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CONCEPTS FOR AIR SUPREMACY & ESSENTIAL CAPABILITIES FOR MODERN AIR SUPERIORITY ASSETS

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Abstract:

The latest studies about air warfare increasingly make emphasize on air-to-ground attack capability of air power and recently performed air-to ground operations. Also, there is a corresponding dwindling of interest toward the more traditional air combat roles. On the other hand, the misperception that the uses and requirements of air power will last on this air-to-ground axis forever may result in constituting an improper force composition. Air superiority is the absolute precondition for air power being freely utilized in air-to-ground missions.

This paper examines defensive and offensive air supremacy concepts, which are two different operational approaches to gain and maintain air superiority, with a critical perspective and suggests that offensive capabilities of the fighters dedicated for air superiority must be in the foreground.

The authors conclude that low observability, manoeuvrability, operational speed, combat persistence, tactical datalink, advanced weapon systems and self protection are the essential capabilities for modern air superiority assets and makes assessments about these critical talents.

Keywords: *Air superiority, air-to-air combat, fighter aircrafts, low observability, manoeuvrability, combat persistence, tactical datalink, self protection.*

1. INTRODUCTION

In the latest studies about air warfare, it can be easily observed that there's an increasing emphasis on air-to-ground attack capability of air power and surface attack operations conducted recently. On the contrary, interest toward the more traditional air combat roles is dwindling in inverse proportion. These cyclical requirements even caused some R&D programs such as *F-22 RAPTOR* and *EUROFIGHTER TYPHOON* to convert into multi-role planes featuring sturdy air-to-ground capabilities while they were originally designed and developed for air superiority roles. But, considering that the requirements and uses of air power will last on this axis forever may lead to an improper force structure.

As mentioned in core tasks and principles of NATO's new strategic concept, "the modern security environment contains a broad and evolving set of challenges to the security of NATO's territory and populations" [8]. Since the end of the Cold War, the complex global security environment has been a stage for a number of limited wars. In these operations, air power was applied virtually

only in forms of local support to ground forces such as Close Air Support and Counter Insurgency, in addition to Deep Interdiction missions with a certain strategic impact. Common aspect of all such operations is that enemy forces rather depend on only GBAD assets and there is almost no hostile force in the air. This condition has resulted in the disappearing of the perception that air superiority is the certain pre-condition for air power being independently applied to air-to-surface missions.

There is an evident conversion of force composition towards multi-role fighters from dedicated air superiority designs amongst some European members of NATO. Norway, Denmark and the Netherlands plan to recompose their force structure with *F-35A*, which is primarily designed for ground attack missions. This course of conduct is the result of the perception that future air operations would commonly be air-to-ground support missions executed by Coalition forces with no real risk of harmful air threat and the conception that defence of the national airspace is no longer a serious matter of concern.

However, threat perceptions outside the Western countries are noticeably different. In conjunction with air superiority, air defence is still a priority mission for the air forces. Japan desires to acquire the *F-22* from USA for air-to-air role, considers the *EF-2000* as an alternative, and also seeks to develop a stealth air superiority fighter named MITSUBISHI *ATD-X SHINSHIN* [3]. China maintains an air force mostly composed of fighter aircrafts optimized for air-to-air combats although having the desire of expanding their deep strike capabilities and multi-role properties. Pakistan and India are very nearly the same. Russia aims to modernize air defence fighters like *SU-27s* and designs *T-50 PAK-FA*, which is estimated as arguably the world's second most capable air superiority fighter after the *F-22*.

2. CONCEPTS FOR AIR SUPREMACY

The need of possessing at least capable when not dedicated air superiority fighters to control the airspace over selected areas is mentioned above. In addition, one of the key points for determining the essential capabilities of air superiority assets is having situational awareness about operational functions of air power and the missions executed by such planes.

2.1 Defensive Air Superiority (DAS) Approach and Mission Considerations (Combat Air Patrol and Intercept). The conventional and most common operational concept for air superiority fighters is to attain and maintain air control over the airspace of interest and to intercept the hostile aircrafts intruding the area. Objective of the mission is to counter enemy air activity over the battleground and/or hindering air attacks inside friendly area.

DAS involves a passive approach to air combat operations. It leaves the benefit of initiative to the enemy and accepts at least some degree of harm by enemy action. It is reactive. On the other hand, limited objectives of DAS missions and the fact that the interceptor fighters operate relatively close to their bases make these missions relatively simpler. However, to be capable of intercepting intruders immediately in forward zone, area defence missions require lots of aircraft deployed at many bases spread out over friendly territory. This requirement is absolutely contrary to the trend in the Western world to decrease the amount of both active airbases and combat aircraft for financial reasons. As a consequence, if such a reduction occurs, remaining air defence fighters need both longer range and higher speed to intercept hostile aircrafts at a safe distance from their targets.

A fighter theoretically tailored for DAS can be a relatively short-range, lightweight type thus having a better air-to-air combat performance. But, it should also have a fuselage large enough to carry adequate number of air-to-air weapons and enough internal fuel for a long combat endurance. Additionally, minimum number of aircraft required to ensure Combat Air Patrol (CAP)

flights for a specific time over designated areas should also be considered.

On the other hand, DAS concept is less practical and feasible due to the widespread availability of long-range stand-off air-to-ground weapons and cruise missiles. To avoid these threats, air defence fighters should engage intruders at long distances equal to or more than the range of enemy stand-off weapons, perhaps more than 250 km, away from their targets. The demands of the case make DAS nearly impossible, especially with a scarce number of fighters operating from a few bases.

2.2 Offensive Air Superiority (OAS) Approach and Mission Considerations (Sweep and Escort). OAS is an alternative and completely different operational approach to air combat. It consists of offensive operations inside enemy territory executed by not only strike aircrafts attacking ground targets but also own air superiority fighters aimed at searching, engaging and destroying enemy air defence fighters. Thus, it forces the enemy into the defensive in its own region. When the adversary air defences have been destroyed, the enemy airspace becomes available and relatively secure for air-to-ground assets.

OAS compels the adversary to concentrate most of its aircraft potential including both dedicated air defence fighters and multirole fighter bombers to defend strategic assets such as energy production plants and transport infrastructure as well as the military forces. By limiting substantial amount of the enemy resources to allocate for its own offensive operations, OAS is also a kind of active defence.

OAS missions such as sweep and escort essentially require fighters with long combat radius and a significant level of low observability. Additionally, OAS fighters should be capable of operating independently from support assets such as Airborne Early Warning&Control and Electronic Warfare platforms while also not depending on any ground control unit. Thus, they need advanced on-board sensors and defensive systems.

Fighters designed for OAS missions will also perform many of the required capabilities when assigned in DAS roles. For instance, significantly long endurance on station in CAP missions could be maintained by full fuel load while short range intercept missions would be performed with a reduced fuel percentage. OAS is a modern defence tool against any crisis requiring demonstration of force, and is characterized by speed, flexibility and effectiveness.

3. ESSENTIAL CAPABILITIES FOR MODERN AIR SUPERIORITY ASSETS

3.1 Low Observability (LO) or Performance. The only air superiority fighter with considerable built-in LO characteristics currently in service is *F-22 Raptor*. Differing from previous LO types (*F-117 and B-2*), the design of *F-22* carries superior LO features without compromising from high flight performance mandatory for its main air superiority role.

In comparison with the *F-22*, the Russian fighter *T-50 PAK-FA* seems to be a more moderate and less determined approach to LO requiring minimum compromise in flight performance. This approach is whether the result of a purposeful design selection or the indication of the Russian incapacity to develop a fighter as stealth as *F-22*. But it is the fact that the *T-50 PAK-FA* will have some weak points about LO performance [4].

On the other hand, the possible negative impact of a categorical LO design approach on other obligatory features for an air superiority

fighter is still an arguable question, as well as its costs. Debates about the cost of *F-22* include not only acquisition costs and high R&D investments in stealth materials, but also the maintenance of the fragile RAM coating with concerns about reliability and availability.

The features that characterize a LO fighter can be analysed as below:

* Overall shape designed with due regards to both LO and flight performance.

* Alignment of the airframe's shape along limited reference lines (i.e. leading and trailing edges of wing and horizontal stabilizers), with due regards to aerodynamics.

* Radar Absorbing Material applied scarcely where really valuable, as the interior surfaces of the air intakes. Increase on the total weight, cost of acquisition/application and burden of maintanence should be considered.

* Sensors and antennas integrated with the airframe.

* Two dimensional nozzles.

* Capacity of internal weapons carriage.

* Divertless intakes that provide fuel-efficient, supercruise performance while presenting low radar reflectivity.

* Thrust Vectoring Control may enable the reduction in dimensions or complete exlusion of vertical and horizontal stabilizers in the future. Therefore, it may strongly reduce radar observability, too.

Other extreme design choices to further lower the RCS entailing considerable performance penalties and production costs would better be avoided.

3.2 Speed and Manoeuvrability. In design of most recent air combat fighters, the capability to sustain maneuvers up to 9g and to achieve extreme angles of attack is aimed rather than highest speed [1]. These capabilities should be seen in relation to the contemporary short range AAMs with IIR seekers and capable of high off-boresight target engagements especially when associated with Helmet Mounted Display (HMD).

High manoeuvrability is instinctively related with Close-In Combat (CIC). But it has also an import role as a "last ditch" defence option in BVR (Beyond Visual Range) combat as well. To avoid medium-range AAMs possessing the required terminal energy for engaging maneuvering targets even at the end of their trajectory, fighters should have high maneuver performance.

On the other hand, it is stated in a study aimed at determining the design characteristics of *F-35* that high turn rate is an ability that supports survivability against former generation SAM systems and BVR missiles but has a little impact on survivability of the aircraft against latest generation threats. In addition, it is asserted that high performance short-range AAMs integrated with HMD system are more vital than high turn rate in result of CIC. Thus, the required turn rate value decided for *F-35* can be reduced due to cost-effectiveness regarding the capabilities of weapons like *AIM-9X* and *ASRAAM* [10].

To combine speed and maneuver advantage in attack, a quick turn away from the target, after launching a missile, can be performed at supersonic speed, and it rapidly increases the range which the returning adversary missile must cover. Speed also reduces the time passing on the way between airbases and CAP areas and thus increases the reproduction of sortie rate. In addition, to be able to catch and escort the strike package again after engaging and defeating enemy air defence fighters that may endanger the package, high speed is a necessity for air superiority fighters.

3.3 Combat Persistence. An important assessment criteria for a fighter is its combat persistence. It can be explained as the number of hostile aircraft which can potentially be engaged in one sortie. Thus, there are two parameters related with combat persistence. One of them is the number and diversity of weapons carried in a typical air combat configuration. The other is combat radius and combat endurance on internal fuel [6]. The fighters need to get rid of external fuel tanks as soon as arriving at the expected combat area since they impact maneuver, speed and LO negatively.

Combat radius seems to be an undervalued performance criteria, especially in European fighter models. European air staffs have accepted a DAS concept in which friendly fighters would only take off when the adversary is just beyond the border for attack

while OAS was never considered. Consequently, the latest three European fighters - the *EF2000*, the *RAFALE* and the *GRIPEN* - have all short combat radius despite being very well designed by other measures.

Using external fuel tanks may be a solution for range but they induce additional drag which consumes up to 20-25% of the additional fuel. This drag effects maximum speed, service ceiling, acceleration and manoeuvrability negatively. Additionally, the number of available stations that carry weapons decrease by loading external tanks to them.

These limitations make Conformal Fuel Tanks (CFT) far more attractive. Although a decrease in the maneuver performance has to be accepted, the drag index is nearly the same as for the "clean" aircraft. Thus, they impose a little penalty to total aircraft performance. LOCKHEED MARTIN introduced them for the latest *F-16s* and it seems an elegant solution [2]. Similar CFTs are ready to be used by *RAFALE* and it is claimed that CFTs for *EF-2000* and *GRIPEN* are also being designed.

3.4 Networking and Datalink. In air operations, various assets participating in a given mission need to share information about the tactical situation and the potential threats. The modern complicated systems used for this purpose are known as datalink and are really essential for both DAS and OAS missions.

Automatic datalink systems are installed onboard most of modern combat aircrafts and this ability can be accepted as a force enhancement feature. Assisting datalink's functionality, Multifunction Displays (MFDs) are used to present the pilots both the big picture of tactical scenario and what they need inside it.

The opportunity of sharing data about tactical scenario and targets yields some significant operational capabilities, particularly in air-to-air combat. For example, a mission commander can command and control the large-force package tactically by analyzing the big picture of the combat area and allocating the favorable assets for engagement with the specific targets, while flying in the backseat of a fighter. Considering its contribution at a higher level, processing and merging of sensor data receiving via datalink from various aircrafts in different geographical positions provides the ability of positive identification and engagement of targets out very long ranges.

Datalink is also used between the launching aircraft and BVR missiles, to update target position data during inertial guidance phase of the missile. Furthermore, missiles like *AIM-120* and *METEOR* are being designed to confirm to the launching aircraft achievement of target lock-on with their active radar seekers [5]. It means that two-way missile datalinks will be in use in the foreseeable future.

3.5 Weapon Systems. Whether a fighter really requires an internal gun system or not has been a matter of discussion for a long time. However, considering some factors, it is assessed that internal gun is a requirement for fighters. Any missile, including the most capable one with high off-boresight lock-on capability, would always have a minimum engagement range in which a pilot wouldn't be able to launch it. In addition, it is not possible to use an AAM as a warning shot though gun can be used like a warning sign. Also, an AAM can't be used against both air-to-air and air-to-ground targets while gun offers this elasticity. However, a few hostile aircraft have been killed by gun attacks in aerial combats since the Vietnam War. As an example, only 5% of the air-to-air kills accomplished during

Operation Desert Storm in Iraq were accomplished using the gun [7].

HMDs compatible with the most recent short range AAMs are considered as lethal as the missiles and may be more effective than them in Close-in Combat (CIC). Although some air combat specialists claim that "dogfight era" is over, the probability of coming across an enemy aircraft at short range can't be ruled out. Actually, such encounter risk and possibility will become higher between similar LO-featured aircrafts due to substantial amount of reduction in their sensors search and tracking capability.

The goal of developing multiple impulse rocket motors for BVR missiles is to extend the engagement range and, more importantly, to obtain high maneuver capability through its trajectory, even in the terminal run to target. This feature enables a fighter to effectively execute the long-range precision engagement which is theoretically called as a distinctive capability of air and space power. But while long range and terminal manoeuvrability problems of AAMs are being solved, positive identification of targets at so long distances before engagement remains a big issue for air superiority fighters.

3.6 Self Protection. The ongoing increase in both the effective range and the precise guidance of latest generation AAMs is a crucial threat that needs to be considered while analyzing BVR and WVR air-to-air combats.

Current countermeasures taken for preventing lock-on and diverting the approaching missile away from its target generally consist of on-board IR/radar warning and deception systems, Miniatur Air Launched Radar Decoy-Jammers (MALD-J) and Towed Radar Decoys (TRD). Also, a tail warning radar has been installed in the rear side of some Russian fighters like the *SU-32FN* and the *SU-34* to cover the rear hemisphere. It is assessed that such an application will be part of *T-50 PAK-FA* defensive system [4].

Besides, there are active self-defence systems such as ELBIT *C-MUSIC* and NOTHROP GRUMMAN *AN/AAQ-24(V) DIRCM*, installed on some large transports and air-liners, aiming at physically destroying the incoming missile's seeker rather than jamming it [9]. Although conceptually similar systems are not currently practical for fighters due to concerns about size, weight and aerodynamic drag, it remains as a vital requirement.

4. CONCLUSION

Air supremacy permits friendly air and ground forces freedom of maneuver and attack. Air superiority fighters are key elements of a nation's defense and deterrent capability. Hostile nations recognize that airpower composed with an OAS concept can strike their vital centers with impunity which enhances all other government instruments of power. This is the timeless paradox of deterrence and the best way to avoid war is to demonstrate to the adversaries that you have the capability and will to defeat them. Hence, OAS is a kind of active defence.

The air superiority fighters possessing essential capabilities such as low observability, manoeuvrability, speed, combat persistence, tactical datalink, advanced weapon systems and self protection ensure accessing, surviving and achieving the effects necessary to win in integrated, high-threat environments.

REFERENCES

1. Carter, B.R. *Time-Optimization of High Performance Combat Maneuvers*. Monterey: Publishing House. (2005).
2. Defense Update. Conformal Fuel Tanks for Advanced F-16 Block 50/52/60. *defenseupdate.com.* [online]. Available: http://defenseupdate.com/products/c/F-16-CFT.htm (January, 2012).
3. Fisher, R. J. Japanese Military Technology Advances. *strategycenter.net* [online]. Available: http://www.strategycenter.net/research/pubID.173/pub_detail.asp (December, 2011).
4. Kopp, C. Assessing the Sukhoi PAK-FA. *ausairpower.net.* [online]. Available: http://www.ausairpower.net/APA-2010-01.html#mozTocId256798 (January, 2012).

5. MBDA. Meteor. *mbda-systems.com.* [online]. Available: http://www.mbda-systems.com/mediagallery/files/Meteor_ds.pdf (January, 2012).
6. Meilinger, P. S. *Range and Persistence: The Keys to Global Strike*. Air & Space Power Journal. (Autumn, 2008).
7. Moore, C. *The Need for a Permanent Gun System On the F-35 JSF*. Alabama: Maxwell Air Force Base. (2007).
8. NATO. *Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organization.* Lisbon. (2010).
9. NORTHROP GRUMMAN. Making Missiles Toast For 50 Years *es.northropgrumman.com* [online]. Available: http://www.es.northropgrumman.com/solutions/nemesis/ (December, 2011).
10. RAND. *The Next Generation Attack Fighter*, Washington D.C: RAND Corporation. (1997).