V/STOL in the United States Marine Corps: The Past, Present, and Future- Why We Need the STOVL Joint Strike Fighter

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EXECUTIVE SUMMARY

Title: V/STOL in the United States Marine Corps: The Past, Present, and Future- Why We Need the STOVL Joint Strike Fighter

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Thesis: There is a three-part argument why the Marine Corps should purchase the STOVL JSF. First, historical examples have demonstrated that the concept of STOVL employment is sound. Second, compared to the capabilities of the JSF, the current inventory of "legacy" aircraft will be incapable of meeting the operational requirements of the future. Lastly, the doctrine of today and vision of tomorrow requires that the Marine Corps field the STOVL JSF.

Discussion:
-Historical Examples: The Falkland Islands conflict, Desert Storm, and Operation Iraqi Freedom demonstrated the viability and utility of STOVL operations in combat. In all three cases, the flexibility and reliability of the STOVL Harrier were vital to their overall success. The flexibility to operate from sea and land bases gave the commander a significant combat multiplier.
-Capabilities: The Marine Corps needs to acquire the STOVL JSF in order to replace its aging TACAIR fleet with a more survivable, flexible, and capable aircraft so that it can meet the operational requirements of the future. The STOVL JSF will have a stealthy airframe, carry precision weapons over greater distances and have an avionics suite that will make it second to none. Additionally, it will put a premium on reliability and affordability, which will mitigate many of the problems seen in legacy aircraft.
-Current Doctrine and vision of tomorrow: The STOVL JSF is in consonance with our current and future doctrine in that it will support the transformation and modernization of Marine TACAIR. Additionally, the STOVL JSF will be a vital part of the future sea base as articulated in *Sea Power 21* and *Marine Strategy 21*. The STOVL JSF will also have a significant role in Sea Strike and Sea Shield, which will enable the U.S. to maintain access to the world's littorals and its interests abroad.

Conclusion:
-Historical examples have shown that STOVL aircraft are viable and an important force multiplier.

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- Our legacy inventory needs to be replaced because it is at the end of its service life, and will be incapable of operating in the 2010 and beyond environment. The STOVL JSF bridges the gap in capabilities that have traditionally existed between conventional and STOVL aircraft. The STOVL JSF will provide an affordable, lethal, survivable, and supportable replacement for the legacy inventory.
-The STOVL JSF will be a key enabler for the future sea base as articulated in current Naval doctrine.
-There are certainly obstacles to the STOVL JSF, but none that cannot be overcome if the Navy and Marine Corps remain committed to the vision of the future.

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Introduction

The Joint Strike Fighter (JSF) Program was created as a result of the Department of Defense (DoD) bottom-up review in 1994. The JSF program eventually grew to include the United States Air Force, Navy, and Marine Corps, eight nations, and, if funded, the estimated $219 Billion program will be the largest DoD acquisition program on record. The Marine Corps has a unique stake in this program with the development of the Short Take Off, Vertical Landing (STOVL) variant. The STOVL concept is not new to the Marine Corps, which has employed the Vertical/Short Take Off and Landing (V/STOL) AV-8B "Harrier" since the early 1970s.

This paper addresses why the Marine Corps should purchase the STOVL JSF. This involves a three-part argument. First, historical examples have demonstrated that the concept of STOVL employment is sound. Second, compared to the capabilities of the JSF, the current inventory of "legacy" aircraft will be incapable of meeting the operational requirements of the future. Lastly, the doctrine of today and vision of tomorrow requires that the Marine Corps field the STOVL JSF.

As early as 1958, American military planners recognized the need for a high performance STOVL Tactical Aircraft (TACAIR).[1] It was not until ten years later, however, after viewing a Hawker Siddeley promotional film, that the Marine Corps' Deputy Chief of Staff for Aviation, Major General K. B. McCutcheon, remarked: "That looks like the thing we've been looking for."[2] This was the first step in the Marine Corps quest to develop a viable, flexible, STOVL aircraft to support Marines on the ground. Over the years, as the program has progressed from the AV-8A to the AV-8B, there has

[1] Bruce Myles, *Jump Jet: The Revolutionary V/STOL Fighter* (San Rafael, CA: Presidio Press, 1978). 129.
[2] Ibid., 130.

been a significant increase in capability of STOVL aircraft. The early AV-8A, although attractive because of its quick response time and high sortie generation rate, was clearly limited by the technology available in the 1960s and 1970s. The Marine Corps had made a conscious decision to trade capability for flexibility. In essence, they sacrificed payload for flexible basing options.

The next generation of Harrier was similar in name alone. The AV-8B has greater range, can carry a greater payload, and in its current configuration has a state of the art avionics suite. It was designed specifically to support the Marine on the ground, day or night. The legacy of the Harrier is that it has proven the fundamental concept of STOVL employment to be sound. As technology progresses, the gap in capability between conventional and STOVL aircraft has continued to diminish to the point where it is no longer a significant factor. The next logical step in the evolution of the STOVL aircraft is the STOVL Joint Strike Fighter.

CHAPTER 1

STOVL: An Historical Perspective

The Falklands

One of the first demonstrations of the successful employment of a V/STOL aircraft was the 1982 Falklands/ Malvinas Islands conflict between Argentina and Great Britain. The conflict was precipitated by over 200 years of disputed claims by the two nations over the rightful ownership of the islands. On April 2nd 1982, Argentina invaded the Falkland Islands with the hopes of wrestling this pair of seemingly strategically insignificant islands from the fading imperial power, Great Britain. The political ineptness of the Argentinean Junta was only matched by the lack of preparation on the part of the British military. The Falklands are located approximately 8,000 miles from Great Britain, and with no friendly airbases in the vicinity at the time the only option available to the British was to launch Task Force 317 to eject the Argentineans from the islands. Operation Corporate was the largest mobilization of British forces since World War II, and at the time this was a monumental undertaking for the British fleet in light of their declining military capability. Beginning in the late 1970s, the British government had cut defense spending in order to aid their ailing economy, resulting in the loss of most of their global power projection. They had placed greater emphasis on meeting NATO commitments on the continent of Europe and had relegated much of their high seas fleet to an anti-submarine role. The Royal Navy lacked the larger conventional aircraft carriers seen in the United States Navy, and consequently had to rely on their smaller V/STOL carriers, the HMS *Hermes* and *Invincible*. They initially went to war with only 20

Harriers, but eventually were able to build their strength to 35.[3] These were a mixture of 28 Sea Harriers, used primarily in the air-to-air role, and eight Royal Air Force (RAF) AV-8 GR 3s, used for ground attack.

The British surface fleet did not have adequate point air defense capabilities at the time. For example, the Sea Dart Surface to Air Missile (SAM) system found on the Type 42 Destroyers lacked low altitude capability. Also, the Sea Wolf SAM system aboard the Type 22 Frigates did not possess adequate range, was susceptible to software glitches, and was largely unproven at the time. Due to these limitations, the Sea Harrier was the primary fleet defense asset, and they proved to be very effective against the Argentine aircraft. The AIM-9L-equipped Sea Harriers accounted for 31 enemy kills compared to 28 Argentinean aircraft that were downed by other weapon systems.[4] The Harrier was largely regarded as the savior of the British fleet. Admiral Sir Henry Leach, First Sea Lord at the time, commented: "Without Sea Harrier, there could have been no Task Force."[5]

Additionally, the RAF GR 3 Harriers proved their merit in the air-to-surface role. Prior to the British landing, the GR-3s were used in the traditional battlefield-shaping role in which they effectively neutralized Argentinean rotor-wing and short-range fixed-wing attack aircraft. They were also used for Close Air Support (CAS) after the British had landed at San Carlos. The RAF GR 3s supported 2 Para's attack on Goose Green and were instrumental in affecting surrender from an Argentinean force that outnumbered the British by more than two to one. "The Harrier's role in this had been crucial. Their devastating attacks against troops on open ground were a serious blow to

[3] Max Hastings and Simon Jenkins, *The Battle for the Falklands* (New York: W.W. Norton and Co. Inc., 1983), 316.
[4] Ibid., 316.
[5] Peter Davies and Anthony Thornborough, *The Harrier Story* (Annapolis, M.D. :Naval Institute Press, 1996), 90.

Argentinian (sic) firepower and morale."[6] Whether analyzing the Harrier's success in air-to-air, or air-to surface operations, one must conclude that it was able to accomplish its mission in the Falkland's campaign because of two key attributes: flexibility and reliability.

The flexibility inherent in the V/STOL capable Harrier allowed the British to explore several basing options, which would not have been available to a conventional carrier-based aircraft. Although the British conducted AV-8 operations primarily from their STOVL carriers, they also built a small Forward Operating Base (FOB) at Port San Carlos. Admiral Woodward, the British Battle Group Commander, was fearful of the Argentine Exocet anti-ship missile threat and consequently stationed his carriers far to the east of the islands. The 850-foot airstrip at the FOB enabled the AV-8s to extend their Combat Air Patrol (CAP) time on station by providing much needed fuel. The Harriers would land vertically, refuel, and perform a Short Takeoff (STO) to cover their next time on station. The FOB also served as a "divert field" when operational necessity required the Harriers to "burn down" below a suitable fuel state that would allow them to reach the carrier. The original plan for the FOB required that it be much larger. However, the majority of the aluminum matting to be used in the construction of the airstrip was at the bottom of the Atlantic due to the loss of the cargo ship, *Atlantic Conveyor*. Were it not for the flexibility of the Harrier and its ability to land on small runways, the FOB would have been untenable, and the British would have lost a valuable air base.

During the course of the conflict, the AV-8 squadrons received an additional 15 aircraft to augment their numbers and replace losses. The majority of the replacements

[6] Ibid., 106.

were brought into theater aboard the *Atlantic Conveyor* prior to its sinking. A small V/TOL pad[7] was built on the deck of the ship, and as the *Atlantic Conveyor* came within range of the British task force, the AV-8s took off vertically and flew to their respective carriers. This capability alone perhaps saved the British fleet because the small contingent of Harriers that the British initially deployed would have been insufficient to stem the tide of the Argentine air assault. It should be mentioned that other options for combat replacements were explored, yet proved to be impractical. While the British Harriers possessed the capability to fly the 3,000 miles and nine hours from Ascension Island to the South Atlantic, they lacked adequate tanker assets to do this with any regularity.[8] The ability to take off vertically from the deck of a cargo ship in order to augment the squadrons already in theater was vital to their success.

The other key factor to the success of the Harrier in the Falklands was its reliability, which allowed it to maintain a high sortie generation rate. From April to June 1982 the British Harriers flew 2,197 sorties and 2,514 flight hours while maintaining an availability rate of 96%.[9] The aircraft often flew three sorties per day and had an average cancellation rate of only 1% throughout the conflict.[10] A high sortie generation rate is desirable for any aircraft, particularly when one is depending on it to protect the fleet and the troops on the ground. The legacy of the Harrier in the Falklands was that it succeeded where no other aircraft could. As Peter Davies observed: “The slogan ‘Mission Impossible Without V/STOL’ appeared in post-war British Aerospace

[7] Vertical Takeoff or Landing (V/TOL) pads are traditionally used by the AV-8 for operations in confined areas that require both a vertical landing and vertical takeoff. In this case, the non-traditional employment of a V/TOL pad proved indispensable for the replacement of Sea Harrier combat losses.
[8] Peter Davies and Anthony Thornborough, *The Harrier Story* (Annapolis, M.D. :Naval Institute Press, 1996), 103.
[9] Ibid., 89.
[10] Ibid., 89.

Engineering commercials and it contained far more truth than the average advertisement. Apart from a small number of complex and hugely expensive raids by the small RAF Vulcan force, there was no other way in which British airpower could have been employed effectively.[11]

Desert Shield/ Desert Storm

The flexibility and reliability of the Harrier were characteristics appreciated by the U.S. Marine Corps in a far different conflict. Unlike the Falklands War, the Persian Gulf War from late 1990 to early 1991 was conducted on a much larger scale. The flexibility of the Harrier was important in this conflict for a much different reason. The British went to war in the Falklands with only 35 V/STOL aircraft because that was all that they could muster at the time. By comparison, the U.S. military conducted the Gulf War with close to 4,000 aircraft.[12] In 1982, the British realized that the only effective means of fixed-wing power projection was through the Harrier. The U.S. and coalition militaries of 1990, on the other hand, had a myriad of airframes to choose from. Their biggest limitation, however, was the lack of available ramp space and suitable air bases to fly them from.

The versatility of the STOVL Harrier allowed it to operate from the full spectrum of ship and shore bases. The USS *Nassau* was converted into a “Harrier Carrier” from which 20 aircraft of VMA-331 operated. The squadron was extremely effective in the closing days of the war because the *Tarawa* class LHA that they flew from permitted them to operate closer to the enemy than a conventional carrier would. They were not

[11] Ibid., 89.
[12] Ibid., 133.

reliant on tanker support, thereby reducing logistical requirements.[13] The Harriers were able to achieve a higher sortie generation rate than conventional carrier-based (CV) aircraft because they were not tied to the limitations of catapults and arresting gear. For example, towards the end of the ground war VMA-331 flew 56 sorties with 19 aircraft on one day alone.[14]

The 66 land-based Harriers operated from King Abdul Aziz Naval Base, located at Jubail, Saudi Arabia, about 100 miles from Kuwait. A smaller FOB was established even closer, 35 miles from the Kuwaiti border, at Tanajib. The FOB at King Abdul Aziz allowed the Harriers to reach the Kuwaiti border in 15 minutes and remain on station for roughly 28 minutes. The Tanajib FOB cut the transit time to the border to a mere five minutes and increased the time on station to 45 minutes if needed.[15] The benefit of the STOVL Harrier was that it was closer to the front lines than any other fixed-wing aircraft, and it did not rely on the overworked tankers to provide fuel for the transit to and from the fight. Additionally, 50% of all Harrier sorties originating from King Abdul Aziz were sent to Tanajib to rearm and refuel. This capability was a tremendous force multiplier because it allowed quicker turn-around times, which resulted in higher sortie generation rates and more ordnance on target. VMA-311, which was the first Harrier squadron to deploy to the Gulf, flew 1,017 sorties during the conflict, and dropped over 850 tons of ordnance on Iraqi units.[16] The land-based AV-8s were the most forward deployed tactical fixed-wing aircraft of the war.

[13] Ibid., 141.
[14] Ibid., 146.
[15] Ibid., 140.
[16] Ibid., 146.

Although the AV-8B was and still is a challenging aircraft to maintain, the squadrons reported readiness rates over 95% throughout the war. As seen in the Falklands, this phenomenal reliability coupled with the inherent flexibility of the STOVL aircraft were key to its success. The 86 aircraft deployed to the Gulf flew 3,380 sorties from 17 January to 28 February 1991.[17] General Norman Schwarzkopf recognized their contribution to the war when he named the Harrier as one of the seven weapon systems that had significantly contributed to the Coalitions quick success.[18]

Operation Iraqi Freedom

As the Harrier evolved from the AV-8B Day Attack aircraft, deployed during Desert Storm, to the AV-8B Harrier II Plus, so did the Marine Corps' concept for its employment. The following excerpt from the March 2004 joint testimony of the Assistant Secretary of the Navy, John Young, the Deputy Chief of Naval Operations, Vice Admiral John Nathman, and the Deputy Commandant for Aviation, Lieutenant General Michael Hough, before the House Armed Services Committee reflects this:

> The AV-8B we fly today is not the same aircraft that we flew 10 years ago. Over the last decade, the Harrier has gone from a daytime air-ground attack aircraft to a night/adverse weather precision strike platform….Today's AV-8B includes a night attack avionics suite (Navigation FLIR, digital moving map, color displays, night vision goggle lighting), APG-65 multi-mode radar, a more powerful and reliable Pegasus (408) engine, and the Litening targeting pod.[19]

[17] Ibid., 141.
[18] Ibid., 148.
[19] The Honorable J. Young Jr., Vice Admiral J. Nathman, Lieutenant General M. Hough, Statement before the House Armed Services Committee, March 25, 2004, <http://www.chinfo.navy.mil/navpalib/testimony/aviation/young040325.txt >(06 December 2004).

This transformation from daytime attack aircraft to a night precision bomber led to a paradigm shift in the AV-8 community. During Desert Storm, the Marine Corps employed the Harrier with a “Dump Truck” mentality since it was primarily limited to dropping non-precision guided munitions. Consequently, the Marine Corps capitalized on its high sortie generation rate and quick response time to deliver a substantial volume of ordnance on the enemy in a very short period of time. Without a targeting pod, the Harrier needed to drop a greater number of “dumb bombs” to be as effective as aircraft that possessed a precision capability.

In 2002, the Harrier received the Litening II targeting pod, which gave it the capability to be a precision bomber. The Night Attack Harrier and APG-65-equipped Harrier II Plus were ideally suited for operating at night. The capability to operate at night enabled the Harrier to fly around the clock and maintain pressure on the Iraqi forces. The Harrier’s precision targeting capability enabled it to achieve first pass destruction of enemy targets.

As seen in Desert Storm, the flexibility of the V/STOL Harrier allowed it to be employed from numerous platforms simultaneously. V/STOL overcame the same obstacles during Operation Iraqi Freedom (OIF) that had faced planners during Desert Storm: lack of suitable fields and a shortage of tanker assets. The “Harrier Carriers” of OIF followed the precedent established by the USS *Nassau* during Desert Storm. The USS *Bonhomme-Richard* and USS *Bataan* sailed with 24 Harriers aboard each vessel.[20] These ships, dedicated solely to V/STOL operations, enabled another 48 aircraft to operate in theater without imposing an additional burden on the already overcrowded bases in Kuwait, Saudi Arabia, and Bahrain. Furthermore, the all-V/STOL

[20] Operation Iraqi Freedom, 3d MAW After Action Brief, slide 15-16.

Harrier Carriers maximized sortie generation because they were not limited by rotary-wing launch and recovery operations normally seen on mixed decks.[21] There were also two detachments of Harriers from the 15th and 24th Marine Expeditionary Units (MEU) available for operations. The positioning of the LHDs and LHAs[22] was another component of the Harriers' success during OIF. The LHDs and LHAs were able to operate much further north than conventional carriers due to their hull design which allowed them to operate in shallower water. By operating from the Northern Arabian Gulf (NAG), Harriers were able to reach their targets much faster and did not have to refuel in the air like their big-deck counterparts did during the opening stages of the conflict. Of the 77 Harriers that took part in Operation Iraqi Freedom, all but 16 were ship-based.

The flexibility to base ashore and on ship not only reduced the logistical footprint ashore, but also reduced the reliance on tankers as the ground element pushed further into Iraq. The First Marine Expeditionary Force (I MEF) established two FOBs and 19 Forward Arming and Refueling Points (FARPs) during its fight to Baghdad.[23] Although primarily used by rotor-wing aircraft, the Harrier proved to be ideally suited for operating from these forward sites. In keeping with the Third Marine Aircraft Wing (III MAW) Commanding General's intent that "We will be flexible and adaptable as we move to gain positional advantages on the enemy",[24] AV-8s used the FARP located on Highway

[21] The term "mixed deck" refers to the combination of fixed-wing and rotary-wing aircraft that a Marine composite squadron will embark aboard an LHA or LHD. Under this condition, operational and safety limitations lead to inefficiencies that are not seen on a deck solely dedicated to fixed-wing operations.
[22] The LHA is defined as an Amphibious Assault Ship, General Purpose while the LHD is defined as an Amphibious Assault Ship, Multi Purpose. The major difference between the ships is that the Wasp Class LHD has a larger well deck and can hold an additional Landing Craft Air Cushion (LCAC)
[23] Operation Iraqi Freedom, 3d MAW After Action Brief, slide 83.
[24] Ibid., slide 13.

1, just 70 miles south of Baghdad, to refuel.[25] Additionally, AV-8s used the FOB at An Numaniyah, near Al Kut, when tankers were not available. During testimony before the House Armed Services Committee, military officials stated:

> AV-8B's demonstrated the expeditionary flexibility of Short Take-Off/Vertical Landing (STOVL) aircraft while becoming the most forward deployed tactical aircraft in theater.[26]

The past has proven that STOVL is not only a viable concept, but also a powerful force multiplier. As advances in technology narrow the gap in capability between Conventional Takeoff and Landing (CTOL) and STOVL aircraft, the case for an all STOVL force in the Marine Corps will strengthen. The next chapter will address current inventory shortfalls and discuss the dramatic increase in capability that the STOVL JSF will provide.

[25] Ibid., slide 81.
[26] The Honorable J. Young Jr., Vice Admiral J. Nathman, Lieutenant General M. Hough, Statement before the House Armed Services Committee, March 25, 2004, <http://www.chinfo.navy.mil/navpalib/testimony/aviation/young040325.txt> (06 December 2004).

CHAPTER 2

Where We Are Today, Where We Will Be Tomorrow

Legacy Inventory

As of December 2004, the Marine Corps plans to purchase 420 STOVL Joint Strike Fighters. The current inventory of AV-8s and F/A-18Cs and Ds will reach the end of their useful service lives in the near future. The Marine Corps has already received the last of its remanufactured AV-8Bs, and based on current attrition estimates the Harrier force will not be able to meet the planned transition schedule, let alone operate beyond 2020.[27] As a means to alleviate this, the AV-8 fleet will reduce its Primary Authorized Aircraft (PAA) from 16 to 14 aircraft per squadron starting in 2005. Headquarters Marine Corps Aviation Plans and Policy (APP) is also exploring the feasibility of transitioning ten AV-8B Day Attack aircraft to the Night Attack configuration due to the anticipated aircraft shortfall.

The Marine Corps' need to field the STOVL JSF is driven not just by the requirement to replace an aging fleet, but also by the need to replace it with a more survivable, flexible, and capable aircraft to meet the operational requirements of the future. Advancements in technology will allow the STOVL JSF to survive in 2010 and beyond threat environment. The STOVL characteristics of the aircraft will open flexible basing options to the Marine Air Ground Task Force (MAGTF) Commander, enabling him to effectively support his operations ashore.

[27] Major R. Sofge, Aviation Weapon Systems Requirements Branch (APW)-22, Head Quarters Marine Corps, Interview by author, 21 Dec. 2004.

The Future Environment

The Marine Corps has recognized that as threat technology advances, the current inventory of legacy aircraft will not be suited to operate and survive in this environment. The Joint System Threat Assessment Report (STAR) prepared for the JSF program in October 2001 defined the future threat environment facing the military. According to unclassified excerpts of the report, the most probable engagement systems that U.S. aircraft will face will be SAMs or other aircraft.[28]

> Digital signal processing in seekers of all types will become commonplace and improve tracking accuracy, clutter reduction, and electronic countermeasures. By 2020, optical signal processing will be applied to some developmental SAM's.…Warheads will continue to be developed and deployed which will improve the probability of kill over more conventional devices.[29]

A common trend is for countries to upgrade their fighter force by adding new weapon systems to existing platforms. This mixture of old technology with new technology results in "hybrid" aircraft equipped with advanced radars capable of supporting air-to-air missiles with active seekers.[30] These threats would significantly hinder the operations of legacy platforms. Additionally, in his Congressional Research Service (CRS) Report for Congress, Christopher Bolkcom offered the following:

> JSF proponents argue that it would be more cost-effective to acquire new generation aircraft than to upgrade current aircraft to such an extent that they could perform effectively after 2010, maintaining that existing planes would require major modifications at considerable cost and would provide

[28] David Turich, "(U) Joint Strike Fighter System Threat Assessment Report" *DOD-1574-0415-00*, October 2001, 3.a.(3) (U).<http://storefront1s.naic.wrightpatterson.af.smil.mil/Documents/STAR/SXX00020/HTML> (01 December 2004).
[29] Ibid.,3.b.(8)(b)(U).
[30] Ibid., 3.a.(3) (U).

> less combat effectiveness than a new JSF family of fighter/ attack aircraft.[31]

The lack of host nation support and suitable runways will also be a driving factor to procure the STOVL JSF for the Marine Corps. Worldwide, there are roughly four times as many runways available that are at least 3,000 feet in length compared to those that are 6,000 feet or greater. The threshold performance parameter for the CTOL JSF is for it to operate from an 8,000 foot runway much like the F-16. The objective performance parameter, however, is for it to conduct operations from a 6,000 foot runway.[32] This will undoubtedly inhibit its ability to operate from forward bases. In contrast, the STOVL JSF will be built with an emphasis on basing flexibility. The objective is for the STOVL JSF to conduct operations from a 500 foot austere site.[33] The future MAGTF will have to operate in this environment. It is absolutely vital that Aviation Combat Element (ACE) assets posses the capability to forward deploy to support the Ground Combat Element (GCE). As seen in Afghanistan, the first fixed-wing tactical aircraft to forward base was the STOVL Harrier at Kandahar Airport.[34]

[31] Christopher Bolkcom, *CRS Report for Congress Joint Strike Fighter Program, Background Status and Issues* (Washington D.C.: The Library of Congress. 2003) 19.
[32] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000).
[33] Ibid., 38.
[34] Lieutenant Colonel L. Schram, Joint Strike Fighter Program Office, *HASC Safety Brief: AV-8B Harrier*, slide 31.

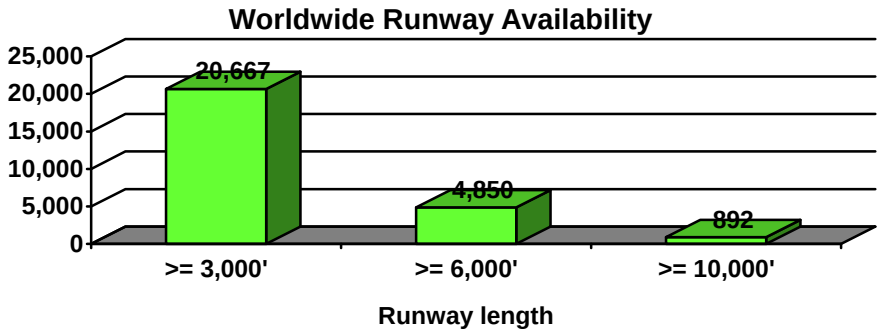

Figure 1 Source: Aviation Plans and Policy-31, Head Quarters Marine Corps

The Joint Strike Fighter Capabilities

The mandate for the Joint Strike Fighter program was "to affordably develop the next generation strike fighter weapons system to meet an advanced threat (2010 and beyond), while improving lethality, survivability, and supportability."[35] The Joint Strike Fighter has leveraged much of the technology incorporated into the airframe, avionics, and engine core of the F/A-22 Raptor. By using proven technology and improving on existing advanced technology, the JSF will meet the four demands of its mandate: affordability, lethality, survivability, and supportability.

Airframe

The low observable (LO) characteristics of the JSF airframe will allow it to survive in the 2010-plus threat environment. The key to this is that although threat radars may be able to detect the aircraft, they will not be able to precisely locate it or gain an accurate solution for weapons employment. Additionally, the low observable airframe may sufficiently delay detection from threat radars long enough to allow the JSF to

[35] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), 5.

either engage or bypass the threat. Figure 2 demonstrates the advantages of a low observable platform. The relative stealth of the JSF will effectively shrink the Missile Engagement Zones (MEZs) of threat systems allowing enhanced freedom of operation and survivability. Additionally, a low observable platform such as the JSF has a tremendous advantage in air-to-air combat. By incorporating an internal weapons bay, the JSF will maintain a smaller radar cross section than current aircraft which carry ordnance on external pylons. This will allow the JSF to detect and engage legacy threats before they can detect it.

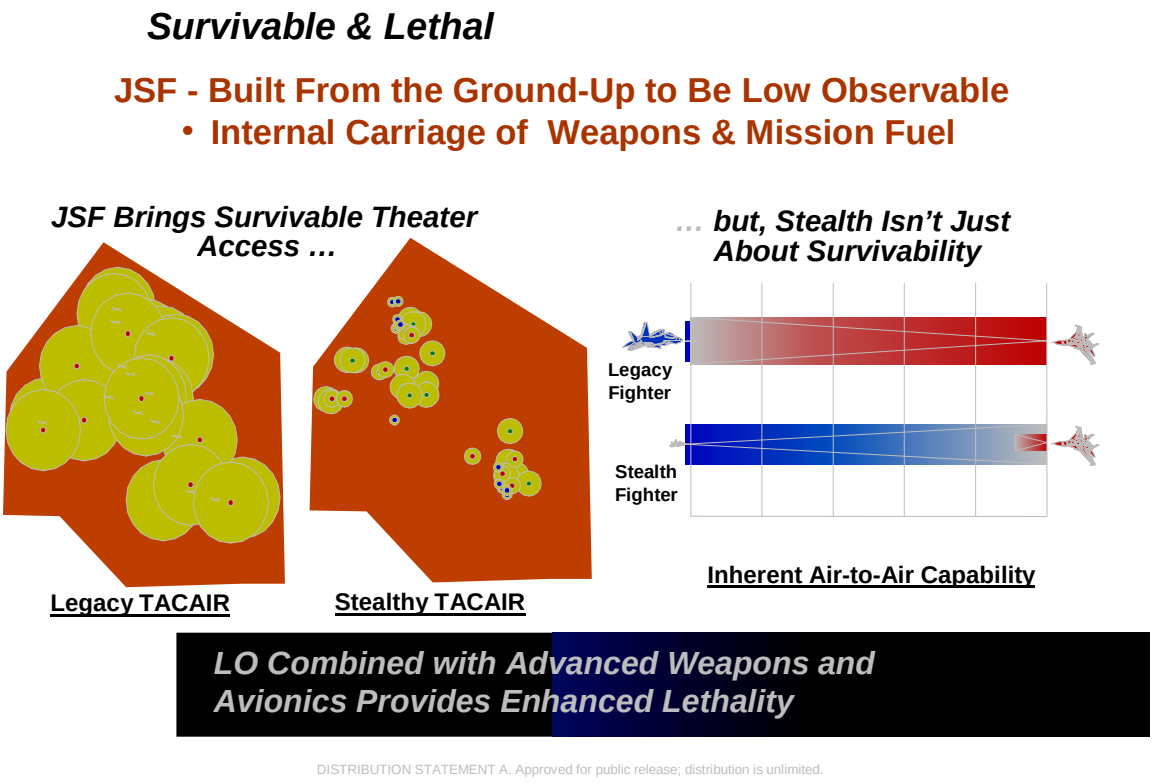

Figure 2 Source: Lockheed Martin

Payload

The Joint Strike Fighter will have the capability to carry a wide variety of air-to-air and air-to-ground munitions. The advertised payload of 18,000 lbs. carried on 11 stations is a substantial increase in capability compared to legacy aircraft.[36] The internal weapons bay has four stations and was designed to carry two AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM) and two other stores. The two remaining internal stations can carry an additional two AMRAAMs or air-to-surface weapons. The greatest difference in the air-to-surface capability between the STOVL variant and the Carrier (CV) and CTOL variants is that the STOVL JSF will be limited to 1,000 lb. class weapons per internal station while the other variants can carry twice that amount.[37] This will not limit the STOVL JSF's mission effectiveness because a 1,000 lb. precision-guided munition (PGM) is virtually as effective as a 2,000 lb. PGM. The STOVL JSF's higher sortie generation rate and quicker response time will also allow it to deliver more ordnance across the target area compared to the CV or CTOL variants, which will typically be located further away.

Combat Radius

The STOVL JSF's threshold performance parameter for combat radius is 450 nautical miles (nm). The objective performance parameter for combat radius is 550 nm. The requirement for the STOVL threshold performance parameter of 450 nm was derived from the need for it to attack targets within 400 nm of the coastline. Although the 450 nm combat radius is significantly less than the 600 nm threshold parameter for the

[36] Lockheed Martin Aeronautics Co. *JSF Program Overview: Public Forum Nov. 04*, Slide 28.
[37] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), *Annex A1- Weapons*, A1-1.

CV JSF, the underlying requirement is the same. The Marine Corps envisions the STOVL JSF operating from up to 50 nm from the coastline while the Navy plans to employ the CV variant from 150 to 200 nm off shore. The net result is that both aircraft will be able to engage targets within 400 nm of the coastline. The advantage of the STOVL JSF is that it is more responsive under these conditions because it is located closer to the target.

Avionics

Perhaps the greatest leap in technology compared to legacy aircraft is in the area of avionics. The avionics suite of the JSF was designed to overcome the shortcomings of legacy aircraft and enable it to operate effectively in the 2010-plus threat environment. According to the Operational Requirements Document: "Each variant must have sufficient onboard systems to search, detect, track, classify/ID, and engage the target set at tactically significant ranges in day, night, and adverse weather environments."[38] The overarching principle behind this capability is "Sensor Fusion."

Sensor Fusion is the seamless integration of on-board and off-board sensors designed to enhance situational awareness (SA), and increase lethality and survivability while reducing pilot workload. This will enhance mission effectiveness by allowing the pilot to focus on tactics rather than on sensor management. The lack of sensor fusion in legacy aircraft has forced today's pilot to prioritize sensor usage. Rather than maximizing the synergistic effect of all the sensors on board the aircraft, the pilot must pick and choose what is important, and when it is important. For example, the AV-8B Harrier II Plus, equipped with the APG-65 radar, has two Multi-Panel Color Displays

[38] Ibid., 12.

(MPCDs) from which the pilot must choose to display pertinent information. Typically, the pilot will have the moving map displayed on one MPCD and the radar displayed on the other. If the pilot needs to view other displays such as the Litening II targeting pod, RWR (Radar Warning Receiver), CAS (Close Air Support) page, or other information, he must switch back and forth between the different systems. The JSF will eliminate this inefficiency by fusing the displays into one overall picture.

The Tactical Situation Display in the JSF provides the pilot information on his wingman, friendly aircraft, threat aircraft, SAMs and targets all in one place.[39] The 8X20 inch contiguous display can be split into four separate displays to show as much or as little information as the pilot requires. The key point is that the Tactical Situation Display is designed to enhance SA, not overload the pilot with information. The battlefield situational awareness that the sensor fusion capability of the JSF will provide will revolutionize the way we employ TACAIR in the Marine Corps. Moreover, the JSF has been dubbed "the Internet Jet" due to its unprecedented data communication capability.[40] It will allow the pilot to share information with wingmen and other friendly units via data link. This will not only build situational awareness, but also enhance survivability and increase lethality on the battlefield of tomorrow.

The Integrated Sensor Suite currently under development by the Northrop Grumman Corporation features five major components: the AN/APG-81 Active Electronically Scanned Array (AESA) Radar, the AN/AAQ-37 Distributed Aperture System (DAS), the Electro-Optical Targeting System (EOTS), Electronic Warfare (EW),

[39] Russ Prechtl, Northrop Grumman Corp, Electronic Systems, *Flying the JSF*, 26 Jan. 2004, slide 5.
[40] *F-35 Sensor Systems*, prod. by Northrop Grumman Corp., 6 min., MPEG video on CD ROM.

and Communication Navigation and Identification (CNI).[41] Figure 3 illustrates these capabilities.

Figure 3 Source: Northrop Grumman

The AN/APG-81 is the heart of the JSF's avionics suite. It is an electronically scanned array radar that has several distinct advantages over legacy systems. Unlike current radars, it has the ability to simultaneously perform air-to-air and air-to-ground functions. The AESA radar has an Electronic Warfare capability, unlike current systems. It has a much faster scan rate than mechanically scanned systems, and since it has no moving parts, it is extremely reliable. Initial ground testing of the AESA was stopped after a simulated 27,000 hours of use, which is more than the projected life of the JSF. By comparison, the average Mean Time Between Failure (MTBF) for legacy radars is 200 to 300 hours.[42] The "dish" of the AESA is a Multi-Function Array (MFA) that is comprised of replaceable components called "Twin Pak Modules." This system will continue to function, albeit with lower capability, if one of the modules fails inflight.[43] One of the drawbacks is that squadron level maintenance personnel will not have the capability to replace a module should it fail. Northrop Grumman maintains that the

[41] Ibid.
[42] Craig Hoyle, "Waking Up to the Reality," *Jane's Defense Weekly*, 18 June 2003, 59.
[43] Russ Prechtl, Northrop Grumman Corp, Electronic Systems, *AN/APG-81 Multifunction Array Radar for the JSF*, 07 Jan. 2005, slide 19.

AESA displays “graceful degradation” in capability if a module fails. In other words, unlike current systems, the AESA will not fail catastrophically if a module fails. Furthermore, since the AESA is projected to exceed the service life of the airframe replacement of the MFA is not likely.[44] The AESA radar has been hailed as one of the great successes of the JSF program not only because of the tremendous jump in reliability, but also because of the substantial increase in resolution and capability compared to legacy systems.

The AESA Radar has the capability to produce ultra-high resolution Synthetic Aperture Radar (SAR) maps. The level of detail is unprecedented in a tactical sized aircraft and the “Big SAR” function of the system allows for detailed mapping of a larger area than can be currently seen. This increases a pilot’s SA because he can maintain a larger frame of reference and does not have to “look through the soda straw” like conventional systems. Additionally, the AN/APG-81 can electronically zoom in on the area of interest without having to re-map the area like current systems. This saves time, allows for faster target acquisition and again, frees up the pilot to concentrate on tactics rather than sensor management. Figure 4 illustrates the advantage of the Big SAR map over current systems.

[44] Russ Prechtl, Northrop Grumman Corp, Electronic Systems, <russ.prechtl@ngc.com> “RE: AESA,” 13 Jan 2005, personal e-mail to the author (13 Jan 2005).

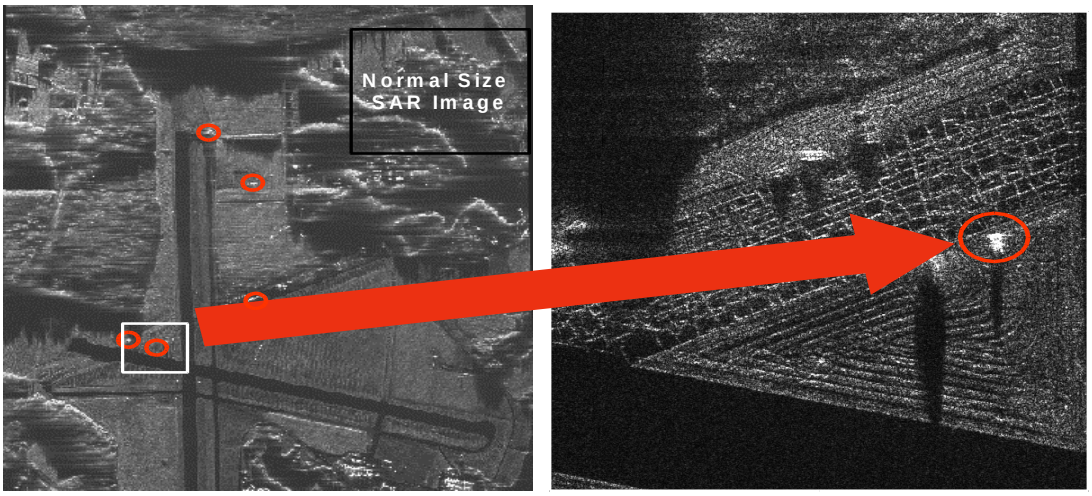

Figure 4 Source: Lockheed Martin

The AESA radar displays targets at tactically significant ranges due to the increased resolution of the system. It also has the ability to classify targets by comparing the contacts to a stored database. The Auto Target Detection and Cuing (ATD/C) algorithm will classify the contact and declare whether it is hostile or friendly. This will certainly reduce pilot workload because it is able to discern the difference between a truck and a tank, and decrease the chance of fratricide by differentiating hostile from friendly.

The AESA radar will be equally adept in the air-to-air arena. The AESA will be required to "search, track and engage six targets simultaneously."[45] It must be capable of prosecuting targets from data passed via off-board sources as well. In keeping with this requirement, the AESA was designed for Beyond Visual Range (BVR) targeting and multiple in-flight AMRAAM support.[46] It is much more effective than legacy systems in the traditional sense as an active radar because of increased detection ranges, more capable processing, and integration with off-board sensors. The AESA is also

[45] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), 13.
[46] BAE Systems, Lockheed Martin and Northrop Grumman, *F-35 Joint Strike Fighter Mission Systems, Multi-Mission Active Electronically Scanned Array (AESA) Radar brochure.*

revolutionary because it can passively search for targets by receiving the electromagnetic energy that they are transmitting. Combined with the low observable characteristics of the JSF, the ability to passively detect an enemy is another method that the JSF will employ to achieve first look, first kill ability.

The passive detection capability, called Electronic Support Measures (ESM), coupled with the Electronic Attack capability of the radar constitute the EW suite for the JSF.[47] Currently, the Marine Corps TACAIR community must rely on the EA-6B to provide escort and EW capabilities. The JSF will have the ability to detect both air and surface threats operating in the RF spectrum, and to a limited extent, have the capability to counter those threats. Although beyond the scope of this paper, the EW capability of the JSF could be explored and enhanced as a possible replacement for the aging EA-6B.

As envisioned, the targeting capability of the JSF's radar coupled with the Helmet Mounted Display System (HMDS), AMRAAM and AIM-9X will make it a lethal platform against enemy airborne threats. However, the advancement in air-to-air and air-to-surface capability of the AESA is only part of the avionics system that will make the JSF a true multi-mission platform that the Marine Corps is looking for. The DAS and EOTS are integrated with the radar to enhance the survivability and lethality of the JSF.[48]

The Distributed Aperture System provides the JSF with a 360-degree protective sphere around the aircraft. The system is comprised of six sensors imbedded in the skin of the aircraft that were initially designed to detect incoming surface-to-air and air-to-air missiles. As an added advantage, it provides all aspect situational awareness not only

[47] BAE Systems, Lockheed Martin and Northrop Grumman, *F-35 Joint Strike Fighter Mission Systems, Multi-Mission Active Electronically Scanned Array (AESA) Radar brochure.*
[48] Additionally, the DAS and EOTS are part of the overall sensor fusion architecture of the JSF.

through missile warning, but also through detection of threat aircraft, tracking of wingmen, and day or night Navigation Forward Looking Infrared (NAVFLIR) capability.[49] The integration of the HMDS could effectively replace Night Vision Goggles (NVGs) currently in use in Marine Corps aviation. The NAVFLIR capability of the DAS is complemented by the capabilities of the EOTS.

The EOTS has several advantages over legacy systems. It is integrated into the fuselage of the JSF and will not compromise the low observable qualities of the airframe. It does not take up a valuable weapons station like today's targeting pods. And since it is ideally situated under the nose of the aircraft, it will not suffer from the masking limitations of externally mounted pods. The EOTS will weigh approximately 200 lbs., or about half of what current pods weigh.[50] Additionally, the STOVL variant will not suffer from asymmetric induced VL performance degradation, as the EOTS is located along the centerline of the aircraft. The EOTS will be capable of long-range air-to-air and air-to-ground target recognition. This will be a significant improvement over current systems because the objective is for the JSF to identify targets and employ weapons at their maximum kinematic ranges.[51] Increased stand off range will potentially enhance survivability. The EOTS will be capable of performing the traditional tasks of targeting systems such as laser designation and ranging, laser spot track, and air-to-surface targeting. It will also enhance the survivability of the JSF by being able to perform tasks such as long range Infrared Search and Track (IRST) and by serving as

[49] Lockheed Martin Aeronautics Co. *JSF Capabilities Brief*, October 2003, Slide 44 notes.
[50] BAE Systems, Lockheed Martin and Northrop Grumman, *F-35 Joint Strike Fighter Mission Systems, Electro-Optical Targeting System (EOTS) brochure*.
[51] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), 14.

an air-to-air targeting FLIR. The final critical capability that ties the sensors of the JSF to external sources is the Communication Navigation and Identification (CNI) system.

The CNI avionics of the JSF features modular, software-programmable radios that simultaneously carry out numerous tasks such as secure voice and data links and beyond-visual-range identification.[52] CNI is the cornerstone of sensor fusion because it enables data transfer between wingmen and other external sources. This will build a more comprehensive picture for the pilot, which will ultimately increase SA, lethality, survivability, and overall mission effectiveness.

Engine

The JSF program calls for a common engine type to power all three variants. Pratt and Whitney and General Electric (GE) have been contracted to develop an interchangeable engine for the JSF. The F135 engine provided by Pratt and Whitney is a derivative of the F119 engine that powers the F/A-22 Raptor. It integrates the proven core of the F119, with a newly designed fan.[53] It leverages technology gained through the research and development of the F119 to reduce the cost and increase the performance of the F135. It is advertised to produce 43,000 lbs. of thrust at an estimated cost of $5 Million per engine.[54] Supportability and maintainability were key factors in the design of the F135 engine. It has 40% fewer parts which Pratt and Whitney believes will increase engine reliability. This in turn will result in a 50%

[52] BAE Systems, Lockheed Martin and Northrop Grumman, *F-35 Joint Strike Fighter Mission Systems Integrated Communications, Navigation and Identification (CNI) Avionics brochure*.
[53] Pratt and Whiney, F135, <http://www.pratt-whitney.com/prod_mil_f135.asp> (23 Dec 2004).
[54] Hugh Risseeuw, Director, Navy and Marine Corps Programs at Pratt and Whitney, Phone interview with author 23 Dec 2004.

reduction of the infrastructure support requirements for current engines.[55] Additionally, the F135 will feature advanced prognostic systems that provide maintenance awareness and automatic logistics support.[56] This is in keeping with the Operational Requirements Document's mandate that the "JSF designs must achieve high engine reliability and durability."[57] The ultimate goal is to achieve higher sortie generation rates and mission effectiveness.

General Electric was awarded a separate contract to develop the F136 engine for both political and practical reasons. Politically, it makes sense for the government to award General Electric the contract in order to keep them in the tactical engine business. The DoD also saw the need to bring in a second engine vendor to mitigate the risk associated with a single provider.

> With this program we have Pratt and Whitney and GE and it's an interchangeable engine. When you look at the number of partners we have and the services in the U.S., you can't take the chance that if something goes wrong with the engine you're going to ground a lot of aircraft throughout the world.[58]

The goal was to generate competition between the vendors that will increase quality and reduce cost. The practice of having two vendors provide a common engine is not new. Pratt and Whitney and GE currently provide engines for the F-16. The difference is that those engines are not interchangeable. The F-16 must undergo an airframe modification in order to accept the other engine. The requirement for the F135 and F136 is that they meet the same weight, thrust, and interoperability specifications.

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[55] Pratt and Whiney, F135, <http://www.pratt-whitney.com/prod_mil_f135.asp> (23 Dec 2004).
[56] Ibid.
[57] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), 23
[58] Lieutenant Colonel L. Schram, Joint Strike Fighter Program Office, Interview by author, 15 November 2004.

The challenges associated with this are not to be overlooked. The situation has forced two competitors to share information in the near term that will lead to competition in the future.

During the development of the Advanced Tactical Fighter (ATF), which eventually became the F/A-22, both Pratt and Whitney and General Electric were rival contractors. When Pratt and Whitney was awarded the contract for the F119 engine, GE effectively shelved their tactical engine development program.[59] The end result was that in the late 1990s Pratt and Whitney was the logical choice to provide the engine for the JSF due to the progress made with the F/A-22 program. Currently, GE is roughly 3-4 years behind Pratt and Whitney in production of an engine for the JSF.[60] It will cost the DoD approximately $3 Billion to bring GE up to speed with their development of the F136. This would negate any advantage gained through the reduction of per unit cost due to competition.[61] Some would argue that this money would be better spent testing the current Pratt and Whitney model. A sounder argument is that the government should accept the additional sunk cost and support an additional vendor to avoid engine related groundings as seen in the Harrier community.

The JSF engine program is currently in the System Development and Demonstration (SDD) phase of production. Engine testing accounts for $6 Billion of the $30 Billion allocated. Pratt and Whitney has produced five of the twelve ground test models and has successfully logged 1,800 hours of testing. By next year, Pratt and Whitney will have amassed four to five thousand hours of engine testing. An additional

[59] Hugh Risseeuw, Dir. Navy and Marine Corps Programs at Pratt and Whitney, Phone interview by author 23 Dec 2004.
[60] Risseeuw, 23 Dec 2004.
[61] Ibid.

22 engines will be produced for flight tests. The ground test program uses Accelerated Mission Testing (AMT) to simulate mission profiles, specifically the changes in engine operating temperature that degrades engine life.[62] The intense testing points to the lessons learned from the F-16 and AV-8 programs.

One of the major criticisms of the JSF is that it is a single-engine aircraft. Critics point to the historical high mishap rate of the AV-8B and F-16 as justification for not purchasing another single-engine aircraft. The Rolls Royce F402-408 engine installed in the AV-8B was the cause of several mishaps and fleet wide Naval Air Systems Command (NAVAIR) groundings (Red Stripes) in 2000. The root cause of this was not conceptual; it was programmatic. In hindsight, the engine was not fully tested prior to Initial Operational Capability (IOC). While testing the engine in the fleet, the Harrier community uncovered engine design and production flaws at the expense of several aircraft. Most notable was the problem encountered with the engine's number three bearing, which resulted in the Red Stripe of 2000. This is a risk that the DoD can ill afford to take in the future.

The JSF program intends to mitigate the risk associated with a single-engine aircraft by stressing proper testing and demanding a high level of engine reliability. Furthermore, the JSF prognostics must correctly predict impending in-flight critical failures in order to allow for safe recovery of the aircraft.[63] According to Lieutenant Colonel Lee Schram of the JSF Program Office, two of the major advantages of the JSF over the Harrier are that it will have a properly tested, very reliable engine, and the JSF

[62] Ibid.
[63] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), 26.

will incorporate engine prognostics, which can properly identify failures before they happen vice merely having indications of a failure at the time of its occurrence.[64]

Weight

The growth in weight of the JSF has been a major concern for the armed services, particularly the Marine Corps. In 2002, representatives from Lockheed Martin and the JSF Program Office formed a Blue Ribbon Action Team in response to an alarming growth in aircraft weight. The team conducted several Bottom Up Weight (BUW) reviews and discovered that all three variants were overweight. The CTOL and CV variants were roughly 2,400 lbs. overweight while the STOVL variant was 3,393 lbs. overweight.[65] Lockheed Martin formed a STOVL Weight Attack Team (SWAT) to mitigate the additional weight and has made considerable progress in reducing the weight of the aircraft. In an article in the *Los Angeles Times*, Rear Admiral Steven Enewold, the JSF program manager, was quoted as saying: "Designers reduced the weight about 2,700 pounds and increased thrust enough to compensate for the remaining 600 pounds of excess weight."[66] The heart of the matter concerning the weight growth with the STOVL JSF is the Vertical Landing Bring Back (VL_{BB}). The STOVL JSF must be capable of executing a VL with two internal 1,000 lb. JDAMs[67] and two internal AIM-120s, full expendables, and sufficient fuel to fly the STOVL recovery profile.[68] Furthermore, STOVL performance is one of the Key Performance Parameters (KPP) for the STOVL JSF. Although the STOVL JSF is about 600 lbs. overweight, the

[64] Lieutenant Colonel L. Schram, Joint Strike Fighter Program Office, Interview by author, 15 November 2004.
[65] Major L. Brown, *Information Paper: JSF Weight History,* (APW-21, 03 Feb. 2004)
[66] Bloomberg News, "Lockheed Aircraft Gets the Go-Ahead," *The Los Angeles Times*, 05 November 2004, C3.
[67] JDAM or Joint Direct Attack Munition is a family of GPS-guided, precision bombs that will be employed by the JSF.
[68] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), 37.

JSF Program office contends that it is still on track and is meeting the Key Performance Parameter for vertical bring back.[69]

Based on the analysis thus far, the STOVL JSF will be exponentially more capable than legacy aircraft. The flexibility and lethality that the STOVL JSF brings to the table will open many more options for the MAGTF Commander. The next chapter will discuss the key doctrinal concepts that will make the STOVL JSF the logical choice for the Marine Corps of tomorrow.

[69] Lieutenant Colonel L. Schram, Joint Strike Fighter Program Office, Interview by author, 15 November 2004.

CHAPTER 3

A Vision of the Future STOVL Force

Joint Vision 2020

Former Chairman of the Joint Chiefs of Staff, General Henry Shelton, promulgated his vision of the future joint force through *Joint Vision 2020*. This vision looks to the future with an emphasis on preparing joint forces to fight the nation's battles 15 to 20 years down the road. This vision describes "the operational concepts and capabilities anticipated of future joint forces. It provides a conceptual template for conducting future military operations and establishes a common azimuth for the Services, combatant commands, Defense agencies, and Joint Staff as they develop plans and programs to evolve the joint force to meet future warfighting requirements."[70]

Joint Vision 2020 is based on several key observations of the future strategic environment. First, the U.S. will continue to have global economic, security, and political interests which will require it to interact with a variety of regional actors. The U.S. will become increasingly interdependent with other nations. Second, the U.S. may not enjoy technological superiority over its adversaries as they continue to develop competing technologies. The U.S. military must develop new doctrine and invest in its personnel in order to capitalize on new technology. Third, the adversaries that the U.S. will face in the future will adapt to its military superiority and potentially focus on asymmetric means to attack U.S. sources power. Lastly, the joint force will be the foundation for future military operations.[71]

[70] Chairman of the Joint Chiefs of Staff, *CJCSI 3100.01A: The Joint Strategic Planning System* 1 Sept 1999, A-2
[71] General H. Shelton, Chairman Joint Chiefs of Staff, *Joint Vision 2020* (Washington: U.S. GPO, 2000), 3-5, 36.

Joint Vision 2020 sets the foundation for the transformation of the military to a force capable of operating in the full spectrum of conflict ranging from War to Military Operations Other Than War (MOOTW). The overarching focus of this vision is full spectrum dominance, which is achieved through the interdependent application of:

- Dominant Maneuver- through speed and tempo.
- Precision Engagement- correct target, desired effects, minimize collateral damage.
- Focused Logistics- correct equipment/supplies at correct location at correct time.
- Full Dimensional Protection- force protection in air, land, sea, and space.[72]

Joint Vision 2020 emphasizes that; in order to attain full spectrum dominance the military requires the steady infusion of new technology, modernization, and replacement of equipment. [73] The Joint strike fighter will serve to transform the military forces of the future. The STOVL JSF will ensure Dominant Maneuver by massing fires through flexibility and increased sortie generation rates. It will enhance Precision Engagement through sensor fusion, using on-board and off-board sensors to correctly detect, identify, and engage air and ground targets with the desired level of destruction. The STOVL JSF will facilitate Focused Logistics through “Autonomic Logistics”, or the “knowledge-based system that identifies and communicates appropriate JSF maintenance, supply, engineering, safety, and training information to support and

[72] Ibid., 3,20,22,24,26.
[73] Ibid., 3.

enhance mission execution."[74] Finally, the JSF will offer Full Dimensional Protection of forces through a combination of the above attributes.

The U.S. Naval Service will continue to be at the forefront of its military power projection. As Joint Vision 2020 states: "The strategic concepts of decisive force, power projection, overseas presence, and strategic agility will continue to govern our efforts to fulfill those responsibilities and meet the challenges of the future."[75] The Navy's interpretation of this vision is through *Naval Power 21… A Naval Vision*.

Naval Power 21…A Naval Vision

Joint Vision 2020 is complemented by *Naval Power 21… A Naval Vision*, which is also the Navy's articulation of U.S. National Military Strategy. This vision defines the new direction of the Navy and Marine Corps as they continue to control the sea and project power and influence beyond the sea in support of national policies.[76] Furthermore, the Navy will use the sovereignty of the sea and enhanced networked sea basing to operate without restriction.[77] This concept will have a profound impact on how the Navy and Marine Corps team will transform its forces to fight future conflicts.

Naval Power 21 is founded on three fundamental pillars. First, the Navy and Marine Corps exist to assure sea-based access worldwide in support of operations ranging the full spectrum of conflict. Secondly, the Navy and Marine Corps will fight to win by projecting both offensive and defensive capabilities. Lastly, the Navy and Marine

[74] Joint Strike Fighter Program Office, *Joint Strike Fighter Operational Requirements Document*. (Arlington, VA.: GPO, 2000), 22.
[75] General H. Shelton, Chairman Joint Chiefs of Staff, *Joint Vision 2020* (Washington: U.S. GPO, 2000), 1.
[76] The Honorable G. England, Secretary of the Navy, *Naval Power 21…A Naval Vision*, October 2002, <http://www.chinfo.navy.mil/navpalib/people/secnav/england/navpow21.pdf> (15 October 2004), 1.
[77] Ibid., 1.

Corps will continue to transform their forces through the introduction of new concepts, doctrine, technology, and training.[78] The STOVL JSF is in keeping with these principles and concepts in that it is a platform ideally suited for sea-based power projection. It has the ability to operate within the littorals and the flexibility to operate from bases ashore if needed. Additionally, the STOVL JSF will allow the Marine Corps to transform its force and win its future battles by providing the Corps with a stealthy, multi-role, precision strike platform with unprecedented lethality and survivability.

Derived from *Naval Power 21*, the Navy and Marine Corps have each created complementary strategies that emphasize the unique capabilities of each service in support of a future joint force. *Sea Power 21* provides the framework for future maritime dominance by the United States Navy, while *Marine Corps Strategy 21* is the foundation for the Marine Corps' 21st century capstone concept, Expeditionary Maneuver Warfare (EMW).[79]

Sea Power 21

In an ever-changing world, the Navy of tomorrow will focus on maritime dominance and forward presence in order to deter in peacetime, rapidly react to crises, and decisively win during war. *Sea Power 21* establishes the key operational concepts that will enable the Navy to achieve maritime dominance in the future. The four main concepts are:

[78] Ibid., 1.
[79] LtCol D. A. Robinson, *Joint Strike Fighter Force Structure for Naval Aviation: A Roadmap for TACAIR Integration* (Quantico: Marine Corps University Command and Staff College. 2003), 2.

-Sea Strike- expanded power projection that employs networked sensors, combat systems, and warfighters to amplify the offensive impact of sea-based forces.

-Sea Shield- global defensive assurance produced by extended homeland defense, sustained access to littorals, and the projection of defensive power deep overland.

-Sea Basing- enhanced operational independence and support for joint forces provided by networked, mobile, and secure sovereign platforms operating in the maritime domain.

-Force Net- the framework for naval warfare in the information age. Integrates warfighters, sensors, command and control platforms, and weapons into a networked, distributed combat force.[80]

Sea Strike is in keeping with the concept of "Precision Engagement" discussed in *Joint Vision 2020*. Sea Strike goes much further than putting bombs on target, however; it encompasses the broad range of capabilities and processes leading up to it. Some of these include intelligence, surveillance, and reconnaissance; time-sensitive strike; ship-to-objective maneuver; information operations; and covert strike.[81] The unique capabilities of the JSF will certainly enhance the Navy's ability to accomplish these tasks.

As the concept of Sea Strike is much broader than simply putting bombs on target, so too is the concept of Sea Shield. Sea Shield envisions national protection from a global perspective. Establishing dominance in forward deployed areas is central

[80] Admiral V. Clark, "Sea Power 21," *Proceedings, Oct 2002,* <http://www.chinfo.navy.mil/navpalib/cno/proceedings.html> (12 Dec 2004), 8,13.
[81] Ibid., 3.

to this concept. Sea Shield will allow for the nation's defense in depth, and the JSF will play a pivotal role in establishing forward maritime dominance.

The foundation from which forward naval power projection will emerge is rooted in the concept of Sea Basing. As stated in *Sea Power 21*:

> As enemy access to weapons of mass destruction grows, and the availability of overseas bases declines, it is compelling both militarily and politically to reduce the vulnerability of U.S. forces through expanded use of secure, mobile, networked sea bases.[82]

Sea Basing will not only have a tremendous impact on the Navy, but also on how the Marine Corps will employ its forces in the future. Sea Basing, as the Navy envisions it, is still in its infancy. There currently is no large-scale over the horizon ship-to-objective maneuver capability in the Navy. The fact is that the Navy still needs a friendly port to off-load its cargo. Future capabilities of Sea Basing are envisioned to include a Maritime Pre-positioned Force (MPF) with at-sea-accessible cargo, heavy equipment transfer capabilities, intra-theater high-speed sealift and improved vertical delivery methods.[83] The MPF replacement, the MPF(F), although not the answer to all of these hurdles, will certainly be a step in the right direction. The Sea Basing platforms of the future will undoubtedly have an impact of how the STOVL JSF will support the Marines ashore therefore; brief discussion of the future L-Class ship is warranted.

Future Sea-Based Options

The two primary sea base options for STOVL aircraft are the Wasp-class LHD and its older counterpart, the Tarawa-class LHA. Currently, these ships embark a six-

[82] Ibid., 7.
[83] Ibid.,7-8.

plane detachment of Harriers to support the MEU aboard. Certainly, one of the advantages of this arrangement is that it provides the MAGTF commander with responsive, lethal fires. Additionally, since the MAGTF's Ground Combat Element trades much of its firepower for mobility, it relies heavily on its fixed-wing and rotor-wing attack aircraft to provide a large portion of its fire support. The Marine Corps will most likely maintain this relationship in the future, and one of the greatest challenges facing the STOVL JSF is what type of ship to base it from in the future. The Tarawa-class LHAs, which have been in service since the 1970s were originally designed for a 20-year service life. This was subsequently extended to 35 years, which is due to expire starting in 2011, roughly one year prior to the introduction of the STOVL JSF. The Navy and the Marine Corps have recognized the need to replace the five aging Tarawa-class LHAs, but the options available are the source of much debate within the Department of the Navy.

In September 2002, the Center for Naval Analysis (CNA) released *The LHA(R) Analysis of Alternatives Summary Report* [84] that studied the alternatives for the replacement of the LHA. The report addressed the four main requirements that were given to them from the Marine Requirements Oversight Council (MROC). These were: that the LHA(R) provide 30,000 square feet for vehicle storage, and be capable of concurrent flight operations between rotor-wing and fixed-wing aircraft. The LHA(R) must accommodate the future ACE to include up to ten JSF and finally, the LHA(R) must have the command and control capability to support a MEB-level operation.[85]

[84] D. Perin et al., *The Center for Naval Analysis, The LHA(R) Analysis of Alternatives Summary Report*, (Alexandria, Virginia: 2002).
[85] Ibid.,1.

As of March 2005, the final design of the LHA(R) has not yet been selected. Some of the options include: the LHD Repeat+, the LHD Plug, and the Dual Tram Line (DTL). The LHD Repeat+ is essentially a copy of the current LHD design with modifications made primarily to the island. The LHD Plug will add an additional 77 feet in length and ten feet in width to the current LHD hull. The most revolutionary design of the three is the Dual Tram Line, which will be 113 feet longer and 33 feet wider than current LHDs. The benefits of the Dual Tram Line compared to the other platforms goes beyond the mere dimensions of the flight deck. The port side of the ship will be dedicated to rotary-wing operations, while the starboard side will be dedicated solely to fixed-wing STOVL operations. This configuration will allow for concurrent flight operations between fixed-wing and rotary-wing aircraft. Current and future LHD designs are incapable of concurrent operations and as a result, suffer from inefficiencies associated with flight deck deconfliction.

Of the options presented in the 2002 CNA report, the only one that clearly met all of the MROC's requirements was the Dual Tram Line design. Of note, the Dual Tram Line design was the only option that allowed concurrent flight operations, and it was the only one that had room for the ACE with the four additional JSF. Whether the Department of the Navy will ever fund the Dual Tram Line is uncertain, and there are several reasons why they most likely will not. The price of the Dual Tram Line is significantly higher than the other options. According to the report, the DTL design will cost $12.5 Billion for four ships vice $8.5 Billion for the LHD-Repeat+ design.[86] At first, this may seem significant, but over the life of the ships, the capability that the DTL brings may more than offset the cost. The CNA report noted that when tested against a

[86] Ibid.,2.

notional large scale MAGTF exercise, the other two designs created shortfalls in aviation coverage that would have to be filled by sorties provided by two large deck carriers (CVs). The DTL design with the additional four JSF could provide 24-hour coverage without the need for the additional carrier sorties.[87] The ramifications of not funding the DTL design to the STOVL JSF will be discussed later in this chapter.

Marine Corps Strategy 21

Marine Corps Strategy 21 "provides the vision, goals, and aims to support the development of future combat capabilities."[88] In keeping with *Naval Power 21*, its vision recognizes that in order to meet the opportunities and challenges of the world's littoral regions, the U.S. will become increasingly reliant on the "continuous forward presence and sustainable maritime power projection of Naval expeditionary forces."[89] The Marine Corps will capitalize on its expeditionary culture to provide the nation with a scalable, task organized MAGTF. Tied to its maritime heritage, the MAGTF will be centered on the Navy's Expeditionary Strike Group (ESG) for the flexibility and sustainability to operate in the full spectrum of conflict. Additionally, in order to meet future challenges, the goal of the Marine Corps must be "to capitalize on innovation, experimentation, and technology and contribute to the development and enhancement of joint capabilities."[90]

Some of these goals that relate to the JSF are:

-Provide combatant commanders with scalable, sustainable, interoperable, expeditionary, combined-arms MAGTFs.

[87] Ibid.,4.
[88] General J. Jones, *Marines Corps Strategy 21*, (Washington, 2000), intro.
[89] Ibid.,1.
[90] Ibid., 5,8.

-Increase integration and interoperability with allied and coalition amphibious, land, and air forces.

-Expand capabilities to observe, visualize and shape the operational area and to attack enemy critical vulnerabilities.

-Enhance responsiveness, integrated, and balanced expeditionary fires leveraging improvements to organic surveillance, target acquisition, aviation and indirect fires.

-Incorporate 21st century operational-level amphibious, maritime prepositioning, aviation and land mobility, maneuver, and sustainment capabilities into the operating force.

-Provide expeditionary-based assets and forces capable of reinforcing and sustaining Naval expeditionary forces in all phases of their operations.[91]

The Marine Corps capstone concept that ties *Marine Corps Strategy 21* to the joint operational level is *Expeditionary Maneuver Warfare* (EMW). EMW states that the Marine Corps is ideally suited to succeed in the future environment due to its "philosophy of maneuver warfare and heritage of expeditionary operations."[92] It calls for a shift in the way the Marine Corps approaches maneuver warfare in that it recognizes "the gradual shift in reliance from the quantitative characteristics of warfare- mass and volume- to a realization that qualitative factors (speed, stealth, precision, and sustainability) have become increasingly important facets of modern warfare."[93] The STOVL JSF will provide this because it is designed with speed, stealth, precision, and sustainability in mind. These attributes, coupled with a the high sortie generation rate and quick response time that the STOVL JSF will provide will enable the MAGTF commander to mass fires with lethality and tempo to destroy the enemy's cohesion and will.

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[91] Ibid., 7-8.
[92] General J. Jones, *Expeditionary Maneuver Warfare: Marine Corps Capstone Concept*, 10 Nov. 2001, <http://www.marines.mil/emw.pdf> (15 Nov. 2004), 6.
[93] Ibid., 6.

Additionally, the STOVL JSF will provide the Marine Corps with a platform capable of supporting it in the expeditionary environment. “Expeditionary operations are typically conducted in austere environments, from sea, land or forward bases.”[94] The STOVL JSF will be the only aircraft capable of operating in all of these environments and will offer the MAGTF Commander the flexibility to base his TACAIR assets in a position best suited to meet his requirements.

Expeditionary Maneuver Warfare also places an emphasis on Sea Basing as a means to facilitate expeditionary operations and maneuver warfare. Sea Basing will enable expeditionary operations by sustaining the forces ashore, and by using the sea as maneuver space, will enhance maneuver warfare by enabling Ship-to-Objective Maneuver. EMW calls for improvement in several key functional areas in order to develop the concept to its full potential. Namely: “C2, maneuver, intelligence, integrated fires, logistics, force protection and information operations.”[95] Of those, several will be enhanced by the introduction of the STOVL JSF.

The STOVL JSF will enhance Command and Control and Intelligence through its CNI and sensor fusion capabilities. By having the capability to communicate with anyone on the battlefield, and by having the capability to correctly target and ID enemy units, the JSF will certainly enhance the MAGTF Commander’s situational awareness. It will allow the MAGTF Commander to “see” what is in front of him and build a picture of enemy intentions to a greater extent than previously possible.

The STOVL JSF will provide lethal integrated fires to the MAGTF. “We will increasingly leverage sea-based and aviation-based fires and develop shore-based fire

[94] Ibid., 7.
[95] Ibid., 11.

support systems with improved operational and tactical mobility."[96] The additional range, payload and precision that the STOVL JSF will provide over current aircraft will allow the MAGTF commander to fight the deep fight in order to shape the battlefield. This can be accomplished without the need for external support. The Low Observable JSF will decrease the requirement for EW platforms such as the EA-6B, and the increased range will allow it to operate independently of tanker assets. Furthermore, the lethality of the STOVL JSF will create gaps which the MAGTF can exploit.

Obstacles to the Way Ahead

The STOVL JSF will face several obstacles before it is introduced into service. As discussed earlier, the Department of the Navy has not decided which ship will replace the LHA. If the Dual Tram Line is not funded, the other options that are available to the Navy will not suit the STOVL JSF or the Marine Corps' needs. The proposed 2015 ACE will be physically twice as large as the ACE of today. This is due to the increased size of the MV-22 and the JSF relative to the aircraft that they will replace. The Center for Naval Analysis estimated that the LHD Repeat+ can only fit six STOVL JSF aboard compared to the ten proposed in the 2015 ACE. Additionally, the LHD Plug would be able to fit eight STOVL JSF aboard.[97] In both cases, the hangar space was deemed not suitable for the larger ACE, and the aircraft would have to be parked closer together, which would put additional demands on the flight deck crew. The lack of adequate hangar and deck space would certainly degrade the capabilities of the STOVL JSF. With a less efficient flight deck and inadequate hangar space, sortie generation

[96] Ibid., 12.
[97] Ibid.,21,23.

rates for the STOVL JSF would suffer. The lack of concurrent flight operations would also exacerbate the situation. With these limitations imposed, the Navy could argue that the Marine Corps does not need the STOVL JSF in the numbers that it has requested. If the Marine Corps is forced to reduce the number of STOVL JSF, it may have to purchase additional CV JSF to meet its sortie requirements. This brings us to the next potential obstacle, which is Naval TACAIR integration.

Since the early 1990's, the Marine Corps has augmented the Navy's Carrier Air Wings by integrating four F-18 squadrons aboard Aircraft Carriers. In 2003 the Marine Corps agreed to add an additional six squadrons to the integration plan bring the total to ten.[98] The Marine Corps plans to honor the TACAIR Integration Memorandum of Agreement with the Navy in the future, and as a result is under considerable pressure to purchase both the CV and STOVL variants of the JSF. The Navy contends that the STOVL JSF will not be suitable for integration purposes. However, the Marine Corps remains committed to an all STOVL force and there are several operational examples to support STOVL and CV fixed-wing integration. In 1976, VMA-231 deployed aboard the *USS Franklin D. Roosevelt* with 14 AV-8As and clearly demonstrated the enhanced air wing effectiveness achieved with STOVL aircraft.[99] The STOVL AV-8A demonstrated that it could launch faster than the CV aircraft, it had a higher boarding rate[100], and it could operate at times when the carrier could not launch or recover the CV aircraft.[101] Additionally, the after action report noted that V/STOL aircraft could be integrated into

[98] Lieutenant General M. Hough, "The Future of Marine Corps Aviation", *Naval Aviation News*, May-June 2003, 8.
[99] USS Franklin D. Roosevelt Post Deployment Report AIR 27-77, "V/STOL Deployment in the CV Environment".
[100] The term "boarding rate" refers to number of successful shipboard recoveries compared to the number of approaches attempted.
[101] Ibid.,I-4.

CV operations without major difficulties or reduction of CV capabilities.[102] In 1992, VMA-311 operated off of the *USS Kitty Hawk* with similar results. The after action report noted: "The AV-8B can operate on the CV without impacting normal ops.(operations) and can take advantage of times within the normal deck cycle unusable to other CV aircraft."[103] Since the STOVL JSF and CV JSF will have greater commonality than has previously existed between STOVL and CV aircraft, it stands to reason that whatever operational challenges exist between the two aircraft, they can be overcome by procedural deconfliction. Furthermore, STOVL aircraft have proven to be a capability multiplier when embarked aboard a CV due to their inherent operational flexibility. Procuring a CV variant JSF at the expense of an all STOVL force is not only unnecessary, it is contrary to Marine Corps expeditionary doctrine. Therefore, the only foreseeable reason for the Marine Corps to purchase a CV variant of the JSF would be if there was a significant delay in the production of the STOVL variant, or if it did not meet the performance requirements.

The introduction of the STOVL JSF has already been delayed by one year due to the weight issue addressed earlier in this paper. It is unlikely that the STOVL JSF will experience further delays because the weight problem has already been solved. Additionally, the CTOL variant is scheduled to have its first flight prior to the STOVL JSF. This will benefit the STOVL JSF in that any unforeseen problems should be exposed during the CTOL test flights. However, one must consider that if the program experiences any significant delay, the Marine Corps may be forced to purchase the CV JSF out of the necessity to replace its aging fleet of aircraft.

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[102] Ibid.,I-5.
[103] Naval Message R 030817Z SEP 92 ZYB, Subject: AV-8 CV Integration After Action Report.

An underlying cause of the resistance by the Navy to an all STOVL force in the Marine Corps is that the Navy, to a large extent, has a cultural bias towards supporting the large deck carrier fleet. With the increased capability of the STOVL JSF, the Navy may view it, and the smaller ships that it will be based from as a threat to the long-term viability of its carrier fleet. Much like the Battleship Captains prior to the bombing at Pearl Harbor, the Carrier Captains of today are resistant to anything that would threaten the prestige of the Navy's capitol ship. Additionally it is only natural that any institution, founded on proud traditions of the past would be reluctant to change. Fortunately, This cultural bias and the other obstacles to the STOVL JSF can be overcome if the Navy and Marine Corps leadership work together and remain committed to their vision and doctrine of the future.

Conclusions

As the MAGTF fights in future wars, it will need responsive and flexible airpower to facilitate expeditionary based operations. Historically, the Marines Corps has benefited from having its own integrated, flexible-based TACAIR. The Marine Corps built on the success that the Royal Air Force and Royal Navy enjoyed in the Falklands. The higher sortie generation rate and quicker response time that the V/STOL Harrier provided in Desert Storm were instrumental to I MEF's success. Its efficiency has been further justified during Operation Iraqi Freedom. The flexibility to operate from land and sea provided a combat multiplier for the Joint Force Air Component Commander (JFACC) in a theater where ramp space and tanker assets were at a premium.

The STOVL JSF will bring unprecedented capability to the Future MAGTF. The current inventory of aircraft will not be suited to meet the threat of tomorrow. The Joint Strike Fighter's combination of stealth, payload, and range will allow it to reach out further and operate in an environment that legacy aircraft will be incapable of reaching, and unlikely to survive in. The advances in avionics will transform Marine TACAIR into a true all-weather, day/night strike asset to the MAGTF Commander. Sensor Fusion will allow the JSF to operate with unprecedented situational awareness and lethality. The engine reliability of the Pratt and Whitney F135 engine will mitigate the reliability issues of legacy aircraft. This in turn will lead to higher readiness and higher sortie generation rates. Additionally, every aspect of the JSF was built with reliability and supportability in mind. Greater mean time to failure of avionics components will reduce the logistics

footprint of the future STOVL force. The end result is that the Marine Corps will have an aircraft more capable of supporting the Marine on the ground.

Joint Vision 2020 paves the way for the transformation of the military. The Naval services, through *Naval Power 21*, echo this call, and expanded on the concepts that would take the Navy and Marine Corps team into the future. In turn, *Sea Power 21*, and *Marine Corps Strategy 21*, articulate how this team would forward deploy in order to meet the needs of the nation. Essential to this transformation is the introduction of new technologies and capabilities that will ensure maritime and littoral dominance.

Expeditionary Maneuver Warfare bridges the gap from strategic direction to joint operational employment for the future MAGTF. The flexibility to base at sea or land makes the STOVL JSF vital to the Marine Corps as the Navy further refines its Sea-Basing concept. Adding speed, depth of reach and interoperability to the battlefield through the STOVL JSF will give the MAGTF Commander an immense advantage over potential adversaries. By integrating situational awareness and precision fires, the STOVL JSF will build a better picture for the MAGTF Commander and create gaps, which will facilitate maneuver warfare.

There are certainly obstacles in the way of fielding the STOVL JSF, particularly with regards to the LHA(R), TACAIR integration, and the cultural bias that exists within the Department of the Navy. The conclusion can be drawn that if the DoN is truly dedicated to the concepts articulated in its doctrine, it will accept the fact that the STOVL JSF is not a threat to the large deck carriers, but instead, a compliment to them. The Navy should fund a suitable Sea-Base for the STOVL JSF that is capable of unlocking its full potential in order to better support the Marine on the ground. In the final

analysis, the historical case has been made that validates STOVL operations. Additionally, the Marine Corps needs a replacement for its legacy TACAIR inventory. Based on the STOVL success of the past, the capabilities of tomorrow, and the vision of the future, that replacement should be the STOVL Joint Strike Fighter.

Bibliography

Books and Magazines

BAE Systems, Lockheed Martin and Northrop Grumman. *F-35 Joint Strike Fighter Mission Systems, Multi-Mission Active Electronically Scanned Array (AESA) Radar brochure.*

BAE Systems, Lockheed Martin and Northrop Grumman, *F-35 Joint Strike Fighter Mission Systems, Electro-Optical Targeting System (EOTS) brochure.*

Bolkcom, Christopher. *CRS Report for Congress Joint Strike Fighter Program: Background Status and Issues*.Washington D.C.: The Library of Congress. 2003.

Bloomberg News, "Lockheed Aircraft Gets the Go-Ahead." *The Los Angeles Times*, 05 November 2004, C3.

Brown, Maj. L. *Information Paper: JSF Weight History*, Aviation -21, 03 Feb. 2004.

Chairman of the Joint Chiefs of Staff, *CJCSI 3100.01A: The Joint Strategic Planning System* .1 Sept 1999.

Clark, Admiral V. Chief of Naval Operations. "Sea Power 21," *Proceedings, Oct 2002*. <http://www.chinfo.navy.mil/navpalib/cno/proceedings.html> (12 Dec 2004).

Colarusso, Laura. "Too Fat To Fight." *Air Force Times*, 19 Jan 2004, 20.

Davies, Peter, and Anthony Thornborough, *The Harrier Story.* Annapolis M.D.: Naval Institute Press, 1996.

England, The Honorable G. Secretary of the Navy, *Naval Power 21…A Naval Vision*, October 2002, <http://www.chinfo.navy.mil/navpalib/people/secnav/england/navpow21.pdf> (15 October 2004).

F-35 Sensor Systems, produced by Northrop Grumman Corp., 6 min., MPEG video on CD ROM.

Hastings, Max, and Simon Jenkins. *The Battle for the Falklands*. New York: W.W. Norton and Co. Inc., 1983.

Hoyle, Craig. "Briefing: Joint Strike Fighter." *Jane's Defense Weekly*, 18 Jun 2003, 59.

Hough, Lieutenant General M. "The Future of Marine Corps Aviation", *Naval Aviation News*, May-June 2003.

Joint Strike Fighter Program Office. *Joint Strike Fighter Operational Requirements Document*. Arlington, VA.: GPO, 2000.

Jones, General J. Commandant, United States Marine Corps. *Expeditionary Maneuver Warfare: Marine Corps Capstone Concept,* 10 Nov. 2001, <http://www.marines.mil/emw.pdf> (15 Nov. 2004).

Jones, General J. Commandant, United States Marine Corps. *Marines Corps Strategy 21*. Washington: 2000.

Lockheed Martin Aeronautics Co. *JSF Capabilities Brief*, October 2003.

Lockheed Martin Aeronautics Co. *JSF Program Overview: Public Forum Nov. 04*. November 2004.

Myles, Bruce. *Jump Jet: The Revolutionary V/STOL Fighter*. San Rafael: CA: Presidio Press, 1978.

Naval Message R 030817Z SEP 92 ZYB, Subject: AV-8 CV Integration After Action Report.

Operation Iraqi Freedom, 3d MAW After Action Brief, obtained from Major R. Sofge, Aviation Weapon Systems Requirements Branch (APW)-22, Headquarters Marine Corps

Prechtl, Russ. Northrop Grumman Corp, Electronic Systems. *AN/APG-81 Multifunction Array Radar for the JSF,* 07 Jan. 2005.

Prechtl, Russ. Northrop Grumman Corp. Flying the JSF, 26 Jan. 2004.

Prechtl, Russ. Northrop Grumman Corp. <russ.prechtl@ngc.com> "RE: AESA," 13 Jan 2005, personal e-mail (13 Jan 2005).

Robinson, Lieutenant Colonel D. *Joint Strike Fighter Force Structure for Naval Aviation: A Roadmap for TACAIR Integration*.Quantico: Marine Corps University Command and Staff College, 2003.

Schram, Lieutenant Colonel L. *HASC Safety Brief: AV-8B Harrier*.

Shelton, General H. Chairman Joint Chiefs of Staff, *Joint Vision 2020*. Washington: U.S. GPO, 2000.

Turich, David. "(U) Joint Strike Fighter System Threat Assessment Report" *DOD-1574-0415-00*, October 2001, 3.a.(3) (U).<http://storefront1s.naic.wrightpatterson.af.smil.mil/Documents/STAR/SXX00020/HTML> (01 December 2004).

USS Franklin D. Roosevelt Post Deployment Report AIR 27-77, “V/STOL Deployment in the CV Environment”.

Testimony and Interviews

Young Jr. The Honorable J., Vice Admiral J. Nathman, Lieutenant General M. Hough, Statement before the House Armed Services Committee, March 25, 2004, <http://www.chinfo.navy.mil/navpalib/testimony/aviation/young040325.txt>(06 December 2004).

Risseeuw, H. Director, Navy and Marine Corps Programs, Pratt and Whitney. Phone interview by author, 23 Dec 2004.

Schram, Lieutenant Colonel L. JSF Program Office, Interview by author, 15 November 2004.

Sofge, Major R. Aviation Weapon Systems Requirements Branch (APW)-22, Headquarters Marine Corps, Interview by author, 21 Dec. 2004.