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THE V-22 OSPREY: A CASE ANALYSIS

by

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The V-22 Osprey: A Case Analysis

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of the requirements for the degree of

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ABSTRACT

This thesis is a case analysis of the V-22 Osprey program. It examines the history of tilt-rotor technology, as well as the history of the program management. Congressional, OSD and USMC/USN interplay is detailed chronologically from 1980 through to 1991 with particular reference to Congressional action during this period. Various studies and simulations are analyzed with the objective of establishing the V-22 as an aircraft which is capable of fulfilling wide-ranging mission criteria established by the Services much more effectively and efficiently than current or planned aircraft. The commercial and foreign military sales markets for the V-22 are also examined. This thesis concludes that the tilt-rotor concept has considerable worldwide potential for both military and civil applications.

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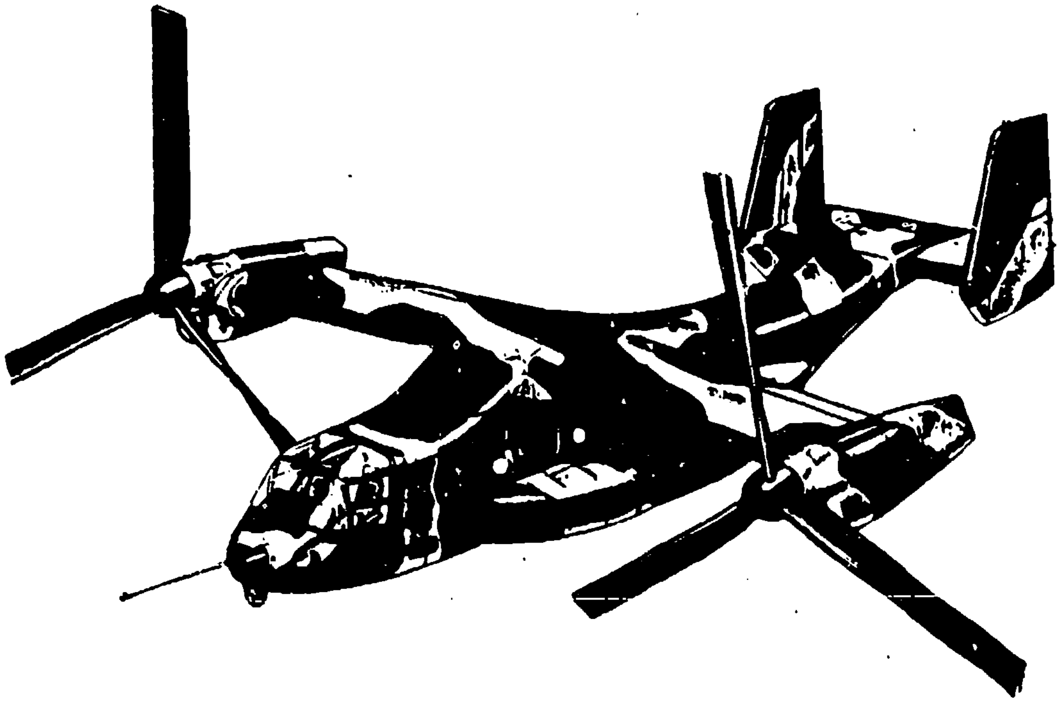
I. INTRODUCTION



> "The Bell-Boeing V-22 Osprey Program is one of the most ambitious aviation acquisition programs in history. The challenge of integrating three new or relatively new technologies (ie. tilt-rotors, all composite airframe, and fly-by-wire digital controls), makes the V-22 Program one of our 'highest tech' aviation acquisition programs. To date, the Osprey's tilt-rotor technology has yet to be integrated successfully into either a commercial or military aircraft [Ref. 1:p. 4]."

The above statement was based on an analysis of the V-22 Osprey Program conducted in 1988. Three years and five prototypes later, the status of the V-22 Osprey remains much the same and the future remains unclear. Although the program was adequately funded through fiscal year 1989 ($333.9 million in advance procurement funding was appropriated for the pilot production long lead time efforts), the V-22 Program is currently in a deadlock status. In an amended fiscal year 1990 budget submission, the Secretary of Defense deleted the program due to its high cost relative to its fairly narrow mission, stating the mission could be performed by helicopters. Subsequently, Congress restored Research & Development funds through fiscal year 1990, but delayed a decision on production funding [Ref. 2:p. 1].

This thesis will review the V-22 Program and analyze the events leading up to its current status in hopes of providing a better understanding of how and why it is such a controversial issue.

The thesis is divided into six chapters: This chapter is a brief introduction. Chapter II will discuss the background and chronological events leading up to concept formulation of the V-22 Program (Milestone 0). Chapter III will analyze program management, contractual developments and acquisition strategy (Milestone 0 through Milestone II). Chapter IV will discuss the interface between Congress, the Department of Defense, and the Marine Corp/Navy while providing an in-depth look at the Congressional history of the program. Chapter V will analyze and compare the V-22 against proposed alternates. Missions investigated include Combat Support, Combat Search and Rescue (CSAR), Anti-Submarine Warfare (ASW), and Special Operations.

Primary emphasis is on the Combat Support or Marine Corps missions as the Marine Corps is the lead service for the program. Chapter VI will analyze the commercial potential of the tilt-rotor concept and detail opportunities available to the contractors apart from the military procurement program, including a brief analysis of Australian requirements. Chapter VII discusses conclusions and recommendations on the program's history and possible future. Included in Appendix A is a list of "V-22 Firsts" contributed by the Bell-Boeing team.

II. BACKGROUND

The V-22 is a tilt-rotor aircraft designed to take off and land vertically like a helicopter and to fly like an airplane by tilting its wing-mounted rotors forward to function as propellers. The V-22 is being developed in a joint effort by Bell Helicopter Textron based in Fort Worth Texas and the Boeing Company based in Seattle Washington. It will be required to perform various combat missions, including medium lift assault for the Marine Corps, combat search and rescue for the Navy, and long range special operations for the Air Force. Details of the aircraft's characteristics are shown in Appendix B.

The concept of the tilt-rotor aircraft is almost as old as the commercial helicopter, formulated at Bell Helicopter in the late 1940's. "Conceptually, this helicopter/airplane could go twice as far and twice as fast as a comparable sized helicopter - on the same amount of fuel. It would have twin 3-bladed rotor systems mounted at the tips of the wing. In the helicopter mode the rotor blades would rotate in a horizontal plane. Then, during forward flight, the rotor hub would be tilted forward 90 degrees and the rotor blades would rotate in a vertical plane like an airplane propeller. Thus, the basic concept of the tilt-rotor was born [Ref. 3:p. 1]."

Evolution of the V-22 Osprey Program continued through the 1950's with the design and development of Bell Helicopter's XV-3, the first tilt-rotor aircraft to successfully convert from helicopter to fixed wing aircraft. This first in-flight conversion took place on 18 December 1958.

The XV-15, a follow-on to the XV-3 tilt-rotor program, was initiated even prior to the XV-3 program's completion: "Research and development continued during the 1960's but with little government assistance. In 1972, the Department of the Army and NASA awarded Bell Helicopter a contract to develop two tilt-rotor demonstrators designated XV-15's. In April of 1977, the XV-15 made its first hover flight and, in July 1979, a full in-flight conversion from helicopter to fixed wing. In 1980, both demonstrators met their predicted speed and altitude of 300 knots and 16000 feet respectively [Ref. 4:p. 5]."

Although the tilt-rotor concept was gaining interest, progress was slow. The Iran hostage situation in 1980 demonstrated the definite need for an aircraft with the capabilities projected of the V-22 Osprey. Timing of the development was not right however, forcing the U.S. to rely on the Sikorshy RH-53 Sea Stallion helicopter for the hostage rescue attempt in Iran. Unfortunately, the RH-53 Sea Stallions proved to be the weak link in the operation and the Iran rescue mission failed; the RH-53 aircraft were incapable of accommodating the rescue mission's weight and flight requirement. In the case of the Iran rescue mission, "the 900 miles of desert exceeded the operational range of all helicopters. A transport aircraft, such as the C-130, was not acceptable because it could be easily detected when landing near Teheran. The U.S. needed an aircraft capable of landing and taking off in a small secure area and flying undetected over a great distance. The U.S. needed an aircraft with the capabilities of the multi-service V-22 tilt-rotor aircraft currently undergoing acquisition. With tactical aerial refueling capabilities similar to the C-130's, the V-22 could have flown secretly across the Iranian desert at 200 knots in its airplane configuration, transformed to its helicopter mode, and landed undetected in a secure confined area near Teheran [Ref. 1:p. 2]."

Possibly, as a consequence of the unsuccessful Iran rescue mission in 1980, the year 1981 proved to be a major progressive leap in the evolution of the V-22 Osprey Program. Following an impressive demonstration on the XV-15 at a 1981 Paris Air Show, the then Secretary of the Navy, John Lehman, directed the Naval Air Systems Command (NAVAIR) to pursue the possible option of the XV-15 as a viable solution to the Marine Corp's aging H-46 fleet of helicopters. NAVAIR established the HXM Helicopter Weapon System Project Office in March 1982 with the first program manager assigned in June. By December of 1981, the Milestone 0 of the acquisition process had been achieved: "The Under Secretary of Defense for Research and Engineering (USD(R&E)) sent a memorandum to the Service Secretaries suggesting that the multiple rotary wing missions of the Army, Air Force, Marines and Navy might best be accomplished by a single advanced aircraft such as the XV-15. In December on 1981, the Secretary of Defense issued a memorandum establishing the Joint Services Aircraft program, JVX. This was regarded as approval for concept formulation, waiving the need for a formal need statement [Ref. 4:p. 6]."

On 7 June 1982, Bell Helicopter Textron Inc. and Boeing Vertol Company announced a teaming agreement to participate jointly in the JVX Program and, six months later, the JVX Joint Services Operational Requirement was published.

The JVX aircraft was officially designated "Osprey" by Secretary of the Navy John Lehman, in January 1985. "The Osprey is an ocean hunting member of the hawk family found throughout the world. It is noted for its agility, powerful wings, and swift flight. The military designation, V-22, was assigned to the new tilt-rotor. The U.S. Marine Corp's aircraft (MV-22A) will allow combat assault of 24 troops. The U.S. Navy's aircraft (HV-22A) will provide a combat search and rescue capability. The U.S. Air Force needs a Special Operations Aircraft (CV-22A), and the U.S. Army (MV-22A) requires and aeromedical evacuation, utility and logistics aircraft. The U.S. Navy is also studying an ASW version [Ref. 3:p. 4]."

May 1988 marked an historical point for the V-22 Osprey, for it was on this date that the Osprey took its maiden flight. Between this significant first flight and the middle of 1991, there have been five V-22's flown and 550 flight hours accumulated. The V-22 flight test program had proceeded along smoothly until 11 June 1991 when MV-22 Osprey tilt-rotor prototype No. 5 crashed just three minutes after its first flight lift-off. Despite this setback, Congress is still providing strong support for the V-22 Program, as evidenced by the inclusion of funding for the program in the FY90 thru FY92 budgets.

III. HISTORY OF PROGRAM MANAGEMENT

As discussed in Chapter II, there was a Joint Memorandum of Understanding between the service secretaries establishing the tilt—rotor aircraft weapon system acquisition program in August 1981. Following that August 1981 memorandum was a memorandum from the Deputy Secretary of Defense on December 30, 1981, which formally established the Joint Services Aircraft Program. Each service took this as approval for concept formulation which would waive the need for a formal need statement. Within the life cycle process for a weapon system acquisition, this served to fulfill Milestone 0. This was arguably the first time that a single aircraft had been identified with the multi-mission capability to serve the needs of all four services. The Deputy Secretary of Defense backed the Army as the executive service and appointed a Marine officer as the initial program manager. With the Army as the executive service the program would be executed using the standard Army development and acquisition procedures [Ref. 5:p. 4].

Each service agreed to reprogram $1.5 million to conduct a joint technical assessment of the technology available for this program. Under this assessment, in addition to the tilt-rotor, other technologies were to be examined. Among those were conventional helicopters, compound helicopters, the advancing blade concept and the lift/cruise fan concept. The tilt-rotor concept had the fewest drawbacks or conversely the most pluses of the technologies examined. Specifically, the lift-cruise fan was not fuel efficient; the helicopter could not meet all the mission requirements for range, speed and maneuverability; and the compound helicopter was heavier and had less hover efficiency. The tilt-rotor's strongest points were in terms of speed and worldwide self-deployability [Ref. 6:p. 22].

In June 1982, the Army Chief of Staff (because the Army was the executive service as appointed by the Deputy Secretary of Defense) formally announced the selection of the Joint Services Aircraft program manager which the Deputy Secretary of Defense had previousl. endorsed. The only formal training in program management this Marine officer had consisted of a three-week Executive Refresher Course and the twenty-week Program Management Course given by the Defense Systems Management College. Although a highly qualified aviator with a bachelor's degree in Electrical Engineering and a master's degree in Management, this was his first assignment as a program manager.

On June 4, 19[illegible], [illegible] Memorandum of Understanding was signed for the Joint Services Advanced Vertical Lift Aircraft Development Program (JVX) by the Secretary's of the Army, Navy and Air Force. There were three specific objectives of this particular Memorandum:

(1) Development of a common advanced technology vertical lift aircraft meeting multi-mission service requirements while achieving a significant increase in performance over current aircraft.

(2) Reducing Department of Defense costs through execution of a joint development program for a common aircraft.

(3) Achievement of the earliest practical Initial Operational Capability (IOC).

IOC tends to be the most crucial date in any weapon system acquisition. The inclusion of the "earliest practical IOC" statement in this Memorandum would seemingly indicate the program's importance to the services. Also included in this Memorandum were development funds for FY 1984 totaling $167 million and conditional funding approval (for planning purposes) for the rest of the development program. The shared funding was divided between the services as follows: Army - 46%; Navy - 42%; Air Force - 12%. A panel of Flag Officers was also established to oversee the program, resolve program issues and report back to their respective services [Ref. 7:p. 23].

During 1982 a Joint Services Operational Requirement (JSOR) was developed. This document identified ten service specific missions plus a joint requirement for self deployment for which the common KVX would be designed. This JSOR was approved in December 1982. Subsequent to that agreement, four missions were deleted in August 1984 and four other missions were added. With respect to aircraft specifics, the requirements called for an aircraft with a cruise speed of 250 knots and a minimum range or 2100 nautical miles, unrefueled. The anticipated buy for the number of aircraft was to be approximately 1100 for the three services.

Milestone I was reached in December of 1982 with the approval to proceed with the JVX by the Under Secretary of Defense. The Deputy Secretary of Defense approved an acquisition strategy for the Joint Services Aircraft on December 8, 1982 which NAVAIR (as the program manager) signed in January 1983. This strategy included risk reduction techniques as follows: use design, wind tunnel, and flight test data already developed during the Army/NASA XV-15 tilt-rotor program; encourage industrial teaming; and competing the preliminary design effort. This strategy also dismissed the requirement for a formal review of the program as required by DOD Directive 5000.1 since the Defense Acquisition Executive had approved the acquisition strategy. The Joint Services Aircraft did not require a separate demonstration and validation phase [Ref. 8:p. 31].

On December 13, 1982, the Secretary of the Navy approved an addendum to the June 4, 1982 Memorandum of Understanding designating the Navy as the executive service for the aircraft replacing the Army. According to the program manager, the Army deferred to the Navy regarding the IOC and the Marines (as part of the department of the Navy) had the most pressing need for an early IOC date. The Under Secretary of Defense (Research and Engineering) directed the Navy to take the executive service lead on December 27, 1982, but only for the airframe with the Army continuing as the executive service for the development of the modern technology engine. This memorandum also shifted the cost sharing proportions established in the original memorandum to:

Navy - 50% (up from 42%), Army - 34% (down from 48%), and Air Force - 16% (up from 12%). After the Navy took over as the executive service, the NAVAIR contracting officer, the Assistant Commander for Contracts (DOD), and legal counsel changed the contracting strategy from fixed-price level of effort to a cost-plus-fee arrangement [Ref. 8:p. 33].

The first Navy contracting officer was named in December 1982. This officer had been the contracting officer for three other programs, but had also been the Navy contracting officer for the Navy's forerunner to the Joint program. The second contracting officer was appointed by the Navy in February 1983. Subsequent contracting officers were from either the Navy or the Marine Corps.

Following the release of the final request for proposals for preliminary design work in January 1983, the contract for preliminary design was awarded to Bell-Boeing in April of 1983. Although the Navy anticipated two contractors would compete during the design stage, the Bell-Boeing team proposal was the only one received. The other anticipated proposal was expected to come from Sikorsky Aircraft but, despite an eight-month extension to the design stage, the proposal from Sikorsky failed to materialize.

In May 1983 the Army withdrew from the joint program. However, they rejoined the team in September 1983 after a Defense Resources Board meeting. This Board approved continuing with a fully funded Joint program for the JVX. The program continued in design development in 1984 with the combined Bell-Boeing team and the support of Congressional funding. The total number of aircraft projected for the program at this point was 913 (down from the originally anticipated 1100) with a unit cost of $14.6 million in 1983 dollars according to the Navy's acquisition strategy of December 1982. In January 1985 the Secretary of The Navy selected the name for the JVX to be the "OSPREY" with the first flight rescheduled for June 1988 and IOC planned for December 1991 [Ref. 8:p. 39].

In March 1985, a decision was made by the Secretary of the Navy to develop the OSPREY V-22 under a fixed-price incentive contract. This was the third shift of contracting type in its short history. When the full-scale development contract was awarded on May 2, 1986, Milestone II in the DOD acquisition process was completed. Six aircraft were ordered into full-scale development.

Coincidentally, the Navy's acquisition strategy was under evaluation from Congressional and House committees' concerned with waste and inefficiency.

Although the teaming agreement was to maintain the Bell-Boeing team with joint production through at least the fifth year from initial production delivery, top Navy management expressed a desire to have Bell-Boeing begin competing with the first production lot. The decision on when to have the two businesses compete, if at all, is still open for negotiation between the Navy and the contractors [Ref. 8:p. 39]. In all likelihood the final production contract will be effectively dual sourcing with the contractors being a Bell-Boeing consortium.

Congress funded the program for Fiscal Year 1986 through 1991 to the total of $2.7 billion of which $2.2 billion has been for research, development test, and evaluation [Ref. 9:p.8]. The first flight of the V-22 OSPREY took place on Sunday March 19, 1989.

In the Secretary of Defense's submission of the Fiscal Year 1990 budget, he deleted the entire program, saying the cost of the program was too high compared to its relatively narrow mission. When he cancelled the program, he also directed that $200 million of the Fiscal Year 1989 procurement funds to be re-obligated.

So what is the program status as of November 1991? The program remains in the development stage and is not currently ready for production, The major problems identified thus far with the program, although there are many minor issues, are with the weight, vibrations, display latency and software development. Additionally, the program has grown in cost. The total production cost, as of April 1991 estimates for 657 aircraft, is now $23.3 billion or $40 million per aircraft excluding engines. (It was $14 million in 1983). It is interesting to note that the total planned aircraft procurement had shrunk from over 1000 to 657 at the time the production portion of the contract was cancelled. It is now generally accepted that yet a much smaller buy will occur if the program ever does proceed to the production stage.

A potentially major blow to the program occurred on Tuesday, June 11, 1991, when the fifth prototype aircraft crashed just about three minutes into its flight in Wilmington, Delaware. It has since been determined that some faulty wiring to a gyro device caused reverse polarity resulting in bad flight control system inputs, and thus should have had little or no detrimental effect on the program as a whole [Ref. 10:p. 14].

The program manager is convinced the problems in the developmental craft can be fixed in production models. Congress is also still behind the aircraft at this time (June 1992). The Secretary of Defense, however, does not feel he can afford the program and continues to not include the V-22 in his budgets. Faced with this instability, Bell-Boeing is actively promoting the potential civilian applications for tilt-rotor technology. Chapter VI examines these non-military aspects and identifies them as a potential alternative. That chapter also considers the markets of foreign military services.

IV. CONGRESSIONAL, OSD, USMC/USN INTERPLAYS

A. EARLY CONGRESSIONAL HISTORY (1980 to 1987)

As discussed earlier, the V-22 procurement program grew out of a Marine Corps requirement to replace its medium lift helicopter capability. The Marine Corps/OSD made the decision to pursue tilt-rotor technology to meet this need and funding for JVX (which later became the V-22) was included in the FY82 Federal budget. Congress subsequently authorized and appropriated funds to initiate the program in FY82. Since that time the program has enjoyed relatively strong support in Congress. Reasons for this include the potential for civilian applications, other service (i.e., Army, Air Force) requirements, and the demonstration of a completely new and unique technology.

During this time the program also enjoyed strong support from within the Defense Department, most notable the Secretary of the Navy, John Lehman and the Commandant of the Marine Corps, General Gray. In addition, the massive military buildup initiated during the first Reagan administration under Secretary of Defense Casper Weinberger ensured adequate program funding.

Despite the favorable climate for the program's initiation, there were nay-sayers both at OSD and in Congress who felt the program's costs and technical risks did not justify its continuance. Against the program almost from its start was Dr. David Chu, head of DOD's Planning, Analysis and Evaluation (PA&E) shop. Secretary Lehman claimed that he "had to fight David Chu every year on the V-22 [Ref. 11:p. 14]." However, Lehman's considerable influence both at OSD and in Congress were successful in keeping the program well supported at both levels. Congress funded Full Scale development of the now "V-22" in FY86 and in May the Navy awarded a fixed-price incentive contract to Bell/Boeing for three ground test articles and six flight test aircraft. As an indication of the importance placed on the program by the Marines Corps, it assigned as program manager, Colonel Harry Blot, fresh from a successful tour as the AV-8B program manager. In 1988 the V-22 was listed as the Marine Corps as well as the Navy's number one aviation priority. The Navy's number one aviation priority at this time was actually the ATA or A-12. As a classified program, however, its status and hence priority were not subject to public disclosure.

Problems with the program surfaced in 1987. A new Navy Secretary, James Webb, under budgetary pressure, endorsed the program but with considerably less enthusiasm than his predecessor. The Army was having second thoughts about continuing in the program due to uncertain cost projections [Ref. 12:p. 2] and the Air force reduced its buy from 80 to 50 special operations force versions, again because of budget constraints [Ref. 13:p. 12].

B. PROGRAM CANCELLATION AND THE EVENTS LEADING UP TO IT (1988-1989)

Problems continued to grow for the V-22 program in 1988. The Army officially dropped out of the program in February, resulting in significant per aircraft cost growth. Additionally, program delays and weight growth threatened the entire program [Ref. 14:pp. 1-3]. The flight test program slipped from mid-1988 to March of 1989, with the first flight of the V-22 on 19 March. Congress became actively involved for the first time in 1988 in urging DOD to investigate the civil applications of tilt-rotor technology as a means of lowering overall program costs and "to give it some resistance to current uncertainty in funding [Ref. 15:pp. 6-7]."

In June of 1988 the OSD PA&E shop headed by Dr. Chu released its report recommending the termination of the V-22 program in favor of a more cost-effective all helicopter option. The report remains highly controversial as it was developed "in house" by the PA&E shop without input from either the Navy or the Marine Corps [Ref. 16:p. 1-4].

The remainder of 1988 was spent investigating various contracting options and funding plans to keep the V-22 a viable program. By the end of 1988 there were definite signs that the V-22 was in trouble. In November OSD cut the Navy's FY90 budget request from $1.2 billion to $900 million, funding 21 rather than the requested 36 production V-22's [Ref. 17:pp. 3-4]. The Marine Corp, however, still considered the V-22 its "highest priority aviation program [Ref. 18:p. 17]." In March of 1989 the Secretary of the Navy, William Ball, recommended a $1 billion cut in funding and a one-year delay in start of production. The Marine Corps opposed both the funding cut and the production delay [Ref. 19:p. 7].

C. PROGRAM CANCELLATION AND SUBSEQUENT CONGRESSIONAL RESPONSE

In April of 1989, the Secretary of Defense Cheney announced the cancellation of the V-22 based primarily on the recommendation of David Chu. As Dr. Chu stated in his earlier PA&E report, "the V-22 was a cost prohibitive option compared to an all helicopter buy of UH-60's and CH-53E's [Ref. 20:p. 18]." An amended FY90 budget was submitted to Congress in May of 1989, deleting all funding requests for the V-22 and, instead, requested funding for a new medium lift replacement alternative study (presumably Chu's all-helicopter option) [Ref. 21:p. 27].

Congressional response to Cheney's cancellation move was slow to materialize, by June the House Armed Services Sub-Committee on R&D had voted to shift $351.8 million from the B-2 and SDI programs to the cancelled V-22 program for FY-90 [Ref. 22:p. 1354]. Congressional support for the V-22, while always strong, increased markedly from June through the end of the year.

Representative Weldon and Senator Specter of Pennsylvania became the primary leaders of a growing coalition of congressmen who strongly supported continued V-22 development. By the end of

1989 this coalition included over 125 members of the House and 20 Senators.

By November both the House and the Senate had included full R&D funding in their FY90 budgets despite OSD's request for the program's cancellation. Production funding, however, remained tentative. A list of those supporting the V-22 is presented in Appendix C.

Congress provided $255 million in RDT&E funding for FY90, as Rep. Foglietta (PA) said, to "allow the Osprey program to fly for another year and to sell itself to the Defense Department [Ref. 23:p. 5]." As part of the FY90 authorization and appropriations bill, Congress also directed OSD to complete a Cost and Operational Effectiveness Analysis (COEA) study of the V-22 program. The Institute for Defense Analysis was tasked with analysis of the V-22, focusing on amphibious assault in a hostile environment, long-range special operations, over-the-horizon landings, subsequent operations ashore, logistical resupply to forward deployed forces and self-deployment missions.

In December, Secretary Cheney ordered the cancellation of $344 million in FY89 advance procurement contracts for the V-22 ($260 million of which had not been spent). This decision set off a storm of criticism from Congressional supporters. The decision to terminate existing FY89 contracts was termed by Rep Weldon as a "blatant disregard of the defense authorization process and for congressional will." By cancelling the V-22 procurement Weldon said, "Secretary Cheney displayed the ultimate in arrogance by trying to administratively subvert the defense budget process while Congress was in recess [Ref. 24"p. 24]." Weldon further stated that "the cancellation decision while Congress was in recess would further gaivanize congressional support and damage the Pentagon's reputation on the Hill [Ref. 25:p. 40]."

D. 1990 CONGRESSIONAL ACTION

In January, still reeling from the decision to cancel FY89 procurement contracts, Congressional supporters tried to determine the legality of Secretary Cheney's cancellation order. Despite their anger with OSD, however, most supporters agreed to abide by the Institute for Defense Analysis (IDA) COEA recommendations which were due to be released in April. In the interim, Rep Weldon continued to solicit support for the program and to lobby fellow congressman. Calling the Pentagon "penny wise and pound foolish" he asked for a re-examination of the PA&E report, arguing that life cycle cost analyses would show the V-22 less expensive [Ref. 26:p. 193].

The PE&E report based much of its conclusions on the technique on dual slinging heavy vehicles on CH-53E helicopters, thus decreasing transport times and/or reducing the number of required helicopters. In testimony before the House Armed Services Committee On February 20th, General Gray said, "I consider this whole dialogue of dual sling options totally ridiculous, it has nothing to do with coming from the sea in a wide variety of scenarios... it has nothing to do with warfighting. It is totally ridiculous and tactically flawed" [Ref.27:p. 6]. General Gray went on to say that a 1989 DOD study found that the helicopter option would cost $6 billion more than the V-22 option.

In April, a study commissioned by Bell-Boeing and conducted by the BDM corporation found the V-22/CH-53E mix vastly superior in combat effectiveness to the all helicopter option but $7 billion more expensive. This was based on a fleet on 602 V-22's [Ref.2:p. 93-94]. The IDA report was also completed in April as mandated by Congress. However, OSD did not release its findings to Congress until mid-May. Because the report's V-22 findings were in favor of the V-22, supporters in Congress accused Secretary Cheney of trying to willfully suppress its results. A discussion of the IDA study is contained in Chapter V of this thesis. Table I provides a summary of the report's findings [Ref.29:p. 42].

TABLE I. SUMMARY OF IDA CONCLUSIONS.

MARINE CORPS MISSIONS

* GREATER SURVIVABILITY OF V-22 PROVIDES THEM A SLIGHT TO MODERATE ADVANTAGE IN AMPHIBIOUS ASSAULT MISSION

* V-22 IS MOST COST EFFECTIVE ALTERNATIVE FOR SUSTAINED OPERATIONS, HOSTAGE RESCUE/RAIDS AND OVERSEAS DEPLOYMENT

** A NEW HELICOPTER SHOULD BE DESIGNED TO MARINE CORPS REQUIREMENTS IF WILLING TO START NEW DEVELOPMENT

** MARINIZE CH-47, IF PROBLEMS WITH QUADRICYCLE GEAR CAN BE OVERCOME AT LOW COST

** COMBINATION OF SMALLER HELICOPTERS IS REQUIRED TO CARRY TROOPS AND CH-53's ARE NEEDED TO SATISFY MEDIUM LIFT REQUIREMENTS

(** THESE CONCLUSIONS ARE ALTERNATIVES TO THE V-22)

OTHER SERVICE MISSIONS

* V-22 IS MORE COST EFFECTIVE THAT HELICOPTER ALTERNATIVES FOR SPECIAL OPERATION, SEARCH AND RESCUE, AND DRUG INTERDICTION MISSIONS

* S-3B IS MORE COST EFFECTIVE THAT SV-22 FOR ANTI-SUBMARINE MISSION

NEAR TERM COSTS

* HIGHER PROCUREMENT COST OF V-22 LEADS TO LARGEST NEAR TERM COSTS OF ALL THE ALTERNATIVES.

In June the Senate Appropriations Subcommittee on Defense, led by Senator Spector, held hearings on the "IDA study of the V-22 Osprey." Others providing testimony included deputy commander for warfighting General Pittman, USMC, who said; "he initially opposed the V-22 but now calls it indispensable" and went on to say that the V-22 would have saved lives in Panama. Dr. Simmons, head of the IDA study presented its results and answered questions from the subcommittee. In rebuttal, Assistant Secretary Chu presented OSD's position with regard to IDA's findings. Dr. Chu disagreed with many of the assumptions used to generate IDA's conclusion and was of the opinion that the high up-front costs of the program do not justify its continuance. Of all those testifying before the subcommittee only Dr. Chu's remarks were against the V-22.

Both the House and Senate embraced the findings of the IDA report as justification for continuing the V-22 program. All members of the Defense Appropriations Subcommittee expressed either strong or at least general support for the program's continuance.

Based on the positive findings of the IDA report, Congressional supporters developed plans to insert funding into the FY91 budget over the objections of Secretary Cheney. However, Defense Department spokesman, Pete Williams, said in a 18 May press briefing, that "long-run cost arguments for the V-22 tilt-rotor have already been rejected and will not prevail if they are the basis for an anticipated reinstatement recommendation from the IDA report [Ref. 30:pp. 288-289]."

Representative Weldon blamed Secretary Cheney's unwillingness to consider reinstating the program on Dr. Chu who, he said, "has always been out to kill the V-22, and when he got access to a new Secretary who needed to make some quick cuts in 30 days, he got his chance [Ref. 11:p. 101]."

The remainder of the year was spent arguing the pros and cons of the IDA report and the cost effectiveness of the V-22. Congress continued its strong support for the program while Secretary Cheney remained resolute on its cancellation. In the end Congress approved an FY91 budget which included $238 million for RDT&E and $165 million for long lead item procurement.

E. 1991 CONGRESSIONAL ACTION

1991 started much the same way as the previous year with the Defense Department submitting its FY92 budget with no V-22 funding. Congress, fearful that Secretary Cheney would not spend appropriated FY91 funds, closely watched the V-22 program [Ref. 31:p. 39].

In April, a Joint Hearing of the Procurement and Research & Development Subcommittees was held to review the V-22 program. Martin Ferber, Director of Navy Issues at GAO, delivered a report on the status of the program [Ref. 32:p. 60]. Several areas of concern were addressed but were felt to be within the capabilities of the contractors to fix. It was felt that the aircraft could go into pilot production in FY92 if long lead procurement funding was provided by July 1991. Program manager Colonel Jim Schaeffer concurred with the GAO report and testified that, "The program is still in the developmental stage and, being a developmental program, problems will be identified. Correction of deficiencies was to be incorporated in a concurrent pilot production lot of 12 aircraft but that contract was terminated."

Termination of the authorized and appropriated production contract was the topic of many of the members' remarks. They accused Secretary Cheney of exercising a line item veto. R&D Chairman Ron Dellums said, "In effect, the Department of Defense is exercising a line item veto of Congress's intent, and that, as we all know, is against the law." Congresswoman Lloyd said of the Department's actions, "In my judgement, the cancellation amounts to an unconstitutional attempt to exercise a line item veto. This is unacceptable." Congressman Dellums also complained that the Navy was not treating the V-22 as a major procurement program and had yet to assign a Program Executive Officer (PEO). Congressman Bennet put it this way, "Maybe the object of the exercise down there (at OSD) is to shoot this snake in its hole, no matter what." Throughout the hearings every congressman expressed at least moderate support for the program while most strongly supported its continuation.

Only the Defense Department's Comptroller and chief financial officer, Sean O'Keefe, was critical of the program. While he acknowledged that the program was not cancelled because of technical concerns, he stated that the Secretary of Defense feels that the program is too expensive, most specifically in the short term. As a compromise, he said that DOD is willing to continue RDT&E efforts as mandated by Congress but that the Secretary remains firmly opposed to procurement. He promised that OSD would release previously held FY91 funds to the Navy to continue the RDT&E effort but that beyond that, nothing else was planned. He also requested $50 million to study alternatives to the V-22 for the Marine Corps medium lift mission.

In related testimony before the Senate Appropriation Committee, General Gray, the Marine Corps Commandant, denied the Marine Corps was lobbying on behalf of the V-22 and demanded to know "who the hell" in the Marine Corps was doing the lobbying. He demanded a list of names, calling it a matter "of integrity and honor [Ref. 33:p. 87]." Despite Gray's denial, congressional sources say that it is well known that the Marine Corps strongly support the V-22 and would like to see the program continue.

F. FY 92 CONGRESSIONAL BUDGET

Congress passed its Defense Appropriations and Authorization bill in late November 1991 and it is generally hailed a victory for the V-22. It provided $790 million (including $165 million of prior year procurement funds) to embark on Phase II full scale engineering and manufacturing development. Three pilot production aircraft were authorized to incorporate engineering changes identified during flight testing. Additionally, it directed the Navy to provide a Test and Evaluation Master Plan TEMP by 1 May 1992 and report results of current testing to Congress by 15 April 1992. Finally, the bill prohibited the Navy from investigating V-22 alternatives until the results of Phase II were available.

V. V-22 VERSUS ALTERNATIVES

A. INTRODUCTION

The economy of the United States continues to slip into the grasp of a recession and the Great Bear of Russia is taking on a role more like a Teddy Bear. What should the Defense Department (DOD) do? They are running out of excuses to "spend the Big Bucks so they can have the best toys." One such area of controversy is the V-22 Osprey which touts some of the newest most sophisticated technology available today. Paradoxically, it is not the DOD trying to spend too much money, it is Congress telling DOD to spend money on a program DOD wants to cancel.

Who is correct? Does Congress see something in the Defense plan that DOD doesn't or is it just another case of parochial interests coming to the surface? Has DOD carefully weighed all aspects of the Defense plan and made their cuts or did they find one big ticket item that would solve their budget crunch? This chapter will delve deeply into some of these questions.

The V-22 was originally designed with the following missions in mind:

U.S. Marine Corps Operations

- Amphibious, ship-to-ship movement
- Subsequent operations ashore
- Long-range offensive operations

U.S. Army Missions

- Medical evacuation (MEDEVAC)
- Army special operations
- Corps airlift
- Self-deployment

U.S. Navy Missions

- Combat search and rescue (CSAR)
- Anti-submarine warfare (ASW)

U.S. Air Force Missions

- Special Operations

Other Agencies and Missions

- U.S. Coast Guard search and rescue (SAR)
- Drug enforcement

Due to the budget constraints in recent years the interest of the Army and Navy has decreased, leaving the Marine Corps missions as the primary focus of the V-22 program.

The three studies of interest which pertain to these missions are the "Institute for Defense Analysis Study of the V-22 Osprey" [Ref. 34:p. 71], "Effectiveness of Tilt-rotor Aircraft in Support of Ground Combat" report [Ref: 35:p. 52] by Lawrence Livermore National Laboratory (LLNL) and BDM International analysis of "V-22 combat effectiveness" [Ref. 28:pp 14-19].

B. LLNL STUDY

This study was performed under the auspices of the U.S. Department of Energy and was sponsored by Bell-Boeing. It considered only the operational capabilities of the V-22 and was limited to a comparison between the abilities of a combination of V-22/C-53E and of CH-60(S)/CH-53E. The focus of the study was to determine what difference increased payload, speed, range and hardness make in supporting Marine Corps amphibious assault and reinforcement missions. The outcome of this study was quantified in terms of battle outcome and attrition to air defenses. The comparison was broken up into two subdivisions classified by the make-up of the aircraft fleets. The first subdivision was for an equal lift capacity. This consisted of 60 V-22 and 20 CH-53E and was compared to 36 CH-60(S) and 52 CH-53E. The second subdivision was for equal cost fleets. The CH-60(S)/CH-53E fleet remained the same while the number of V-22's was reduced by 12 aircraft (48 V-22 and 20 CH-53E).

The scenario for the study was a U.S. Marine Expeditionary Unit (MEU) in Lebanon as part of a UN peacekeeping force. A MEU is approximately one infantry battalion in strength, with normal reinforcements including a tank platoon. Political events in the Middle East have prompted Syria to deploy an armored column to seize the Beirut-Damascus Highway. The MEU is ordered to block the movement, but it is recognized that it does not have sufficient combat to power to do that unassisted. A USMC expeditionary brigade (MEB) is available for reinforcement, but must be vertically-lifted from amphibious ships if it is to reach the MEU in time. Two infantry battalions could be lifted directly to the MEU's location, the third battalion and the heavier equipment would be landed in Beirut and would proceed overland to the MEU. The lift aircraft must traverse indigenous area defenses in Lebanon controlled by unfriendly forces. Close-air support is not available to either side.

The two graphs detailed in Figure 1 depict the balance of all systems (right) and combat power (left) available to a ground commander (designated blue force for the purpose of this study) throughout the battle.

The conclusions drawn from the study in the equal lift and equal cost scenarios are three-fold. First, as Figure 1 shows, the V-22/CH-53E equal lift fleet delivers two to three times more combat power during the battle than the alternate fleet. The equal cost fleet delivers less combat power than the equal lift fleet, but much more that the helicopter fleet. The V-22 fleet delivers the combat force reinforcements more than twice as fast as the alternates and thereby permits better utilization of the weapon systems.

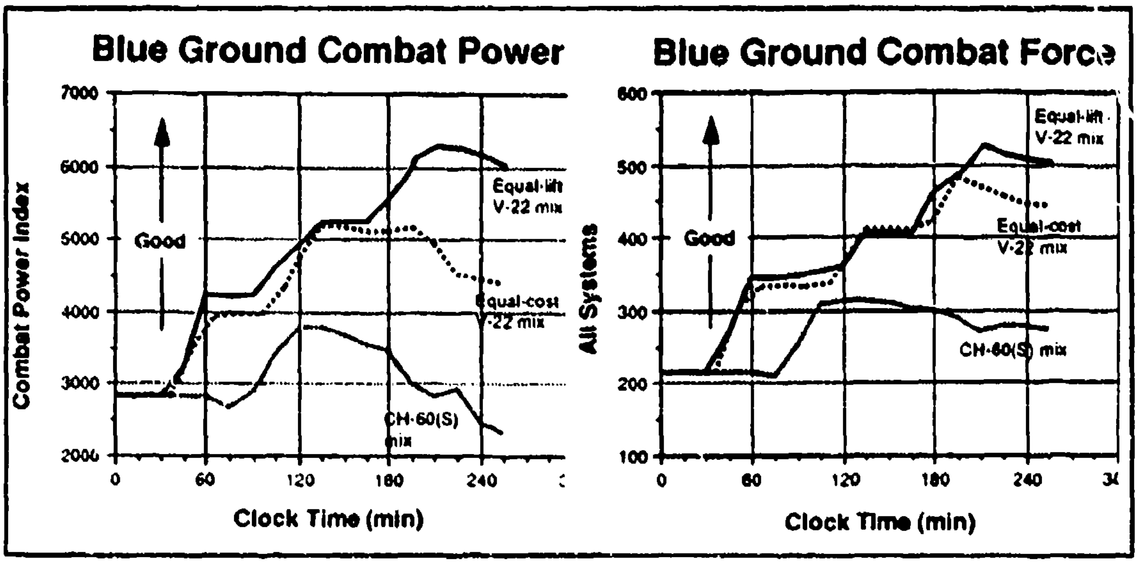


Figure 1. Buildup of Marine ground forces.

Figure 2 depicts the correlation of forces and means (COFM), also known as the relative combat power ratio (red, blue), as a function of time. The LLNL study used Soviet weighting criteria to develop a simplified Soviet style COFM. Interestingly, Soviet doctrine specifies that if the COFM falls below 1.8 the probability of success would be jeopardized. As can be seen, the reduction of red force relative strength (below 1.8) only occurred in the V-22/CH-53E combination. Figure 2 shows the V-22 is able to reinforce the Blue forces quickly enough that the Red force's (Blue force's opposition) forward momentum is dissipated and the balance of forces is changed from one favoring the Red forces to one favoring the Blue forces. This is never the case in the all-helicopter force because the combat power buildup is too slow.

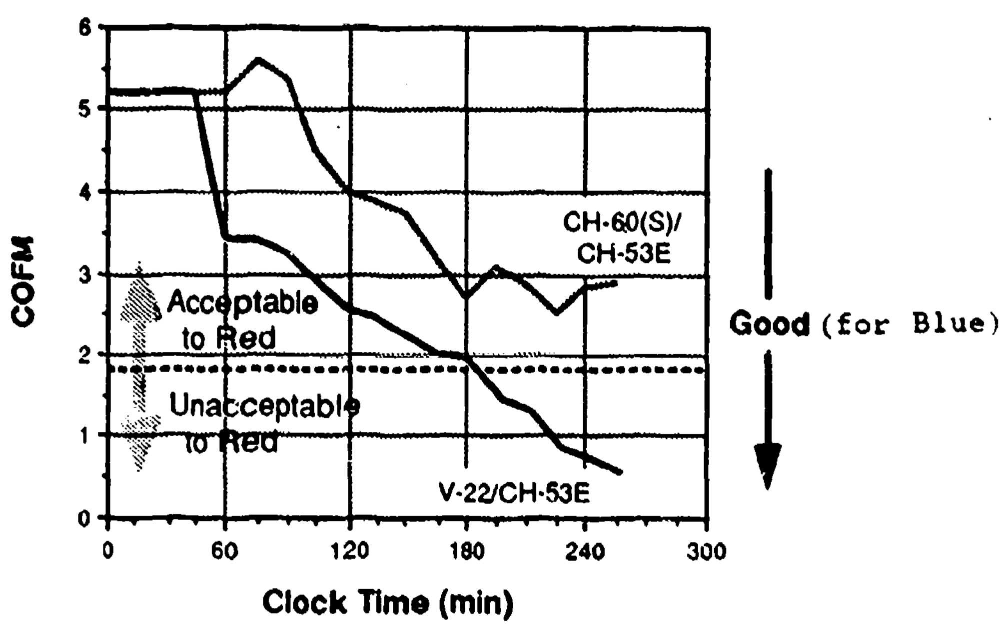


Figure 2. Correlation of Forces and Means (COFM).

Third, as Figure 3 shows, the V-22 losses to ground-based air defense are at least ten times less than that of the two other aircraft examined in the study. This fact is attributed to the intrinsic hardness of the V-22 and its greater speed. The V-22 fleet also experienced a smaller loss of CH-53E due to the fact that they were only needed for the heavy-lift missions.

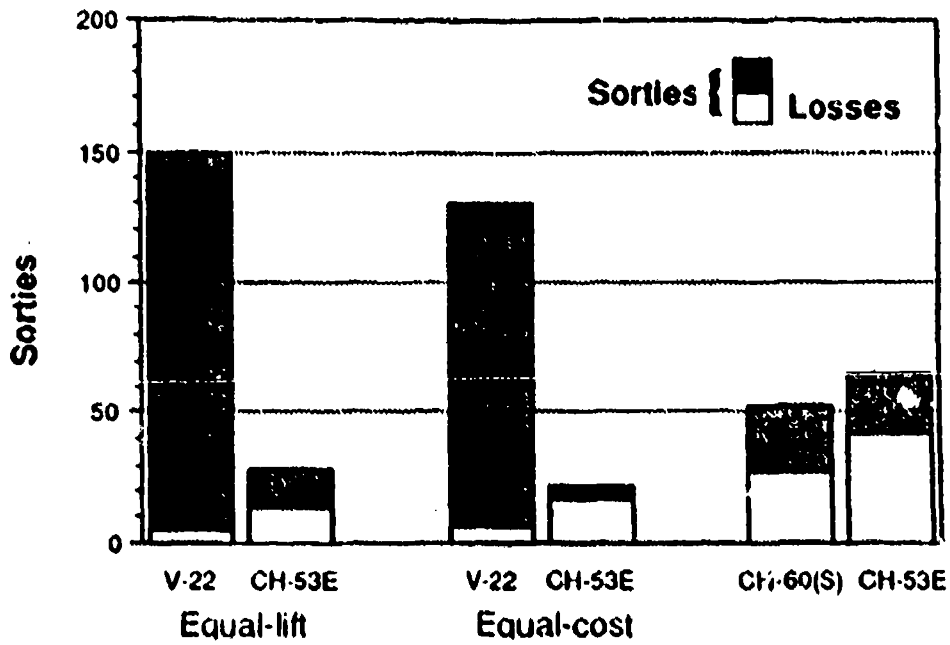


Figure 3. Aircraft vulnerability to land-based air defense.

C. IDA STUDY

The Institute for Defense Analysis (IDA) study, "Assessment of Alternatives for the V-22 Assault Aircraft Program," addressed all the reasonable V-22 alternatives. This list included the CH-53E+, CH-46E+, CH-60(S), New Helicopter (Boeing Model 360), EH-101 (UK/ITALY), CH-47M, and Super Puma (France). The IDA study was a Cost and Operational Effectiveness Analysis (COEA).

The missions that the IDA study addressed are listed in Table II [Ref. 37:p. 32].

TABLE II. MISSIONS EXAMINED BY IDA STUDY.

Marine Corps	Other Service or Agency
- AMPHIBIOUS ASSAULT (INCLUDING OVER-THE-HORIZON LANDINGS)	- COMBAT SEARCH AND RESCUE (NAVY)
- SUBSEQUENT OPERATIONS ASHORE (INCLUDING RESUPPLY TO FORWARD DEPLOYED FORCES	- LONG RANGE SPECIAL OPERATIONS
- DEPLOYMENT MISSIONS	- DRUG INTERDICTION
- HOSTAGE RESCUE OR RAID	- ANTISUBMARINE WARFARE (NAVY)

1. Cost Comparisons.

The first item to be considered is the cost comparison between the V-22 and its alternatives. It is clearly seen in Figure 4 that the V-22 is significantly more expensive both in recurring flyaway costs (which includes recurring management, hardware, software and configuration change costs) and average procurement cost (which includes recurring flyaway costs plus weapon system costs and initial spares).

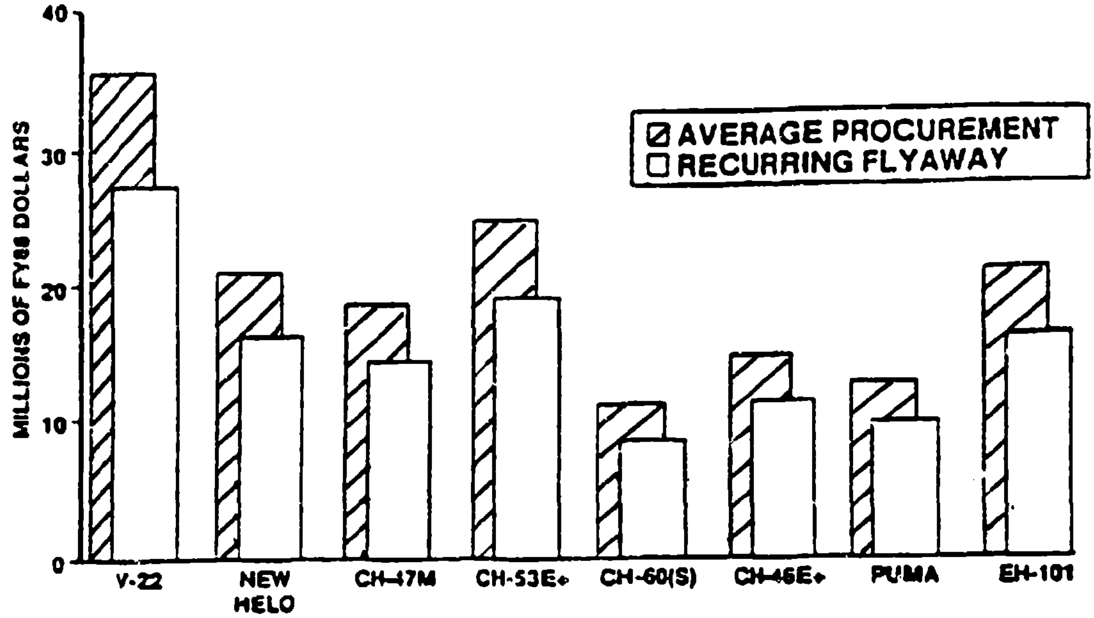


Figure 4. Unit Procurement Costs.

The V-22 average procurement cost is about $35 million with the next most expensive aircraft (CH-53E) averaging $25 million. The large V-22 cost can be traced to the additional expense incurred in the flyaway cost component of the program cost; in particular, the digital avionics and fly-by-wire flight control system. The V-22's fully integrated cockpit is one of the most advanced of any military aircraft. The extensive use of multifunctional (full color) displays (as alternatives to analogue dials and gauges) and digital flight management systems contribute significantly to flight safety, mission capability and survivability. However, the additional cost is not small.

2. Sustained Operations.

The next mission that was examined was the sustained operations mission. Figure 5 shows the comparative results. In this scenario the aircraft would be used to support combat operations ashore. The measure of effectiveness in this scenario was the number of equivalent payloads that could be delivered per day over a 30-day period. The black column represents a scenario with flat terrain, a fast threat response and half single sling/half double sling for heavy loads. The white column represents rolling terrain, slow response and all double sling loads. Again the V-22 proves to be a more capable platform.

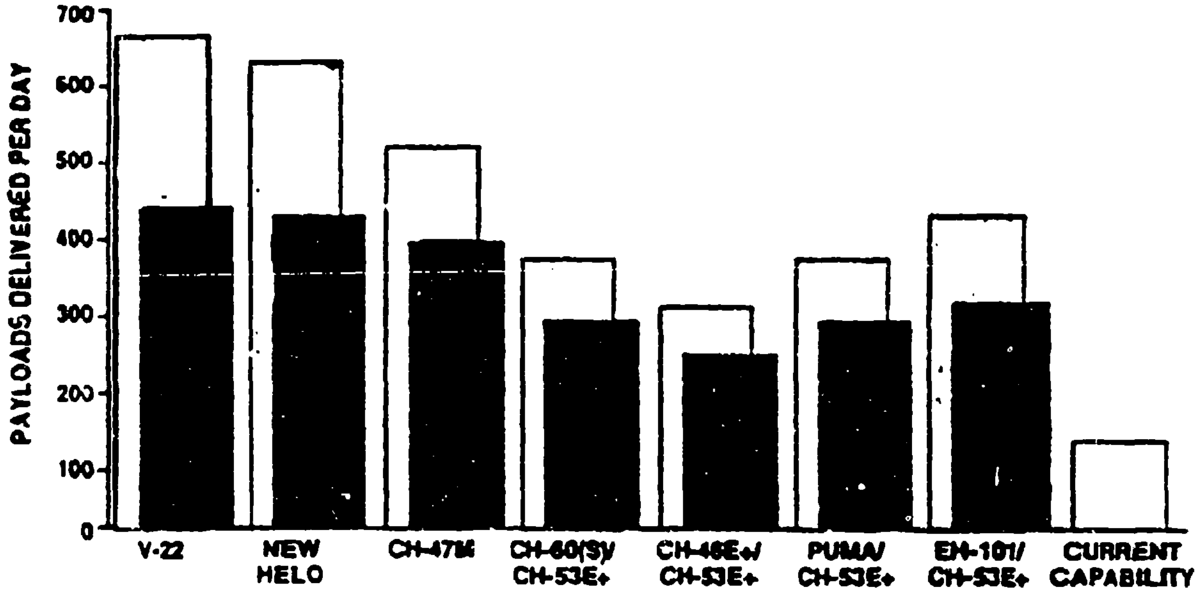


Figure 5. Sustained Operations.

3. Other Mission Scenarios.

The remaining Marine Corps missions that were considered in the report supported the same conclusions as the preceding scenarios. The Hostage rescue scenario showed that the V-22 could operate from a substantiality greater distance (greater standoff distance) and had a 5-to 12-hour advantage in the amount of time it would take to reach the hostage site from the same starting position. In the deployment mission the V-22 was able to self deploy (start, take off and land without auxiliary machinery) therefore reaching the theater of operation sooner, intact and ready to deploy troops. In operations involving extended range, conventional helicopters often require refueling at the deployment point. The V-22's characteristics allows planners extended range/endurance flexibility. Additionally, the V-22 does not require an external auxiliary power unit, or additional equipment/personnel to fold the rotors.

Summarizing the results for Other Service or Agency mission capabilities, the V-22 was found to be more cost-effective than helicopter alternatives for special operations, search and rescue, and drug interdiction missions.

4. In Conclusion.

Throughout the IDA study, the V-22 is shown to be the most capable alternative to the present assets. It should be noted that all of the proposed helicopter alternatives also provided increased capability over present fleet assets. The major draw back to the V-22 at this time is that its higher procurement costs lead to the largest near-term costs.

D. BDM INTERNATIONAL STUDY

Using 1990's data, BDM International conducted a combat effectiveness analysis based on government approved data and used a vertical assault scenario representative of a mid-intensity conflict in which three Marine battalions were landed ashore. The measures of effectiveness (MOE) were:

a. Aircraft availability for subsequent operations

b. Productivity, combat power build up ashore over time

c. Survivability, losses of aircraft, Marines, and helo deployable equipment to enemy ground based air defenses

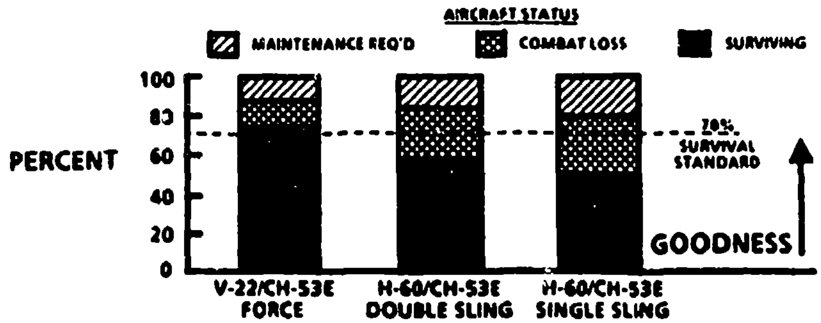


Figure 6. Aircraft Availability.

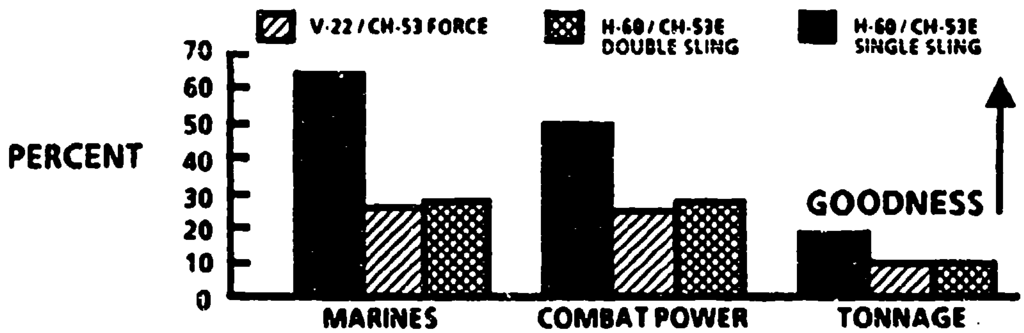


Figure 7. Productivity, Combat Power Buildup.

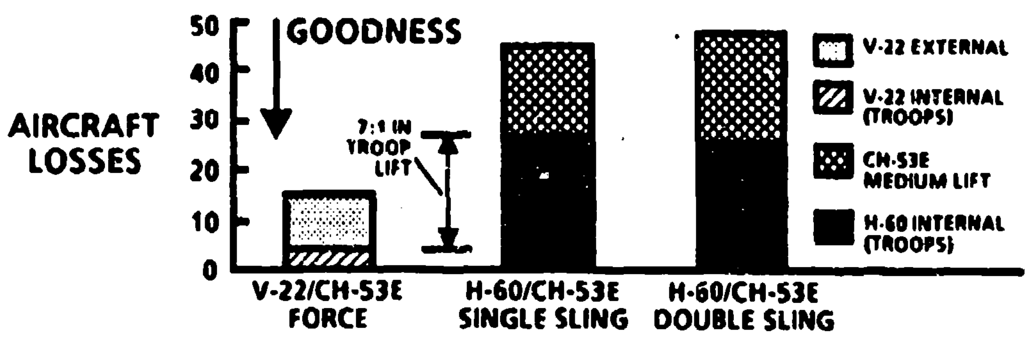


Figure 8. Aircraft Losses.

The BDM study compared a fleet of V-22's/CH-53E's to an all helicopter fleet of H-60's/CH-53E's. The fleet size was determined by the number of deck spots available on the amphibious ships supporting the simulated operation. As Figures 6, 7 and 8 illustrate, the V-22 was found to be superior to the all helicopter fleet in each of the MOE examined [Ref. 28:pp. 14-19]. Specifically:

a. Figure 6 illustrates that only the V-22/CH-53E fleet had sufficient aircraft available after the initial assault to support subsequent operations.

b. Figure 7 illustrates that the V-22/CH-53E fleet delivered twice the number of troops, combat power and tonnage in the critical initial 60-90 minutes of the assault.

c. Figure 8 illustrates the survivability of the V-22/CH-53E fleet, compared to the all helicopter fleet, it was superior by a factor of 3:1, and by 7:1 when carrying troops.

E. SUMMARY OF LLNL, IDA AND BDM STUDIES

In summary, these three studies show that the V-22's speed, range and survivability advantages would enable even a reduced fleet to be more effective than all the proposed helicopter alternatives in each of the four Marine missions examined. Also, the V-22 delivers more combat power to the battle area faster than the helicopter fleet and, has a significantly smaller attrition rate in battle.

F. V-22 PECULIAR SUPPORT EQUIPMENT COMPARISON

As part of the V-22 Full Scale Development (FSD) program, validation of the reliability characteristics of key aircraft components began in October 1986. The V-22's logistic support resource requirements were also being validated during the FSD program. The V-22 is designed to be compatible with a wide range of current government support equipment (CSE). Further, it is designed to require substantially fewer pieces of peculiar (unique) support equipment (PSE) than current operational equipment. This was done to reduce maintenance requirements as well as enhance tactical mobility and reduce demands on airlift and sealift assets. As Table III shows, the V-22 would enter fleet operations with significantly fewer items of required peculiar equipment. Bell-Boeing is using the flight test program to validate requirements for both CSE and PSE to support the V-22

TABLE III. V-22 PECULIAR SUPPORT EQUIPMENT (PSE) COMPARISON.

AIRCRAFT*	ORGANIZATIONAL MAINTENANCE	INTERMEDIATE MAINTENANCE
AV-8B Harrier II	546	847
CH53E Super Stallion	550	700
SH-60B Seahawk	150	200
MV-22A Osprey	91 **	162 ***

* Fleet aircraft data from NAVAIR records
** Actual count, less 16 inventory items (covers, tiedowns, downlock pins, etc.)
*** Estimated final count - analysis approximately 90% complete.

G. SPECIFIC INCIDENTS WHICH NEEDED THE V-22

Following are several incidents in which the V-22 would have been a significant advantage. The brief incident descriptions were created from various news articles, documentaries, discussions and readings such as House Armed Services Committee hearings in 1989/90 and transcripts of testimony to the GAO Committee on Naval Aviation (April 1991).

1. Personnel Rescue

In 1980, Operation Eagle Claw, the attempted rescue of the American hostages in the Tehran Embassy failed. The entire raid could have been accomplished with a special operations force in tilt-rotors alone instead of four kinds of aircraft and a split second timetable of coordination of all four services. The raid would have been done in eight hours instead of the planned 35, with a far higher probability of success.

In 1983, a Navy pilot was shot down over Syria. Instead of being recovered in 20 minutes with a strike rescue V-22, he became an international incident, a lingering political embarrassment to the government.

On 25 October 1983, Operation Urgent Fury sent an assault force into Grenada. Operational specialists say that had we used a force of V-22 aircraft, staged from nearby islands, the operation might have been completed in two days instead of three, with more surprise, greater precision and perhaps less loss of life. More importantly the students could have been rescued almost immediately after the arrival of U.S. forces. Rescue troops could have been delivered directly to the campus using the VTOL-capable V-22.

In 1987, the Air Force/Navy raid on Libya was a great success, but a plane was lost. The U.S. military had no way to rescue the crew or even to quickly assess if they were alive. A V-22 rescue aircraft would have been on the scene and the incident would have passed [Ref. 6:p. 14].

2. Operation Desert Storm.

Rather than examine all aspects of Desert Storm in which a V-22 could have operated (more effectively and efficiently than conventional helicopters), two phases of an amphibious operation, assault and subsequent ashore operations will be briefly discussed. A detailed analysis provided by Lieutenant General Keith Smith USMC (Ret) of the V-22's potential in Desert Shield/Storm is included at Appendix D.

During the assault phase it is generally preferable to stay as far as possible from landing areas defended by the enemy and to conduct assaults from over the horizon. This gives the advantage of keeping support ships out of harms way for as long as possible as well as providing an opportunity for tactical deception. Because of the limited range of the current shipborne medium lift capability, extensive and continued over the horizon assault launch capability was not available to Desert Storm planners. However, the V-22 could have provided this. Despite this, the threat of an amphibious assault so preoccupied Iraqi planners, that they positioned troops and equipment for a primary coalition attack from sea, and thereby gravely miscalculated their vulnerability from the northern, rear and western flanks.

During the subsequent operations ashore phase, pivotal to success is the ability of an attacking unit to strike at a decisive point, at the right time, and with the correct forces/fire power mix to defeat the enemy. To accomplish this task amphibious assault aircraft must have speed, range and payload capacity to respond rapidly to an ever-changing battle field situation. Helicopter operations in Desert Storm were dictated as much by logistics as by tactics. The limited range of the current U.S. military helicopter force required the establishment of a succession of Forward Army and Refuelling Ports from which close support for assault forces could progress.

Figure 9 graphically illustrates the advantage a V-22 has over conventional aircraft. The flight envelope area surpasses that of a helicopter and most of that of a turboprop aircraft.

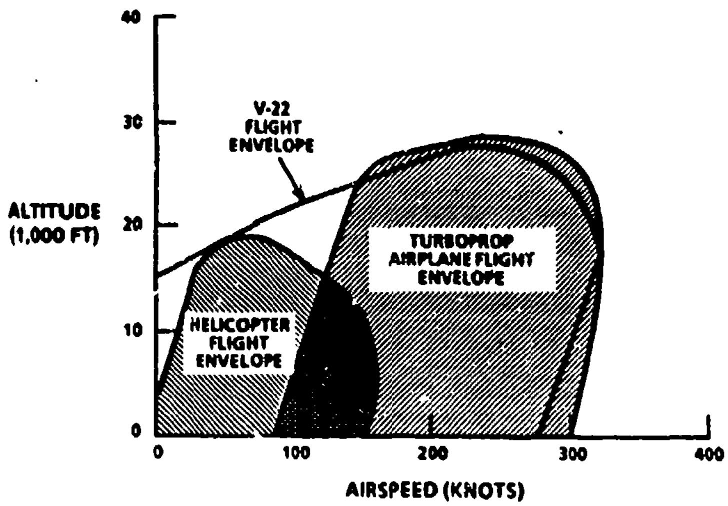


Figure 9. V-22 vs Helicopter/Turboprop Flight Envelopes.

Because range depends on factors such as airspeed, fuel capacity, load, hover requirements and take off/landing configurations, specific comparisons between helo, turboprop and tiltrotor would yield extensive data. Figure 10 provides a comparison of the three aircraft categories, showing specific range (nautical miles per hour of fuel) in relation to airspeed. Additional V-22 range data and mission endurance for the various V-22 configurations is provided at Appendix B.

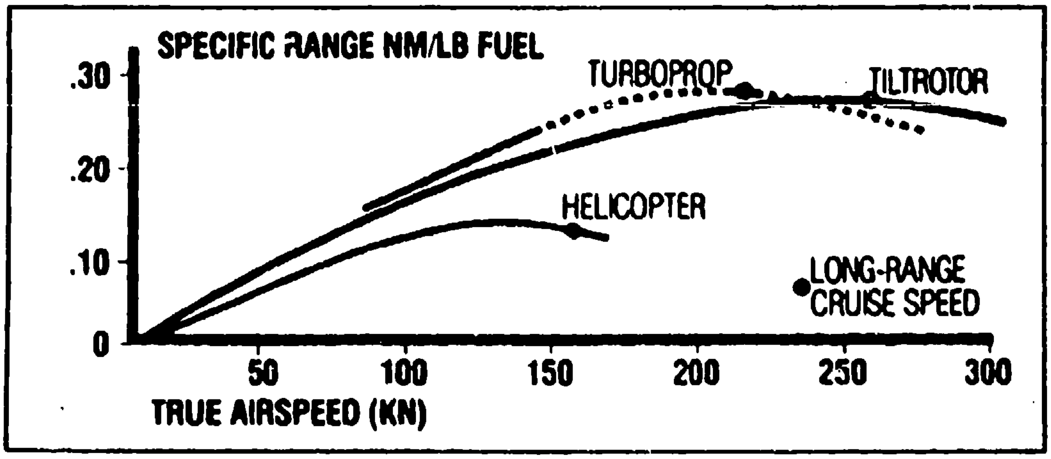


Figure 10. Specific Range (NM/LB Fuel) to True Airspeed.

As the coalition forces clearly demonstrated during Desert Storm, a force that can operate effectively at night and during adverse weather conditions has a distinct advantage over those who are limited in mobility and daylight fighting capability. Although the current helicopter fleet operated adequately in South-West Asia, (intrinsic helicopter limitations not withstanding) the presence of a V-22 component augmenting the conventional helicopter fleet would have provided battle planners with a force multiplier factor of enormous benefit both at night and during adverse weather.

3. **Conclusions.**

All of these scenarios; MEU in Lebanon, Operation Eagle Claw and Desert Storm, could happen again and, in terms of specific equipment, the U.S. military is no better prepared today than they were then.

What value should be placed on the V-22's capabilities in such scenarios? It is reasonable to conclude that the V-22 is equally cost effective in the long-term and its performance capabilities will offset its higher per unit cost. It would seem therefore to be a strategic error to scrap the V-22 program in an attempt to solve the budget deficit.

VI. CIVILIAN AND FOREIGN MILITARY SALES POTENTIAL

A. INTRODUCTION

Recognizing the vagaries of the Department of Defense acquisition process and susceptibility to change for even the most certain procurement agreements, Bell-Boeing has developed a strategy which is designed to protect and continue the development of the tilt-rotor concept in the event of the loss of congressional support. Essentially, Bell-Boeing is marketing a civil variant of the military V-22. In addition, there has also been considerable effort made to secure overseas orders for the military version.

Because of it military and civilian applications the V-22 has considerable export potential and provides the means for shoring up the deteriorating American aviation industrial base. The European share of the global jet transport aircraft market has grown from approximately two percent in the early seventies to nearly twenty percent by 1990 with signs of continued growth [Ref. 38:p. 13].

B. FOREIGN INTERESTS

Typical of the burgeoning European Aerospace industries' growing domination is the foreign rotorcraft manufacturers' share of the world market which has grown steadily from a few percent in the 1950's to more than fifty percent today. The efforts of the Bell-Boeing V-22 project made the United States a world leader in tilt-rotor (and composite material) technology.

> "If America is to maintain and strengthen our competitive position, we must continue to not only create new technologies, but to more effectively

translate those technologies into commercial products [Ref. 39:p. 20]."

However, it is considered in many circles, both industrial and governmental that, if the military abandons the V-22, both European and Japanese competitors will capitalize on its proven potential.

Three European aerospace companies, Aeritalia (Italy), British Aerospace (England), and Dornier Gmbh (West Germany) have formed a consortium to assess potential military markets for the tilt-rotor concept in Europe and throughout NATO. Japanese firms including C. Itoh and Mitsue are currently assessing the potential military market for tilt-rotor aircraft in Japan. Another consortium, Eurofar, including French-based Aerospatial, Gruppo Agusta in Italy, Messerschmitt-Bolkow-Blohm Gmbh in West Germany, Westland Helicopters Ltd in England and Construcciones Aeronauticas SA in Spain, has organized to field a civilian aircraft incorporating tilt-rotor technology [Ref. 40:p. 9].

Mr Jim McDaniel, Deputy Director of the Federal Aviation Administration's Civil Tilt-rotor Program Office, accurately reflects much of the current thinking regarding this subject in his statement [Ref. 41:p 9]:

> "I am convinced that the tilt-rotor is coming without question. Whether it will be an American-made tilt-rotor, there is some question...If we build it, we become the only supplier of this thing five years ahead (of Europeans and Japanese), and we become an exporter of this technology instead of an importer of technology. It's going to help with our balance of payments. It's going to help with our industrial base...What we don't want to happen is for this technology to go the same way as the videocassette recorder technology, which was an American invention. We're buying them all from Japan now,

and it would be a shame if that happened to the tilt-rotor."

C. CIVILIAN OPPORTUNITIES AND BENEFITS

Concurrent with military development, extensive technical and market studies sponsored by Bell-Boeing, NASA, FAA, and DOD have been carried out in order to determine how best to adapt tilt-rotor technology to the highly lucrative civilian sector of world aviation operations.

In June 1987, the final report of a NASA/FAA/DOD Civil Tilt-rotor Study stated its support for a number of national transportation goals and objectives, stating that the tilt-rotor will, "Expand development of a nation's transportation infrastructure, and reduce airspace/ground congestion problems." This, along with other findings, supported a 1987 study from the Aeronautical Policy Review Committee of the President's office of Science and Technology Policy which specifically highlighted tilt-rotor technology as playing a major role in an integrated national air transportation system and recommended:

> "...Civil derivatives of military tilt-rotors, operating in the vertical or short takeoff modes, are foreseen with the economy, productivity, and maintainability of fixed wing passenger aircraft. Advanced craft of this kind can provide improved inter-city and inter-regional transportation, reducing congestion in U.S. airports without major investments in new runways..."

The report also noted that while airport congestion problems are severe in the United States, they are worse abroad. European and Japanese authorities have not only expressed great interest in the timely availability of technology to relieve a heavily burdened transportation system, they also are investing in their own tilt-rotor/tilt-wing technology development.

The following is a summary of the two principal findings of this study [Ref. 37:p. 42]:

1. **Large export market:** The market opportunity portion of this study estimates an American commercial tilt-rotor could generate $28 billion in exports in its first 10 years of availability, assuming timely development of the commercial tilt-rotor (CTR) aircraft and an appropriate air and ground infrastructure.

2. **National economic development:** Manufacture of the CTR aircraft and development of supporting vertiports has a positive effect on national employment. Besides the direct CTR and vertiport development jobs, employment diversification results as manufacturing and service industries develop around the new hubs of transportation (vertiports). Quantifying national economic development was not the principal focus of this study, but it can be noted that industry would have to invest at least $2 billion more to produce the United States' first commercial tilt-rotors. Additionally, an initial network of 25 vertiports would require private or local investment of $1 billion to $2 billion. Relatively speaking, vertiports are economical to build and conserving of land, as little as $40 million and 5 acres. A system of vertiports would serve to distribute the demonstrated favorable economic impact of urban airports throughout the community. Considering multiplier effects, a study done for the Department of Commerce concluded the increased national economic

activity would be approximately $80 billion for every 1,000 commercial tilt-rotors produced.

A Bell-Boeing study titled "Civil Tiltrotor Missions and Applications" (February 1991) suggests that the commercial tilt-rotor could enjoy a substantial short-haul and commuter market. Much of this traffic could be diverted to tilt-rotors, which do not require runways. Freed-up runway slots can be made available for more efficient longer flights by larger jets. The useful life of crowded airports could therefore be extended. Expense and land use could be minimized by locating vertiports over freeways, railroad yards, piers, etc. Small urban airports might be suitable in lieu of vertiports in some locations. Expensive construction of new runways and new airports - environmentally difficult in most urban areas - could be postponed or eliminated.

D. TECHNOLOGY ISSUES

The combined postwar investment of the U.S. aerospace industry and the U.S. Government in tilt-rotor research and development exceeds $2.5 billion [Ref. 42:p. 6]. From this foundation, tilt-rotor technology is ready to move to the next logical phase, which includes two separate but complementary activities:

(1) Initiation of production of a military version to meet the government's needs.

(2) An iterative program to demonstrate tilt-rotor technology to the commercial marketplace.

There are striking differences between commercial and military tilt-rotor aircrafts stemming from the V-22 military mission requirements. Meeting military requirements significantly increases fuel consumption, adds structural weight, and adds complexity. Requirements such as MILSPEC damage tolerance features, infrared sensors, combat related avionics, rear loading ramps, folding rotors and other mission specific equipment all increase the cost to build. A commercial V-22 variant would be lighter, less complex and more efficient. Additionally, there is no doubt that ultimate efforts toward development of a commercial version will lead to design improvements that can improve the quality and performance of military tilt-rotors. Likewise, military production aircraft may contribute to "proving" the tilt-rotor concept by demonstrated success. Taken together, the safety, reliability, and cost effectiveness of tilt-rotors could be verified.

Commercial airlines have underscored the importance of demonstrating and validating the commercial viability of the tilt-rotor. They have expressed reluctance to commit to a comparatively revolutionary vehicle such as the tilt-rotor until the technical, cost, and operational system risk issues have been satisfactorily resolved [Ref. 43:p. 19].

Continued evaluation of the potential civil applications of the tilt-rotor and continued development of tilt-rotor systems and infrastructures is therefore required. This continued effort, coupled with the experience gained with pre-production platforms such as the XV-15 and production V-22 aircraft, can help establish the requisite levels of confidence in the commercial marketplace and a basis for a decision leading to production of the civilian tilt-rotor.

Beyond congestion relief, civilian tilt-rotors could be available for service in these areas:

-Improved air travel and access to rural and isolated areas.

-Disaster Relief.

-Public service (police, fire, and emergency medical services.)

-Coast Guard, border patrol, and drug interdiction.

The technology to produce a successful commercial tilt-rotor is clearly emerging. But focusing solely on the technology and the aircraft, although they are important, is not sufficient. As the world's civilian airspace system now exists, the tilt-rotor's potential to reduce ground and air congestion cannot be realized [Ref. 44:p. 31].

E. USE OF AIR SPACE ISSUES

Commercial fixed-wing aircraft need runways several thousand feet long, are limited to shallow approach paths, and operate from large, centralized airports; the entire airspace system has evolved around and is structured to those needs. Lacking an airspace infrastructure tailored to exploit its unique capability, the tilt-rotor is "just another helicopter" operating in a fixed-wing world.

Without a paradigm shift, decades could pass before the system would evolve to allow CTR's potential to be tapped. In the interim, national resources will be wasted - in a holding stack over Chicago, waiting for a slot out of La Guardia, or stuck in traffic on an access road to Washington's National Airport.

The question to be faced is: whose problem is air and ground congestion? Air carriers claim that it is not theirs. The FAA charter is directed first to safety and second to capacity. Airport operators' interests are local, not national, in scope. Manufacturers build only those aircraft that airlines will buy.

F. CIVIL CONFIGURATIONS AND USES

In July 1987 Bell-Boeing commissioned a study into civil tilt-rotor missions and applications [Ref. 43:p. 8]. Appendix C shows civil tilt-rotor configurations developed for the study. One configuration, the CTR-800 is based on the original XV-15 tilt rotor size; two configurations, the CTR-22A/B and CTR-22C, are derivations of the V-22 military tilt-rotor; and two configurations, the CTR-1900 and CTR-7500, are all new (but technically feasible) civil tilt-rotors. In addition to the airlines there are also world wide markets in the following areas:

1. Drug Enforcement. For drug enforcement work, speed, range, and endurance are critical, as is the ability to take off and land vertically (on unprepared surfaces). This mission would involve interception and pursuit on the ground as well as in the air, in all weather, day and night, and invariably little warning

of launch time. The CTR-22A/B variant would be ideal for this role as it has necessary range, speed, size, and its rear ramp would facilitate the rapid loading and off loading of necessary personnel. Additionally, the CTR-22A/B (being of military descent) would have good ballistic tolerance against certain weapon catagories.

2. Police. Additional to mission criteria required for drug enforcement, police applications would be in the area of prisoner transfer, high priority personnel transfer, airborne patrols/surveillance, search and rescue, and SWAT operations. The CTR/800 variant would be most applicable to these missions.

3. Coast Guard. Between 1978 and 1983, the U.S. Coast Guard launched more that 145,000 aircraft rescue mission, mostly to locations within the 150 nautical-mile range of their HH-65 helicopter. The tilt-rotors range and speed make it an ideal alternative to the HH-65 in the search and rescue mission. The V-22 has significantly more airborne endurance time and its all-weather capability and ability to hover without severe downwash effects considerably improve chances of rescue success. As 91% of all short range recovery missions involve fewer that 10 people, the CTR-800 would be applicable to this mission.

4. Medical Evacuation. Because of conventional helicopter constraints in the area of range and speed the tilt-rotor would provide vastly improved evacuation capability and reduced transit time. Additionally, pressurization and good ride quality would enhance the ability of medical attendants to administer treatment as well as provide a stable environment for the patient. With a

range in excess of 600 nautical miles at the lighter mission weight of a medical transport role, the service area of a base hospital can be dramatically increased (and with it, increased revenues). For the medical mission the pressurized CTR-800 would be appropriate.

5. Fire. Fire Departments use of VTOL aircraft for commander control, personnel transfer, search and rescue missions is well established. In most cases a small tilt-rotor with its speed and range would ideally substitute for helicopters. For fire rescue missions and smoke jumping operations the larger CTR-22 series tilt-rotor would be ideal.

6. Public Service. In addition to the previous categories the tilt-rotor would satisfy innumerable public service requirements such as disaster relief.

G. TECHNOLOGY SPIN-OFFS

Much of the technologies used in V-22 production are also being developed by the aviation industry at large. These technologies include advanced cockpit displays, fly by wire and advanced multiplex data base systems (avionics). There is also the area of composite fiber construction in which the V-22 is a trailblazer. Bell-Boeing have found that composite construction provides strength, stiffness and corrosion resistance at nearly 25% less weight that conventional metal alternatives. Interestingly, from a military and police point of view, research has shown that composite materials have better ballistic tolerance and crack resistance than metals. Other areas which could provide technological spin-offs for both military and civil aviation are [Ref. 45:p. 44]:

* Thrust power management systems
* Engine and Transmission health monitoring systems
* Thermoplastics
* Carbon brakes
* Alloys
* Laser inertial system
* Avionics software
* Fibre optic use in aircraft

H. AUSTRALIAN MILITARY APPLICATIONS

In addition to the previous mentioned civil applications, all of which apply to the Australian environment, the huge undeveloped land mass that constitutes Australia's northwest dictates that a rapid reaction capability to any developing threat be included in the defense force structure. The current rapid reaction of the Australian Defense Force (ADF) is centered around the Army's fleet of UH-60 Black Hawk helicopters. The UH-60's limited range, endurance, lift capability and personnel capacity constitute severe limitations on rapid reaction planning. With major Army bases being located on the east coast the ADF needs VTOL aircraft with necessary range to reposition combat into the remote northwest. The V-22 could do this. Figure 10 shows the rapid self deployment range of an east coast based V-22 fleet. A typical rapid deployment scenario would involve 24 combat troops plus their equipment boarding each V-22 in Brisbane, utilizing in-flight refueling or utilizing existing fuel facilities at Alice Springs (Central Australia). The rapid deployment force would be positioned anywhere on the north-west coastline within 7 hours of departure.

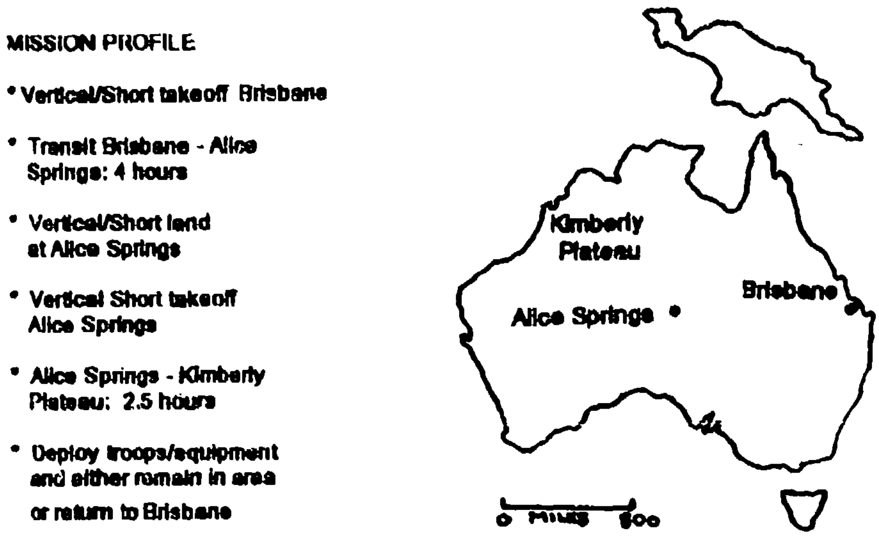


Figure 11. V-22 Rapid Self Deployment.

Another possible military application for the V-22 is in the area of land-based anti-submarine warfare (ASW). For the northern coastlines, particularly the sparsely populated and mineral rich northeast and northwest, ASW presents unique problems to the Australian defense planners. Australia does not have an aircraft carrier, and long range fix wing ASW aircraft, such as the Royal Australian Airforce's PC3 Orions, are limited by the absence of active sonar and dipping capabilities. The V-22 ASW variant could provide those capabilities. This aircraft, operating from established (or improvised) land bases, would significantly augment naval shipborne ASW facilities and, in its capacity as a force multiplier, provide significantly increased flexibility to battle planners. Figure 12 provides an indication of V-22 land-based ASW coverage and time on station from the cities of Broome in the west and Cairns in the east.

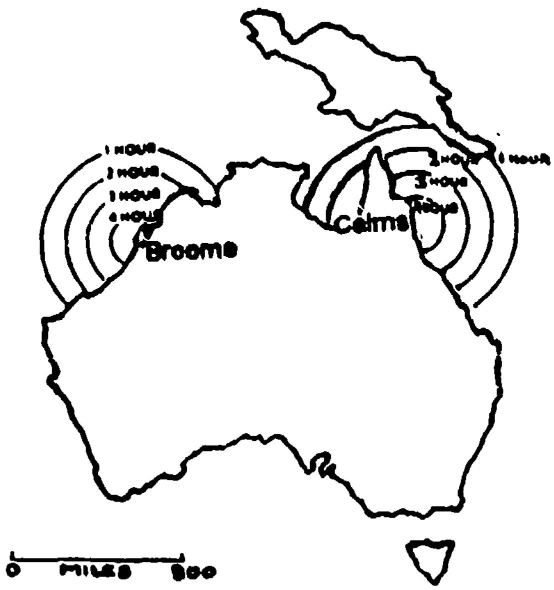


Figure 12. V-22 Land-Based ASW Operations.

In addition to the rapid deployment and ASW capabilities of the V-22, many (if not all) the mission capabilities required of the V-22 by the U.S. military (details of which are included in Chapter V) would be utilized by the Australian Defence Force and other militaries throughout the world, thus providing significant foreign military sales potential.

VII. SUMMARY AND CONCLUSIONS

A. SUMMERY

This thesis has provided a comprehensive overview of the V-22 program. The origins of the program were discussed and the Iranian Hostage mission was cited as graphic evidence of the need for a aircraft featuring the V-22's unique characteristics. Program management is always pivotal to the success of a new system and Chapter III of the thesis discussed the history of the V-22 program management and, using Milestones terminology, traced the program's progress as well as Congressional, OSD and the U.S. Military Services' involvement.

A more detailed analysis of the influences of various key players in the development process; i.e. Congress, OSD and the USN/USMC was given in Chapter IV. This chapter showed how the V-22 program grew out of a Marine Corp request to replace its medium lift capability and, despite strong support from personnel such as John Lehman (Secretary of the Navy) and General Gray (USMC Commandant), the program was destined to a life of continual scrutiny cancellation and uncertainty. Various program cancellation decisions were discussed as was Congressional action during the period 1980 thru 1992. Throughout the program's history Congressional support for the tilt-rotor has been second only to Bell-Boeing's.

Alternatives to the V-22 were discussed in Chapter V. The cost question was discussed and the question asked "Is it worth the trouble and cost?" Although innumerable studies have been made on the tilt-rotor concept and, more particularly the V-22, two studies were cited in this chapter. The first, provided analyses of comparative performance of a combined V-22/CH-53E force and a CH-60(s)/CH-53E force. The second study addressed all reasonable V-22 alternatives. Both of these studies identified that the V-22's characteristics of speed, range, and survivability would enable a V-22 fleet to be more effective than all proposed helicopter (VTOL) alternatives.

In a politico-financial climate which calls for military operational drawdown and decreased budgetary allocation, a system with purely military applications necessarily subjects itself to the limitations such a climate imposes. Thus Chapter VI analyzed the civil potential of the tilt-rotor concept and its use by foreign military services. The fact that considerable worldwide interest in the tilt-rotor concept exists was also discussed. With air traffic congestion (and its consequent pollution, both noise and environmental) becoming an increasingly high priority problem, innovative solutions must be found. The tilt-rotor concept may well provide the answer as well as provide some shoring up of the eroding U.S. aviation industrial base.

Japan's primary interest in the tilt-rotor would be to ease civil air traffic congestion. In contrast, the Australian market would be much more diverse and offers considerable potential for both initial sales of the V-22 in its current configuration as well as ongoing sales as the aircraft develops. As proven with the McDonnell Douglas F/A-18, Australia is capable of high quality component manufacture which could also take place in the V-22's case.

The Australian military currently relies on a small fleet of 4 CH-47D Chinook helicopters to fulfill the VTOL medium lift mission. This fleet is aging and is unable to satisfy the vast number of medium lift and rapid deployment requirements of even a low level conflict. Kangaroo '89, Australia's largest ever peacetime exercise to that date, highlighted the severe difficulties arising from limited medium lift capability [Ref. 46:p. 22]. With the land phase of the exercise being carried out in northwest Australia it quickly became apparent that the lack of airfields, road and rail networks (the few that existed would be susceptible to flooding) made fuel and ammunition resupply a critically limiting factor in battle planning - the V-22 would have been ideally suited to the task of logistic support.

The SAR and ASW capabilities of the V-22 would be of enormous benefit to the Royal Australian Navy. By utilizing its advantage in speed and range its force multiplier potential becomes apparent. Military V-22's would also be able to effectively augment civil authorities in missions such as disaster relief, drug enforcement, policing and fishery patrol.

B. CONCLUSIONS

The preceding historical perspective illustrates the many complexities outside the control of the program manager. In the case of the V-22 the program manager has had very little effect on the direction of the program. He has had to respond primarily to outside events; specifically, the decision by Secretary Cheney to cancel the program and the subsequent decisions by Congress to keep the program alive.

It is clear that the Defense acquisition process has been anything but efficient for the V-22. It appears that Secretary Cheney's desire to quickly kill the program and thus reap maximum cost savings has been foiled. Even if the V-22 is ultimately cancelled, over $3 billion dollars will still have been spent on the program. Alternately, if the V-22 continues to production the result will be a significantly reduced aircraft buy (231 aircraft vice the original 657) and at a considerable growth in unit cost.

The prospect of greatly constrained future defense budgets make it apparent that the United State government agencies cannot continue to waste billions of dollars arguing over a program's viability.

There is undoubtedly civil potential and this area needs to be actively pursued. Despite the need for defense dollars to initiate production, with successful marketing and proven ability to fulfill civil missions private sector funding would be forthcoming. There is also the consideration that if the tilt-rotor concept is not fully developed in the U.S., in all likelihood Japan, Korea or Taiwan would produce the aircraft and thus reap the benefits of market share. To illustrate established thinking and the Asian demand (and, by inference, Europe) the 1992 Asian Vertiflite Seminar announced the need for a helicopter expressway in the air as a solution to Japan's chronic land-based traffic congestion. The plan calls for the division of Japan into 600 sectors and the building of a heliport in each sector thus establishing an airborne expressway which could be used by the V-22. In addition, a Japanese industrialist is quoted as saying, "If you produce the aircraft, we will buy it. If you do not, I guarantee we will build it [Ref. 47:p. 20]."

Given the shrinking defense dollars available in the 90's and the desire to maintain a viable state-of-the-art defense industrial base, programs must be designed which can take advantage of potential Foreign Military Sales and more importantly, commercial applications. This means that while the V-22 program may not be entirely cost effective on military grounds alone, the technology generated for the national industrial base may be incentive enough to continue with the program. The Defense Department, however, should not be made to shoulder the entire financial burden of these development programs. Congress should provide joint funding for "National Technologies" programs such as the V-22 as a means of maintaining the United States leading technological position among developed countries.

In conclusion, for a variety of technological, economic, and political reasons, the 1990's will be an era of considerable change in the planning for and execution of naval warfare. Older, well proven maritime strategies, tactics, and weaponry will inevitably feel this impact and mounting challenges to tactical air power from modern air defenses can be anticipated. In order to confront and solve these problems, new technology, of which the tilt-rotor is one, offers excellent potential.

APPENDIX A

V-22 FIRSTS

- The V-22 is the first aircraft to be developed from the ground up to serve the needs of all four U.S. armed services.

- The V-22 is the first U.S. aircraft to be completely designed by computer, rather than by engineering drawings produced by hand.

- The V-22 is the first full-scale tilt-rotor development program ever undertaken by an nation.

- The V-22 is the first production aircraft whose airframe will be fabricated almost entirely of composite materials, chiefly graphite-epoxy solid-laminate structure. Only about 1,000 pounds of metal will be used: mostly fasteners and copper mesh laminated into the outer surfaces to provide lightning protection.

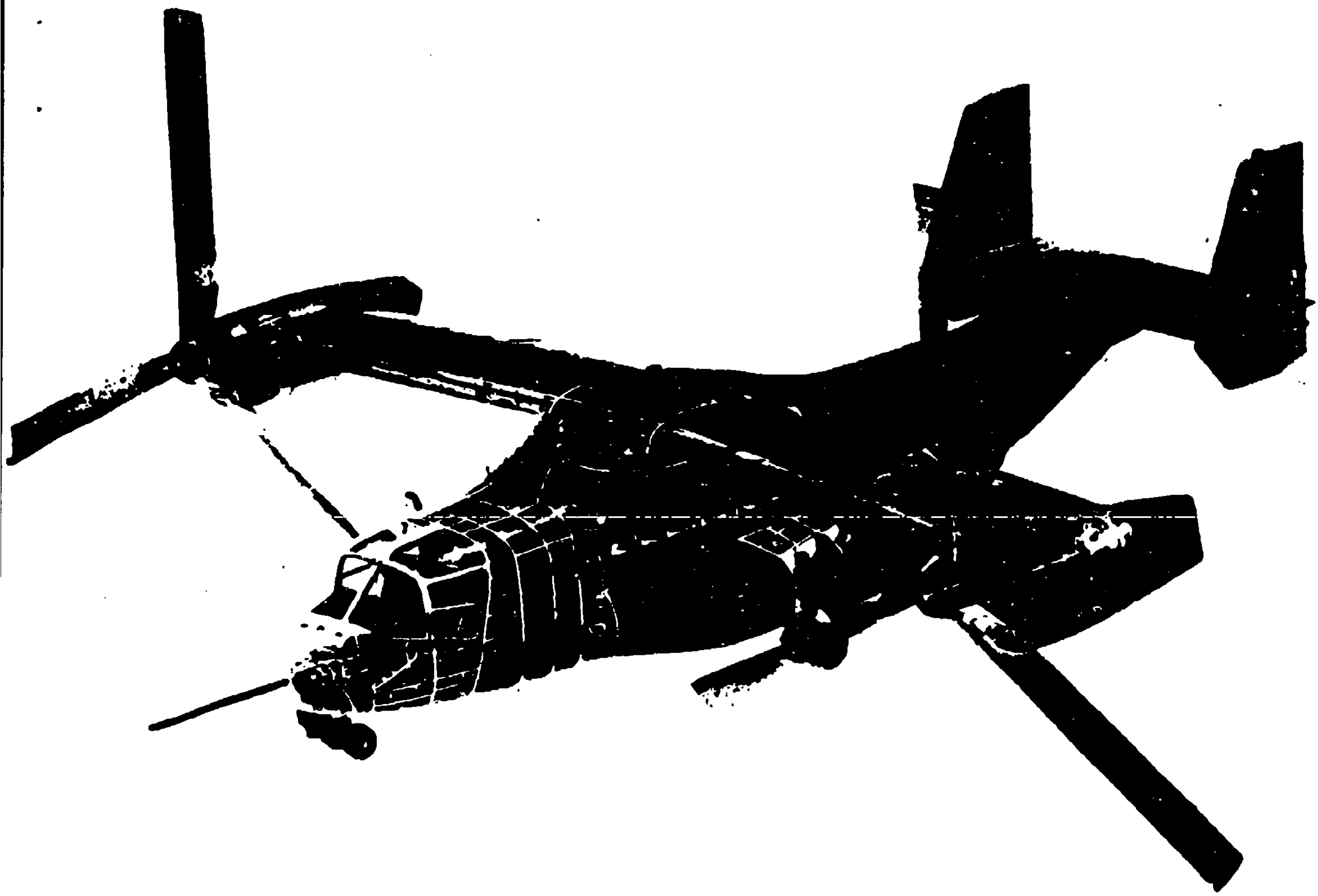
- The V-22 is the first U.S. major weapon systems procurement program negotiated under new U.S. Navy acquisition policies that require the contractors to finance and own the majority of the tooling, a requirement that provides substantial savings to the taxpayers.

- The V-22 is the first aircraft whose wing can be rotated parallel to the fuselage in order to create a compact rectangle necessary for operation and storage aboard ships.

- The V-22 is the first fixed-wing aircraft to use cross-connected propulsion systems that enables it to maintain balanced thrust with only one engine operating.

APPENDIX B

AIRCRAFT CHARACTERISTICS[1]



STANDARD AIRCRAFT CHARACTERISTICS

MV-22 "OSPREY"
BELL-BOEING

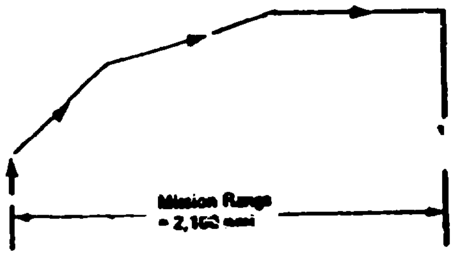
1. NAVAIR document 00-110AV-22-1 dated June 1986

NOTES

MISSION DEFINITIONS

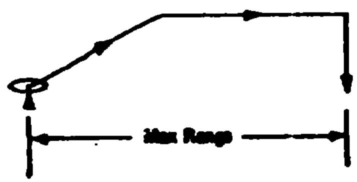
(7) SELF-DEPLOYMENT

Takeoff: Warmup/idle 10 minutes, STO @ SL/90°F at max power
Climb: Climb to best cruise altitude @ IRP
Cruise: Cruise/climb to 25,000 ft @ V_{BR}
Cruise: Cruise to maximum range @ V_{BR}
Reserve: 10% of initial fuel



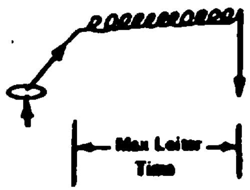
(8) RANGE MISSION

Takeoff: Warmup/idle 10 minutes, VTO (STO for USAF) @ mission altitude/ambient (2 minutes @ IRP)
Climb: Climb to mission cruise altitude @ IRP (no climb for land assault missions)
Cruise: Cruise @ V_{BR}
Reserve: 20 minutes sea level loiter @ V_{BE} or 10% initial fuel, whichever is greater



(9) ENDURANCE MISSION

Takeoff: Warmup/idle 10 minutes, VTO (STO for USAF) @ mission altitude/ambient (2 minutes @ IRP)
Climb: Climb to mission cruise altitude (no climb for land assault missions)
Loiter: Loiter @ V_{BE}
Reserve: 20 minutes sea level loiter @ V_{BE} or 10% initial fuel whichever is greater



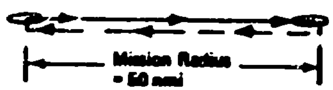
◯ LOADING CONDITION COLUMN NUMBER

NOTES

MISSION DEFINITIONS

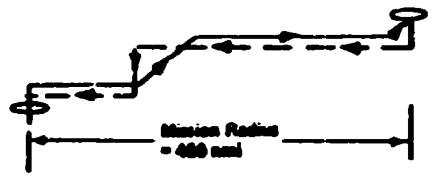
(4) LAND ASSAULT, EXTERNAL CARGO LIFT (USMC)

Takeoff:	Warmup/idle 10 minutes, VTO @ 3,000 ft/91.5°F (1 minute @ IRP)
Cruise:	Cruise to mission radius (speed not to exceed 130 ktas)
Hover:	HOGE @ 3,000 ft/91.5°F (2 minutes @ IRP), drop P/L
Maneuver:	5 minutes @ IRP
Cruise:	Cruise back @ V_{BR}
Reserve:	30 minutes sea level loiter @ V_{BE} or 10% initial fuel, whichever is greater



(5) COMBAT SEARCH AND RESCUE (USN)

Takeoff:	Warmup/idle 10 minutes, VTO @ SL/103°F (1 minute @ max power)
Cruise:	Cruise @ V_{BR} (500 ft AGL)
Climb:	Climb to 2,000 ft @ IRP
Cruise:	Cruise @ V_{BR} to mission radius
Climb:	Climb to 3,000 ft @ IRP
Hover:	HOGE @ 3,000 ft/91.5°F (7.5 minutes @ max power) Pick up P/L, HOGE (7.5 minutes @ max power)
Descent:	Descend to 2,000 ft (no fuel used, no distance credit)
Cruise:	Cruise back @ V_{BR}
Descent:	Descend to 500 ft AGL (no fuel used, no distance credit)
Cruise:	Cruise back @ V_{BR}
Reserve:	30 minutes sea level loiter @ V_{BE} or 10% initial fuel, whichever is greater



(6) LONG RANGE SPECIAL OPERATIONS (USAF)

Takeoff:	Warmup/idle 10 minutes, STO* @ SL/103°F
Cruise:	Cruise @ V_{BR}
Climb:	Climb to 1,000 ft @ IRP
Cruise:	Cruise to mission radius @ V_{BR}
Climb:	Climb to 4,000 ft @ IRP
Hover:	HOGE @ 4,000 ft/95°F (5 minutes @ max Power)
Descent:	Descend to 1,000 ft (no fuel used, no distance credit)
Cruise:	Cruise back @ V_{BR}
Descent:	Descend to sea level (no fuel used, no distance credit)
Cruise:	Cruise back @ V_{BR}
Reserve:	30 minutes sea level loiter @ V_{BE} or 10% initial fuel, whichever is greater

*STO is 2,000 ft maximum distance to clear 50 ft obstacle

JP-4 fuel shall be used for the USAF LRSOF mission

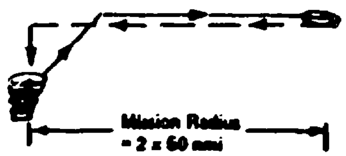
◯ LOADING CONDITION COLUMN NUMBER

NOTES

MISSION DEFINITIONS

(1) AMPHIBIOUS ASSAULT, TROOP LIFT (USMC)

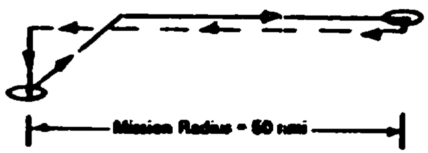
Takeoff:	Warmup/idle 10 minutes, VTO @ SL/103°F (1 minute IRP)
Loiter:	Loiter 40 minutes @ V_{BE}
Climb:	Climb to 3,000 ft @ IRP
Cruise:	Cruise to mission radius @ V_{BR}
Maneuver:	5 minutes @ IRP
Hover:	HOGE/land @ 3,000 ft/91.5°F (2 minutes @ IRP), drop P/L, VTO @ 3,000 ft/91.5°F (1 minute @ IRP)
Maneuver:	5 minutes @ IRP
Cruise:	Cruise back @ V_{BR}
Descent:	Descend to sea level (no fuel used, no distance credit)
Loiter:	Loiter 15 minutes @ V_{BE}
Hover:	HOGE/land @ SL/103°F (2minutes @ IRP), pick up P/L, VTO @ SL/103°F (1 minute @ IRP)
Climb:	Climb to 3,000 ft @ IRP
Cruise:	Cruise to mission radius @ V_{BR}
Hover:	HOGE/land @ 3,000 ft/91.5°F (2 minutes @ IRP), drop P/L, VTO @ 3,000 ft/91.5°F (1 minute @ IRP)
Cruise:	Cruise back @ V_{BR}
Descent:	Descend to sea level (no fuel used, no distance credit)
Reserve:	30 minute sea level loiter @ V_{BE} or 10% initial fuel, whichever is greater



⬭ Hover symbol (HOGE, VTO/land, maneuver)

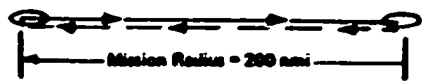
(2) AMPHIBIOUS ASSAULT, EXTERNAL CARGO LIFT (USMC)

Takeoff:	Warmup/idle 10 minutes, VTO @ SL/103°F (1 minute @ IRP)
Climb:	Climb to 3,000 ft @ IRP
Cruise:	Cruise to mission radius (speed not to exceed 130 ktas)
Hover:	HOGE @ 3,000 ft/91.5°F (2 minutes @ IRP), drop P/L
Maneuver:	5 minutes @ IRP
Cruise:	Cruise back @ V_{BR}
Descent:	Descend to sea level (no fuel used, no distance credit)
Reserve:	30 minute sea level loiter @ V_{BE} or 10% initial fuel, whichever is greater

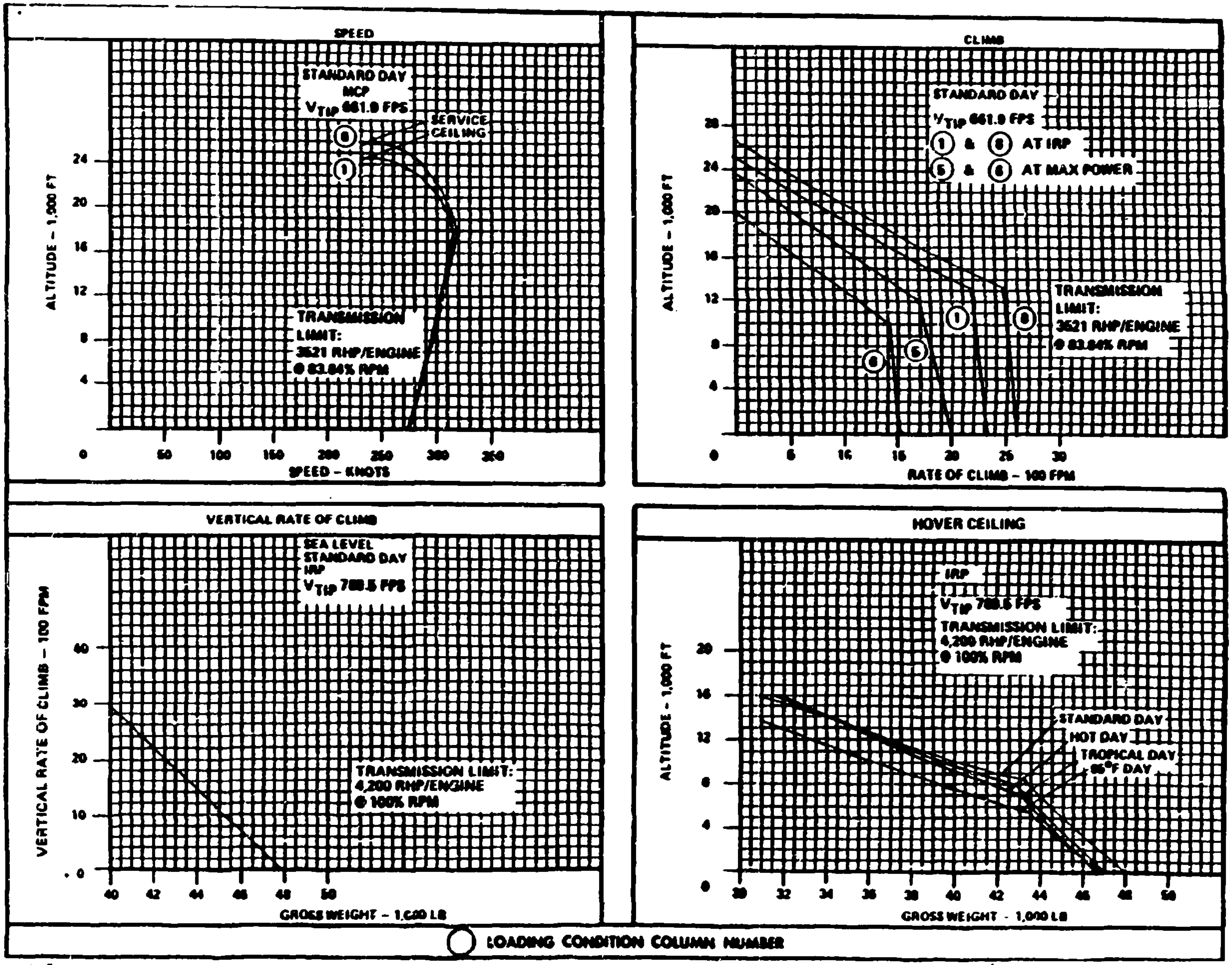


(3) LAND ASSAULT, TROOP LIFT (USMC)

Takeoff:	Warmup/idle 10 minutes, VTO @ 3,000 ft/91.5°F (1 minute @ IRP)
Cruise:	Cruise to mission radius @ V_{BR}
Hover:	HOGE/land @ 3,000 ft/91.5°F (2 minutes @ IRP) Drop P/L, VTO @ 3,000 ft/91.5°F (1 minute @ IRP)
Maneuver:	10 minutes @ IRP
Cruise:	Cruise back @ V_{BR}
Reserve:	30 minute sea level loiter @ V_{BE} or 10% initial fuel, whichever is greater



◯ LOADING CONDITION COLUMN NUMBER



SPEED
STANDARD DAY
MCP
V_{TIP} 661.9 FPS
SERVICE CEILING
8
1
TRANSMISSION LIMIT:
3521 RHP/ENGINE
@ 83.84% RPM
ALTITUDE – 1,000 FT
0
4
8
12
16
20
24
50
100
150
200
250
300
350
SPEED – KNOTS
CLIMB
STANDARD DAY
V_{TIP} 661.9 FPS
1 & 8 AT IRP
5 & 6 AT MAX POWER
TRANSMISSION LIMIT:
3521 RHP/ENGINE
@ 83.84% RPM
1
8
5
6
ALTITUDE – 1,000 FT
0
4
8
12
16
20
24
28
5
10
15
20
25
30
RATE OF CLIMB – 100 FPM
VERTICAL RATE OF CLIMB
SEA LEVEL
STANDARD DAY
IRP
V_{TIP} 788.5 FPS
TRANSMISSION LIMIT:
4,200 RHP/ENGINE
@ 100% RPM
VERTICAL RATE OF CLIMB – 100 FPM
0
10
20
30
40
42
44
46
48
50
GROSS WEIGHT – 1,000 LB
HOVER CEILING
IRP
V_{TIP} 788.5 FPS
TRANSMISSION LIMIT:
4,200 RHP/ENGINE
@ 100% RPM
STANDARD DAY
HOT DAY
TROPICAL DAY
95°F DAY
ALTITUDE – 1,000 FT
0
4
8
12
16
20
30
32
34
36
38
40
42
44
46
48
50
GROSS WEIGHT – 1,000 LB
LOADING CONDITION COLUMN NUMBER

PERFORMANCE SUMMARY (STANDARD DAY CONDITIONS)

Revision A

TAKE-OFF LOADING CONDITION		Amphibious Assault (Troops) ①	Amphibious Assault (Cargo) ②	Land Assault (Troops) ③	Land Assault (Cargo) ④	Combat Search and Rescue ⑤	Special Operations (A) ⑥	USMC Self-Deployment ⑦
TAKE-OFF WEIGHT (E)	lb.	46,021	44,250	44,787	44,081	47,921	53,556	60,500
*Fuel internal/external (JP-5) (6.8 lb/gal)	lb./lb.	6,839	3,536	6,584	3,338	13,368	16,387 (A)	26,119
Payload	lb.	5,760	8,300	5,700	8,300	880	2,880	0
Disc loading	lb./sq. ft.	19.8	19.5	19.7	19.4	21.1	23.6	26.7
Vertical rate of climb at SL /Std	fpm.	1,090 (F)	1,340 (F)	(F)	1,410 (F)	1,000 (B)	NA	NA
Absolute hovering ceiling (OGE Std)	ft.	6,000 (F)	6,500 (F)	5,500 (F)	6,800 (F)	4,400 (B)	NA	NA
Max. rate of climb at SL/Std (H)	fpm.	2,320	2,400	2,350	2,420	2,030	1,490	1,080
Service ceiling (G)	ft.	24,680	24,830	24,680	25,020	23,110	20,180	17,950
Speed at S.L. (H)	kn.	273	274	274	274	272	268	264
Max. speed/altitude (Std Day) (H)	kn./ft.	316/18,000	316/18,000	316/18,000	316/18,000	314/17,000	305/16,500	294/16,000
O.E.I. Service ceiling (G)	ft.	11,300	11,600	11,450	11,800	9,350	5,750	S.L. (B)
Min. speed (O.E.I.) (B) (C)	kn.	38	37	38	37	45	63	90
Max. speed (O.E.I.) (B) (C)	kn.	231	232	231	233	228	221	202
Combat radius	n. mi.	2 x 50	50	200	50	460	520	NA
Mission time	hrs.	1.84	0.675	2.01	0.710	4.0	4.6	NA
Average cruising speed	kn.	274	170	246	170	244	251	NA
Cruising altitude	ft.	3,000	3,000	3,000	3,000	2,000	1,000	NA
Range/Mission Time nmi/hours		515/2.21	108/.83	495/2.20	101/.78	1,020/4.24	1,115/4.47	2,100/7.92
Average cruising speed	kn.	233	130	226	130	241	249	264
Cruising altitude	ft.	3,000	3,000	3,000	3,000	2,000	1,000	12,000-25,000
Maximum endurance	hrs.	2.80	.83	2.50	.78	5.20	5.80	10.01
Endurance speed	kn.	176	130	174	130	171	179	223/170
Endurance altitude	ft.	3,000	3,000	3,000	3,000	2,000	1,000	10,000
Combat Loading Condition ⑧		60% fuel		60% fuel		60% fuel	60% fuel	
Combat Weight	lb.	42,488		42,333		42,773	47,800	
Engine Power		MCP		MCP		MCP	MCP	
Fuel	lb.	4,103		3,860		8,021	8,220	
Combat Speed/Cruise Altitude (D) (H)	kn./ft.	284/3,000		284/3,000		280/2,000	276/1,000	
Rate of Climb/Cruise Altitude (D) (H)	fpm./ft.	2,570/3,000		2,580/3,000		2,500/2,000	2,020/1,000	
Combat Ceiling (500 fpm) (G)	ft.	22,200		22,400		23,700	20,800	
Rate of Climb at SL/STD (H)	fpm.	2,800		2,820		2,800	2,030	
Max. speed at SL/Std (H)	kn.	276		276		276	272	
Max speed/altitude-time airspeed (H)	kn./ft.	318/18,000		318/18,000		318/18,000	314/17,000	
Landing Weight		33,615		33,584		38,000	38,926	37,193
Fuel	lb.	892		981		1,337	1,637	2,612
Absolute hovering ceiling (OGE)	ft.	14,200 (F)		14,240 (F)		12,800 (B)	10,200 (B)	11,900 (F)

NOTES

PERFORMANCE BASIS: ESTIMATED DATA GUARANTEE LEVELS OF PERFORMANCE (SD-572-1) AND ENGINE SPECIFICATION FUEL FLOWS

*WING AUXILIARY FUEL TANKS ARE USMC MISSION ROLE EQUIPMENT

(A) JP-4 FUEL (6.5 LB/GAL)
(B) MAX POWER
(C) SEA LEVEL
(D) MISSION CRUISE ALTITUDE
(E) ADD 200 LB OF TAXI/WARM UP FUEL TO OBTAIN RAMP WT
(F) IRP
(G) MCP
(H) XMSN LIMIT: 3621 RHP/ENG @ CRUISE RPM (V_{TIP} = 661.9 FPS)

POWER PLANT

No. & Model:	2 T406-AD-400
Manufacturer:	Allison Gas Turbine Division
Engine Spec No.:	937 (Fourth Draft) 22 July 86
Type:	Turboshaft

RATINGS

	SHP	RPM	ALT
Maximum	6150*	15,000	Sea Level, 59°F
Intermediate	6150*	15,000	Sea Level, 59°F
Maximum Continuous	5890	15,000	Sea Level, 59°F
Transmission Limits:	3621**	12,675	Cruise rpm
	4200**	15,000	USMC
*Engine Torque Limit 2,153 ft-lb	4570**	15,578	USN, USAF
	6820	15,578	OEI

Exhaust Nozzle Area 317 in.^{2}

**RHP

ELECTRONICS

VHF/UHF Radio AN/ARC 182

VHF/UHF Encryption KY 58

VHF/UHF Control Head C-10319A

HF Radio ARC-190, ARC-190

HF Encryption ANDVT

IFF APX-100

IFF Security Kit 1A TSEC

Intercom AIC-30 (CFE)

FM Homing (CFE)

Digital Message Device OA-8990

Radar Beacon APX-78

Radar Warning APR-39A

Missile Warning AAR-47

Chaff Flare/ Jammer Dispenser ALE-39

SAHRS USN-2

Tacan ARN-118

VOR/ILS MB ARN-144

Doppler APN-217

Cara APN-232

VHF/UHF ADF OA-8697

Inertial Nav System SKN-2443 (CFE)

Mission Computers AYK-14 (XN-6)

Interface Units (CFE)

VSLED (CFE)

DTS (CFE)

UFD (CFE)

DEU (CFE)

CDU (CFE)

HMD (CFE)

FLIR (CFE)

Multifunction Radar (CFE)

Night Vision Goggles (CFE AN/AVS-6)

MISSION AND DESCRIPTION

The V-22 is a multimission aircraft designed for use by all services. The unique ability of the tiltrotor to combine VTOL operations with high altitude and high airspeed flight permits such multimission applications.

The U.S. Marine Corps will use the V-22 for Vertical Assault Transport of troops, equipment and supplies from amphibious assault ships and land bases.

The U.S. Navy will use the V-22 for combat search and rescue, delivery and retrieval of special warfare teams, and logistics transportation in support of the fleet.

The U.S. Air Force will use the V-22 for long range special operations missions, delivering and retrieving U.S. Army special forces troops and equipment at mission radii in excess of 500 NM.

The U.S. Army will use the V-22 for care medical evacuation, special forces infiltration and exfiltration and long range assault logistics support.

The V-22 Osprey is a tiltrotor aircraft with two 38 foot rotor systems and engine/transmission nacelles that are mounted on each wing tip. These rotor systems are powered by two T406-AD-400 engines. The aircraft operates as a helicopter when taking off and landing vertically. Once airborne the nacelles are rotated 90 degrees forward thus converting the aircraft into a turboprop airplane for high-speed, fuel-efficient flight. The rotors are synchronized by means of an interconnect transmission shaft that runs through the wing between the two nacelle mounted transmissions. This shaft also provides power transmission from one rotor system to the other in case of an engine failure.

This aircraft folds up compactly for stowage aboard ship. This is accomplished by folding the rotor blades inboard in front of the wing, then swiveling the wing to be parallel to the fuselage.

The V-22 airframe is almost completely composite construction. It has crashworthy seating for combat troops, two external cargo hooks for carriage of outsized equipment, a rescue hoist, a cargo winch and pulley system of loading and unloading heavy internal cargo loads and an aft loading ramp which permits quick egress and exit of both troops and cargo.

The Osprey is capable of all weather instrument flight, day or night, and continuous operation in moderate icing conditions. The Navy and Air Force aircraft are equipped to fly in these same conditions at very low level.

Although all services use a common aircraft, the Marine Corps and Army designation is MV-22A, the Air Force designation is CV-22A and the Navy designation is HV-22A.

DEVELOPMENT

First Flight (estimated)	1988
Service Use (estimated)	1991

DIMENSIONS

Main Rotor

Diameter:	38 ft
Disk Area:	2,268 ft^2
Blade Area:	261.52 ft^2
No. of Blades:	3 per rotor

Length		Height		Width	
Maximum:	688 inches	Maximum:	261 inches	Maximum:	1,014.9 inches
Folded:	751 inches	Folded:	217 inches	Folded:	221 inches
				Tread:	182.6 inches

WEIGHTS

Revision A

Loading	(USMC) Weight (lb)	Load Factor Airplane	Load Factor Helicopter
Empty	31,818		
Operating	32,623		
Design	39,500	+4.0, −1.0	+3.0, −.5
Combat	42,712	+3.7, −.92	+2.77, −.46
Max Takeoff (VTO)	47,500	+3.3, −.84	+2.5, −.42
Max Takeoff (STO)	55,000	+2.87, −.72	
Self-Deployment (STO)	60,500	+2.61, −.65	

FUEL AND OIL

FUEL

Gal.	No. & Type of Tanks	Location
2,438	2 Non Self-Sealing	Cabin (Self-Deployment)
928	2 Partial Self-Sealing	Sponsons
190	2 Self-Sealing	Wing
580	8 Self-Sealing	Wing
300	1 Partial Self-Sealing	Aft Sponson

Fuel Grade JP-4/JP-5/JP-8

Fuel Spec MIL-T-5624

OIL

Engine (gal)	1.93	Spec: DOD-L-85734
Transmission (gal)	26.376	Spec: DOD-L-85734

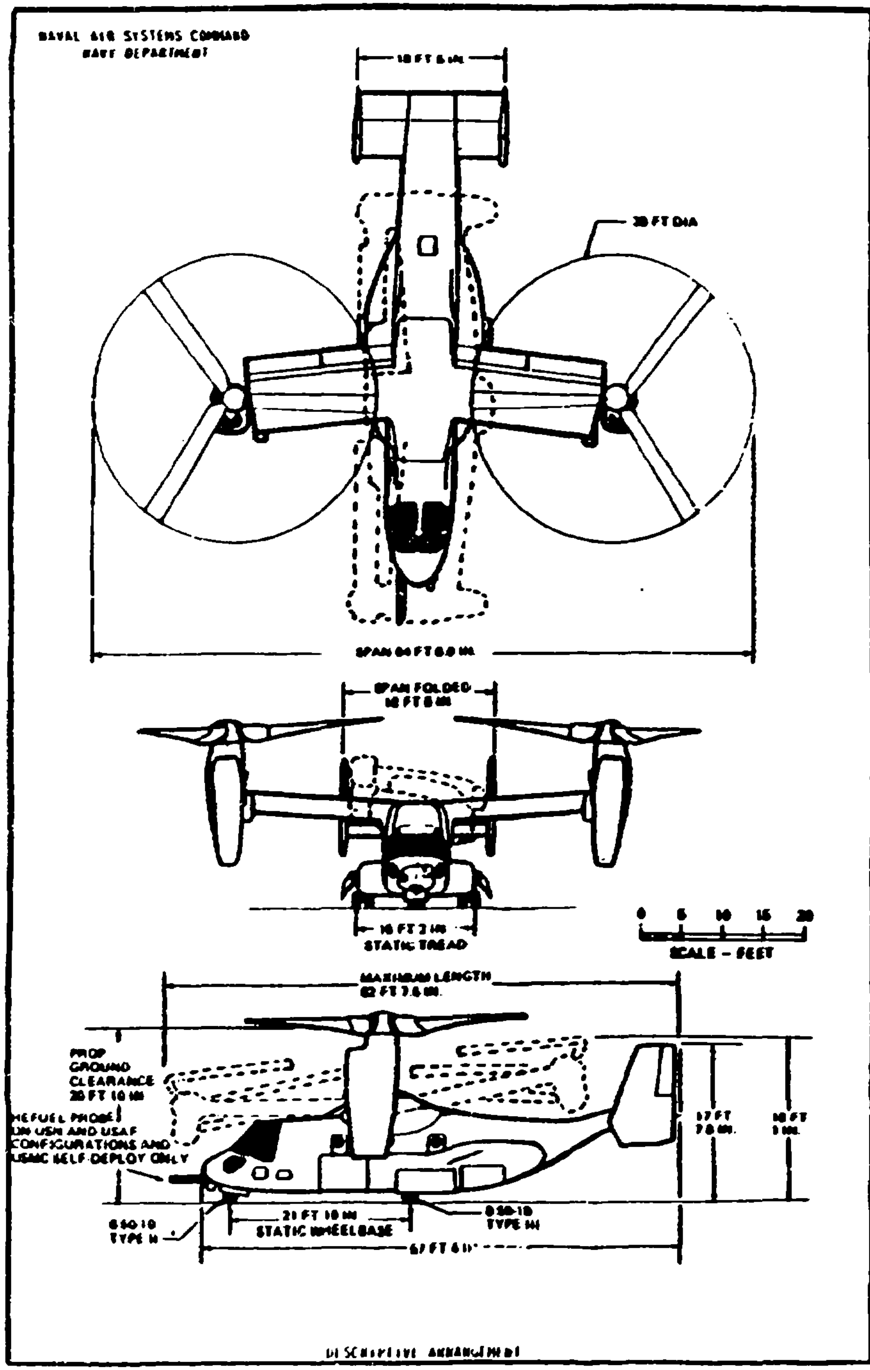
ORDNANCE

Provisions for Two (2) .50 Caliber Cabin Guns.

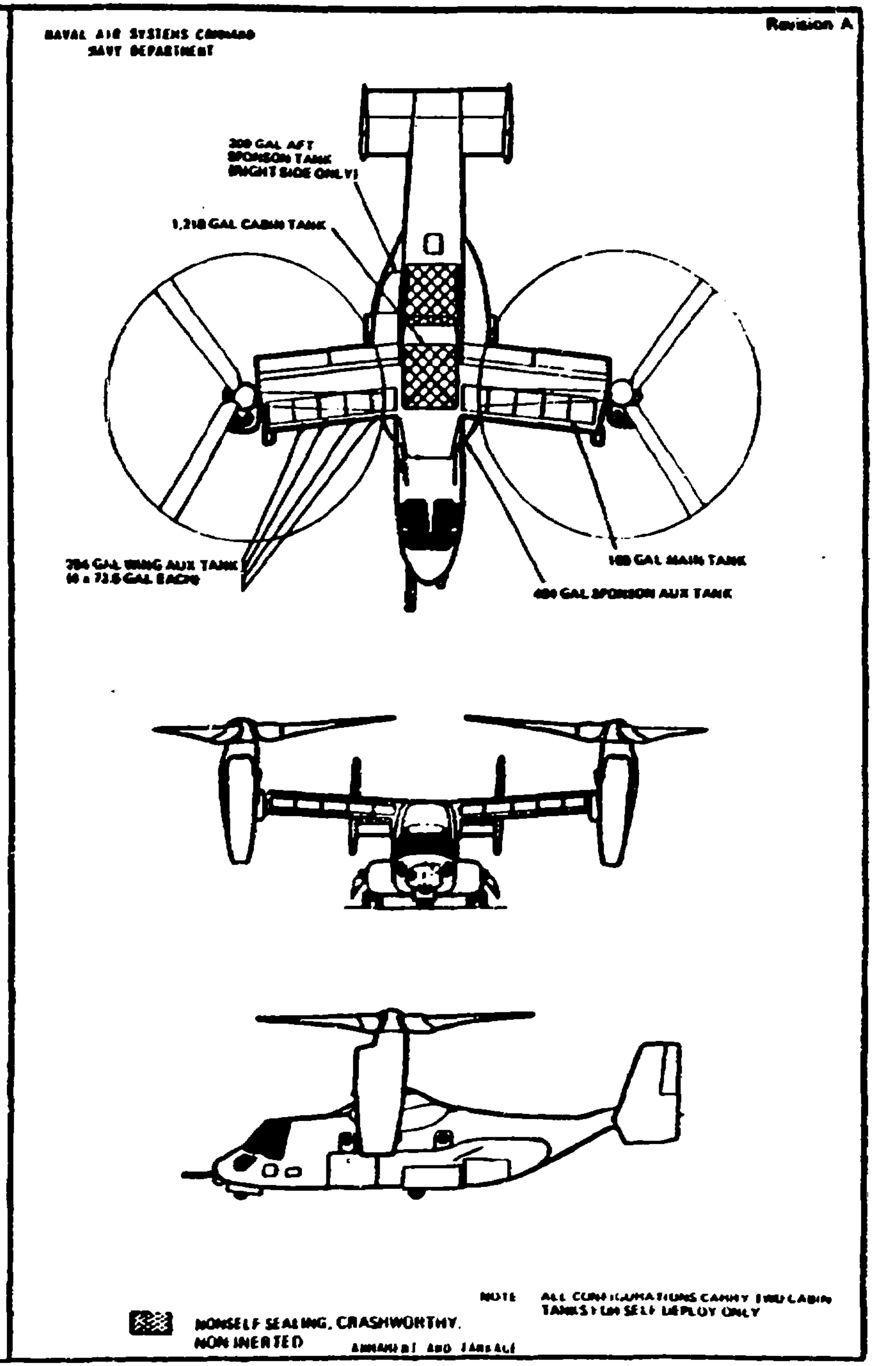
Additional Provision for Ramp Mounted Gun (USAF only)

ACCOMMODATIONS

Crew (mission)	3
Cabin Size Clearance	
Length:	290 inches
Width:	71 inches
Height:	72 inches
Usable Volume:	858 ft^3
Rescue Hatch Dimensions:	40 inches x 29 inches
Provision for Troop Seats:	24
Provision for Litters:	12
Rescue Hoist Capacity:	600 lb
Cargo Hook Capacity:	15,000 lb
Cargo Floor Limit:	300 psf
Max Cargo Weight:	20,000 lb

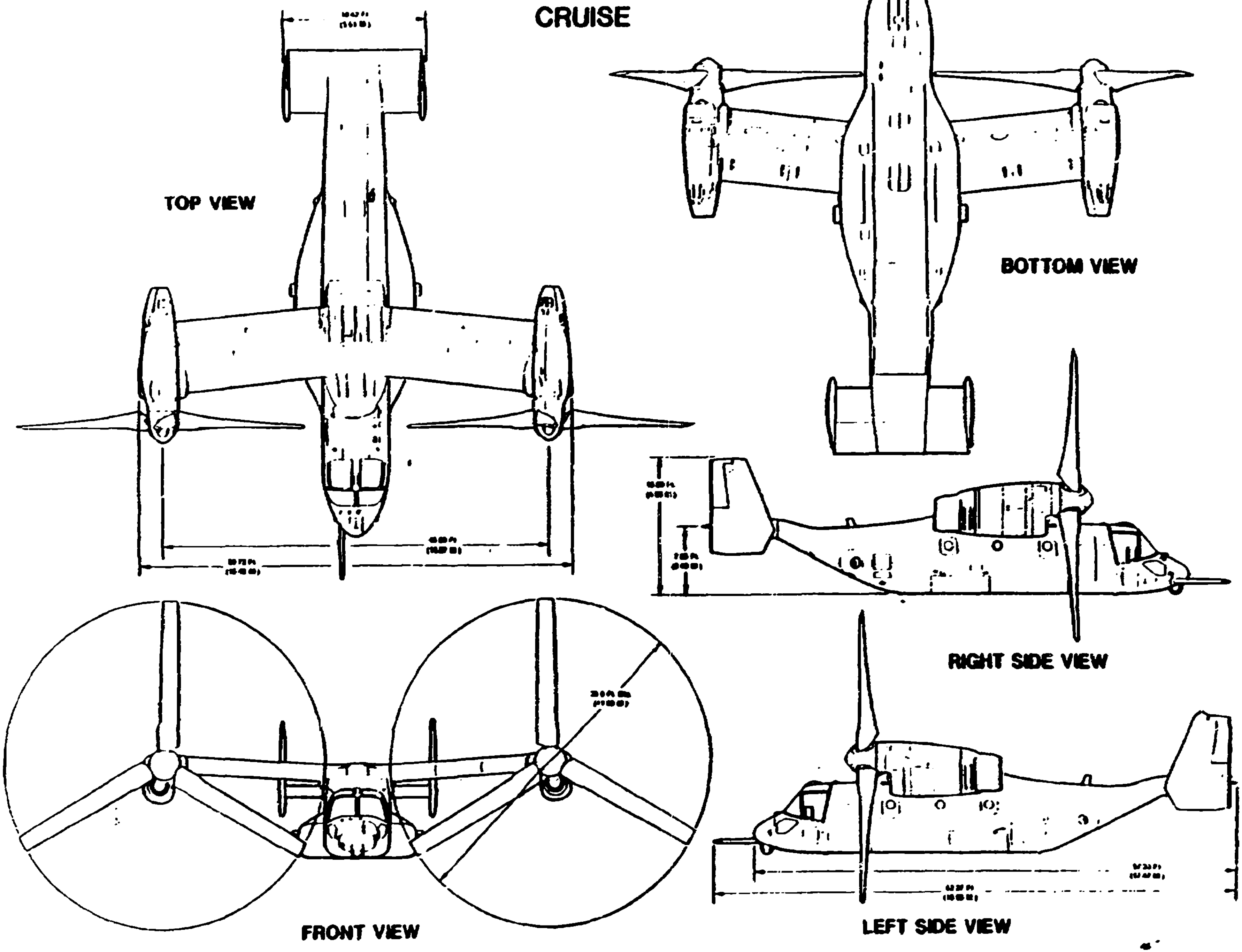


NAVAL AIR SYSTEMS COMMAND
NAVY DEPARTMENT
38 FT DIA
SPAN FOLDED
STATIC TREAD
0 5 10 15 20
SCALE - FEET
MAXIMUM LENGTH
PROP
GROUND
CLEARANCE
STATIC WHEELBASE
DESCRIPTIVE ARRANGEMENT

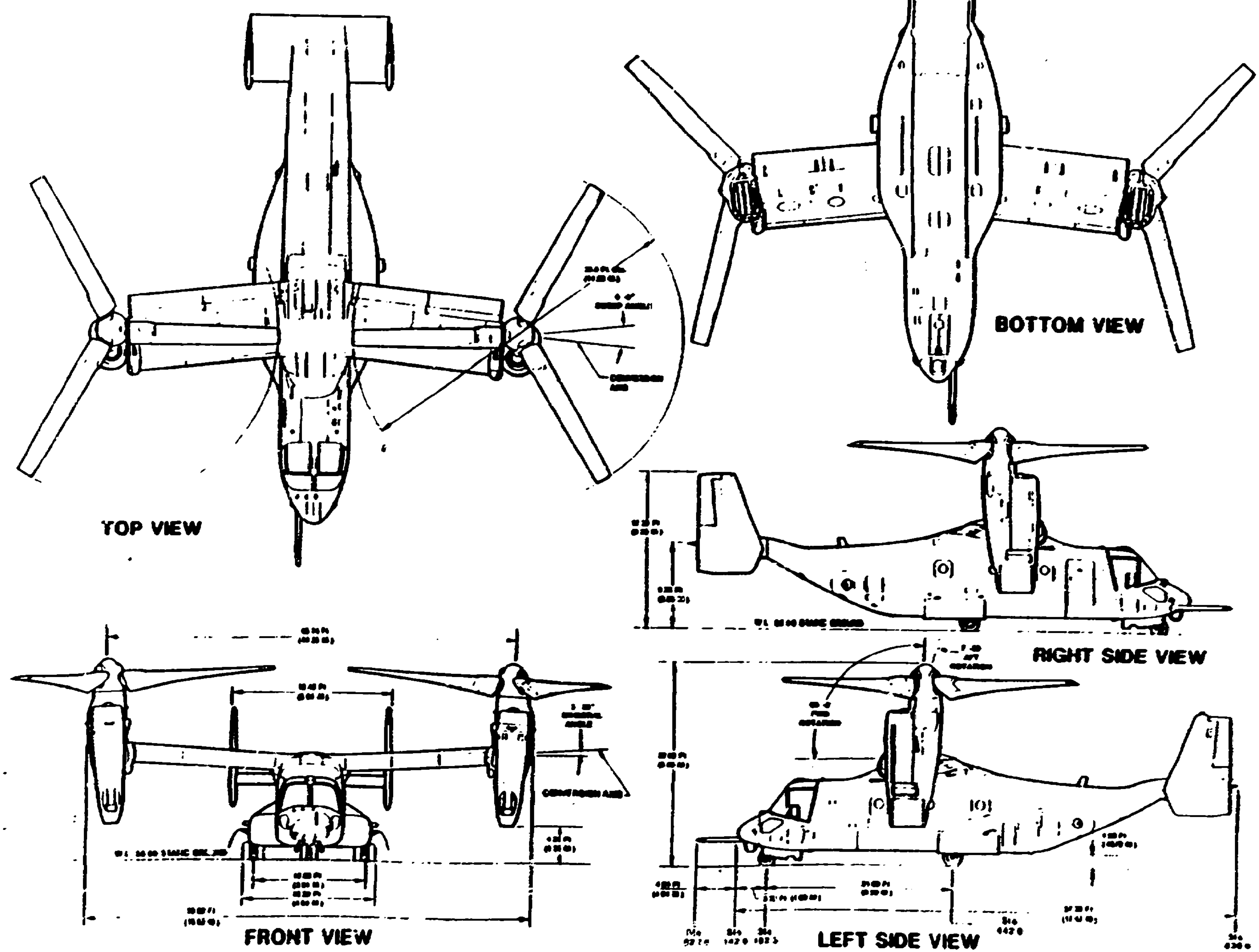


Revision A
NAVAL AIR SYSTEMS COMMAND
NAVY DEPARTMENT
300 GAL AFT
SPONSON TANK
(RIGHT SIDE ONLY)
1,218 GAL CABIN TANK
188 GAL MAIN TANK
400 GAL SPONSON AUX TANK
NONSELF SEALING, CRASHWORTHY,
NON INERTED

V-22 OSPREY
BASELINE CONFIGURATION
CRUISE



V-22 OSPREY
BASELINE CONFIGURATION
HELICOPTER



APPENDIX C

CONGRESSIONAL TILT-ROTOR TECHNOLOGY COALITION

HOUSE:

CURT WELDON, PA.
PETE GEREN, TX.
DAVE MARTIN, NY
FRANK MCCLOSKEY, IN.
NEWT GINGRICH, GA.
JOHN BRYANT, TX.
NORM MINETA, CA.
MARTIN LANCASTER, NC
TOM CARPER, DE
RAY MCGRATH, NY
GEORGE HOCHBRUECKNER, NY
JOE MCDADE, PA
JOHN MURTHA, PA
LANE EVANS, IL
ALBERT BUSTAMANTE, TX
SOLOMON ORTIZ, TX
JAIME FUSTER, PR
RONALD MACHTLEY, RI
MARTIN FROST, TX
JOE BARTON, TX
JAMES INHOFE, OK
DUNCAN HUNTER, CA
CHARLIE WILSON, TX
MIKE ANDREWS, TX
JOHN MILLER, WA
RALPH HALL, TX
CHARLES STENHOLM, TX
TOM DOWNEY, NY
BILL SARPALIUS, TX
JAKE PICKLE, TX
TOM FOGLIETTA, PA
WALTER JONES, NC
DICK ARMEY, TX
JACK BROOKS, TX
JIM CHAPMAN, TX
KIKA dE lA GARZA, TX
HENRY GONZALEZ, TX
GREG LAUGHLIN, TX
LARRY COUGHLIN, PA
JAMES SAXTON, NJ
CARLOS MOORHEAD, CA
GUS YATRON, PA
TOM RIDGE, PA
DAN BURTON, IN
SHERWOOD BOEHLERT, NY
SID MORRISON, WA
PETER KOSTMAYER, PA
ARTHUR RAVENEL, SC
JOLENE UNSOELD, WA
BOB DORNAN, CA
ROD CHANDLER, WA
DON RITTER, PA
DANA ROHRABACHER, CA
JOE KOLTER, PA
GEORGE GEKAS, PA
ELTON GALLEGLY, CA
ROBERT WALKER, PA
CHRIS COX, CA
FRANK HORTON, NY
CHRIS SMITH, NJ
MARILYN LLOYD, TN
MEL HANCOCK, MO
JERRY COSTELLO, IL
DAN GLICKMAN, KS
DAVE BONIOR, MI
BEN JONES, GA.
CRAIG WASHINGTON, TX
BOB STUMP, AZ
BILL CLINGER, PA
PETER DEFAZIO, OR
AUSTIN MURPHY, PA
NORM SISISKY, VA
RON PACKARD, CA
JACK BUECHNER, MO
JIM MCDERMOTT, WA
MIKE PARKER, MS
BOB CLEMENT, TN
GEORGE BROWN, CA

APPENDIX C (cont)

CONGRESSIONAL TILT-ROTOR TECHNOLOGY COALITION

ROBERT BORSKI, PA
JOSEPH GAYDOS, PA
BEN BLAZ, GUAM
BOB MCEWEN, OH
NORM DICKS, WA
JIMMY HAYES, LA
MIKE MCNULTY, NY
STEVE BARTLETT, TX
RON COLEMAN, TX
GERALD SOLOMON, NY
BILL YOUNG, FL
JAMES OBERSTAR, MN
HELEN BENTLEY, MD
MATTHEW MARTINEZ, CA
BOB WISE, WV
JOE SKEEN, NM
PAT ROBERTS, KS
WILLIAM BROOMFIELD, MI
ALLAN MOLLOHAN, WV
AMO HOUGHTON, NY
MATT MCHUGH, NY
FRANK PALLONE, NJ
JIM LIGHTFOOT, IA
HARLEY STAGGERS, WV
PETER KOSTMAYER, PA
DAVID PRICE, NC
ELIOT ENGEL, NY
JOHN MYERS, IN
BILL LIPINSKI, IL
RON DE LUGO, VI
BEVERLY BYRON, MD
ALEX MCMILLAN, NC
BUD CRAMER, AL
BERNARD DWYER, NJ
J.P. HAMMERSCHMIDT, AK
WAYNE OWENS, UT
BOB CARR, MI
BEN NIGHTHORSE CAMPBELL, CO
ROBERT TORRICELLI, NJ
BILL HEFNER, NC
JAMES BILBRAY, NV
ROBERT ROE, NJ
ROBERT MRAZEK, NY
JOHN J RHODES, AZ
BILL LOWERY, CA
DENNIS HERTEL, MI
BILL GREEN, NY

SENATE:

ARLEN SPECTER, PA
ALFONSE D'AMATO, NY
DAN COATS, IN
PHIL GRAMM, TX
LLOYD BENTSEN, TX
BENNETT JOHNSTON, LA
CLAIBORNE PELL, RI
ORRIN HATCH, UT
STEVE SYMMS, ID
RICHARD LUGAR, IN
JOHN BREAUX, LA
CONRAD BURNS, MT
WENDELL FORD, KY
ALAN CRANSTON, CA
TERRY SANFORD, NC
ROBERT KASTEN, WI
JOHN CHAFEE, RI
FRANK LAUTENBERG, NJ
JOHN SEYMOUR, CA
HARRIS WOFFORD, PA

APPENDIX D

STUDY OF THE V-22'S POTENTIAL IN DESERT SHIELD/STORM

By LtGen. Keith Smith, U.S. Marine Corps (Ret.)

This article examines the potential deployment and employment advantages that a Desert Shield/Storm force equipped with the MV-22 Osprey could have provided compared to the actual medium lift helicopter force which was deployed. The analysis primarily concerns substitution of CH-46Es and CH-53Ds in I Marine Expeditionary Force (IMEF) with a force of MV-22s which would have provided a comparable capability. It is also noted that similar advantages would accrue to the U.S. Army if some UH-60s were substituted with the MV-22.

The success of the five-month Operation Desert Shield deployment and 100-hour Desert Storm campaign will result in analysis and assessment of all aspects of both for years to come. Force structure and weapon systems effectiveness will be examined in great detail for lessons learned. While such studies will be invaluable to improve existing force composition, Operation Desert Storm will also provide an excellent opportunity to compare developmental systems with the demonstrated capabilities of currently fielded systems. The superb execution of both operations allow them to serve as excellent benchmarks to measure the effectiveness of future programs.

DEPLOYMENT

Deployment of a large force is a complicated and difficult operation at best. Desert Shield required the largest deployment of U.S. forces since the Vietnam War, and to ensure a reasonable probability of success, demanded that the major elements of the force were in place and operationally ready as quickly as possible. The major pacing factors in the deployment phase were the distances to be flown and the number of C-5 and C-141 strategic airlift sorties available. The demands for space on those critical sor-

DAY	DEPART	REFUEL	ARRIVE	DISTANCE (NM)	FLIGHT TIME (HRS.)	DAYS
1st	Kaneohe		Alameda	2,075	8.3 hrs.	1
2nd	Alameda	Tinker	Cherry Pt.	2,211	8.8	1
3rd	(crew rest Cherry Pt.)			0	0	1
4th	Cherry Pt.	Bermuda	Lajes	2,489	9.7	1
5th	Lajes		Sigonella	1,969	7.4	1
6th	Crew rest Sigonella			0	0	1
7th	Sigonella		Saudi Arabia	1,806	6.8	1
				TOTAL	41.0	7

Figure 1. Kaneohe Bay Deployment

DAY	DEPART	REFUEL	ARRIVE	DISTANCE (NM)	[illegible]IT [illegible] (HRS.)	DAYS
1st	El Toro	Tinker	Cherry Pt.	2,012	8.1	1
2nd	Cherry Pt.	Bermuda	Lajes	2,489	9.7	1
3rd	(crew rest Lajes)			0	0	1
4th	Lajes	Bermuda	Sigonella	1,969	7.4	1
5th	Sigonella		Saudi Arabia	1,806	6.8	1
				TOTAL	32.0	5

Figure 2. El Toro Deployment

	24 CH-46E/20 CH-53D	44 V-22	DELTA
C-5 Loads	18	0	-18
A[illegible]kers	0	0	0
Sup[illegible] Aircraft	0	5	+5
Cost to move ($ millions)	5.5	3.2	-2.3
Time to load (days)	10	0	-10
Transit Time (days)	1	7	+6
Time to unload/reassemble/flight check (days)	10	0	-10
Days till combat ready in Saudi Arabia	21	7	-14

Figure 3. Marine Deployment Summary. Marine Aircraft could have been combat ready two weeks sooner.

that current medium lift helicopters required were of major proportion. Although helicopters were high priority items for early arrival in the objective area, they competed with other high priority forces for critical lift assets. Had the MV-22 been available to the Desert Shield force, it would have provided approximately the same lift capability. To ensure time-distance equality in the comparison, the MV-22 aircraft are assumed to have originated from the same stations as did the actually deployed helicopters. Twenty-four MV-22s were originated from MCAS El Toro, CA, and 20 from MCAS Kaneohe Bay, HI, for a total of 44 aircraft self-deploying. The remaining 16 New River-based MV-22s were assumed to be sealifted with amphibious ships.

To enable self-deployment, the Osprey, with four internal fuel tanks installed, has a flight ferry (no payload) range of 2,100 NM with a 10 percent fuel reserve. Although not required for Desert Shield deployment, (See Figures 1 and 2) it is also equipped for in-flight refueling.

The time to load factor in Figure 3 is the hours required to load a C-5 with CH-46Es or CH-53Ds. Trained personnel, special tooling, ground handling equipment, and ramp space availability were pacing factors. The comparison uses minimum instead of actual Desert Shield deployment times. During Desert Shield, the actual lift by 10 C-5 equivalents of 12 CH-46Es and 12 CH-53Ds from El Toro took 41 days from first airlift launch to last airlift landing in Saudi Arabia. It should be noted, however, if there were unlimited trained personnel, special tools, ground handling equipment, ramp space, and strategic lift available, the El Toro lift would have used only 25.5 hours from start to finish. Load planning factors are as indicated in Figure 4 below.

	CH-46E	CH-53D	UH-60	AH-1W	AH-64	V-22
C-5 Capacity	3	2	6	8	6	0
C-141 Capacity	0	0	2	2	2	0
Load time (Hrs.)[1, 2]	5.0	5.0	2.0	8.0	6.0	0
C-5 unload time (Hrs.)	2.0	3.5	2.0	.5	4.0	0
Assembly time/Flight check maintenance (Hrs.)	16.0	25.0	3.0	.5	.5	0
Internal tank removal and check (Hrs.)	0	0	0	0	0	4.0

1. Crew of 6-8 skilled maintenance personnel required. Only three to five aircraft can be disassembled or assembled at a time because of limited availability of special tools, ground handling equipment and trained personnel.
2. Times shown are per C-5 or C-141 load.

Figure 4. Loads, loading and maintenance profile.

GENERAL PERFORMANCE FACTORS	CH-46E	V-22
Cruising speed (KTS)	125	250
Combat radius (NM)	70	400
Payload (Lbs.)	4,400	10,000
Troop lift (USMC)	16 - 18	24
HMMWV lift (External)	0	1
Maintainability (MMH/FH)	22	11
Combat survivability (Ratio)	1	3

Figure 5. CH-46E Vs V-22 Comparative Performance Data

Using the above example of self-deployment, the advantages to I MEF of an MV-22 equipped force for Desert Shield would have been:

- Combat ready in Saudi Arabia 14 days sooner than the CH-46/CH-53D fleet
- 18 C-5 load equivalents freed to lift other forces
- Deployment directly to dispersed operational sites, avoiding airport congestion
- Aircraft and flight crews prepared to undertake the full range of medium-lift missions on day of arrival

ARMY DEPLOYMENT

A brief examination of the U.S. Army deployment indicates similar lift saving advantages would have resulted with some portion of the UH-60 force being replaced with the MV-22. Actual airlifted U.S. Army helicopter deployment of 105 UH-60S indicated utilization of 18 C-5 equivalents. The flow time for the air movement was 39 days for the 101st Air Assault Division, Fort Campbell, KY (90 aircraft) from first take off to last landing in Saudi Arabia.

DESERT STORM EMPLOYMENT

Performance and employment advantages of the MV-22 are examined in several mission areas: amphibious operations, tactical recovery of aircraft and personnel (TRAP), special operations (SOC), and other related operations. A general comparison of performance characteristics of the CH-46E and MV-22 is contained in Figure 5. These figures are utilized in the following employment scenarios.

AMPHIBIOUS OPERATIONS

Although it was ultimately not required in Desert Storm, an amphibious task force (ATF) was prepared to conduct amphibious operations if directed. The Gulf coastline of Iraqi-occupied Kuwait presented an opportunity to facilitate the general offensive by outflanking the Iraqi fortified line facing U.S. forces in Saudi Arabia, cutting major lines of communication, and establishing a lodgment for follow-on introduction of coalition forces. In recognition of our amphibious capability, Iraq deployed 60-68,000 personnel to Kuwait's coastal region with the primary mission of establishing a defense in depth against a possible landing. Additionally, the beaches were mined extensively. Within this scenario, the advantages offered by an MV-22/CH53E force compared to an equal-lift CH-46E/CH-53D force in an amphibious assault are examined. The speed, load, and range capabilities combine to provide an overwhelming advantage. For example, in order to land MEF assault elements within 90 minutes (considered minimum

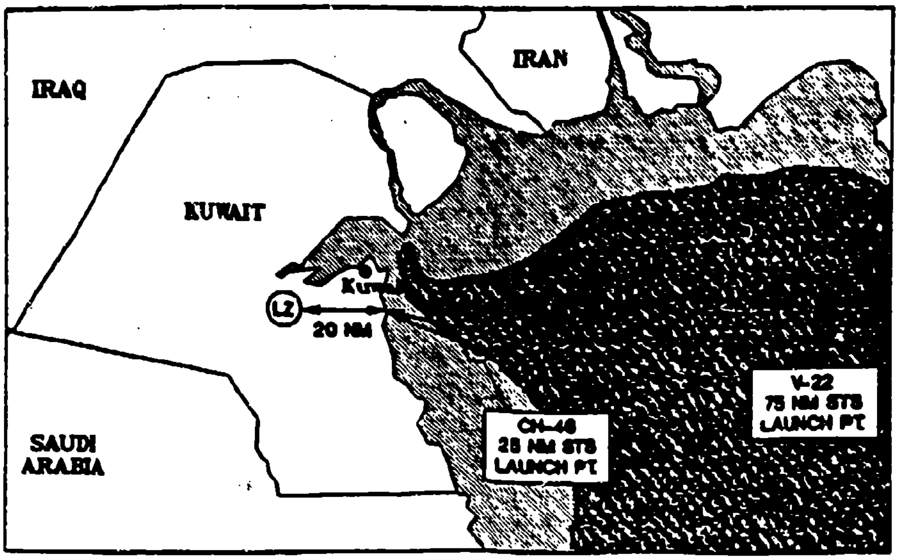


Figure 6.

acceptable) in a landing zone 20 NM inland, a CH-46E/CH-53E force would have to launch from a point no farther than 25 NM offshore; whereas, an MV-22/CH-53E force could launch at 75NM offshore, fly 20 NM inland, and still make the 90-minute time requirement. The map, Figure 6, superimposes these distances of 25NM and 75 NM on the Persian Gulf in the vicinity of Kuwait and illustrates several salient points:

The upper Persian Gulf is a relatively small and very shallow body of water, studded with oil rig platforms that will effectively compress ATF maneuver room. With exception of a deep water ship channel leading into Kuwait harbor, unacceptably shallow water, in this case mined, extends from about 10NM to 30NM offshore. Because of water depth limitations, the only possible launch point available to the CH-46 force at 25NM is in the middle of the channel leading to Kuwait port facilities. This would almost completely eliminate maneuver room and would place portions of the task force about 12NM offshore and within range of long-range artillery fire

The map demonstrates the advantage inherent in the MV-22 force's capability of launching at 75NM. The ATF would clearly be beyond line of sight from the Iraqi coastline and in water deep enough to maneuver with reasonable safety. If the ATF were to move in to a 50NM launch point, Figure 7, it would still be comfortably within the distance needed for an OTH operation and yet maintain maneuver room.

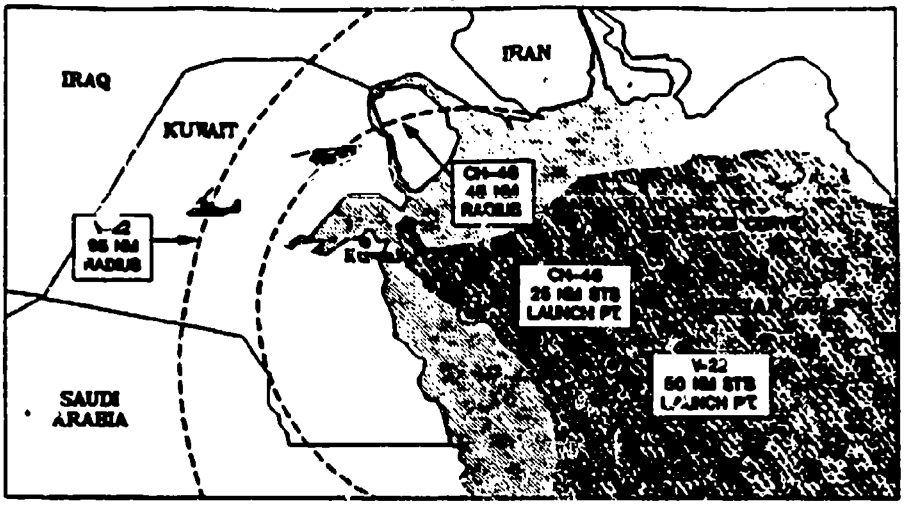


Figure 7.

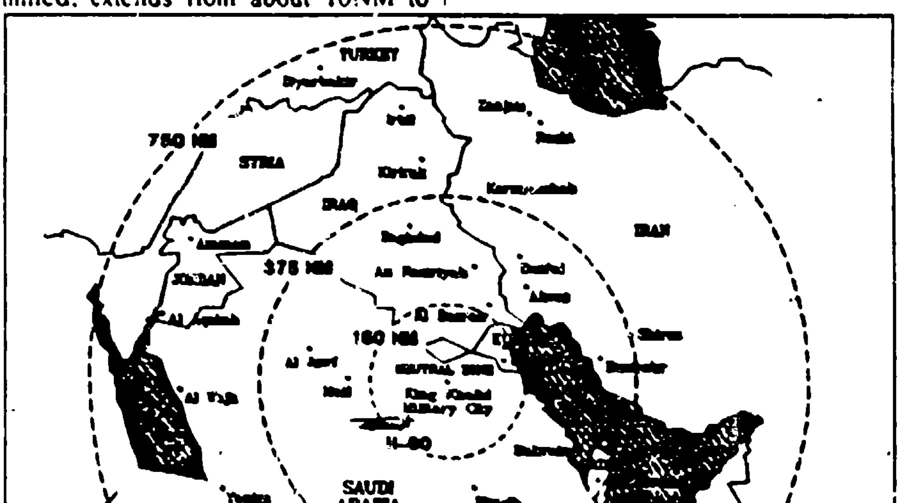


Figure 7.

In summary, the MV-22's greater speed, range, and lift capacity would have opened up most of Kuwait and southern Iraq to the vertical envelopment arm of amphibious exploitation without appreciably hazarding the fleet. These increased capabilities would have seriously complicated the Iraqi defensive arrangements. Instead of concentrating only on a coastal band about 20 miles wide, the Iraqis would have, of necessity, had to face the prospect of contending with landings practically the length and breadth of Kuwait and the southern portion of their own homeland as well. In fairness, it must be said that the CH-46 force could have reached into Kuwait and undoubtedly was prepared to do so, but, as the map shows, only about half as far and at considerable risk to the amphibious fleet.

TACTICAL RECOVERY OF AIRCRAFT AND PERSONNEL (TRAP)

Unfortunately, the air-to-ground phase of Desert Storm provided several opportunities to exercise the TRAP mission to recover downed aircrewman. Many efforts were successful—some were not. At least some of the unsuccessful rescue attempts, and some which were not attempted, were due to the large distances of the downed aircrew from friendly lines. Figure 8 above shows the vastness of the Desert Storm area and the disposition of potential targets.

Given the assets that were available, the probability of successful search and rescue within the majority of the area was severely limited. During recent testimony before the Senate Armed Services Committee, Army Gen. Carl Stiner stated, "Special operations forces assigned to rescue American aircrews shot down inside Iraq quickly came face to face with the limitations of their helicopters."

Compared to the current force of CH-46/CH-53's, the MV-22 would have provided a significantly greater probability of rescuing and returning downed aircrew with the least possible risk to aircraft as a result of several performance factors: range, speed and survivability. The increased range advantage almost doubles the area of coverage to include all of Iraq. The MV-22 range capability is such that after picking up the downed aircrew, it could continue unrefueled into Turkey, further enhancing survivability. When the increased speed of the aircraft, 275kts, is added to the increased range and considered with historical data that indicates the probability of rescue decreases significantly after the first hour on the ground, the advantage of the MV-22 becomes overwhelming. Additionally, considering the emphasis during Desert Storm on night TACAIR operations, the probability of a single sortie being shot down at night decreased as a result of the cover of darkness. However, the frequency of night downings increased simply

	H-53	CV-22
UNFUELED RADIUS	325	520 (COVERS 9/10 OF IRAQ)
SPEED	125	250 (PERMIT TOTAL MISSION AT NIGHT)
TIME	7.08	3.54
HOVER OUT OF GROUND EFFECT (HOGE)*	NO	YES
SURVIVABILITY		
SMALL ARMS		ADVANTAGE
MISSILE		ADVANTAGE
NIGHT/ALL WX/TERRAIN FOLLOWING	LIMITED	YES
MAX ALT (TRANSIT)	10,000 FEET	25,000 FEET

* Based on 885NM mission, hover at midpoint, exfiltrating one special forces team with equipment (12 personnel 4,000 lbs) with midpoint hover conditions, 4,000 feet + 40C

Figure 9. Special Operations Mission performance comparison

because of the massive number of night sorties. The night, adverse weather capability of the MV-22 would have significantly enhanced the ability to effect successful rescues at night, thereby providing an additional benefit of increased survivability of the mission.

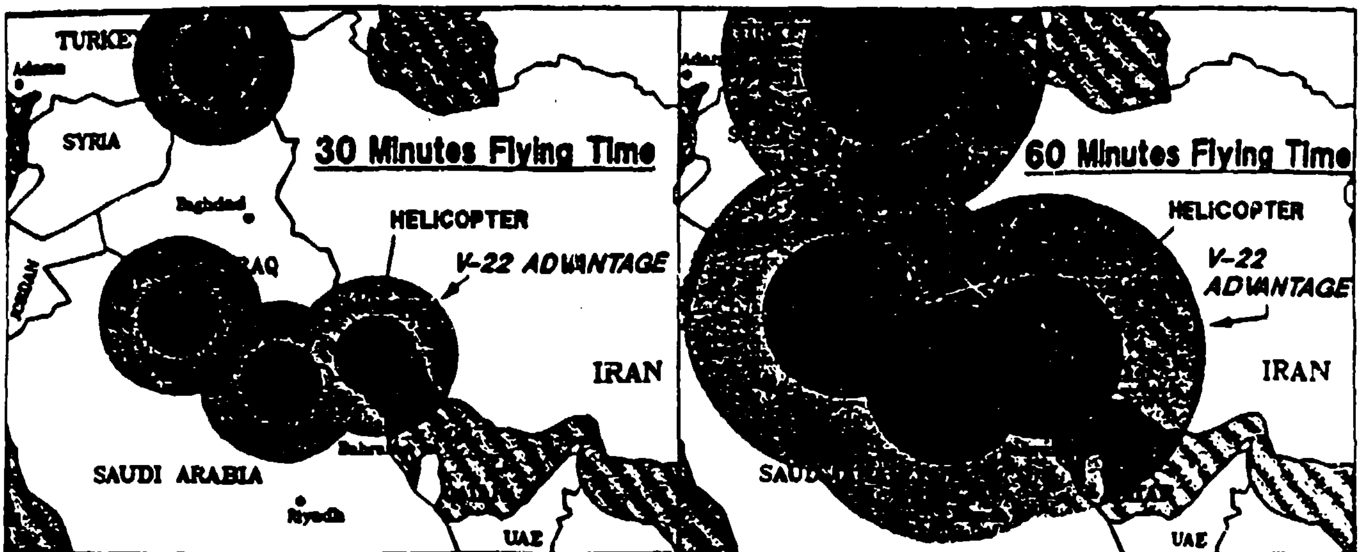
SPECIAL OPERATIONS CAPABLE (SOC)

The Osprey is ideally suited to the special operations mission. Its speed, range, and maneuverability allow a commander to attempt missions, with reasonable certainty of success, that he would previously have rejected out-of-hand. When Iraq is examined with respect to distance, terrain and the threat, it is evident that SOC missions previously regarded as "not doable" are possible. On SOC missions such as hostage rescue, special reconnaissance, airfield seizure, and direct action against such targets as SCUD sites, increased capability means increased odds for success. In many cases, helicopters simply could not meet the vital requirements for range, speed, survivability, hover power, or transit altitude. Additionally, SOC forces prefer to execute missions under cover of darkness because of the clandestine nature of most of their operations. Therefore, it becomes very important to mission success to have vertical lift capability that has sufficient speed to infiltrate, accomplish the objective, and exfiltrate in a relative short period, thus allowing the entire mission to be conducted with surprise and stealth under cover of darkness. For instance, to operate against some of the key targets north of Baghdad would require helicopter-borne forces over six hours of just transit time from northern Saudi Arabia to north of Baghdad and return. The MV-22 could perform the same mission in half the time. See SOC mission comparison in Figure 9.

As an example, the 855NM mission depicted in Figure 9 done by helicopter would require some part in daylight, and would require a forward area refueling point and/or numerous air refuelings, additional risk factors that raise the odds against a successful operation. The MV-22 on such a mission would require only two nighttime refuelings over friendly Saudi territory and under the cover of darkness.

OTHER MISSIONS

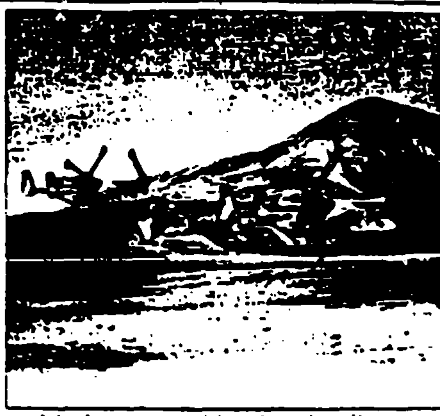
MedEvac. The time elapsed between injury and arrival at appropriate medical facilities has been proven to be directly linked to mortality rate. Speed advantage of the MV-22 alone is significant enough to save lives. During Desert storm, if allied forces had experienced the extensive casualty rate predicted by some, medical facilities in northern Saudi would have quickly filled to capacity. The range advantage of the MV-22 would have per-



mitted evacuation from front-line aid stations directly to medical facilities in central Saudi or hospital ships.

Chemical and Biological Survey Operations. Had Iraq utilized chemical and biological (CB) weapons as it had threatened, a fast, responsive, accurate CB survey to determine areas contaminated and the degree of contamination would have been of utmost importance. Currently, CB surveys are done by both air and ground vehicles. Both not only require special monitoring equipment, but also that the individuals and equipment conducting the surveys must be protected individually since current helicopters are not sealed against agent penetration. The aircraft itself will become contaminated inside and out and will be a hazard until decontaminated—a difficult, dangerous task. The MV-22, with its built-in chemical and biological protection systems, could have accomplished these surveys faster and with considerable more safety than helicopters. Importantly, the MV-22 would receive only surface contamination, which is easily and safely removed. Interiors, critical components, and most important, crew and passengers are located inside the aircraft which is sealed against NBC agent penetration.

High-Speed Resupply. During Operation Desert Storm, planned use of high-tech components, weapons, and ammunition would have provided coalition forces a significant advantage if major resistance had materialized. Not only would such items likely have been consumed rapidly



and in large quantities, but the distances over which resupply would have had to have been transported were vast, and availability of high-grade surface transportation systems scarce. Large quantities of missiles, fire control, night vision and other high-tech equipment would have been used on a daily basis. Since all these items were in short supply and relatively fragile, normal truck transportation systems would not have been appropriate or have met time requirements. The ability of the MV-22 to fly long distances at high speed and then land vertically in the vicinity of front-line units would have made it the ideal aircraft for the rapid resupply mission.

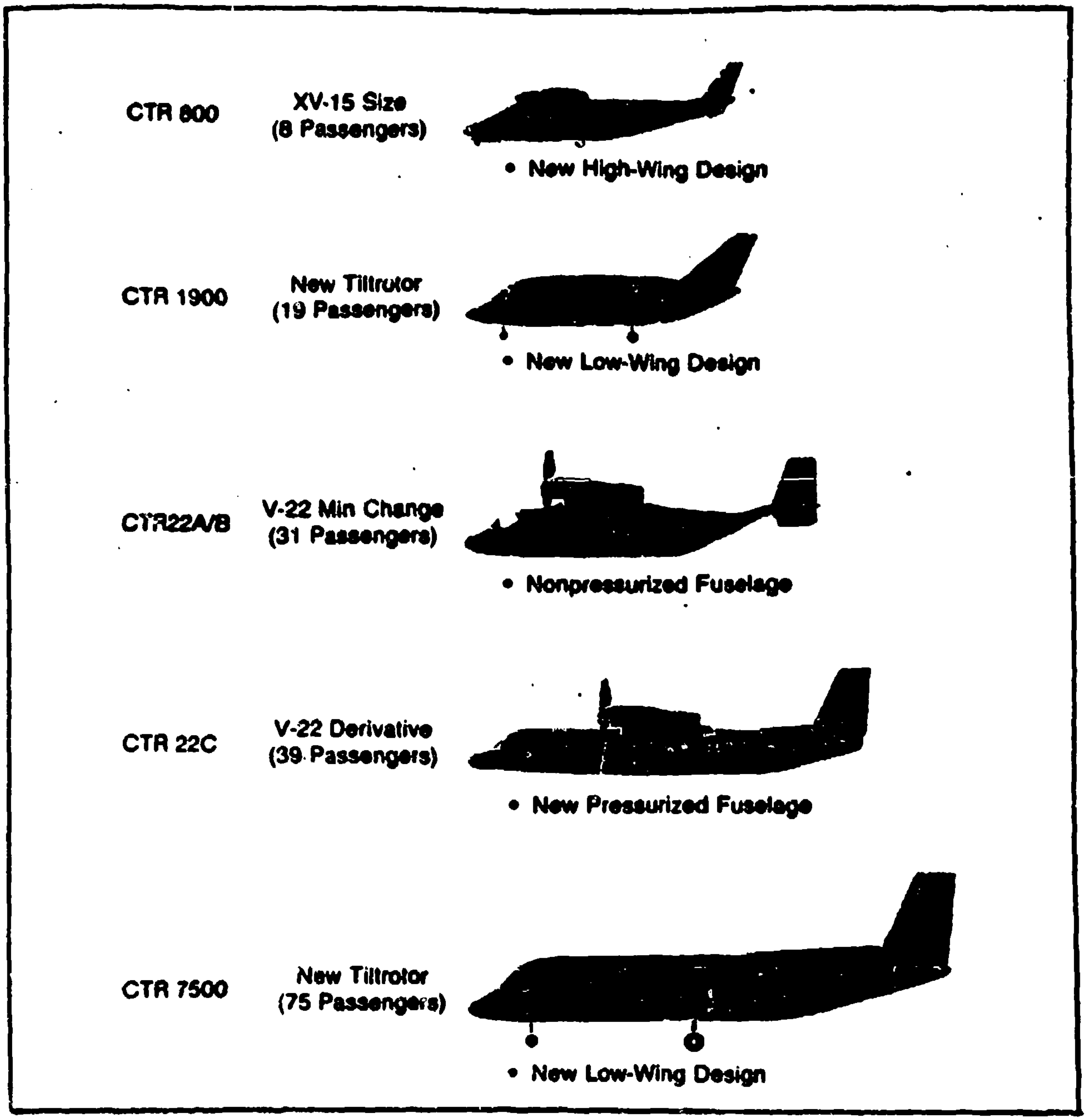
Insertion of a Blocking Force. The synergistic value of speed, range, payload, survivability, and a relative stealth advantage as a result of a reduced sound footprint that the MV-22 brings to the battlefield offers the commander maneuver warfare opportunities that are not existent in the current force. The resultant advantages offer the potential of expanding the battlefield, gaining decisive surprise, and maintaining momentum beyond the enemy's ability to cope. The capabilities of the MV-22 virtually limit the opportunities for maneuver warfare only to the imagination of the commander.

CONCLUSION

If the MV-22 had been available for the CH-46E/Ch-53D and Army UH-60 missions in Desert Shield/Storm operations, it would have enormously improved deployment flexibility, reduced deployment costs, and significantly reduced the time for Marine and Army aviation units to become combat ready in-country. During operation Desert Shield/Storm, in every operational employment scenario considered, the MV-22, in concert with other helicopter and fixed wing assets, would have provided a quantum increase in balanced force effectiveness. The warfighting advantages of the MV-22, with its significant increase in range, speed, and survivability, would have been a significant force multiplier. It would have added a whole new dimension to existing SOC capabilities and could have rescued a downed aircrew twice as fast, with a higher probability of success, than any existing aircraft. Overall, the margin of superiority that the Osprey could have provided in force maneuverability and support has been the dream of warriors over the entire history of conflict. The bottom line: the MV-22 Osprey will reduce risk, expand the battlefield, and save lives! ★

APPENDIX E

CIVIL TILT-ROTOR CONFIGURATIONS[2]



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