000 m	300 km
	6	40 km/15.000 m	200 km
4	6	40 km/15.000 m	200 km
	18	8 km/4.000 m	70 km

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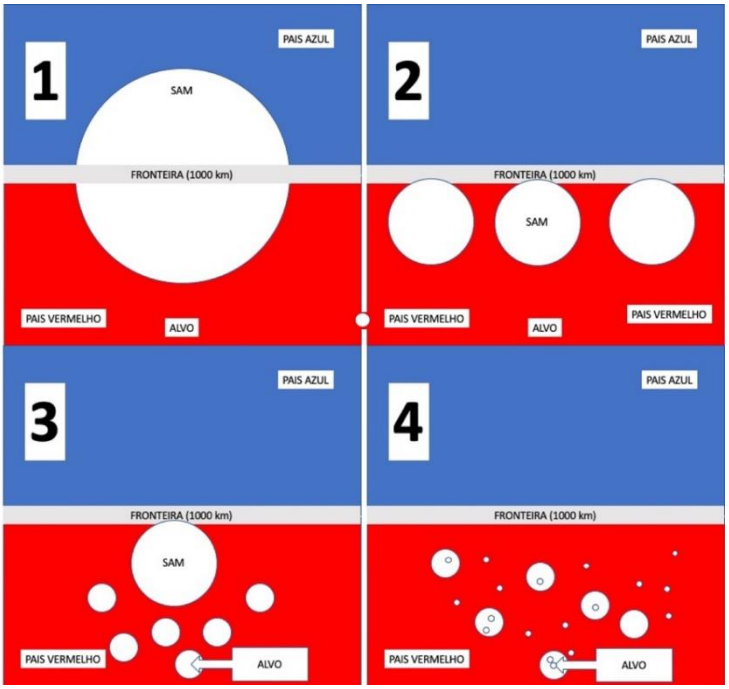

Fig. 1 - Presentation of the main aspects of scenarios of the first part of the interview.

Then, more complex and realistic scenarios were exposed. The Figure 2, which shows the distribution of surface-to-air missile (SAM) on December 31, 1964 in the USA, was used to exemplify a defense in depth. The Figure 3, which demonstrates the coverage of the S-400 and S-300s used in the anti-access function by Russia, was used as a representative of a peripheral defense. It is worth mentioning that, even in this question, there is a simplification of reality with academic purposes, since Figure 3 presents only Russian anti-access systems, which, isolated, form a kind of peripheral defense. If the area denial systems belonging to the Military Districts of that country were added, the scenario would be similar to what was presented in Figure 2, which would prevent the comparison between the strategies, the main objective of the interview.

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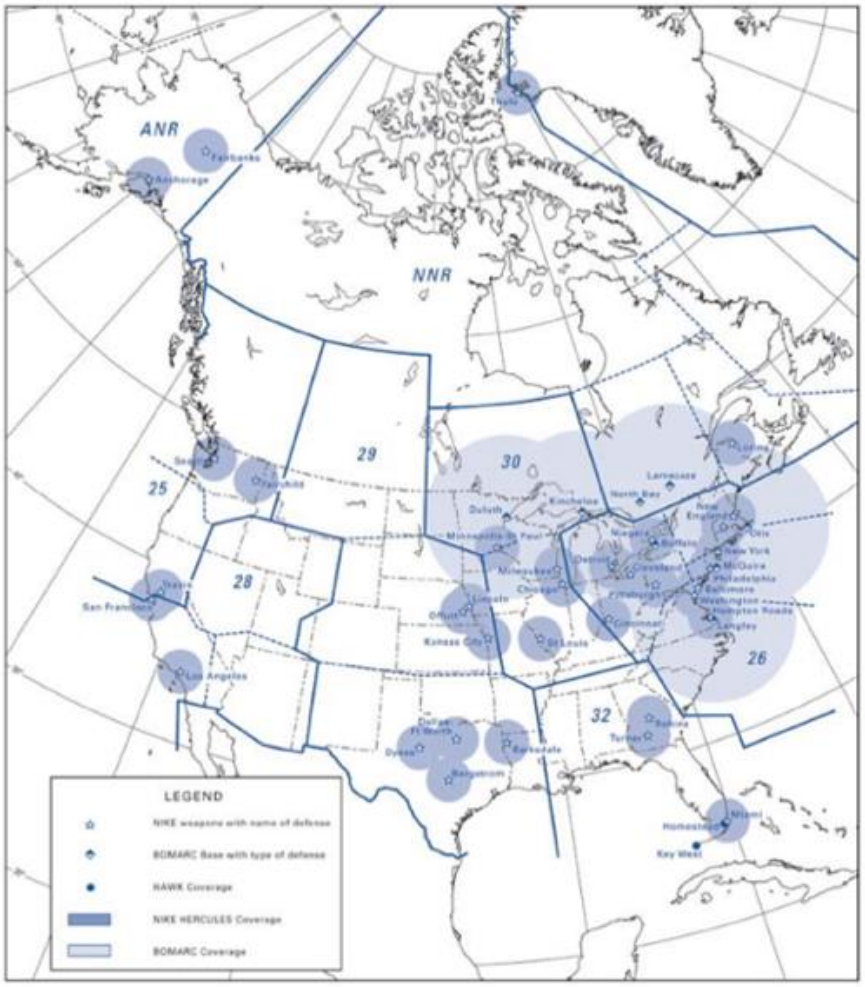

Fig. 2 - Distribution of SAM as of December 31, 1964.
Source: LEONARD (2011)

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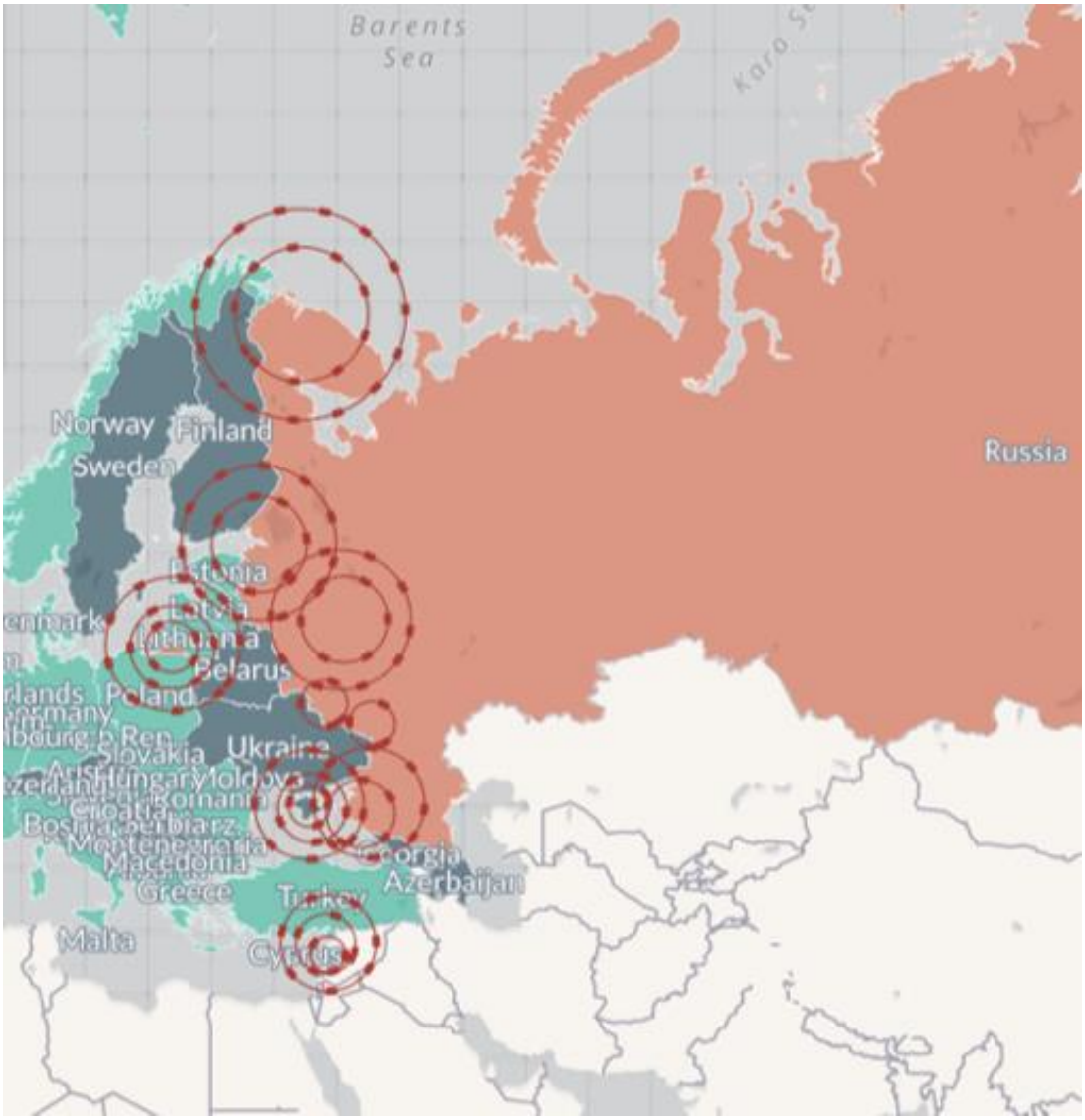

Fig. 3 - Coverage of the S-400 and S-300 of the Russian A2/AD.

Source: WILLIAMS (2018).

FINDINGS

The results of these interviews are shown below. In addition, figures have been inserted that present

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only the results referring to the higher probability of engagement by the ground-based air defense and less probability of carrying out the mission by the pilots, since the responses of a lower likelihood of engagement and a greater likelihood of fulfilling the mission were diametrically opposed.

1. **Probability to be engaged by the armament of ground-based air defense in scenarios representative of selected extracts of reality.**

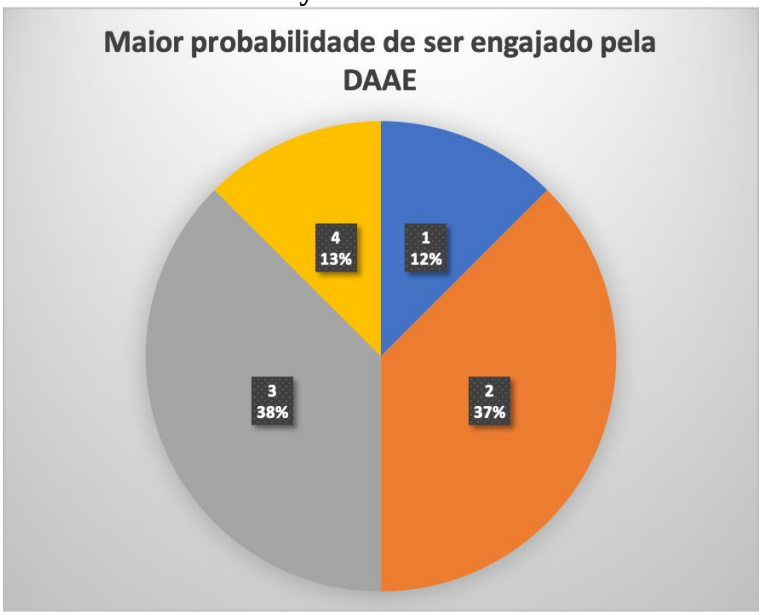

Fig. 4 – Distribution of choices, in scenarios representative of selected extracts of reality, of the greater probability of being engaged by ground-based air defense.

Considering that, in the first part of the interview, scenarios 1 and 2 present the peripheral aerospace defense strategy, while the 3 and 4 demonstrate the strategy in depth, it is perceived in the interpretation of the graph in Figure 4 that there was a perfect balance in the distribution of the choices between the two strategies, demonstrating that, in this item, the deterrent effect of both was equivalent in the sample consulted.

In summary, the justifications presented by the officers who chose the peripheral defense strategy as the most likely to engage were:

a) in scenario 1, the radar covers almost the entire border, so there is a high probability that the attacker will be detected and engaged when trying to enter the Red country;

b) in scenario 2, as there are many ground-based air defense batteries arranged along the border, there is a high probability of the attacker being detected because the radars of the

three batteries together can cover the entire border strip. Thus, the attacker will probably be engaged;

c) still in scenario 2, the area covered over Red is more extensive, increasing the risk of engagement. One respondent did not consider the area covered over the territory of Azul in scenario 1 as a threat, because, since the attacker knows the terrain well and, in a real case, combat and reconnaissance aircraft would be used to locate the emitting radar and, consequently, the battery, he understood that the raider would probably be able to divert from the area covered by the missiles. Systems distributed deep into Red's territory would not allow for these earlier actions. However, he pointed out that if there were, in scenario 1, two batteries arranged near the border, in place of the single battery that was presented, he would have chosen this scenario as the most likely of engagement, because, even knowing the location of the batteries, he could not pass outside the range of action of the same.

These arguments are complemented with those of respondents who chose the peripheral defense strategy as less likely to engage by the defender:

a) one respondent understood that scenario 4 has the highest survival rate because the type of weapon system allows evasive maneuvers that can save the aircraft even if an ground-based air defense missile has been launched against it;

b) in scenario 4, with the means dispersed, the coordination between them becomes more difficult, which increases the probability that the attacker will not be engaged;

c) one respondent did not consider the short-range batteries of scenario 4 as threats, as he understood that he could fly over Red territory and drop his bombs at an altitude higher than those weapons would reach.

The justifications presented by the officers who chose the defense strategy in depth as the most likely of engagement by the defender, in summary, were:

a) in scenario 3, depending on the deployment that is made, the defender manages to cover all sectors of approach to the main targets, increasing the probability of the attacker being engaged by the ground-based air defense;

b) in scenario 1, there is only one problem to be resolved. The pilot can use the terrain to avoid detection by that single radar. In scenarios 3 and 4, there are several problems, which increases the complexity of the scenario. Between the two, scenario three was understood as the most likely of the aircraft to be engaged due to the large armament radar capacity of the system that is close to the border, added to the fact that a dedicated ground-based air defense covers the target;

c) in scenario 3, the complexity of the scenario is increased due to the long-range ground-based air defense system near the border, which is worrisome for the pilot on the return

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after the attack, as it does not allow the use of a direct route to the country itself, increasing the exposure time over the enemy territory, in addition to generating extra fuel consumption. This risk is increased by the fact that this defense is likely to be on alert after the Blue aviation attack;

d) an attacker facing scenario 4 would likely attempt to enter Red country at a low altitude to avoid the radars of the 40 km range systems, but this would be exposed to the 8 km range systems, which are distributed at various points, including the target. He points out that he would try to enter the nighttime to hinder the engagement by portable missiles.

This argument reinforces the position of a respondent who chose scenario 1 as less likely to be engaged, who stated that, in that situation, he would fly at low height over valleys (not within the valleys, where there could be high voltage wires, but at the level of the edge of the same, at zero height concerning the external terrain). He stated that, in this way, the long-range system alone would probably not detect him.

2. Probability to fulfill the mission in scenarios representative of selected extracts of reality

Fig. 5 – Distribution of choices, in scenarios representative of selected extracts of reality, of the least probability of fulfilling the mission.

Differently from the previous answers, given the question of which scenarios the fighter pilots understood that they would be less likely to fulfill the mission, scenarios 3 and 4, representative of

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defense in depth, had a much higher choice rate, respectively 63% and 25%, totaling 88% for this strategy, while no respondent indicated scenario 1 and only 12% chose 2. Thus, it is perceived that, in such a question, the strategy of in depth aerospace defense generated a perception of threat much higher than the peripheral in this sample of respondents. The difference from the previous responses was based on the fact that the attacker can be engaged after dropping his bombs, and therefore having fulfilled the mission. Thus, in general, it was understood as coherent by the interviewees to unlink the answers to the two questions.

The officer who considered scenario 2 as the least likely to fulfill the mission did not follow this line of reasoning and understood that there was a linear relationship between the lower probability of being engaged and the greater the probability of fulfilling the mission, justifying his choice because he had previously indicated scenario 2 as the one with the highest likelihood of engagement.

In summary, the justifications of the officers who chose the defense strategy in depth as less likely to fulfill the mission were:

a) scenario 3 is the one that presents the highest probability of engagement along the route, added to the fact that, as the target is protected, if the attacker is detected and/or engaged, it can be challenging to perform an evasive maneuver to avoid the ground-based air defense missiles and even launch the bombs;

b) in scenario 3, the SAM radar at the border can alert the defense about the incursion. Because the amount of means to be coordinated is not very large and the scope of these means is good, including around the target, the probability of the mission being long is reduced;

c) one respondent considered scenario 3 to be less likely to accomplish the mission because the large number of radars arranged on the ground would increase the likelihood of detection and, consequently, there would be a reduction in the surprise factor, which would leave the target's ground-based air defense in readiness and make it difficult to execute the launch of the bombs. Although Scenario 4 had even more radar, he didn't consider it the least likely to accomplish the mission because it could launch its weaponry outside the systems' vertical range of employment, 4,000m.

Added to these justifications are the ideas presented by those who understood the scenarios of peripheral defense as being more likely to be fulfilled by Azul's mission:

a) the highest probability of fulfilling the mission is in scenario one since the long-range missile is less maneuverable, increasing the efficiency of the evasive maneuvers that the pilot performs when a missile is launched against him. In addition, the threat to the aircraft would come from only one direction in this scenario, simplifying the performance of these maneuvers;

b) scenario one allows for greater accuracy at the time of the attack, as a dedicated system

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does not protect the target. On the other hand, because there is more than one layer of systems dedicated to target protection in scenario 4, the probability of the attack being effective is reduced.

3. Probability to be engaged by the armament of ground-based air defense in complex scenarios

Fig. 6 – Distribution of choices, in complex scenarios, of the most negligible probability of fulfilling the mission.

Having been presented with scenarios corresponding to distributions of ground-based air defense systems close to the real ones in peripheral and in depth defense strategies, 75% of the interviewees understood that the latter represented the highest probability of engagement of an incursion, as shown in Figure 6.

Officials who chose the defense strategy in depth as more likely to engage, in short, said they were based on the following reasons:

a) a) in peripheral defense, the probability of being detected is high, but some diversionary maneuver or saturation of the defenses of a certain point can be used to force entry. Then the path is clear to the target. In the US in depth defense scenario, some threats are distributed from the vicinity of the border to the points that will be attacked, generating risk to the attacker throughout the flight. In addition, the area to be attacked is with a

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defense very difficult to transpose;

b) to counter the defense in depth, the attacker would have to try to mount a "minimal risk route" between the positions defended by the SAM. However, several factors can take you away from that route, such as weather or detection, by the aircraft's radar alert receiver, which would be being illuminated by the radar of an opposing air defense aircraft. This diversion can lead to the attacker being detected and engaged by the ground-based air defense. In addition, because the ground-based air defense is mobile, the information considered for setting up this route can change quickly, allowing the defender to detect the attacker and engage from the new defensive positions. It was highlighted that the complexity of the problem for the attacker would be significantly increased if the scenarios involved the use of diversified means, such as jet fighter aircrafts and SAM, especially if the latter had different ranges and types of guidance.

Those who chose peripheral defense as more likely to engage, in short, reported understanding that the Russian device has a detection capability that allows the alert of defensive means well in advance, since the coverage reaches even most eastern European airfields, covering the possible routes of approximation. With this arrangement, it would be not very likely to achieve a contour that would allow entering the territory without being detected and engaged.

4. Probability to fulfill the mission in complex scenarios

Fig. 7 – Distribution of choices, in complex scenarios, of the most negligible probability of fulfilling the mission.

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The question of which of the two scenarios would represent the lowest probability of the mission being accomplished brought a percentage of 87% of evidence of defense in depth, as shown in Figure 7. The choices were mainly based on the following reasons:

a) in the case of the Russian peripheral defense, it was considered that there were unprotected centers of gravity, including the country's capital. As these would probably be the targets, it was understood that there would be a greater probability of fulfilling the mission as long as it could pass through the initial barrier. In the defense in depth of the United States, the situation was reversed: the main sensitive points would probably be defended with dedicated ground-based air defense, reducing the probability of mission fulfillment;

b) in the case of the defense in depth, the decentralization of ground-based air defense means makes it necessary to avoid many threats throughout the flight. In peripheral defense, once the first barrier is passed, the mission becomes less risky.

DISCUSSION AND IMPLICATIONS

The aerospace defense in depth strategy was the one with the highest threat perception among the interviewed fighter pilots. The article has implications in the following fields of research: (i) civil aviation (Dias, M., Lopes, R., 2020; Dias, 2019; (ii) commercial aircraft industry Cruz, B.S.; Dias, M., 2020); (iii) air cargo transportation (Dias and Lopes, 2020b), among others. Some points related to this strategy deserve to be highlighted. First, it is noticed that almost two-thirds of the pilots interviewed chose, among scenarios of extracts of reality, such as the least likely to fulfill the mission, which presented a long-range battery arranged near the border and six medium-range systems arranged within the opposing country.

The reasons that motivated such choices bring relevant information: the pilots stated that the more variables in the problem they had to face while flying over the opponent's territory, the less likely they were to accomplish the mission; in addition, they understood as reckless the fact that the amount and range of radars and of missiles allowed the coverage of a considerable area of the territory, in particular, the points defended and much of the border strip, where the attacker would have to pass in two moments, that is, both when entering the hostile territory, when, if detected, would alert all defenses, eliminating the surprise factor; and, after the airstrike in the opposing country, when escaping, when it would have to avoid a battery whose position would not be known and which would certainly be alert. This also corroborates the relationship between the mobility of the systems and the perception of threat generated by them. The fact that they knew that there were radars and missile launchers capable of detecting and engaging them in the territory they would fly over added to the uncertainty about the position of such systems, clearly caused restlessness in the interviewees. The

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distribution in depth, which makes it challenging to locate ground-based air defense batteries by electronic or optical sensors of reconnaissance aircraft operating in the friendly territory near the border, has also proved to be a factor in increasing uncertainty and, therefore, threat perception.
Thus, all these factors evidence the high perception of threat associated with systems with different ranges and types of guidance, provided with strategic and tactical mobility, and that allow an integrated operation with air defense aircraft. Therefore, the combat pilot imagines that the existence of various types of land air defense missiles represent variables that make the problem of their survival more complex, because, in this way, in an attempt to defend themselves against a medium, the attacker ends up exposing himself the other, as in the case of the pilot who tries to make a low-height incursion to avoid being detected by radar. However, with that, it enters the range of portable missiles.

CONCLUSION AND FUTURE RESEARCH

The high management of countries at risk of conflict has taken action to deter the rulers of potential opponents from initiating aggressive action. The aerospace defense, of which the ground-based air defense is part, has been one of the instruments used. In the case of the USA and Russia, the defense in depth has been privileged.
The present research aimed to verify whether the vision of the strategy that generates the greatest threat perception and, consequently, has a more significant deterrent potential of senior management is aligned with that of military pilots who may be exposed to face the weapons deployed from according to such a strategy. The results indicate that yes.
In addition, analyzing the information obtained, some relevant characteristics of ground-based air defense systems were perceived in such a way that they became an excessively complex problem solution for the possible adversary, influencing his decision-making process to discourage him to action, since they reduce the likelihood that the opponent will "find a way" to reach the national centers of gravity. Among these features stand out:

a) have different ranges and types of guidance;
b) allow for the change of position quickly;
c) be able to act in an integrated manner with each other and with air defense aircraft;
d) are deployed in sufficient quantity to withstand and face concentrated attacks.

It is understood that the perception of threats reported here can influence the propensity of an aerospace defense strategy to deter potential opponents. Thus, the knowledge obtained through this work can contribute to countries that aim to improve their defense capacity.
For future research, we encourage an investigation to verify what are the impacts on the perception of threat of fighter pilots related to the integration between the various defensive systems (air defense aircrafts and ground-based air defense) acting synergistically in the same part of the airspace, increasing the complexity of the problem that will face the attacker.

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