JSF: The Need for a Two-Seat Variant
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Introduction

In the 1970's, the requirement to replace the F-4 Phantom aircraft was identified. The manufacturer's concept and design teams focused on selling the technologically advanced single-seat variant of the F/A-18. The decision makers argued, "modern technology was to absorb the increased workload that was the task of the second crewman."[1] After several flight tests and cost analysis studies, the Marine Corps identified the need for and purchased a dual seat F/A-18 Hornet.

The Marine Corps faces a very similar situation in the twenty-first century with the purchase of the fifth generation, technologically superior F-35 Joint Strike Fighter (JSF). The JSF's sophisticated technology includes stealth, fighter performance, integrated sensor fusion, net enabled operations and advanced sustainment.[2] The Marine Corps has decided to replace the F/A-18, AV-8B and the EA-6B platforms with one single aircraft, the F-35B Short Take Off and Vertical Landing (STOVL) variant. The purchase of one single airframe to replace the current USMC aircraft may be economical but it accepts a great deal of risk by relying on one single variant. A way to mitigate this risk is to purchase an additional JSF variant. The Marine Corps needs to supplement the STOVL variant with Lockheed Martin's proposed development for the Navy CV variant of a two-seat F-35 because it will enhance the JSF's

survivability and lethality while maximizing its supportability and affordability.

Background

The existing Marine Corps F/A-18, AV-8B and EA-6B fleets are nearing the end of their intended service life and will be replaced by the F-35B STOVL variant. The Joint Strike Fighter Program is the Department of Defense's largest and most expensive acquisitions program. The program budget is in excess of $500 billion.[3] The JSF program includes a multiservice and multinational partnership of three services and eight countries. The JSF is a low observable multi-role fighter designed to execute Air-to-Air and Air-to-Ground missions in high threat areas. Lockheed Martin Aeronautics Company is producing three configurations: the conventional takeoff and landing (CTOL) variant for the Air Force, the carrier variant (CV) for the Navy and the Short Take-Off/Vertical Landing (STOVL) variant for the Marine Corps. Lockheed Martin initially proposed the development of a two-seat variant of the JSF that could be available in 2015.[4] The Marine Corps did not express any interest on this proposed design and instead elected to modify the STOVL variant to meet their electronic attack requirements.

Survivability and Lethality

The Marine Corps' expeditionary nature demands that the Marine Air-Ground Task Force (MAGTF) adapt to its assigned

mission. The JSF will take the Aviation Combat Element's (ACE) capabilities to an unprecedented new level with its fifth generation technology. The survivability of the JSF includes limiting the probability of detection while utilizing on-board countermeasures to survive in combat. The lethality of the JSF includes the synergy of on-board and off-board sensors to identify and track targets to employ precision munitions. Former Air Force Chief of Staff, General John Jumper demanded the JSF to "compress the kill chain," and prosecute targets "within single digit minutes" of being detected.[5] Although the single seat JSF offers superior capabilities and lethality, the drawback that remains on the one seat design is the demand on one person to assimilate and decide on all the information available. The implementation of a dual-seat JSF will increase its rate of survivability and lethality.

The JSF will have integrated sensor fusion and net enabled operations. The integrated sensor fusion will merge the scanned array radar, the electronic-optical targeting system (EOTS) including the forward-looking infrared (FLIR), and the infrared search and track (IRST). Additional sensor integration will include an electronic warfare suite and a distributed aperture system (DAS) that will allow the pilot to point his head to the intended target, designate it and employ weapons.[6] The fusion of information intends to reduce the pilot workload while having

global situational awareness of the battlefield. This sensory overload will lead to a situation of high cognitive demand and task saturation. One study on a pilot's mental workload by Khatwa and Helmreich(1999) suggests, "research clearly indicates that task saturation and overload are significant factors in aircraft accidents."[7] A pilot could process the information displayed in a low threat environment but the results would arguably be different in a high threat environment. A two-seat variant can process this high volume of information more efficiently and effectively.

According to JSF Air Systems Requirements Manager, Rick Johnson, "flying a profile simulating the destruction of enemy air defense (DEAD) mission has shown the highest degree of task saturation so far."[8] Therefore, the two-seat JSF can manage and process the information that is the result of the aircraft's sensor integration particularly during a high threat forward air controller airborne (FAC(A)) scenario. Maj Kanapathy, a former TOPGUN instructor, stated, "Currently the two-seat F/A-18 incorporates advanced systems that cannot easily be optimized by a single aviator."[9] The two-crew members can multi-task concurrently as the amount of tasks that demand attention increase. The pilot can build situational awareness of the battle space by maneuvering the aircraft, maintaining a visual lookout and checking the weapons status while keeping a safe

distance from any formidable threat. Simultaneously, the weapons and sensors officer (WSO) can establish communications with the ground unit, use the integrated sensor suite to deconflict friendly and enemy positions, and positively identify and designate enemy targets. Essentially, there are two concurrent, multi-dimensional cycles of John Boyd's observe, orient, decide and act (OODA) cycle assimilating data at a faster and more efficient rate.[10] This will decrease the JSF's exposure to enemy threats in the target area by decreasing the time required to acquire and prosecute targets. The two-seat concept will enhance General Jumper's directive of the JSF while maintaining the program goal of maximizing its survivability and lethality.

Supportability and Affordability

The Joint Strike Fighter Program stresses the commonality of design and equipment across the three variants. The program goal is to maintain that commonality "at 70 to 90 percent in terms of production costs."[11] Keeping that percentage is vital to staying on schedule and within the budgetary allotment. A common design eases the supportability of the JSF by reducing the logistical footprint to operate and maintain. The bottom-line is reducing the amount of people and parts required equals needing less money. Modifying a CV variant to a two-seat cockpit would create greater similarities. Airframes, engines

and avionics will fall within the 70-90 percentage of commonality.

The STOVL variant has the greatest amount of uniqueness in its design to conduct vertical takeoffs and landings. Three distinct main components contribute to the uniqueness: the shaft-driven-lift fan system, located directly behind the cockpit; the roll ducts which keep the aircraft level when vertically landing or taking off, and a three bearing swivel main engine nozzle which turns the nozzle 90 degrees when transitioning from vertical to horizontal flight. Recent testing has identified the need to reduce the overall weight of the STOVL airframe to meet the lift capability of the Pratt & Whitney F119 engine. This modification will inherently create even more uniqueness by requiring its own STOVL airframe and continue to increase the cost of the F-35B. The Government Accountability Office (GAO) in their March 2007 report, "the JSF program acquisition costs have increased by 12 percent per aircraft".[12] The increase in cost is directly attributed to the Marine Corps F-35B STOVL variant. Congress is now raising questions about the supportability and affordability of the F-35B STOVL. The Congressional Research Service (CRS) Report for Congress released in October of 2007 states:

> While designing an aircraft that meets both the Air Force's and the Navy's needs is challenging, the Marine Corps' STOVL requirement may be what makes or breaks this joint

> program because it appears [to be] the most technologically challenging variant and is a leading cost driver. The costs and complications of pursuing the [F-35B] STOVL variant (including reducing weight growth) are leading some to suggest that the JSF program would be more feasible and more affordable if the F-35B were cancelled. In this case, the Marine Corps would buy the CV JSF instead of the STOVL variant. It is also feared that changes to STOVL variant that are required to achieve its desired weight could reduce the level of commonality between the three variants. This would be detrimental to the original goal of the JSF program.[13]

If Congress terminated any further development of the F-35B, it would create unfavorable financial circumstances that would be absorbed by the program partners. These reports identify the lack of affordability with all the STOVL specific requirements that are not common to the other two variants.

Counterargument

The Joint Strike Fighter is a joint, multinational acquisition program for the Air Force, Navy, Marine Corps and eight cooperative partners. The program focuses on four pillars: survivability, lethality, supportability and affordability. The single-seat, single-engine aircraft design incorporates the common requirements of the involved services and international partners. The production of three variants will meet mission specific requirements while still maintaining a high degree of design commonality. The objective of the commonalities is to reduce the overall cost in design and supportability.

The design goal of the sophisticated fifth generation technology is to reduce the pilot's workload. Reducing the pilots workload translates as relying on the technology to meet all the requirements previously done by the second crewmember. According to Col Sanborn, the JSF Deputy of Air System Requirements, "The JSF's technology will perform all the tasks that were normally done by a two seat aircraft and fuse raw data in a way that simplifies the decision making process for the pilot."[14] The shortcomings of Col Sanborn's comment is the over reliance on technology. Technology is not the limiting factor. The human using the technology is the limiting factor. The materials used do not limit an aircraft G-limit, it is limited by the pilot flying it. The same principle applies when processing information. This is where a two-seat variant makes sense.

Not all interested in the JSF are willing to overlook this benefit in lieu of its sophisticated technology. Israel has expressed the desire to purchase a two-seat JSF. Aviation Week & Space Technology interviewed a senior Israeli Air Force official stating:

> Nonetheless, he worries that the JSF will start showing its limitations within five years. Among the drawbacks will be its one-person crew. As a result, "we can't operate the F-35 by itself," the retired general says. "We really need two-seaters, with one person concentrating on flying and someone else focused on the strike mission. One man can't take advantage of all the options," particularly since JSF

capabilities will include jamming, information warfare and network attack.[15]

FAC(A) is one of the staples of Marine aviation. The Marine Corps ability to provide the MAGTF commander this capability exponentially increases the MAGTF's striking power. Marine Aviation Weapons and Tactics Squadron (MAWTS)-1, which provides standardized training in all aspects of the employment of Marine Aviation, performed a qualitative assessment (QA) of the single seat FAC(A) concept. The conclusion of the QA states, "MAWTS-1 believes two seat platforms may execute FAC(A) with greater lethality, but single seat and two seat platforms are both capable of executing this [FAC(A)] mission."[16]

Even though the commonality of design and production may have its cost effectiveness, it seems to sacrifice a great deal of product utility for the end user. The production of a two seat CV JSF could gain the interest of additional partners; therefore making the financial requirements less burdensome.

Conclusion

The F-35 Joint Strike Fighter will offer technological advancements that far surpass any measure of combat capability ever seen. The danger lies in the over reliance on technology to replace the warfighter. According to MCDP-1 Warfighting, "Technology can enhance the ways and means of war by improving humanity's ability to wage it, but technology cannot and should

not attempt to eliminate humanity from the process of waging war."[17] The design and employment of two-seat aircraft is combat proven as a more survivable and capable platform. The Marine Corps' employment of FAC(A) offers the MAGTF commander a tremendous advantage of projecting combat power. The single seat JSF has indisputable means of conducting the multi mission requirements of the platforms it is replacing; however, it would be imprudent to overlook the enhanced survivability and lethality of a two-seat option simply because of commonality of design and advances in technology. **2049 words**

Endnotes

[1]Major Joseph A. Papay, "Single-Seat Fighters:A Question of Survivability," Command and Staff College (CSC) 1989,p.2.

[2]David Jensen, "F-35 Integrated Sensor Suite: Lethal Combination," *Avionics* Vol 29, Iss.10, October 1, 2005 http://www.proquest.com/ (accessed, November 30, 2007).

[3](U//FOUO) Rick Johnson, "F-35 Lightning II Anatomy of a Fifth Generation Fighter" briefing presented at F-35 Joint Strike Fighter Program Office, Alexandria, VA, 14 December 2007.

[4]Christopher Bolkcom and Anthony Murch, "F-35 Lightning II Joint Strike Fighter (JSF) Program: Background, Status, and Issues." *CRS Report for Congress* RL30563. (Washington, DC: Congressional Research Service, Library of Congress, updated 25 October 2007)

[5]Jensen "F-35."

[6]Jensen "F-35."

[7] Ying K. Leung and Charles H. Morris. "Pilot Mental Workload: How Well Do Pilots Really Perform?" *Ergonomics*, 15 December 2006, URL:<http://dx.doi.org/10.1080/00140130600857987> accessed 3 December 2007.

[8]Johnson briefing, 14 December 2007.

[9]Ivan Kanapathy 2006. Crew Solo in the F/A-18D. *United States Naval Institute. Proceedings*, November 1, 66,68. http://www.proquest.com/ (accessed December 1, 2007).

[10]Robert Coram. *Boyd: The Fighter Pilot Who Changed the Art of War, (*New York: Little Brown and Company, 2002) 344.

[11]Colonel Russell A. Sanborn, USMC, Deputy of Air Systems Requirements, Joint Strike Fighter Program, Alexandria, VA, interview by author, 14 December 2007.

[12]Government Accountability Office (GAO), *Joint Strike Fighter: Progress Made and Challenges Remain,* Rpt 07-360. (Washington, DC: March 2007. Cited hereafter as GAO.

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[15]David A. Fulghum, Robert Wall and Douglas Barrie. “Israel Wants JSF as Soon as Possible,” *Aviation Week & Space Technology,* online ed., 16 December 2007, URL:<http://www.aviationweek.com> accessed 18 December 2007.

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