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THE CONTINUING REQUIREMENT FOR V/STOL IN THE CLOSE AIR SUPPORT ROLE

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

W. F. GILLILAND, MAJOR, USMC
B.S., West Texas State University, 1965

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This study reviews the history of JET-V/STOL and the many concepts that have evolved over the years. The requirements for close air support are thoroughly discussed and the impact that V/STOL has had on those requirements is presented. The paper concludes with a discussion of Western world military employment concepts as well as those of the Soviet Union.

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TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Modern battles are fought and won by air, land and sea forces working together, and the interaction and cooperation between these forces extends into almost every function of combat. Given the complex and important interactions between such forces, the requirement for cooperation and teamwork becomes apparent. The United States Marine Corps has the unique advantage of being the single truly unified and integrated air-land team capable of projecting combined arms combat power ashore. Thus, historically, the Marines have been employed as a force in readiness--one capable of projecting that combat power of the United States in response to crises anywhere in the world.

The combat element of the Marine Corps is organized into division-wing teams. The Marine aircraft wing, the air combat element of this force in readiness, is vital to the success of the ground force. The Marine aircraft wing exists to provide air support for the Marine on the ground. The Marine who crosses the beach or assaults the hill can be confident of being supported by those with whom he has trained--those who understand and share his concern for reaching his assigned objective.

The mission of Marine aviation, as stated in FMFM 5-1,

> . . . is to participate as the supporting air component of the Fleet Marine Force in the seizure and defense of advanced naval bases and for the conduct of such land operations as may be essential to the prosecution of a naval campaign.[1]

The integration of aviation functions to fulfill the primary mission of service with the fleet in the prosecution of naval campaigns results in Marine aviation being the nation's only tactical air and helicopter assault force which is trained, equipped, and ready to operate from sea bases and austere expeditionary bases ashore. This inherent versatility enables Marine aviation, although relatively small, to be ready to respond whenever and wherever needed with a composite force capable of meeting the majority of enemy threats.

Requirements peculiar to the Marine Corps, such as amphibious assault and operations from austere sites on land require unique weapons systems and concepts that will allow the rapid build-up of combat power ashore. Marine aviation must be capable both of phasing ashore rapidly, and of providing the ground commander the support he needs at the moment he needs it. For continued accomplishment of this mission, all new equipment must be carefully chosen. It must be capable of operating from both ship or shore bases, and capable of rapid relocation from one expeditionary site to another. Furthermore, the equipment selected should not place excessive demands on the logistic system, or be degraded in capability as a result of operation in an austere environment.

Ordinarily, technological and fiscal realities govern the selection of the equipment available to Marine aviation. Unilateral development of aircraft to meet Marine aviation requirements is not likely. Historically, the Marine Corps has been forced to be innovative in adapting equipment developed for other services or purposes to meet Marine requirements. Often, it has revised tactics and doctrine to accommodate or exploit a capability gained through acquiring equipment not specifically designed for Marine Corps use.

Marine aviation introduced the tactical use of the helicopter for United States forces in 1948. It was an innovative move, and represented a departure from the norm; however, skeptics questioned the practical value of such a complex machine. Despite this criticism, the Marine Corps adapted the helicopter to its tactics, and exploited the concept of vertical envelopment. This once innovative approach to a specific requirement for responsiveness and tactical mobility is now an accepted standard on the modern battlefield.

Since introducing the helicopter, the Marine Corps has endeavored to expand and exploit the potential afforded by aircraft with vertical and short takeoff and landing (V/STOL) capabilities. A requirement existed for an aircraft that was capable of providing a more flexible means of fire support during amphibious operations--an aircraft that would incorporate the speed, firepower and survivability of a jet, while providing the basing flexibility of a helicopter. The advantages of such flexibility and responsiveness had been demonstrated by helicopter forces both in Korea and Vietnam. This requirement for flexibility and responsiveness in a high-performance attack aircraft was first identified by the Marine Corps in 1957.[2]

Eleven years after recognizing the need for such a V/STOL aircraft, the British built Harrier was the only operational high-performance V/STOL aircraft to emerge from worldwide development efforts. The Harrier provided a marked improvement in V/STOL operational effectiveness without an unacceptable degrading of performance characteristics; at the same time, it did not require a great increase in overall support and maintenance. The Harrier offered Marine aviation the speed, firepower and survivability of a jet with the basing flexibility of a helicopter. Thus, in 1968, a plan to procure the Harrier for the Fleet Marine Force was initiated. The first U.S. Harriers, designated AV-8A by the Defense Department, were introduced into Marine Corps service in April, 1971, as a result of the 1968 plan.[3]

Six years after the formation of the first AV-8A squadron, the last of the original procurement of 110 aircraft was delivered. During this six-year period, two more tactical squadrons had been formed along with one training squadron. The AV-8A program was innovative and it has been under close scrutiny since its inception. There have been and still are many skeptics of the need for high performance V/STOL aircraft. On the one hand, the Marine Corps has been criticized for becoming entrenched with a technological curiosity of limited tactical potential; on the other, it has been praised for its determination and foresight.

This paper proposes that V/STOL is the future of Marine Corps tactical aviation. Unfortunately there is not complete agreement on this issue. Therefore the purpose of this thesis is to examine the impact of the V/STOL concept on tactical aviation, with a particular emphasis on Marine Corps aviation. What this innovative step by Marine aviation has provided for the ground commander, and what the V/STOL concept has contributed to the Marine Corps' unique close air support doctrine must be considered, along with the question of whether or not the AV-8A has fulfilled the mission for which it was procured. These and many other questions concerning V/STOL aviation and its close air support role will be examined in this paper.

This analysis of over six years of V/STOL experience comes at a time when criticism of this innovative concept has never been greater. Unfortunately, this increased criticism coincides with the increasing accident rate the AV-8A has experienced during the past year. Twenty-seven of the 110 AV-8's purchased have crashed since 1971, with a loss of eleven pilots.[4] The Harrier accident rate and resultant widespread media coverage have resulted in the aircraft being referred to as: "The Marines' Bad Luck Plane" and "The Death Machine."[5] During a time of imposed fiscal constraints, this criticism of V/STOL aviation may doom the Harrier or more importantly the V/STOL concept to share the same fate as many other technological advances of other eras, such as the machine gun and the torpedo. Only recently Defense Secretary Harold Brown decided to cut back development of the AV-8B, the follow on to the AV-8A. The Secretary's tentative decision was based on his view that the military ". . . should take a more cautious route and not speed too quickly into a new breed of program."[6] Whether this tentative decision to cut back funding of an advanced V/STOL aircraft is formalized or not remains to be seen; however, the impact of such a decision could be far reaching and should be made only after a careful analysis of all the facts, accumulated over the past six years of United States operational V/STOL experience. Therefore, a close analysis of the practical applicability of this concept is most appropriate at this time.

An analysis of the past six years would not be complete without considering the Soviet emergence into the V/STOL arena. Through V/STOL, the Soviets have achieved a rapid route to seaward deployment of tactical air power. How this new Soviet threat will impact on future U.S. V/STOL employment and projects is a question that cannot be ignored.

In summary, then, this introduction has provided an insight into the scope of the evaluation that will follow--an evaluation of V/STOL aviation and the viability of its role in close air support. The following chapters will present the history of V/STOL technology and the emergence of the Harrier, Marine close air support and what the V/STOL concept contributes to the close air support mission, operational employment and concepts for V/STOL aircraft, and the Soviet experience with V/STOL. Finally, the question of whether or not the past six years of experience warrant the purchase of improved models of the AV-8A, and further research and development in the field of V/STOL technology will be considered.

FOOTNOTES

[1]For complete discussion of the operational employment and missions of the Marine Aircraft Wing, see FMFM 5-1, Marine Aviation, 1976, Chapter 1.

[2]LtCol John D. Carlton, "Marine Air: Responsive, Innovation, Adaptation, Exploitation," Marine Corps Gazette, May 1974, p. 50.

[3]"First Harriers Delivered to Marines," Armed Forces Journal, January 18, 1971, p. 17.

[4]"Pilot Selection, Training Altered as Crashes of AV-8A Mount," Aviation Week & Space Technology, August 1, 1977, pp. 24-25. Navy Times, September 26, 1977, p. 4, col. 2. "Marines to Press for AV-8B In Spite of Opposition, Accidents," Aviation Week & Space Technology, September 19, 1977, p. 25.

[5]"The Marines' Bad Luck Plane," Time, August 15, 1977, p. 15. Editorial, The News and Observer, (Raleigh, North Carolina), July 28, 1977.

[6]New York Times News Service dispatch, The Kansas City Star, September 13, 1977.

CHAPTER II

JET V/STOL

For thousands of years, man watched the birds and tried to duplicate their flight. It was not until the Middle Ages, and the advent of the hot air balloon, that man would first get aloft in pursuit of his dream of flying. Finally, centuries later, the Wright brothers opened the door to the skies. With the aeroplane came the autogyro, the helicopter, supersonic fighter, and space vehicles. Each new development brought new possibilities for progress. Until the mid-20th century, however, a missing link in this chain of progress existed. It was a vehicle that could land like a helicopter, yet soar aloft at the high speeds of a supersonic fighter. Achieving these two extremes of speed in flight from the same aircraft demanded more than man's technology could supply up to that time.

About twenty-three years ago, the early experimental V/STOL airplanes first flew. With these first aircraft came an abundance of new words and acronyms to describe their strange characteristics. These definitions have not changed over the years, and to assist the reader some of them should be explained at this point: VTOL means vertical take-off and landing, such as that seen in the helicopter; STOL means short take-off and landing, such as that accomplished by a large-winged, slow-speed plane; a V/STOL aircraft is one that can take-off in a heavier condition after a short deck run, and land either vertically or with a short roll-out.

HISTORY

It is difficult to credit any one person with the invention of V/STOL, although some credit must be given to the World War II provisional patent specification by vonWolff. His work covered the deflection of jet efflux by cascades and bending jet pipes to improve aircraft performance and maneuverability. At the time of vonWolff's design idea, turbojets produced little thrust and were far too heavy, as a result, VTOL could not be achieved and the potential gains in deflecting jets for STOL were negligible. There is no evidence of a direct link between the post-war publication of vonWolff's document and a successful V/STOL project, but he is credited with grasping the essential fact that the gas turbine engine was not rigidly linked to its thrust vector as was the reciprocating engine.[1] The characteristics of the jet engine made it easy to point its thrust vector in virtually any direction required, merely by changing the direction of the exhaust flow.

Most early V/STOL programs and concepts were developed and abandoned in parallel, with little interaction or cross-flow of information between the early participants, namely France, West Germany, Great Britain, United States, and the Soviet Union. However, one project, the United States developed Bell X-14, did act as a catalyst for others. The X-14 achieved V/STOL by turning jet efflux from two horizontally mounted engines through a 45-degree cascade, and then through a similar but rotateable unit. This gave the pilot the capability of jet lift or horizontal thrust, or any intermediate angle. This first practical application of vectored thrust was a major breakthrough, which encouraged British and later Soviet designers to produce the first operational jet-powered V/STOL aircraft.[2]

CONCEPTS

The vertical and short take-off and landing (V/STOL) concept is not new. For many years air theorists were fascinated with its possibilities and started treating its design problems by trading off some V/STOL ability to increase other important design factors, such as speed and range. V/STOL capability did not come without penalty, but penalties may prove acceptable in the light of getting the job done. These visionaries foresaw a variety of V/STOL aircraft useful for both military and civil purposes.

The primary requirement of jet-lift V/STOL is essentially one of achieving a difficult objective by brute force, that is simply provide enough thrust to overcome the vertical take-off weight of the aircraft. There are dozens of aircraft designs under the overall V/STOL or STOL, labels but they are either non-jet powered or are slow speed aircraft and their development is not germane to this paper. Many jet V/STOL designs and concepts have emerged over the years providing airplanes that perform as high-speed jets, but also have VTOL or V/STOL capabilities. An expanded discussion of each concept is offered below.

1. Lift/Cruise - The best known jet V/STOL design is that commonly called lift/cruise or deflected thrust design. A single, high bypass, fan jet engine is used exhausting its fan through two forward ducts and its regular core engine air through two similar ducts further aft along the fuselage. Each duct can be swivelled, from vertical for take-off and landing, to horizontal for normal flight. A major design problem in the lift/cruise scheme is inherent to engine type and location. The high bypass fan jet requires a large frontal area for air intake, when coupled with the requirement for exhaust ports to be located near the

aircraft's center of gravity, a high drag fuselage results. This causes large airspeed penalties in the supersonic range. The basic brute force approach and high bypass fan will probably limit the combat application of the lift/cruise scheme, despite its unique success in the field.

2. Lift Plus Lift/Cruise - Another brute force approach to jet V/STOL is called the lift plus lift/cruise design. In this scheme, a regular jet engine is fitted with a swivelling exhaust nozzle to deflect the exhaust either straight out or down, or to any intermediate angle. This concept creates a significant thrust force aft, requiring balancing forces forward to provide vertical control and lift. This normally is accomplished with one, two, or more small lift engines imbedded in the fuselage just aft of the cockpit. The lift engines are full-fledged, high powered, but very short life span engines. They are used only for a few minutes on each landing and take-off, which permits their design to be finely tuned for a great amount of thrust from very small, lightweight construction.

The lift plus lift/cruise concept has many advantages, such as low frontal area, adequate lifting thrust, and while cruising a conventional engine afterburner is available if installed as part of the basic engine. However, the drawbacks of this scheme are many. The most obvious is the blow-torch effect of the engine exhausts and the associated side-effects of debri from these blasts, a special pad or hard surface is required to operate aircraft utilizing the lift plus lift/cruise design. Reingestion of hot gasses from the exhaust air can also create problems as it recirculates back into the intake of the lift engines. Jet engine performance is appreciably degraded when hot air is ingested. When airborne in conventional flight the aircraft is penalized by the extra engines which cannot be used except for landing. Tactically, such a decrease in combat load is unacceptable. The lift plus lift/cruise design needs all engines fully operational to take-off or land in a vertical mode. In this case the multiplicity of engines tends to degrade, rather than enhance the safety and survivability of the design. Despite these shortcomings, the lift plus lift/cruise concept is a design that industry and the military believe can be built at a fairly low technical risk.

3. Rotating Nacelles - Another brute force idea tried in the past involves rotating the engines, usually in wing-tip nacelles. This scheme avoids the penalty of extra lift engines, since all the lift power is provided from the same engines used for cruising in flight. This concept, like the others, is not without its problems. With the engines at the wing tips, extra sources of power are required for pitch and directional control. Wing tips are usually not at the fore-and-aft center of gravity, which adds to the pitch control problem. The high-powered engines have serious ground erosion and reingestion difficulties, and an engine failure in vertical or horizontal flight induces tremendous asymmetric forces which would probably result in loss of the airplane. Cross-shafting has been looked at in recent years as a method of solving this asymmetry problem. The idea of swivelling wingtip engines is interesting but tactically unsound.

4. Lift/Cruise Fan - The fan-in-wing or lift/cruise fan idea provides a method of reducing the jet blast problems which any brute force approach involves. In this scheme, the regular cruise engine exhaust is used to drive three or more lift fans imbedded in the wings and forward fuselage in a triangle arrangement. The lift fan pushes a large volume of ambient air downward, providing the lifting force required for

vertical flight. The fans are augmenting devices that can provide as much as 25,000 pounds of lifting force from a basic jet engine rated at only 10,000 pounds of thrust.

The penalties of this design are the large holes in the wings and fuselage required to house the fans. This reduces the amount of fuel that can be carried in the wings and also the amount of fuselage space that could normally be used for carrying additional equipment. The fans in the wings are additional weight and a thick high drag wing is required to house them. High drag wing designs are not compatible with supersonic performance. The fan-in-wing design has been proven but little development has been done in the area of thinner fans that would be required for high speed wings. The major attraction of this concept is its low and cool downwash characteristics which negate the requirements for special launching areas.

5. Thrust Augmentation - The final V/STOL concept which warrants review has far more possible applications than those mentioned previously. This design uses aerodynamic augmentation to develop thrust from nozzles built into a wing. Thrust from the regular cruise engine exhaust is diverted into ducts in the lifting surfaces. A span wise venturi throat is created by deflecting flaps ahead of and behind the duct, and the jet efflux gas is ejected downwards through slots in the ducts. This high velocity flow entrains about eight times its own mass of ambient air and thereby generates an increase in lifting thrust over that available from the engine alone.

The thrust augmented wing or TAW concept involves no additional engines and most likely will not produce large pitch change problems while transitioning to wingborne flight. The major disadvantage of this scheme at this time is whether or not it will really perform as expected. If the TAW is successful it will have low efflux qualities similar to the lift-fan design. Once airborne, the aircraft will have the same characteristics of a single engine, high performance supersonic jet. It should have the best transitional flight characteristics of all the designs previously discussed.

FUTURE CONCEPTS

After many years of effort the jet-lift V/STOL concept has emerged as the only operational V/STOL tactical application. Though successful, the concept has drawbacks and it does not appear that present technology will produce a supersonic V/STOL aircraft before the 1990s. Key technology must be developed in the areas of aerodynamics, propulsion, and flight dynamics in order to achieve this goal. The large variety of configurations and propulsion system arrangements that are currently being proposed for future V/STOL applications reveals the inadequate state of the art. With no reduction in programs now underway, four to five years of development should produce a V/STOL aircraft with fewer shortcomings, utilizing something other than the jet-lift concept.[3]

DEVELOPMENT OF THE HARRIER

In October 1957, the first Harrier type lift/cruise configuration drawings, using the vectored thrust principle, first appeared. A period of over 11 years was to lapse before the definitive aircraft was ready for service. Michel Wibault, a French engineer, is credited as the originator of the V/STOL fighter concept.[4] As early as 1954, Wibault completed project studies for a vectored thrust ground attack gyrocopter. Wibault's scheme for thrust vectoring failed to capture the imagination of the French government/industry complex and he turned to the U.S. Mutual Weapons Defense Program for support. They in turn passed results of his research on to British engineers. The idea of vectored thrust was finally pursued by the Bristol Siddeley Co., under the direction of Dr. Stanley Hooker, working in conjunction with Hawker Siddeley Ltd.[5]

While appreciating the merits of Wibault's concept, the British designers believed his proposal would be limited because of weight and bulk due to engine requirements. This realization on the part of the British engineers, that the major stumbling block facing successful V/STOL would be the engine, led to extensive efforts to develop an engine that would make V/STOL a viable concept. This engine development effort began in 1957 and by September 1959 the first of the Pegasus engines was tested. The Pegasus design utilizes both low and high pressure air exhausted through four rotatable cascade type nozzles. With this engine came the first potential for design of a practical high-performance V/STOL aircraft.[6] The Pegasus has proven to be a sound, reliable engine that has not changed in basic design with the development of later model engines.

Initially the early development of both the engine and airframe was entirely a private venture, but sufficient interest was aroused within the military forces of the North Atlantic Treaty Organization (NATO) to secure United Kingdom government funding assistance for two prototypes, this funding was later increased to provide for the development of four aircraft.

Metal for the prototype aircraft (the P.1127) was first cut in March 1959 and on 21 October 1960, the first tethered hovering trials were made. The first free hover and conventional flight was conducted on

19 November 1960. The prototype aircraft was powered by a Pegasus engine producing 11,000 pounds of thrust, fuel was only available for two minutes of hovering on the first hovers due to the very narrow margin of thrust over weight. The second prototype P.1127 flew in July 1961, with a 13,000 pound thrust Pegasus III engine. It was with the Pegasus III installed that the first full transitions from hovering to forward flight were made on 12 September 1961.[7]

Hawker Siddeley Aviation succeeded in generating the first really practical international interest in V/STOL, resulting in a management agreement between the United Kingdom and Federal German governments on the P.1127 airframe and engine. In December 1961, American interest became apparent with the United States government suggesting that a research program be conducted to evaluate the V/STOL fighter concept under operational conditions. The United States recommendation resulted in the formation of a tri-national evaluation squadron. The squadron was formed with the P.1127 utilizing the Pegasus V engine. This later model Pegasus was capable of 15,200 pounds of thrust. The P.1127 with the Pegasus V was later renamed the Kestrel and the tri-national squadron agreed to procure nine Kestrels and 18 engines. The squadron was established on 15 October 1964, and conducted trials from April to November 1965.[8] Upon disbandment in February 1966, the Kestrels were assigned to the three countries for continued research. Six of these aircraft came to the United States and a few are still in use at Edwards Air Force Base and at NASA's Langley, Virginia facility.

Concurrent with the P.1127 program, Hawker Siddeley had been working on a supersonic bi-service design that was to meet both Royal Air Force and Royal Navy requirements. This prototype was cancelled in 1965 by the

British government and replaced by a new type, initially referred to as the P.1127 (RAF) and named Harrier in 1967. A development contract was issued for six aircraft in the spring of 1965 and the first development Harrier flew on 31 August 1966. All six aircraft were flying by July 1967, the last two being fitted with the Pegasus 101 engine. The Pegasus 101 was the engine selected for initial installation in the production model Harrier. The first production model Harrier flew on 28 December 1967, this was the first aircraft of a production contract calling for 60 that would form the nucleus of four Royal Air Force squadrons.

While the Harrier has been dubbed the "Tin Lizzie" of the jet V/STOL era, it is important to realize that it is not of first generation technology but a culmination of years of design and testing. Viewed externally, the Harrier has an obvious family resemblance to the P.1127 and Kestrel, but here the similarity ends. The Harrier is fitted with a large package of operational equipment, and a completely revised engineering system that leaves it with but a five percent commonality when compared to the Kestrel.

The analogy has often been made comparing the introduction of the Harrier into operational service with that of the helicopter, however there is little similarity between the two. The Marine Corps acquired a proven weapons system with over fourteen years of research and development invested without the large expenditure of development costs.

FOOTNOTES

[1]R. M. Braybrook, "V/STOL: Stalled?" Proceedings, U.S. Naval Institute, October 1974, p. 33.

[2]Henry R. Palmer, Jr., Remarkable Flying Machines (Seattle: Superior Publishing, 1972), p. 82.

[3]For a detailed discussion of future V/STOL concepts, see the following articles:

Clarence A. Robinson, "Navy Plans Emphasis on V/STOL," Aviation Week & Space Technology, March 1, 1976, pp. 12-16.

Clarence A. Robinson, "Grumman VTOL Aimed at Small-Ship Use," Aviation Week & Space Technology, September 20, 1976, pp. 15-20.

"V/STOL Technology Advances Expected," Aviation Week & Space Technology, January 31, 1977, pp. 70-81.

Clarence A. Robinson, "Navy Restudies Carrier Options," Aviation Week & Space Technology, September 5, 1977, pp. 14-16.

"Advanced Harrier Pushed for Fleet Use," Aviation Week & Space Technology, November 28, 1977, pp. 55-61.

Clarence A. Robinson, "Navy to Seek Design Proposals for New V/STOLs," Aviation Week & Space Technology, November 28, 1977, pp. 34-51.

[4]Colonel Thomas H. Miller, "Flying the Harrier," Marine Corps Gazette, May 1969, p. 24.

[5]Raymond Honkin, "Harrier Into Service," Flying Review International, September 1969, p. 38.

[6]A. W. Bedford, "The Hawker P.1127 V/STOL Strike Fighter," Journal of the Royal Aeronautical Society, December 1962, p. 743.

[7]"The P.1127 Analysed," Flight International, October 1962, p. 4. (Reprint).

[8]Kestrel Evaluation Squadron, Investigation of V/STOL Concept - Final Report, February 1966. pp. 1-23.

CHAPTER III

CLOSE AIR SUPPORT

The Marine Corps pioneered the concept of close air support in the jungles of Nicaragua in 1927. From this primitive beginning, the Marine air-ground team was formed. Much has been written about the exploits of the Marine air-ground team during World War II and Korea. This chapter will discuss briefly the early history of the development of close air support and the Marine air-ground team. It will conclude with a review of the requirements of the ground commander for effective close air support and the impact that V/STOL technology and aircraft have had and will have on the close air support mission.

THE EARLY YEARS

Some Marine planners recognized early that a Marine air arm might be a useful addition for an advanced base force. It is difficult to speculate whether or not these planners envisioned the actual role that aviation would perform in future conflicts, but the foundation for the Marine air-ground team was laid when Lieutenant Alferd A. Cunningham was ordered to flight training in May 1912. Despite the foresight of these visionaries, there were only five qualified aviators by June 1916, and nothing had been done in the way of organizing Marine aviation.

With the outbreak of World War I, Marine aviation expanded rapidly and the formation of squadrons quickly exceeded the equipment available. Due to this lack of equipment Marine aviation did not see combat until late 1918, when U.S. Marine squadrons arrived in France and were equipped with British De Haviland aircraft. They did not have the opportunity to provide air support to the Marine brigade fighting in the trenches. When World War I ended the Marine air and ground elements had not moved toward the formation of an air-ground combat team.[1]

In February 1919, the Marine Corps took the first step toward integration of its air and ground forces when two observation squadrons were sent to Santo Domingo and Haiti for service with Marine brigades assigned to the areas. These small units quickly won acceptance from their ground counterparts for their ability to perform tactical reconnaissance, liaison with long range patrols, and support of isolated stations. On occasion the aviators experimented with air to ground attack tactics, and some credit them with the first successful dive bombing.[2] Strictly speaking, however, these were nothing more than isolated adventures. Most missions were routine and unglamorous.

The principal accomplishment of these two pioneer squadrons was far more significant than the total of their missions. They are given credit for establishing the first rapport between ground and air units which would in later years become a unique characteristic of the Marine Corps. They paved the way for the association that would develop during the five years of the Nicaraguan campaign, which formed a bond between the ground and air elements of the Marine Corps.

The anti-guerrilla operations of the Marines against Nicaragua's General Sandino, provided the impetus that was to strengthen the bond between air and land forces. Despite often amusing frustrations and misunderstandings as to the proper role of supporting aviation, the newly formed air-ground team began to gain a partial appreciation of each others' problems. One such problem was effective communications. The aircraft of 1927 carried no radio equipment, and the ground forces had only cumbersome and unreliable radio sets. The problem of communicating was not insurmountable, however, as techniques utilizing cloth panels laid out on the ground in a predetermined arrangement were experimented with. The pilot responded to these early air panels with wing and engine signals.[3]

The usefulness of aviation in reconnaissance, liaison and for emergency transportation had been demonstrated and accepted. However few ground commanders were ready to admit that the air arm was capable of effective combat support. There had been little opportunity to demonstrate a ground attack capability. This skepticism was to be reversed with the air action at Ocotal, Nicaragua, on 16 July, 1927. This date is generally recognized to be the first organized dive bombing and low altitude attacks ever made in direct support of ground forces.[4] The battle of Ocotal established Marine aviation as a full partner in the Marine air-ground team.

The partnership that was building between air and ground forces is best described by the following incident. During October 1927, the Marine air element suffered its only combat casualties when one of the aircraft was hit and crash landed, the pilot and his enlisted observer were seen running away from the wreckage. They were never sighted alive again, but their misfortune touched off a series of heroic efforts by Marine ground forces in an effort to rescue the downed crew. The efforts by these ground patrols helped cement the beginning of air-ground coordination which was to develop over the years into a lethal combination.

By the end of 1928, the coordination between air and ground units had greatly improved with practice, and it can be said that Marine aviation came of age during the Nicaraguan campaign. The lessons learned were incorporated into training manuals, and the officers and men who flew in Nicaragua became leaders and innovators during the great air-land battles of the Pacific, where the doctrine of close air support was refined to an exact science.

During three major wars, several smaller conflicts and the intervening peaceful years, the Marine Corps has refined, improved and developed doctrine, tactics, techniques and equipment for effective close air support of the Marine on the ground.

REQUIREMENTS FOR CLOSE AIR SUPPORT

Since its inception, close air support has become an essential ingredient in any successful land campaign. It is considered as a supporting arm by the ground commander, and he must integrate it into the ground scheme of maneuver. Close air support is defined in the Joint Chiefs of Staff Dictionary of U.S. Military Terms as: "Air attacks against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces."[5]

There are two distinguishing characteristics of close air support that differentiate it from other attacks of ground targets by tactical aircraft. These are the close proximity of targets to friendly troops and the requirement for integration of each air strike with the fire and movement of those supported troops. These characteristics imply a requirement for careful identification of targets and accurate delivery of ordnance as well as a scheme of coordination that protects the aircraft from friendly artillery, mortars and air defense systems while delivering ordnance.

The requirements for effective close air support are similar to the fundamentals of land warfare in that they have been alternately changed, ignored, redefined, rediscovered, and ultimately evolved into their present state. The Congress of the United States has on two occasions constituted special subcommittees to investigate the adequacy and effectiveness of close air support.[6] The Department of Defense conducted their own study on close air support during 1971. This study was based on the testimony received from a panel of ground officers that had employed close air support during ground combat tours in Vietnam.[7] The ground commander is the consumer or recipient of close air support and could be considered the judge and jury when discussing its effectiveness. The requirements developed by the 1971 Department of Defense study should be considered in evaluating the effectiveness of any close air support system or concept. An expanded discussion of the essential requirements is offered below.

1. Response Time - The most important single ingredient of close air support is getting on target fast. The ground commander requires rapid response to his request in order for the close air support to make a meaningful contribution to the accomplishment of the mission. Response time is measured as the total elapsed time from initial request until the first ordnance is delivered.

Responsiveness is becoming more important to the ground commander. Fast moving tanks on today's battlefield, with their overwhelming firepower, can quickly overrun a position. The close air support system must be able to rapidly engage these targets. The responsiveness of the system depends on four separate elements: (1) The time required for the tactical air request to be processed and the resource to be allocated. (2) The time required to launch aircraft. (3) The time required to fly the distance to the target. (4) The time taken to integrate the close air support mission into the scheme of maneuver of the ground commander. Response time is minimized by reducing the elapsed time of all the elements.

U.S. Marine Corps control procedures and methods of employing close air support aircraft are designed to minimize response time. Requests from supported units are expeditiously processed and aircraft are provided as the situation dictates. If units are pinned down by heavy casualty producing weapons, timely response is most urgent. Experience gained in Vietnam indicates that the first fifteen to twenty-five minutes of the battle are critical. This window of response time will only become smaller in the future as threat forces continue to develop and utilize high speed, rapid rates of advance and overwhelming firepower type tactics.

2. Target Identification - Target detection or identification is the key element in the integration of close air support into the fire and maneuver scheme of the ground commander. Means of target identification should provide the aircraft a high probability of target acquisition and first round effectiveness, utilizing high-speed low-level attack techniques.

The techniques for accomplishing target identification will vary, but each requires close coordination between the aircraft and the ground commander. Current methods of identifying targets are outdated. Enemy air defense systems in future conflicts will require that close air support missions be flown utilizing high-speed low-level attack techniques. The days of dry runs for target identification, high overhead patterns, and miltiple passes are over. The requirement exists today for a timely, positive means of target identification, this will require even closer coordination between the aircraft and the ground commander. Pilots will have to be more knowledgeable of the tactical situation, terrain, and friendly and enemy disposition, in order to successfully accomplish their mission. Although past methods have served their purpose, new techniques need to be developed that will improve target identification.

3. Fire Support Coordination - Command and control procedures must provide for the rapid integration of each air-strike into the ground commander's scheme of maneuver without degrading his ability to employ simultaneously artillery and other ground fires. Doctrine, procedures and organizational structure must allow the ground commander to coordinate fires on the target. He must be able to maximize the use of the required airspace for all supporting arms while ensuring safety of personnel. Establishment of this coordination will reduce delays in fire support and eliminate the cease fire of ground weapons while close air support missions are in progress.

Centralized control ensures coordination and proper application of available assets. This coordination requires reliable communications among air control agencies and between control agencies and assigned aircraft. Command and control systems must be designed to optimize utilization of aviation resources through centralized control when the situation permits, but the air-control system must also be effective in a situation which demands decentralized control.

4. Communications - Aircraft and ground radios should have compatible frequencies and the ground commander should not be required to maintain cumbersome equipment in order to communicate with aircraft. Both the ground unit and the aircraft should have similar secure voice capability. Standard operating procedures should include terminology and

frequencies for air ground communications. Ground units down to platoon level, should be able to communicate with aircraft in the absence of airborne or ground forward air controllers.

Timely and dependable communications may be extremely difficult to achieve against threat forces. The potential enemy has a sophisticated jamming and deception capability which may preclude effective communications. The close air support system must allow for the delivery of ordnance during periods of enemy jamming with minimal degradation of effectiveness.

5. All Weather Capability - Threat doctrine is to attack at night, around the clock and under all weather conditions. In Vietnam the enemy was noted for establishing contact when close air support and other supporting arms were limited by bad weather. Therefore, the ground commander requires a close air support system that can operate during periods of low ceilings and reduced visibility. Current technology provides highly accurate radar bombing systems, but a requirement continues to exist for aircraft to operate under low ceilings in order that ordnance can be delivered closer to friendly units.

6. Ordnance - Effective close air support requires that ordnance expended on a target be capable of destroying or neutralizing the target. Aircraft must be capable of defeating all types of targets with the full spectrum of ordnance. This requires the capability to deliver the optimum ordnance at the time and place required. Modern area munitions such as CBU's and Rockeyes have diminished the importance of this requirement since these munitions are effective against both personnel and armor.

The success of close air support not only depends on the previously stated requirements but certain other conditions must be satisfied as well. Air superiority, suppression of enemy air defense and the proficiency of the aircrews involved must be considered.

It is generally acknowledged that at least local air superiority is required to provide security for attack aircraft involved in close air support. Local air superiority does not imply air supremacy, a term that suggests complete dominance of airspace. Air supremacy, like that enjoyed in Vietnam, is an impossibility on future battlefields, primarily due to improvements in antiaircraft weaponry. The question now is: "Can we attain local air superiority in order to effectively conduct close air support missions?" It may be necessary to utilize dual purpose aircraft to provide air-to-air protection.

Because of the advances in technology, aircraft have become increasingly vulnerable to antiaircraft fire. Enemy antiaircraft weapons must be neutralized or destroyed. The density of air defense weaponry that we can expect on the future battlefield makes this condition an extremely difficult one to satisfy. The U.S. Marine Corps must develop a coordinated suppression doctrine similar to the joint Army/Air Force SEAD (Suppression of Enemy Air Defense) doctrine. The SEAD doctrine makes use of all available arms of both the Army and the Air Force to effectively neutralize the enemy's air defenses. The Army's primary weapon for SEAD is their field artillery.

The Marine Corps has organic air assets, in addition to its artillery assets, which would enhance the effectiveness of a SEAD campaign. Tactical jet aircraft also provide the Marine Corps with electronic warfare systems. An effective SEAD doctrine for the Marine Corps should rely heavily on the integration of airborne electronic warfare assets as well as artillery and organic air assets.

Aircrew proficiency requirements have continued to increase with the introduction of multiple mission aircraft into the inventory. This, coupled with the increasing threat of enemy air defense systems, places an unparalleled requirement on aircrews to maintain a combat ready status.

The ultimate measure of close air support is its capability to fulfill the tactical support requirements of the ground commander's scheme of maneuver. If a close air support weapons system is to gain the confidence of the users, it must be developed to meet the user's requirements. The Marine close air support system is user oriented and designed to be responsive to the requirements of the ground commander. The Marine ground commander views close air support as an element of the total of his combat power, he sees it as an integral part of the overall land battle.[8]

With each study on close air support numerous deficiencies arise; however, the primary desires of the ground commander continue to be responsiveness and accuracy. He desires that ordnance appear rapidly after he calls for it and that it be delivered on the target that is threatening him. Experience has shown that response times are too long for immediate air requests. The responsiveness that the ground commander desires can be partially achieved through basing flexibility of close air support assets. Requirements for large fixed bases decrease flexibility, increase vulnerability and reduce responsiveness and sortie rates.

Flexibility of employment has been restricted as new tactical aircraft required long runways. These newer aircraft began appearing late in the Korean conflict. This requirement resulted in Marine aviation elements being based further and further away from the Marine ground combat element. Following the Korean conflict the recognized need for flexible basing of close air support assets resulted in the Marine Corps' development of the short airfield for tactical support (SATS) expeditionary airfield.

Throughout the Vietnam conflict Marine air regularly supported ground units over 150 miles away, this distance could be covered in about 30 minutes, but this was often too late to meet the response time required by the ground commander in contact with the enemy. No matter what the ordnance carried, or how much, it is to no avail if it arrives after the critical decision point. As pointed out earlier the critical decision point in a small unit engagement usually comes in the first twenty-five minutes of the battle. The geographic separation between Marine air and ground units was rapidly making air-ground coordination a thing of the past. This separation, except for helicopter units, created a loss of rapport and did not allow for the close personal coordination that had become a trademark of the Marine air-ground team. Adequate close air support was provided through costly airborne alert status as well as questionable pre-planned missions, but it was evident that a better way had to be found to meet the responsiveness required by the ground commander as well as reasons of economics and effectiveness.[9]

V/STOL RESPONSE

Marine Corps planners recognized the advantages of V/STOL aircraft in the close air support role and the special interest that was placed on the development and employment of aircraft with a V/STOL capability has been discussed in the first two chapters of this paper. The AV-8A Harrier represented an entirely different approach to improving responsiveness through flexibility in basing that had not existed since World War II. This flexibility made the Harrier an ideal close air support aircraft. It was a V/STOL aircraft that was small, fast, extremely maneuverable and could operate from roads, grass or bombed out airfields. The Harrier represented a new dimension in close air support.

What unique improvements did V/STOL technology and the Harrier offer the ground commander? This question is best answered in two words, operational flexibility. Through the flexibility of V/STOL, close air support assets have the inherent capability to react rapidly to a wide range of missions under varying operational conditions.

V/STOL aircraft represented an entirely different approach to improving responsiveness, through ground loiter and austere forward sites near the forward edge of the battle area (FEBA), exploiting the capabilities of either vertical or short take off. A flexibility of basing not available in conventional fixed wing aircraft.

Many benefits are derived through the forward basing of V/STOL aircraft: (1) The distance to the target is significantly reduced allowing quick reaction. (2) Lines of communication are shortened, reducing the time required to process the tactical air request. (3) Pilots are more knowledgeable of the tactical situation, terrain, friendly and enemy disposition, thus the aircraft can be quickly integrated into the fire and maneuver of the ground force. Forward based aircraft can wait on the ground until the ground commander needs assistance and then quickly respond to his requirements. This simplifies the process of integrating the close air support with the firepower of other supporting arms, thereby reducing response time to a minimum.

Response time comparable to forward basing can be achieved by air loiter; however, this is expensive to maintain, requiring a large number of aircraft, large amounts of fuel, and increased support requirements of maintenance and ordnance. Additionally air loiter exposes aircraft to enemy air defense systems for extended periods of time. V/STOL type aircraft cut response times to less than one-half that of conventional aircraft on ground alert.

Target identification, a key element in the integration of close air support into the maneuver scheme of the ground commander, is improved by locating the supporting close air support assets near the FEBA. Pilots will receive extensive briefings, often from their ground counterparts, that will enhance the coordination required for rapid target briefs and identification. These briefs will be accomplished prior to pilots assuming an alert status.

Enemy air defense systems require innovative ideas for marking targets on the part of both the pilot and the ground commander. Target marking will have to be coordinated precisely with the pop-up delivery technique of the aircraft in order to ensure first-run effectiveness. This type of coordination can only be achieved through face-to-face contacts that can be made near the FEBA.

Fire support coordination procedures must not inhibit a ground commander's employment of other supporting arms. Forward basing of the Harrier allows the aircraft to fly a low-level high-speed profile both into and out of the target area. This reduces the number of controlling agencies the aircraft is required to communicate with. The direct air support center (DASC) is capable of integrating the mission into the other supporting arms requirements of the ground commander.

The Harrier as a weapons system does not possess the all weather capability of some attack aircraft, but during periods of low ceilings and reduced visibility the aircraft will be able to operate visually. Through basing flexibility the aircraft will already be in the operating area, thus reducing the requirement to fly into the area at altitude and then attempt to penetrate below the clouds in order to run a visual ordnance mission. The Harrier based near the FEBA will be able to launch, fly a mission and recover while remaining clear of clouds.

The close coordination between ground and air units that is available through forward basing allows for the development of communication procedures and techniques that could be utilized during the delivery of ordnance. This coordination would permit the delivery of ordnance without the aid of a forward air controller, should one not be available. The Harrier has radios that are compatible with ground units down to the platoon level.

Weather and enemy defenses are major factors in the choice of ordnance. One solution to this problem is to load various types of ordnance on the aircraft so that it will have some of the proper type. This may not always be practical. Optimum ordnance delivery capability can be achieved through selectively loading forward based aircraft. Ground loiter near the FEBA provides more flexibility in changing ordnance or fuzing if desired.

The requirement for supporting the ground commander has not changed since the inception of close air support. Only the techniques and execution of close air support have changed, as enemy weaponry has improved or as new equipment was introduced into service.

FUTURE OF CAS

What does the future hold for CAS operations? Is it possible that air defenses are getting too sophisticated? Can we anticipate that classic close air support as practiced in World War II, Korea, and Vietnam, may be an outmoded concept except under favorable conditions. At first glance the case against CAS is simple, it appears that the balance of capability lies heavily in favor of new air defense systems. Their increasing effectiveness in recent years has imposed serious constraints on the employment of close air support assets on the modern battlefield.

The 1973 Mideast War is the most commonly cited example of the improvements that have been made in air defense weaponry.[10] Observers of that war have stated that it is pointless to continue to produce and employ close air support aircraft on the modern battlefield. If these observers are right in their assessment, U.S. forces will be unable to employ their single most formidable means of firepower in which we enjoy an advantage relative to the Soviets.

The lack of tactical air power on the modern battlefield would have a significant impact on the employment of Marine ground forces, for the ability to employ tactical air in the close air support role is a major factor upon which their survival depends. The success of Marine Corps peculiar operations is predicated on the ability to conduct tactical air operations in support of the ground element.

The question of whether or not it is feasible to employ close air support on the modern battlefield will not be answered in this paper. The hypothesis presented herein is that the future survival of close air support assets on the modern battlefield depends on the continued development of V/STOL technology and concepts and their application in conjunction with efforts directed at defeating an enemy's air defense systems.

FOOTNOTES

[1]General Vernon E. McGee, "The Evolution of Marine Aviation," Marine Corps Gazette, August 1965, p. 22.

[2]McGee, p. 23.

[3]General Vernon E. McGee, "The Genesis of Air Support In Guerrilla Operations," Proceedings, U.S. Naval Institute, January 1965, p. 53.

[4]McGee, p. 54.

[5]Joint Chiefs of Staff Publication 1. Dictionary of Military and Associated Terms. (Washington: U.S. Government Printing Office, March 1973).

[6]U.S., Congress, House, Committee on Armed Services, Subcommittee on Tactical Air Support, Close Air Support, Report, February 1, 1966 (Washington: Government Printing Office, 1966).

U.S., Congress, Senate, Committee on Armed Services, Special Close Air Support Subcommittee, Close Air Support, Hearing, April 1972 (Washington: Government Printing Office, 1972).

[7]U.S., Department of Defense, Department of Defense Close Air Support Report (Washington: Government Printing Office, 1971).

[8]Colonel Stanley P. Lewis, "V/STOL Close Air Support in the U.S. Marine Corps," Proceedings, U.S. Naval Institute, October 1976, p. 113.

[9]Lewis, p. 114.

[10]"Both Sides of the Suez; Airpower in the Mideast," Aviation Week and Space Technology. Special Edition (New York: McGraw-Hill, 1975).

CHAPTER IV

V/STOL EMPLOYMENT

Currently there are four tactical employment concepts utilizing V/STOL aviation assets. The United States Marine Corps has developed a single, multi-phased concept for the Harrier; the Royal Air Force has devised two basic concepts utilizing the Harrier, and the Soviet Union has developed a single employment concept for its YAK-36. This chapter will discuss the Marine Corps' and Royal Air Force's employment as well as some emerging naval concepts. The Soviet Union's experience with the YAK-36 will be covered in a separate chapter.

The tactical employment concepts utilizing V/STOL assets, in use today, exploit the basing flexibility of the aircraft. Inherent in this basing flexibility are the tactical operating characteristics of mobility, flexibility, and versatility. All of these operational considerations are enhanced and in some cases revolutionized in their application to V/STOL aircraft employment.

V/STOL aircraft allow the planner freedom from vulnerable fixed bases and rigid employment concepts. Freedom from fixed bases provides dispersal and concealment of tactical air assets. Dispersal and concealment are military principles that have gained validity throughout years of conflict. In order to understand the importance of these principles the question of airfield vulnerability must be addressed.

Airfields have always been lucrative targets, whether through pre-emptive strikes or continued attacks. Military planners have always considered the threat of tactical air could best be neutralized by the destruction of the airfields from which tactical air operates. On the modern battlefield, airfields are more vulnerable because of the development of precision-guided munitions (PGM). PGM are particularly effective against fixed installations. This would indicate that airfields are more susceptible to destruction than they have been in the past. This tends to add further validity to the principles of dispersal and concealment on the modern battlefield.

James Digby of the Rand Corporation, writing on the effectiveness of precision-guided munitions, had the following comments:

> It will become much less desirable to concentrate a great deal of military value in one place . . . If the attacker has a finite number of PGM, any one of which has a high probability of destroying its target, then it is better to force him to spread them over many targets which are individually of small value.[1]

While Digby was not referring specifically to airfields, the implications are clear. Precision-guided munitions can probably defeat airfield defenses and render runways ineffective. Mr. Bill Bedford of Hawker Siddeley Aviation Ltd., a strong proponent of V/STOL, best summarized the argument against large airfields and the concentrating of assets when he referred to the static airfield as being the "Achilles Heel" of tactical aviation.[2] The capabilities of PGM paint a dim future for fixed installations, but their effectiveness can be reduced by applying the principles of dispersal and concealment.

V/STOL assets achieve dispersal through basing flexibility. Dispersal is achieved without effecting the versatility, responsiveness, or flexibility required for effective tactical air operations.

MARINE CORPS CONCEPT

The Marine Corps' multi-phased employment concept was developed to support the Marine Amphibious Force during the amphibious assault.

Marine Amphibious Forces are balanced, self-sufficient forces with a broad spectrum of capabilities. They are a mobile force available to provide almost immediate response ranging from a show of force to assault on a hostile shore. This force possesses a high degree of tactical mobility and can project combat power ashore in varying degrees of strength consistent with national interest, aims or objectives. The force can be rapidly withdrawn, providing the national command authority the positive control of the level and duration of United States involvement. An amphibious force has the complete freedom of action required for projection of combat power. Local airfields, port facilities or overflight rights are not required for the successful prosecution of amphibious operations.

Historically the amphibious operation, requiring forceable entry into enemy held terrain, is one of the most difficult of all military operations. The rapid buildup of combat power ashore, from zero capability initially to fully coordinated combined arms combat power, is the key to success in the amphibious operation. The Marine Corps long ago recognized the value of close air support in the amphibious assault. In the absence of artillery support available in conventional land warfare, the Marine Corps evolved the techniques of close air support (CAS). During the early phasing ashore of the operation, close air support and Naval gunfire represent the only supporting arms available to the Marine ground commander. Naval gunfire assets have decreased significantly since World War II, and close air support is the only resource available during the early phase of the amphibious operation.

The capability to conduct tactical air operations is essential to the success of the amphibious assault. This requires a flexible, responsive aviation combat element structured to meet the anticipated situation. V/STOL aviation provides that flexible response through basing flexibility.

Basing Flexibility - From the preceding chapter on close air support, it can readily be seen that much of the time consumed during the CAS mission equated to transit time or loiter time, if the airborne loiter mode was used. Basing near the FEBA, utilizing the flexibility of V/STOL, was given as one of the ways of reducing the response time between request and accomplishment of the mission. Other benefits of this basing flexibility are: (1) The aircraft can carry heavier ordnance loads when the operating radius is short, due to less fuel required for transit time. (2) The transit time per sortie is reduced, thus more sorties per aircraft are available. Also more ordnance can be delivered on target during a given period of time by the same number of aircraft. (3) Less maintenance time per mission cycle is required, since less flight time is accrued.[3]

Flexibility is the most significant operational characteristic of tactical aviation. The basing flexibility of V/STOL aircraft allows for employment from shore bases or afloat. Operational circumstances will dictate the basing scheme to be utilized, but they can be generally categorized as: (1) sea bases, (2) sea platforms, (3) main bases, (4) facilities or (5) forward sites.

1. Sea bases utilized are the LPH or LHA. These ships were designed primarily for helicopter use and transportation of landing force assets. Operational experience has shown that a detachment (6 aircraft) of AV8's can operate aboard these ships along with helicopters without degrading the capabilities of either. The flight deck of the LPH or LHA

allows the option of a short take-off (STO) which significantly increases the payload of the Harrier. The sea base provides all weather operational capability and intermediate level maintenance support. They have the capability to sustain operations for extended periods of time.

2. Sea platforms may be the flight deck of any helicopter capable ship. The vertical take-off capability (VTO) of the AV-8A enables it to operate from any platform that can handle the CH-46 or CH-53 helicopters. The AV8 will cycle from the sea base to the sea platform, where it will await a mission in ground loiter. Sea platforms are utilized much the same way as forward sites and as such only minimal support is available, normally fuel and ordnance.

3. As control of the beachhead is gained, AV8 operations are established ashore and move inland as the FEBA moves. The main base ashore will be capable of providing complete support for the V/STOL squadron. It will provide the capability to operate day, night and all weather conditions. A main base will normally be an existing airfield that the AV8 will share with other aircraft. If an existing airfield is not available a main base will be established capable of handling twenty aircraft, with a runway length of at least 1,500 feet.

4. As the FEBA moves inland with the expansion of the area of operations, it is desirable to locate AV8 detachments nearer supported ground units. The type of installation used is a facility. The facility should have a minimum runway length of 600 feet and be capable of handling up to ten aircraft. A battle damaged existing airfield could easily be used as an AV8 facility or one could be established ashore within a 72 hour period. Organizational maintenance, fuel and ordnance will be provided at the facility. The facility will support day and night visual flight operations.

5. Individual aircraft or a section of AV8's may be located at forward sites when circumstances call for rapid response. A forward site is a ground loiter alert station where direct liaison can be established with the forward air controller. An abandoned or bombed airstrip or a segment of road could be utilized for a forward site. The segment of road would allow for short take-off or landing operations (STOL) to increase the payload. The tactical situation will dictate the type of support available at the forward site, but normally nothing more than fuel will be provided. Operations from a forward site will be day visual flight operations only.

Advantages provided by forward basing in supporting Marine ground forces during the amphibious assault have been amply demonstrated by the multi-phased Marine concept. The Marine Corps has validated their V/STOL employment concept and has incorporated the various basing concepts into their training and operational deployments.

RAF CONCEPTS

The RAF developed two concepts of employment, one for their three squadrons in Germany and another for the squadron in England. Both concepts utilize the basing flexibility of the Harrier.

RAF squadrons in Germany are tactically deployed as part of NATO's air forces. The aircraft are dispersed at a number of preselected sites where maximum use is made of concealment and existing facilities, such as barns, woods, and roads. Concealed logistic parks provide support to the sites. Sites contain enough fuel for 24 hours of operation and are restocked at night. The concept is based on mobility. Each site is virtually self-contained and is capable of rapid movement and relocation. It is not uncommon for a pilot to launch from one site and to recover at a completely new location. Site moves would be made as the tactical situation dictated.

Sites are capable of daylight operations only and limited to visual flight conditions. Within the sites, each aircraft is connected to the site headquarters by telephone, thus allowing briefing of the pilot while he is in the cockpit. This allows greater responsiveness and high sortie rates. This concept has proven to be very successful. RAF Harriers have achieved high sortie rates per day, rapid response times, and achieved this without their sites being detected.[4]

The employment concept for the one Harrier squadron in England is based on that squadron being completely deployable by air. The entire squadron, including its personnel and logistic support, is deployed to an airfield. The aircraft are then dispersed, either within or just outside the airfield perimeter. The aircraft are concealed, and then operate the same as those in Germany, except that the airfield taxiways, ramps, or runways are used for take-off and recovery.

Admittedly, this concept is not the best of the two alternatives, but it has been proven successful and is clearly applicable in principle to operations by other V/STOL aircraft operating from airfields. Experience has shown that while an attacker may know the location of an airfield, individual aircraft that are dispersed and concealed are hard to destroy. Additionally, if these dispersed aircraft possess V/STOL characteristics, it is virtually impossible to stop operations completely by simply attacking the airfield.[5]

NAVAL CONCEPTS

Since the end of the Korean conflict, the projection of combat power by naval forces has been used numerous times by the United States to respond to crises throughout the world. The aircraft carrier plays a major role in this power projection by naval forces. Despite the unique ability of carriers to respond to crises, the future of the large aircraft carrier concept is being seriously questioned. As aircraft carriers have become more complex and costly the United States Navy has been asked to study reducing the number of carriers currently in the fleet, and it is unlikely that another nuclear carrier will be built.[6] Faced with this problem the U.S. Navy was quick to recognize the possibilities that V/STOL offers.

While the future of large carriers is being questioned, the need for long-range maritime patrol aircraft integrated with high-performance combat aircraft based with the fleet still exist. These combat aircraft provide fleet protection as well as quick reaction for the long-range patrol aircraft. The vulnerability of the fleet without air cover has been documented in naval history. If the large carrier concept proves to be too expensive to support, the requirement for responsive high-performance aircraft can still be met by using sea based V/STOL aircraft dispersed from a variety of sea platforms. Seaborne V/STOL aircraft provide a less expensive means of fulfilling any of the traditional missions of naval aviation. Already Western world and Soviet navies are developing V/STOL capable ships and various V/STOL concepts of employment are emerging. Worldwide, the V/STOL concept is being pursued more aggressively by naval air power than by land-based air forces.

Since introducing the AV-8A into service the Marine Corps has deployed Harriers aboard air-capable ships both in support of the Marine on the ground and in support of the fleet. A Marine squadron recently completed a 10-month cruise aboard a conventional aircraft carrier, where the integration of V/STOL and conventional flight operations proved to be a compatible concept. The Harrier provided the carrier a combat capability and flexibility that did not exist with conventional take-off and landing aircraft.

The future is bright for the naval applications of V/STOL technology. The appearance of the Soviet's V/STOL capable ship only lends emphasis to the desirability of such applications. Great Britain is currently working with its Sea Harrier project that will utilize the Royal Navy's new through-deck cruisers now being built. The Spanish have also deployed the Harrier taking advantage of V/STOL in its naval air arm.

FOOTNOTES

[1]James Digby, Precision-Guided Weapons, The International Institute for Strategic Studies, Adelphi Paper No. 118, Summer 1975, p. 4.

[2]A. W. Bedford, "Is the Airfield the Achelles Heel of the Conventional Combat Aircraft?", Interavia, May 1972, p. 497.

[3]LtCol J. W. Orr, and LtCol R. E. O'Dare, "V/STOL will do the job from carriers, sea platforms, airfields - or parts of all. Even roads, pads or whatever," Marine Corps Gazette, May 1977, p. 40.

[4]Wg Cdr Peter P. W. Taylor, "The Impact of V/STOL on Tactical Air Warfare," Air University Review, November-December 1977, p. 77.

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CHAPTER V

SOVIET V/STOL

When the first Soviet aircraft carrier passed through the Bosporus and the Dardanelles into the Mediterranean Sea in July, 1976, it was not only the ship that gained the attention of the Western World, but also the aircraft that it carried. The appearance of the KIEV and its YAK-36 "Forger" vertical takeoff and landing aircraft marked yet another milestone in force modernization achieved by the Soviet military in the past twenty years. With the deployment of the aircraft carrier KIEV and the helicopter carrier MOSKVA, Soviet air forces have transitioned to a balanced force capable of performing a variety of basic military tasks.[1]

The United States and other nations have deployed ships as bases for weapons systems, but the Soviets were the first to deploy ships specifically designed to integrate weapons systems. Basing is defined as providing support for the airborne weapons system, whereas integrating means that the ship and aircraft are mutually supporting parts of the total weapons system. The Soviets first integrated their anti-submarine warfare aircraft aboard the MOSKVA class helicopter cruiser. Their next effort at integration was the KIEV class carrier.[2] The deployment of the KIEV was linked with the development of the Forger, their first operational high performance VTOL aircraft.

Aerospace is one of the most capable segments of Soviet industry and it would be foolish to ignore recent Soviet achievements in the V/STOL field. The emphasis Soviet aviation has put on the V/STOL concept is considerable and it is apparent that V/STOL holds a much higher priority in the Soviet Union than in the United States. The purpose of this chapter is to look at Soviet progress in V/STOL, briefly compare the Forger and Harrier, assess the impact of the KIEV Forger deployment, and examine future roles and missions of Soviet V/STOL forces.

The appearance of a V/STOL aircraft had been anticipated for some time, but the precise form that it took was a surprise to many. In 1967, the Soviets first publicly demonstrated three STOL fighter test aircraft with lift engines and one experimental V/STOL vectored thrust aircraft. The vectored thrust aircraft was assigned the name Freehand. A few years later intelligence sources identified an additional V/STOL development aircraft, thought to be destined for use on the KIEV. This aircraft was known as the Ram-G, with a vectored thrust propulsion engine and fore and aft lift engines similar to the West German VAK-191. For some unknown reason this aircraft has not been developed beyond initial evaluation and testing. The Soviets first experimental design utilizing vectored thrust, the Freehand, was developed into the YAK-36 Forger. This new aircraft utilizes two lift engines forward and a single lift/cruise engine aft with swivelling exhaust nozzles.[3]

Although design specifications for the aircraft to be deployed on the KIEV class ships are not known, it is obvious from the design of the Forger that the Soviets concentrated on vertical take-off and landing rather than STOL. The emphasis on VTOL would seem to indicate that the weapons/load carrying capability of the aircraft has not been one of the principal design criteria. It is certain that the aircraft was designed and developed for use aboard the KIEV class ship. This certainty is supported mainly by the fact that the aircraft elevators, utilized to move the aircraft from above or below decks, are sized exactly for the Forger and its folded wing span. The elevators appear more as slots in the deck than as conventional aircraft elevators. It has been assumed that the Yakovlev design bureau is responsible for the Forger since it developed the Freehand, but it is more likely the result of collaboration between two Soviet bureaus.[4]

Although the Forger was most likely developed for a different role than that of the Harrier, these two aircraft represent the only operational V/STOL combat aircraft. It is therefore necessary to compare the two aircraft and their relative merits.

The Harrier has the advantage on the basis of overall flexibility and simplicity of operation. It offers the choice of V/STOL, VTOL and STO/VL, whereas the Forger is only capable of VTOL. The Forger is very vulnerable during VTOL operations, acceleration is slow and transition to wingborne flight takes up to one and a half minutes from lift-off. There is also the increased potential of engine failure when operating with three engines, the loss of any one would be catastrophic during the critical take-off and landing phases. However, because the lift and propulsion engines in the Forger are separate, no large frontal area for intake air is required.

The Harrier is more maneuverable in flight due to lower wing loading and a higher thrust to weight ratio. The Harrier's ability to vector thrust in flight cannot be overlooked when discussing maneuverability. The ability to vector thrust in flight has proven to be a real asset in air combat situations. The Soviets on the other hand, by using a thin mid-mounted wing coupled with a small frontal area for air intake, appear to be seeking higher dash speeds at the expense of maneuverability. The lift plus lift cruise concept can benefit considerably in forward speed with only small increases in main engine thrust.

The Forger, with only four external hardpoints, is limited in weapons carrying capability, despite future increases in total lift thrust that may be achieved. The Harrier, with seven hardpoints, is capable of a greater mix of ordnance as well as weight.

The Soviet aircraft has some advantages over the Harrier. Its VTOL flight characteristics will allow it to operate from small deck spaces on various Soviet vessels. The Soviets have achieved an all-axis stabilization system that appears to be superior to the Harrier, thus enhancing operations from small decks. Take-offs and landings have been described by observers as rock steady. Additionally, the folding wings of the Forger allow storage in greater numbers than the Harrier.

The aircraft observed aboard the KIEV are part of the first production run and design modifications and refinements are likely in the next two or three years. The Forger will require uprated engines and some way of increasing the combat load, most likely through fitting a centerline pylon, if it is to move toward matching the Harrier in load carrying capability.

The performance differences between the Harrier and the Forger are not significant when considered as part of the overall balance of the world's naval powers. However, there are many aspects of the Forger that are significant. It is the first high performance VTOL design to be deployed operationally since the Harrier. Additionally, the Forger was conceived and designed as part of an overall air-capable Soviet Navy. It is not just an isolated aircraft design.

The deployment of the Forger should have considerable impact on the thinking of the military services of the Western World. The Soviet Navy has added another dimension to its capabilities, and the Forger has added considerable reinforcement to the validity of the V/STOL concept. Many have called the appearance of the Forger the biggest boost to V/STOL since the Harrier became operational. Lieutenant General Thomas H. Miller, Marine Corps Deputy Chief of Staff for Aviation, when asked about the impact of the Forger commented, ". . . maybe it proves that while we may not have convinced some people on our side, we have obviously convinced them on the other side! Let us just say that it has strengthened our confidence in our own efforts."[5]

Prior to the deployment of the KIEV and her VTOL aircraft the Soviet Navy had been severely restricted by the range limitations of land based aircraft. The appearance of the KIEV comes at a time when increasing numbers of bases are available to Soviet aircraft, but the KIEV remains the most significant base. The familiar words, once used to describe United States carriers, of flexibility and mobility can be used to describe the KIEV. As a base she is politically independent and represents a symbol of Soviet capabilities.

The ship and her aircraft can operate in high-threat areas where there is a danger of carrier or land based air attack. The Forger represents the main armament of the KIEV, and despite its limitations it would be effective against second line warships and merchant vessels. It could be used in an air to air role to intercept patrol aircraft and helicopters, including those launched from ships to provide reconnaissance against Soviet warships.

The Soviets realize that the V/STOL concept has much to offer, and with the success they have achieved with the Forger the Western World can expect to see a more sophisticated V/STOL aircraft in the near future. John W. R. Taylor commented, in Jane's Aerospace Review 1976-1977, that, "if the Soviet Navy was prepared to show off the YAK-36 (Forger) so blatantly, we must assume that it is regarded as merely a first step toward something better."

The KIEV is the largest and most expensive warship to be produced in the Soviet Union, and at least two more KIEV class carriers are being built. A total of four are expected by 1982. As these ships deploy with their embarked VTOL aircraft and as the Soviets continue to observe their capabilities, more V/STOL capable ships are expected. It is believed that the Soviets are planning to assign their next KIEV class carrier to the Pacific. Japanese sources indicate they have received a contract from the Soviets for a floating dock capable of handling a KIEV class ship. Vladivostok appears to be the likely location.[6]

Until now, it has been thought that the Forger would be employed strictly in antisubmarine and interceptor roles. During recent operations in the Mediterranean, however, the aircraft has been observed making surface attacks. Couple these recent observations with the Soviets' concern for airfield vulnerability, and it seems evident that it is only a matter of time before a land-based ground attack VTOL or V/STOL aircraft appears in Eastern Europe to oppose NATO forces. This new V/STOL aircraft could well be one that will take advantage of the KIEV's 600 foot length for STOL operations as well, thus allowing higher take-off weights to be achieved.

Through V/STOL technology the Soviet Navy, that was once a predominantly submarine force, is emerging suddenly as an international, long range, balanced instrument of Soviet national policy.

FOOTNOTES

[1]Bernard Weinraub, (New York Times News Service) "Air Attack Threat to NATO," Kansas City Times, January 30, 1978.

[2]Capt Gerald G. O'Rourke, "Our Coming Air-Capable Navy," Proceedings, U.S. Naval Institute, May 1977, p. 98.

[3]"V/STOL's Coming of Age," Interavia, January 1977, p. 27.

[4]Ibid.

[5]"V/STOL's Coming of Age," p. 34.

[6]"Soviets Buy Floating Dock," Aviation Week & Space Technology, January 16, 1978, p. 34.

CHAPTER VI

CONCLUSION

This paper has examined the V/STOL concept and what it means to tactical aviation. The development of V/STOL technology was first examined in an effort to show that the concept is nothing new. In fact the first V/STOL patent specifications were traced to the World War II era. The first experimental V/STOL aircraft flew over twenty-three years ago. Since that flight many concepts have been tested, resulting in the development and operational deployment of the AV-8A Harrier. The Harrier is the result of design and modification refinements of two earlier aircraft, representing over eleven years of testing. It is truly not a first generation airplane, as the helicopter was when it was introduced.

Next, the requirements for close air support were examined, specifically as they applied to the Marine air-ground team. The requirements for close air support have not changed, but the V/STOL concept represents a significantly new approach toward meeting these requirements; mainly through exploiting the basing flexibility provided by V/STOL aircraft.

What then has V/STOL provided the ground commander? That question was answered by discussing V/STOL employment concepts. V/STOL aviation assets provide employment flexibility and increased responsiveness for the ground commander. The V/STOL concept is ideally suited for the amphibious assault. Combat ready forces afloat with V/STOL aviation assets represent a potent force, immediately responsive to the National Command Authority.

The final part of this paper examined Soviet development of V/STOL aircraft and V/STOL capable ships. It is apparent that the Soviets place a high priority on V/STOL development and operational deployment. Thus far the United States has failed to recognize the significance of an air capable Soviet Navy. The Western World is rapidly losing the advantage it once held in V/STOL technology.

V/STOL is a viable concept, with a future in tactical aviation. When the relative merits of different alternatives or concepts are discussed, opponents have a tendency to focus on certain disadvantages and usually fail to reach a balanced view. The V/STOL vs. conventional aircraft argument is no exception. Opponents of the V/STOL concept tend to focus on the aircrafts' accident rate as being a distinct disadvantage of V/STOL and fail to recognize the many advantages of the aircraft. Much has been written about the AV-8A accident record but little analysis has been done by those writers.

V/STOL aircraft routinely perform missions in shorter time than conventional jet aircraft resulting in less flight time per flight. They operate from unconventional facilities and are exposed to the increased hazards of more takeoff and landing cycles during a given number of hours. Since flight hours are used as the measurement base for accident rates, this tends to skew the rate in favor of conventional aircraft. Despite the recent increase in AV-8A accidents and their possible impact on the future of the program, the overall Harrier accident rate compares favorably with those of conventional fighter/attack aircraft. The increase in mishaps is not related to design deficiencies but is primarily attributed to pilot error factors during conventional flight. Modifications are being made to improve aircraft flying qualities and reduce pilot workload, but such improvements are normal process for any aircraft.

Research for this paper revealed that very few people in the decision making process are knowledgeable of the V/STOL concept or its applications, although many are already convinced one way or the other. This lack of knowledge was exhibited recently by Representative Robert L. Leggett, Chairman of the House of Representatives, Task Force on National Security, Committee on the Budget, when he stated that a large part of what he knew about the Harrier was from what he read in the newspapers. He further indicated that newspapers dealt mainly with the aircrafts' accidents. At the time Representative Leggett made this statement, he was presiding over hearings on tactical air warfare. These hearings will have a direct bearing on the defense budget for the next five years. The broad scope of this paper then has been to provide further information on V/STOL concepts and applications.

The Marine Corps has validated the V/STOL employment concept and is committed to an all V/STOL light attack force by the mid 1980's. The Marine mission requires a maximum of scenario independent flexibility, a characteristic to which V/STOL is well suited. Further, V/STOL offers highly responsive close air support for the Marine air-ground team. With an understanding of the role of Marine air as part of the air-ground team and of tactics and methods of employment utilized by V/STOL assets, the Marines' commitment to an all V/STOL force is understandable.

V/STOL has a future in tactical aviation. Unfortunately, some of the indications for the future of V/STOL are clouded. Years of practical experience and thousands of flight hours have been accumulated since the Harrier first flew. Much has been learned about operational concepts, logistic support, and operating costs. New concepts have been developed and modified, keeping pace with changing tactical requirements. Yet despite these many years of V/STOL experience, skeptics remain.

This skepticism was directly reflected in the fiscal year 1979 budget. All production funding for the AV-8B was eliminated and prototype funding was reduced by one-half. In separate guidance for preparing FY 80 budgets, the Navy and Marine Corps were told that the AV-8B would not be built unless it was proven more cost-effective than other non-V/STOL aircraft.

While there are obvious political and economic considerations that must be recognized, the military advantages offered by the V/STOL concept far outweigh the political and economic factors that have surfaced thus far. Present applications and future concepts that are attainable through the advanced technology of composite wings and increased engine thrust present a strong case for continued research and development in V/STOL technology.

V/STOL has come of age and will be accepted by those who now doubt the capability of fixed-wing jet aircraft with vertical take-off and landing ability. More importantly, the V/STOL concept is necessary to further enhance close air support for the Marine rifleman in combat because of its unique capabilities. Finally, the V/STOL program and concept goes beyond providing V/STOL for the Marine Corps--it is the only program which will give operational continuity to the United States V/STOL experience into the 1990's.

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