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## THESIS

A PRELIMINARY FEASIBILITY STUDY FOR THE UTILIZATION  
OF A TILT-ROTOR AIRCRAFT (MV-22) FOR LOGISTICAL  
SUPPORT TO THE MILITARY OUTPOST ALONG THE  
VENEZUELAN JUNGLE AREA BORDERING COLOMBIA

by

Victor Manuel Ponte

June 1988

Thesis Advisor:

Richard D. Wood

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COLOMBIA

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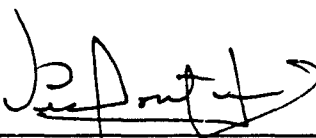
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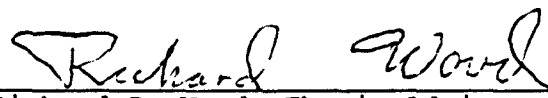
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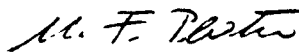
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## ABSTRACT

Resupply to remote jungle outposts/villages along the Venezuelan frontier is conducted via river boats along the Arauca and Meta Rivers, which define the border with Colombia. The lack of usable airstrip/landing sites in this area, precludes the use of conventional STOL aircraft, while the remote location restricts the use of helicopter due to range limitations. This is aggravated by a harsh rain forest climate that makes visual air navigation difficult. Additionally, frequent guerilla attacks on boats operating along this lifeline waterway makes its use less than desirable. This thesis examines the feasibility of a tilt-rotor aircraft, to include site preparation, navigation/approach procedures, to provide the necessary logistical link to this region.



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TABLE OF CONTENTS

I. INTRODUCTION ..... 1

    A. BACKGROUND ..... 1

    B. OBJECTIVES ..... 4

II. THE TILT-ROTOR SYSTEM AIRCRAFT ..... 5

    A. ORIGINS ..... 5

    B. CAPABILITIES ..... 7

    C. CHARACTERISTICS ..... 9

    D. VULNERABILITY AND SAFETY FEATURES ..... 12

III. MISSIONS ..... 17

    A. RANGE MISSION ..... 17

    B. MEDICAL EVACUATION ..... 24

    C. COMPUTER SIMULATION ..... 28

IV. COMPARISON BETWEEN THE MV-22 AND THE  
    CONVENTIONAL HELICOPTER ..... 42

    A. POWER REQUIRED TO HOVER ..... 42

    B. NOISE LEVEL ..... 42

    C. VIBRATION ..... 44

    D. PRODUCTIVITY ..... 45

V. LANDING SITE ..... 51

    A. SITE SELECTION CRITERIA ..... 51

    B. NEW SITE PREPARATION ..... 53

VI. CONCLUSIONS ..... 61

VII. SUMMARY ..... 64

LIST OF REFERENCES ..... 67

BIBLIOGRAPHY ..... 69  
INITIAL DISTRIBUTION LIST ..... 70

LIST OF TABLES

I STAFF RECOMMENDATION OF THE AMERICAN COLLEGE OF  
SURGEON FOR AN EMERGENCY MEDICAL TRAUMA CENTER ..... 27

II SIMULATION INPUT DATA ..... 31

## LIST OF FIGURES

1. Military Post Locations .....	3
2. Army/Nasa XV-15 Tilt-rotor .....	6
3. Tilt-rotor Characteristics .....	10
4. Performance Comparison for Off-shore Support .....	21
5a. Vertical Take-off Low Altitude (Sea Level) .....	23
5b. Curves of Payload Versus Range .....	23
6. Dimensions of XY-15 Tilt-rotor in Meters .....	29
7. Simulation 1 .....	32
8. Simulation 2 .....	33
9. Simulation 3 .....	34
10. Simulation 4 .....	35
11. Simulation 5 .....	36
12. Simulation 6 .....	37
13. Simulation 7 .....	38
14. Simulation 8 .....	39
15. Curves of Power Required Versus Speed .....	43
16. Fuel Consumption .....	43
17. Rotorcraft Hover Noise Levels .....	45
18. Vibration .....	46
19. Productivity and Response Time for a Dash Mission .....	48
20. Productivity for a Simple Range Mission .....	50
21. Payload Fractions for a Simple Range Mission .....	50
22. Possible Military Outpost Area .....	52



23. Locking Groove .....	55
24. Completed Lock .....	55
25. GAIL Beam Pattern .....	58
26. Approach to Lighted "T" Pattern in Landing Zone .....	60

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## I. INTRODUCTION

### A. BACKGROUND

Along its frontiers, Venezuela has established sovereignty by means of military outposts and small rural villages. Land access to this zone is most frequently impossible or very limited. For this reason waterways, small aircraft and helicopters are the primary means of transportation in and out this zone. The waterways are available about four (4) months out of a year during the rainy season. This season provides enough water to the rivers to make them deep enough to be navigable. The type of boat capable of navigating the rivers are about 30' in length and 3' in draught. Most of the time airstrips, runways and landing sites are unpaved and limited in size due to the jungle environment. The distances to these areas from the nearest supply point is in the average about 200 nautical miles. To reach these areas a helicopter must carry the basic load of supply plus the fuel required for a safe return trip. This makes any mission a high risk mission. Also weather conditions limit and sometimes make it impossible to provide supply.

In conjunction with this, there has been incidents along the fluvial border with Colombia. Insurgents from this neighboring country have opened fire against cutters that

patrol the zone creating hazards and interfering in transporting supplies.

None of this military outposts have a complete equipped medical center so the eventual emergencies have to be transported to an emergency center that is sufficiently equipped and staffed to handle a variety of medical situations and we know how important a rapid transport is in determining a trauma victim's chance of survival.

All these factors could easily be a reason of discomfort for personnel in the military post reflecting in low moral and low productivity at their duties.

For the development of this study, the most critical located remote military outpost along the border, was chosen. Distance to supply point, medical facilities, climate, passage ways available, personnel requirements and the amount of provisions by weight necessary for a 15 days operation were the factors considered in determining the selection. This location did not have verti-port landing nor could be helped with aerial navigational aids. Therefore, construction of a expeditionary airfield (VSTOL) with the basic needs to provide safe landings and vertical takeoffs is considered.

We will stage this at Puesto Naval "CIN Jose Cipriano Quintero" in San Fernando de Atabapo located next to Orinoco River and at 120 miles from Pto. Ayacucho where medical facilities and supply points are found. Average yearly

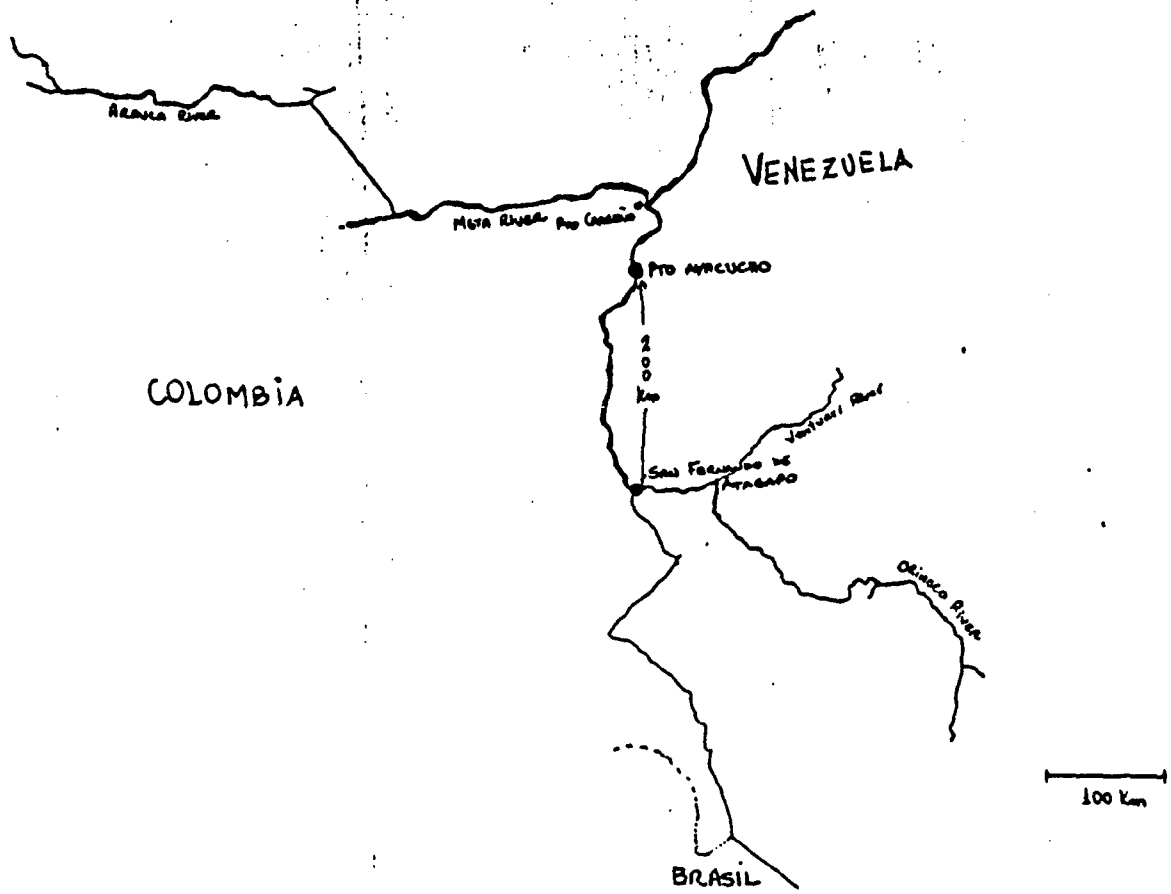


Figure 1 Military Post Locations

temperature is 90°F, humidity 80%, rainfall is around 200 cloudy days a year and is considered a tropical rain forest.

#### B. OBJECTIVES

The most important objective of this study is to see how feasible the use of a tilt-rotor aircraft (V-22 Osprey), operating under the above mentioned conditions, enables a safe and efficient mission accomplishment. Also to compare between a conventional helicopter and a tilt-rotor to determine which is the most productive in terms of velocity, time to complete a mission, range, payload and fuel consumption in long range and aeromedical evacuation missions.

To determine ways to construct and expeditionary vertiport in the region based on low cost and basic necessities to insure a safe landing and takeoff, that is, having a lighting system and guidance terminal.

The final objective of this study is to serve as a base in the decision making process for the Venezuela's Government in a future and possible acquisition of the MV-22 "Osprey."

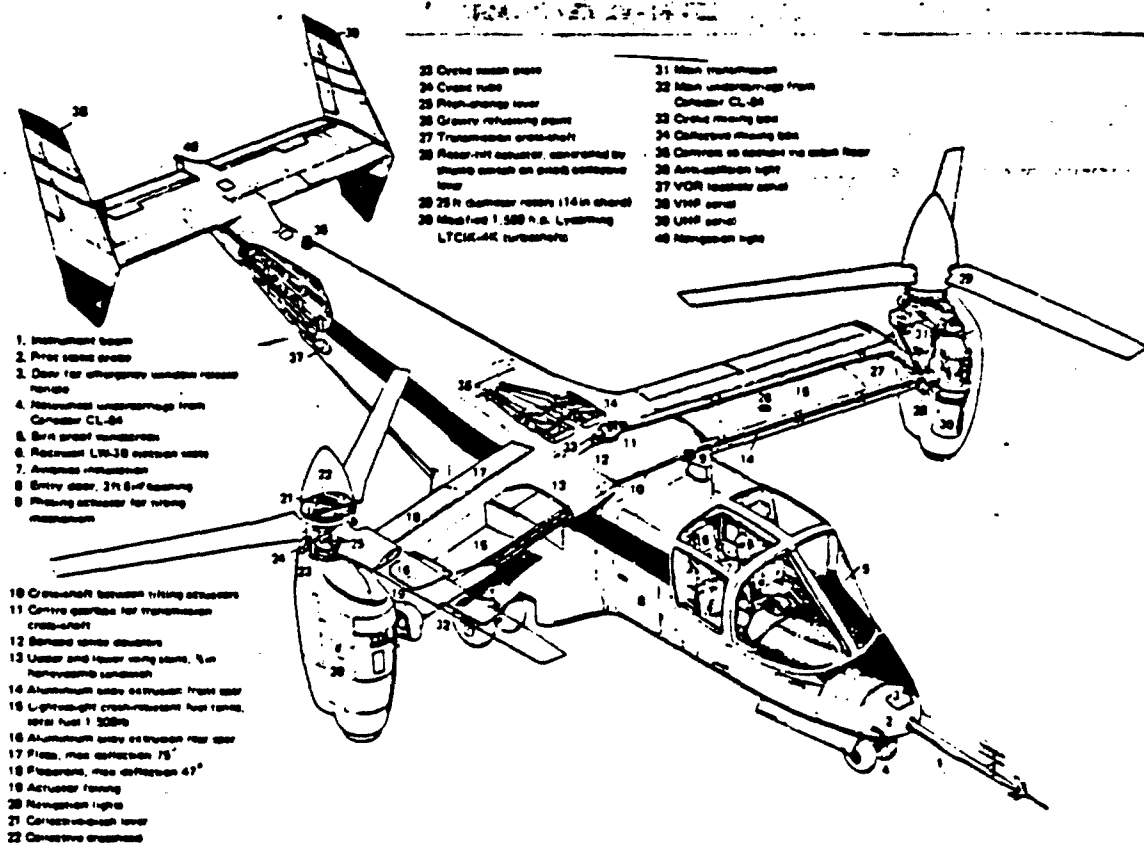
## II. THE TILT-ROTOR SYSTEM AIRCRAFT

### A. ORIGINS

The origin of the Osprey can be traced to 1968 when the Marine Corps issued an operational requirement for a follow-on to the CH-46 Helicopter. For various budgetary and technological reasons the program was delayed.

In 1977, Bell XV-15 Tilt-rotor was flight tested. By 1982 this tilt-rotor demonstrated that technology had matured to the point where it no longer made tactical sense to proceed with a 1970's technology helicopter development. DoD issued the V-22 Joint Services Operational Requirement. The Tilt-rotor was the only viable operational concept that met these requirements and offered the chance of meeting both the Marine Corps and other DoD requirements for medium vertical lift.

The contract for Preliminary Design (PD) was awarded in 1983. Since then, the Osprey's design and operational concept have been further refined through a comprehensive airframe PD phase. Design, fabrication and test responsibility is divided among Bell and Boeing and their subcontractors. Bell Helicopter has primary responsibility for the wing, transmission and rotor system while Boeing Vertol has the fuselage, avionics, landing gear and flight controls. Subcontractors include Grumman for the tail



- |                                          |                                       |                                      |
|------------------------------------------|---------------------------------------|--------------------------------------|
| 1. Instruction boom                      | 23. Cycle mesh plate                  | 31. Main transmission                |
| 2. Prop shaft brace                      | 24. Crest tube                        | 32. Main undercarriage from          |
| 3. Dowel for emergency landing rotor     | 25. Pre-engage lever                  | Cessna CL-44                         |
| 4. Retracted undercarriage from          | 26. Gravity releasing point           | 33. Cycle mesh bar                   |
| Cessna CL-44                             | 27. Transmission cross-shaft          | 34. Collective mesh bar              |
| 5. Brake pedal mechanism                 | 28. Rotor-rot actuator, operated by   | 35. Control as shown in cutaway view |
| 6. Retracted LTV-30 control cable        | shape control on prop collector       | 36. Anti-collision light             |
| 7. Avionics rack/box                     | 29. 25 hp gearbox rotor (14 in chord) | 37. VOR indicator panel              |
| 8. Entry door, 2 1/2 ft x 4 ft opening   | 30. Modified 1,500 h.p. Lycoming      | 38. VHF panel                        |
| 9. Pitching actuator for wing            | LTCM-4K turboprop                     | 39. UHF panel                        |
| 10. Cross-shaft between flying actuators |                                       | 40. Navigation light                 |
| 11. Drive gearbox for transmission       |                                       |                                      |
| cross-shaft                              |                                       |                                      |
| 12. Balance cable assembly               |                                       |                                      |
| 13. Upper and lower wing struts, 1/2 in  |                                       |                                      |
| non-retracting cable/rod                 |                                       |                                      |
| 14. Aluminum tube extension from star    |                                       |                                      |
| 15. Lightweight carbon-fiber fuel tank,  |                                       |                                      |
| total fuel 1,500 lbs                     |                                       |                                      |
| 16. Aluminum tube extension from star    |                                       |                                      |
| 17. Flaps, max deflection 75°            |                                       |                                      |
| 18. Flaps, max deflection 47°            |                                       |                                      |
| 19. Actuator towing                      |                                       |                                      |
| 20. Navigation light                     |                                       |                                      |
| 21. Collective mesh bar                  |                                       |                                      |
| 22. Collective crosshead                 |                                       |                                      |

Figure 2 Army/NASA XV-15 Tilt-rotor



section, IBM for avionics integration and Lockheed Georgia for wing control surfaces. Full Scale Development will culminate with six flight test aircraft and three ground test vehicles.

B. CAPABILITIES [Ref.1]

The Tilt-rotor concept has the capability of takeoff and land vertically like a laterally displaced tandem rotor helicopter. The wing-tip mounted rotors can then be pivoted to a vertical plane so that the aircraft becomes a high speed turbo prop airplane capable of speeds up to 300 knots and beyond. During transition or conversion period the aircraft speed increases and lift is transferred from the rotor to the wing. Operating now as a conventional airplane, it can cruise for more than two hours. To land the proprotors are rotated up to the helicopter rotor position and flown as a helicopter to a vertical landing. Another key benefit that was realized early in the development of Tilt-Rotor was the external acoustic signature of the vehicle in forward flight. For propulsive efficiency, the rotors are slowed after transition to the airplane mode. The slow turning rotors along with their vertical orientation makes the aircraft quieter. For many years, the tilt-rotor had been promoted for a broad range of military missions. Both helicopters and fixed wing aircraft could be replaced by a more versatile machine that was faster than helicopters and one that did not need the

infrastructure that airplane requires. A series of demonstrations and operational tests includes: survivability tests against ground based defenses, terrain following evaluations, shipboard operations at sea off a helicopter carrier, over water rescue simulations nap-of-the-earth flying, slope landing and air to air survivability test have been made.

The Osprey will weight in at about 32,000 pounds empty. Its cargo compartment, designed to carry 24 persons, measures 6 by 6 by 24 feet and is entered by either a rear ramp or forward door. Large fuselage sponsons house the main landing gear, the fuel tanks, the environmental control unit and some carry on equipment. Other of the advantages of this unique aircraft is its ability to deliver virtually conventional airplane performance when operating with its rotors partially tilted forward. In this configuration on a very short runway it can make a rolling take-off at gross weight up to 55,000 pounds. This capability allows it to double its helicopter-mode payload. With additional fuel tanks, it will have an unrefueled ferry range of 2,100 nautical miles giving it a worldwide self-deploy capability. Unlike air-craft of the past, the V-22 composite material structure will not be nearly so susceptible to corrosion from salt spray, stack gas and engine exhaust. The V-22 is being specially designed for ease of maintenance ashore and at sea and is also designed to be compatible with ship

services such air, electrical and fuel system including a hover in flight refueling capability for emergency or small deck operations.

C. CHARACTERISTICS [Ref.2]

1. Dimensions: (Figure 3)

Main Rotor

Diameter	: 38 ft.
Disk Area	: 2268 ft <sup>2</sup>
Blade Area	: 261.52 ft <sup>2</sup>
# of Blades/rotor	: 3/rotor

2. Length

Maximum	: 688 inches
Folded	: 751 "

3. Height

Maximum	: 261 inches
Folded	: 217 "

4. Width

Maximum	: 1014.9 "
Folded	: 221 "
Tread	: 182.6

5. Weights

Loading	Weight (lb)
Empty	31,772
Max Takeoff (VTO)	47,500
Max Takeoff (STO)	55,000
Self-deployment (STO)	60,500

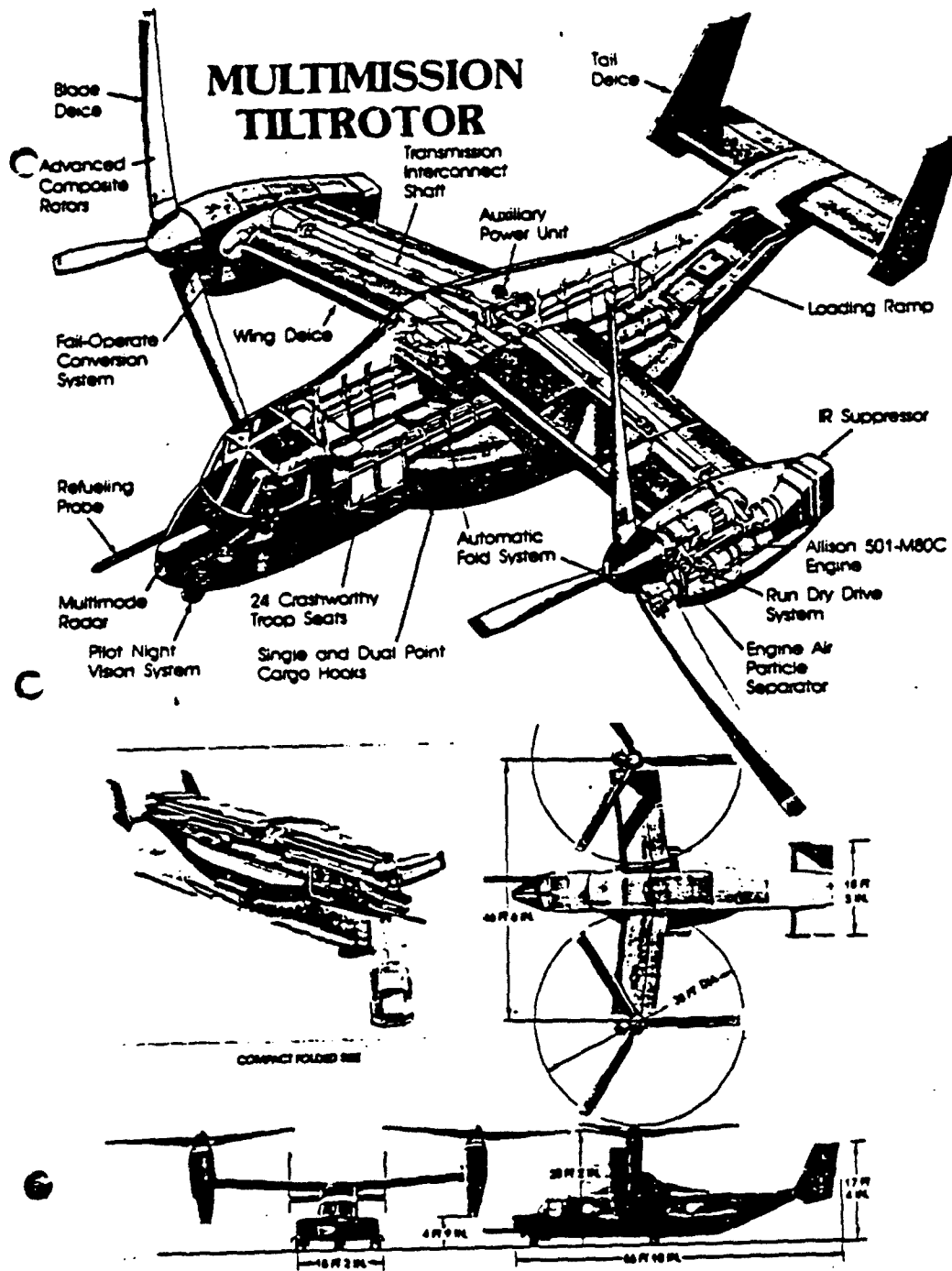


Figure 3 Tilt-rotor Characteristics

6. Fuel

Gallons	# & type of tanks	location
2,436	2 non self-sealing	cabin
928	2 partial self-sealing	sponsons
199	2 self-sealing	wing
588	8 self-sealing	wing
300	1 partial self-sealing	aft. sponson

7. Oil

Engine	: 1.93 gal	Spec DOD-L-85734
Transmission	: 25.375 gal	Spec DOD-L-85734

8. Accommodations

Crew (mission) 3

9. Cabin size clearance

Length	: 290 inches
Width	: 71 "
Height	: 72 "
Usable volume	: 858 cubic feet
Rescue Hatch dimensions	: 40 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 psi.
Maximum cargo weight	: 20,000 lb

10. Ordnance

Provision for two (2) .50 caliber

Cabin guns

Additional provision for ramps

11. Speed

Maximum speed at sea level/standard day : 275 Knots

12. Power Plant

No and model 2 T406-AD-400

Manufacturer Allison Gas Turbine Division

Engine Spec No 937 22 July 85

Type Turboshaft

Ratings

	SHP	RPM	ALT
Maximum	6,150	15,000	Sea level, 59°F
Intermediate	6,150	15,000	Sea level, 59°F
Max Continuous	5,890	15,000	Sea level, 59°F
Transmission	3,524	12,575	Cruise rpm
limits:	4,200	15,000	USMC

Exhaust nozzle area : 500 in<sup>2</sup>

Engine torque limit : 2,153 ft-lb.m

D. VULNERABILITY AND SAFETY FEATURES

Some definitions will be helpful for further discussions.

1. Survivability: the capability of an aircraft to avoid and/or withstand a manmade hostile environment. [Ref. 3] The MV-22 toughness can be examined by looking at

Joint-Service survivability design requirements, by learning how survivability objectives are being met, and by seeing how combat survivability will contribute to fulfilling the missions in the most demanding of circumstances.

2. Vulnerability: is the inability of the aircraft to withstand one or more hits by the damage mechanism, to its vincibility, to its liability to serious damage or destruction when hit by enemy fire. [Ref. 3]
3. Damage Mechanism: is the output of the warhead that causes damage to the target such as penetrators, fragments, incendiary particles and blast.
4. Critical Components: those components which, if either damaged or destroyed, would lead to an aircraft kill.
5. Susceptibility: probability that the aircraft is hit by a damage causing mechanism or the likelihood of the aircraft being hit. The aircraft's speed, agility, countermeasures and detectability bear directly on the latter. Once an aircraft encounters a hail of lead and steel, then vulnerability takes command. Vulnerability is the aircraft's response to being hit.

One of the Joint Services Operational Requirements (JSOR) is:

The aircraft shall be resistant to flight-critical damage imposed by hits in vital areas by 7.62mm and 12.7mm armor incendiary (API) projectiles at 90% of their respective muzzle velocities. Similar resistance to 14.5mm API projectiles is desired.

The MV-22's 275 Knots speed and ability to perform evasive maneuvers while pulling up to four (4) G's provide considerable survivability advantages over slower, less maneuverable helicopters. Because of its all-composite proprotors resistance to tree-strike damage, the Osprey can fly nap-of-the-earth missions while in either helicopter or airplane mode, providing the V-22 with terrain-masking options well beyond the ability of nearly all other

aircraft. In the low-tech world of eardrums and eyeballs, helicopters announce their approach with far reaching rotor noise, and confirm their whereabouts by the familiar whop-whop of their whirling rotor blades. However, the V-22's low noise, high speed airplane mode will make it far more difficult for enemy ears to narrow a sky-search area while looking for a target; their eyes will have to continue to sweep the limitless horizon. Moving up to the technology scale, an enemy's effort to detect the Osprey's infrared (IR) emissions will not be easy. Engine nacelle suppressors significantly reduce the airplane's signature. The IR suppressor's variable geometry maximizes efficiency throughout the airplane's flight regime from hover to high-speed cruise. In the helicopter mode the V-22's IR signature almost disappears due to masking and ground diffusion of the downward-directed exhaust. [Ref. 4]

Vulnerability, as previous stated refers to an aircraft's ability to absorb hits from enemy fire and continue flying. The V-22's kill criteria is that after taking a hit, the aircraft must provide 30 minutes of evasive flight followed by a normal safe landing. Because riflemen equipped with fully automatic weapons constitute a considerable Anti-aircraft threat, the first stipulation is that the V-22 should offer complete resistance to 7.62mm API rounds. Next, the V-22 should provide considerable tolerance to 12.7mm and 14.5mm API ammunition. All V-22



flight critical components are being made tolerant to these projectiles.

Since the V-22 was subjected to multiple overlapping design trade-off studies and optimizations, its ballistic tolerance requirements are expressed in terms of vulnerable area, as opposed to being stated solely in terms of damage to specific components or combining such damage with vulnerable area factors.

Vulnerable area is derived by multiplying the area presented by each component or subsystem by the probability that a hit on that item will force the aircraft down.

Probability of kill = susceptibility \* Vulnerability

$$P_k = P_H * P_{K/H}$$

where

$$P_{K/H} = A_v/A_p \quad A_v = \text{vulnerable area.}$$

$$A_p = \text{presented area.}$$

The actual calculation of vulnerable area used computer generated random-shot lines summed over 26 views of the aircraft and were compared against vulnerable areas of existing aircraft similar to the V-22.

V-22 vulnerability reduction features in large measure depends upon on subsystem redundancy and separation. Careful placement of pumps, generators, and other components provides maximum shielding. The trip, separated fly-by-wire flight control system, eliminates the relatively high vulnerability otherwise associated with a helicopter's

mechanical flight control linkages. Fuel tanks and the spaces around them are protected with a combination of nitrogen inerting, foam, ultraviolet sensing free-suppression units and self sealing crashworthy fuel tanks.

The aircraft can be flown, converted from airplane back to helicopter, and make an emergency landing with the following combinations: [Ref. 5]

1. Loss of one primary hydraulic system and loss of the backup hydraulic and loss of all electrical system or loss of both primary hydraulic system and loss of both A.C. system and one D.C. system.
2. Conversion can be made with either one of the conversion actuator, normally both are used together. In the event that both primary hydraulic systems are lost or the conversion control system fails to operate, the emergency conversion handles can be pulled and the third motor will convert from airplane to helicopter.
3. In an emergency the crew can eject while on the ground as well as in flight. In an emergency on the ground, if time permits, they can ballistically jettison the overhead and/or side canopies and climb out. These canopies can also be jettisoned from the outside by a rescuer pulling a handle at the nose of the aircraft. The aircraft has been designed to crash load factors and is equipped with crashworthy wing fuel cells and breakaway fittings. A fire extinguisher is located in the cockpit. Each nacelle has a fire extinguishing system with two (2) extinguisher bottles on each side.
4. If a double engine failure should occur, the rotors will windmill in the airplane mode and autorotate in the helicopter mode. Since autorotation can be entered from the airplane mode as well as the helicopter mode, the aircraft can glide to a suitable landing area.

### III. MISSIONS

#### A. RANGE MISSIONS

The suitability of an aircraft to perform a given mission depends on the relative fashion in which the aircraft performs the mission and how well it compares with other aircraft performing the same mission as well as other modes of transportation. Economy of operation is also a very important factor that needs to be considered, however, this type of consideration is not within the scope of this study.

There are certain military and civil missions which appear particularly well suited to the characteristic capabilities of the tilt-rotor. The efficient cruise performance of the tilt-rotor also results in increased point to point mission productivity within a 50 to 500 nautical miles radius. One obvious mission application is the search and rescue vehicle. This mission requires the rapid response and extended range capability earlier discussed and in addition must have a loiter capability in the search area. With variable pylon angles, the tilt-rotor can search at the airspeeds required by the conditions.

[Ref. 14]

For example, for an ocean search, where the area is large and open, the airspeed would be higher than for a search over a forested area. During the rescue, extended hover out of ground effect may be necessary. The tilt-rotor, with its low disc loading, would be well suited for this operation. The good productivity potential of the tilt-rotor makes it a likely candidate for logistic support missions. The ability to disperse aircraft landing areas and the elimination of the need for runways would give an added degree of flexibility.

Another potential application is to the utility mission. As the name implies, this mission is made up of a number of diverse requirements. The Navy Type A/V/STOL is an example of this type of mission. Basically this mission requires VTOL and adequate range/payload/airspeed capability to be productive. For Navy application, the ability of the vehicle to operate aboard the ships is an important factor.

Some of the same characteristics that make the tilt-rotor attractive for military missions also make it attractive for civil missions. The tilt-rotor promises to be a "two edge sword" on the fuel and energy crises. It will offer extended speed, payload and range over that of the helicopter for a support of off-shore oil operations. This will be a boom to the exploration and production of oil at greater distances from shore than is now practical.

The V-22 is the one aircraft that can meet all vertical lift mission requirements for the different services. The Marine Corps will use the MV-22 Osprey for its medium assault transport in amphibious assault and subsequent operations ashore. The Navy will use two versions: its HV-22 will perform combat search and rescue, special warfare and fleet logistic support missions, and its SV-22 will function in anti-submarine warfare (ASW). The air force will use the CV-22 for long-range exfiltration of special operation forces. The Army will use its MV-22 for combat transport of troops and supplies, aeromedical evacuation, search and rescue and support of special operation forces. As a basic troop and cargo aircraft, the V-22 is much more productive than the helicopters currently performing these missions. [Ref. 24]

Medical evacuation is an extremely important function for the services, a function that proceeds much more rapidly and efficiently with the V-22, the combat ambulance of the future. Configured to transport and furnish enroute medical care to 12 critically sick, injured, or wounded patients, the V-22 becomes the principal medevac vehicle for moving patients to medical facilities. The V-22 can also move mobile hospitals, personnel, equipment and supplies quickly to cover mass casualties or other large-scale emergency situations.

### 1. Range Missions

Long range vertical lift is particularly needed to provide supplies to off-shore islands during seasonal weather changes when neither ships nor all-terrain ground vehicles can be used. Native Venezuelans located in remote and isolated areas could be served by the V-22.

One obvious application could be in the resupply of Los Monjes Islands, northeast from Punto Fijo in the Paraguana Peninsula, of 4,000 pounds payload. Figure 4 shows a comparison of a tilt-rotor, a helicopter and a ship operating this role. The speed of the tilt-rotor is 280 knots, the conventional helicopter's speed is 130 knots and the ship's is 15 knots. The tilt-rotor's speed advantage provides a mission block time of 22 minutes for a 100 nautical miles mission and uses 48 gallons of fuel, while the helicopter takes 45 minutes and uses 81 gallons of fuel. The ship takes 6 hours 40 minutes and uses 200 gallons of fuel for the same mission.

With the V-22 capacities the requirements for logistic support to remote areas can be carried out without great difficulty. Limitations in time and distance is not a problem with respect to the V-22 since it is both, a helicopter and airplane. Its capacity of landing in a short distance or runway, its speed, its ability to operate at night and in adverse weather conditions, being able to navigate for long missions, carrying internal or external

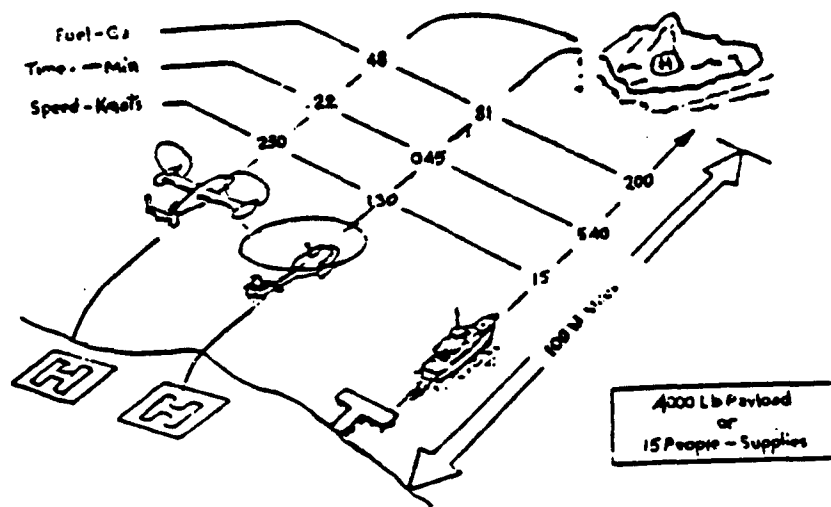


Figure 4 Performance Comparison for Off-shore Support

payload of 10,000 to 15,000 pounds, logistic missions from Caracas to La Orchila, to Los Monjes or to any other of the Venezuelan islands can be accomplished satisfactory. The same type of missions can be normally carried out at the southern part of the country, for example from Pto. Ayacucho to San Fernando de Atabapo. In areas where landing is virtually impossible transportation, recovery and resupply of critically needed items can be done by vertical resupply utilizing the winch. At the same time, operating ships that are in need of some spare part or some emergency evacuation, can be accomplished by a tilt-rotor aircraft.

If we analyze a mission from Pto. Ayacucho to San Fernando de Atabapo with the purpose of transporting 6000 pounds cargo on a 95°F day and a distance of 182 nautical miles, we can observe that performing a vertical takeoff (VTO) and flying at sea level, we obtain a range of 400 miles whereas a CH-47A helicopter would not be capable of transporting that payload at sea level cruise altitude. (Figure 5a) [Ref. 8] But the VTOL aircraft presented has been designed for efficient high-speed flight. As a result, they should have the capability for longer range missions if operated at an economical cruising altitude. To investigate this, cruise performance was calculated for a realistic cruise altitude of 20,000 feet. Figure 5b shows payload/range curve for the tilt-rotor. A comparison of Figure 5a with Figure 5b shows that the zero payload/range



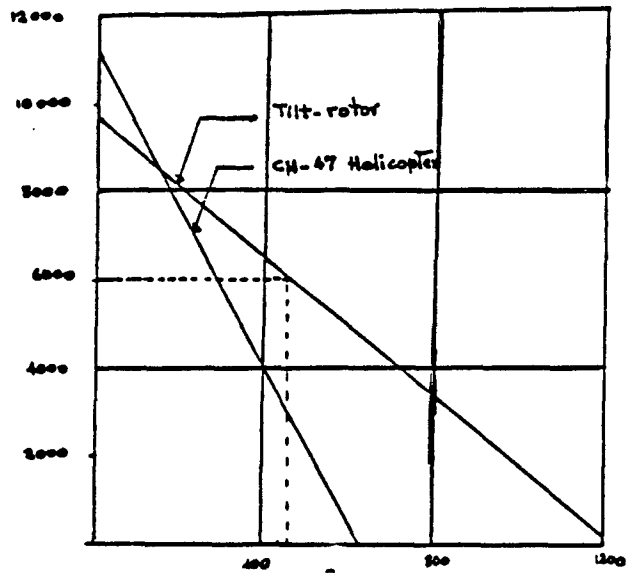


Figure 5a Vertical Take-off Low Altitude (Sea Level)

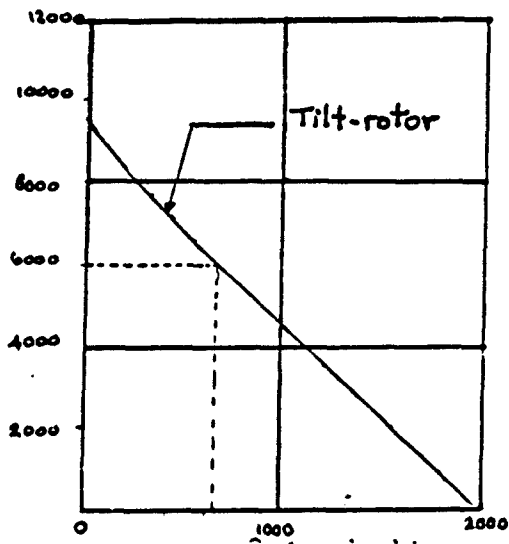


Figure 5b Curves of Payload Versus Range

can be increased by about 60% by cruising at 20,000 feet. The zero-range payload of the tilt-rotor at this altitude is an impressive 1970 nautical miles. The range carrying 6,000 pounds of payload is approximately 630 nautical miles, about 230 nautical miles more in comparison with the 400 nautical miles at sea level cruise.

#### B. MEDICAL EVACUATIONS

In this section, we will investigate the feasibility and benefits of a system of rotorcraft-based emergency medical centers with sufficient range and capacity to serve the Venezuelan border along the Meta and Orinoco Rivers. The isolation, transportation constraint, and level of existing medical facilities indicate the desirability of a system capable of rapidly transporting trauma victims throughout the region to an emergency center that is sufficiently equipped and staffed to handle a variety of medical situations. Such a system of health care facilities will improve the level of health care in the region. In addition to accidental death caused by motor vehicle accidents, drownings, falls, burns, poisoning and firearms, many people die prematurely from critical medical illness that did not receive urgently needed medical attention. As stated before, the two most critical factors determining a trauma victim's chance of survival are rapid transport to a medical facility, and the ability of the medical facility to provide a high level of expert emergency health care.

Survival is directly proportional to the ability of the trauma center to respond to the accident with adequate and appropriate care, and is inversely proportional to the severity of the initial injury and to the square of the lapse time between the injury and stabilization of the unstable patient [Ref. 9].

The south-west border area with Colombia is characterized by inadequate transportation of victims, and small, unequipped emergency facilities. It is important to analyze the potential demand for REM centers in this region. A common concern of all new REM centers is the prediction of the number of patient who will require rotorcraft transfer. The simplest method of estimating rotorcraft utilization is based solely on the size of the population served. The average number of rotorcraft transport per 100,000 population is approximately 31 per year in the U.S. [Ref. 9].

It is generally true that a center located in an isolated area like Pto. Ayacucho will experience a greater demand rate for helicopter transfer than a center that is located in a densely populated area like San Fernando de Apure. The apparent reason being that in a metropolitan area in which most of the population is located relatively close to an emergency center, rapid transport can usually be provided by ground vehicles. In the more isolated regions, ground transport is often not a viable option if speed and a smooth ride are important factors, as they are in most trauma situations.

Currently none of the existing hospitals in the region can qualify as a trauma center as defined by the American College of Surgeons (See Table I). The general health care in the region is in need of improvement. By utilizing the concept of centralized REM centers to serve relatively large geographic areas, more efficient use can be made of the limited resources available. For this study we are going to assume two Trauma Centers with status 3 (Qualified Trauma Center) located in San Fernando de Apure and Ciudad Bolivar and a small hospital located in Pto. Ayacucho.

The rotorcrafts examined in this study are the tilt-rotor air-craft and the helicopter. The tilt-rotor is an aircraft which can be flown either as a helicopter or as fixed-wing aircraft, combining the versatility of a helicopter with the speed and range of a fixed-wing aircraft. The transition from one mode to the other is done smoothly in a matter of 12 seconds. The implications for medical rescue operations are obvious.

Since its use in the Korean war, the helicopter has shown the importance of quick response time in emergency rescue operations. But the helicopter has neither the speed nor the range of a fixed wing aircraft. The tilt-rotor combines the speed and range of a fixed-wing aircraft with the ability to fly directly to the scene of an accident and back to the medical facility. As we mentioned earlier, the tilt-rotor is capable of flying 300 knots, fully twice the

TABLE I

STAFF RECOMMENDATIONS OF THE AMERICAN COLLEGE OF SURGEONS FOR AN EMERGENCY MEDICAL TRAUMA CENTER

Staff	No. for 24 hours coverage
General Surgeon	5
Anesthesiologist	5
Neurosurgeon	5
Orthopedic surgeon	5
Thoracic surgeon	5
Urologist	5
Internist	5
Pediatrician	5
Radiologist	5
Emergency room physician	5
Nurses	45
Other	
Blood bank technician	5
Lab technician	5
Inhalation therapist	5
X-ray technician	5
X-ray technician (vascular)	5
Medical records technician	5

speed of current emergency medical helicopters. The range of the tilt-rotor is equally impressive with an effective range of approximately 700 miles. The cabin dimensions of the XV-15 are roughly 1.5 x 1.5 x 4.0 mt. A medevac vehicle of this size can be fitted for a multipatient, casualty evacuation role or it can be tailored to serve as a fully equipped flying emergency medical facility (Figure 6).

The initial cost of the tilt-rotor will be higher than either a helicopter or fixed-wing aircraft; the current cost projections are approximately 10% more than the helicopter of the same passenger size. However, because the tilt-rotor can go twice the speed and distance that a helicopter can on the same amount of fuel, there will be many situations where the tilt-rotor will be very cost effective. Furthermore the tilt-rotor will be exceptionally useful and cost effective in situations where it is necessary to cover large sparsely populated areas. The higher initial cost must then be measured against the benefit of serving a large region with a single medical facility.

#### C. COMPUTER SIMULATION

In an attempt to analyze the results of locating REMS Centers in the region under study, a Monte Carlo simulation was used at NASA Ames Research Center in Moffet Field, California. The program generates accidents in a given region according to criteria input by the user and then it calculates the time required to provide assistance to each

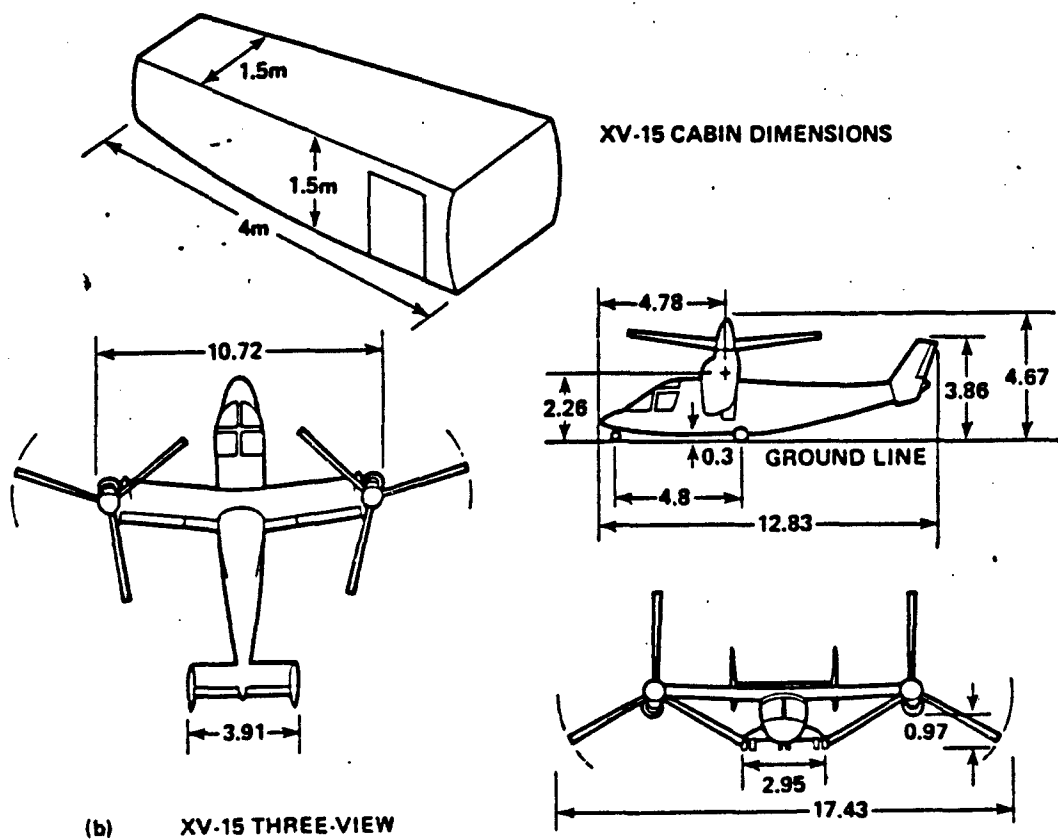


Figure 6 Dimensions of XY-15 Tilt-rotor in Meters

accident using the closest available aircraft. Table II provides the computer simulation input data.

The availability of an aircraft depends on its location, range, speed, and whether or not is currently being used for a previous rescue, or is out of service because of repairs or bad weather. The program accepts as input the locations and categories of hospitals, the number and capacity of rotorcrafts at each hospital, the region in which a given percentage of accidents will occur, and other data relating to rescue time, response time, etc. The program was developed on a Mackintosh microcomputer and makes extensive use of graphics for both input of data and illustration of the simulation. The output of the program includes the average wait time before the victim is taken to the nearest appropriate hospital, the number of accident victims which were not rescued because of the lack of an available rotorcraft, and the number of hours per week that each helicopter speeds flying. Figures 7 to 14 illustrate the results of eight (8) simulations.

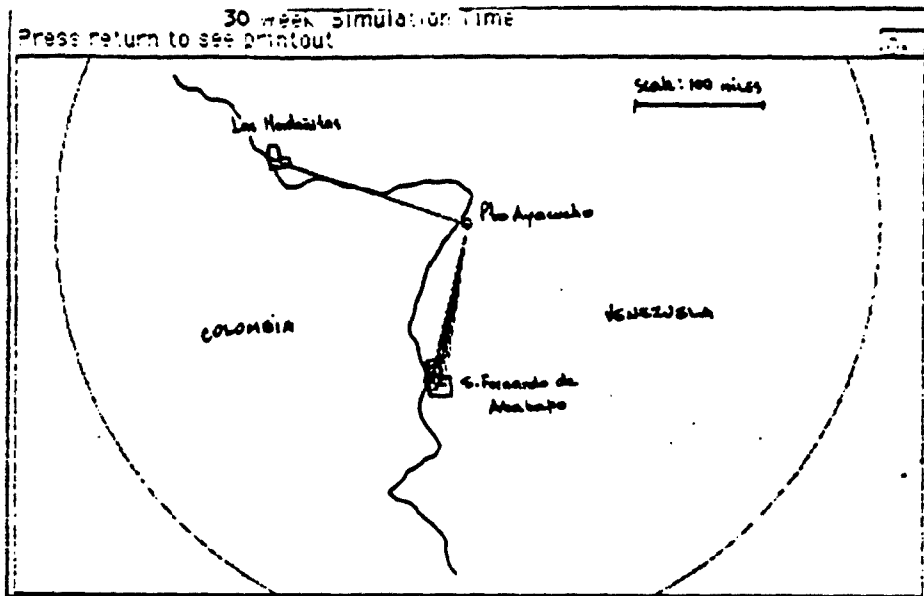
In the first two cases the trauma center was located in Pto. Ayacucho. A helicopter was located in this trauma center to serve the areas of San Fernando de Atabapo and Las Montanitas.

The rotorcraft was assigned a speed of 150 Knots and a range of 300 miles to represent a helicopter with extra fuel tanks and a speed of 280 Knots and a range of 580 miles in



TABLE II  
SIMULATION INPUT DATA

Number of accidents per year	24
Average duration of maintenance (min)	90
Time between call and take-off	10
% of accidents needing transfer to a trauma center	95
Hour/week in maintenance	06
% of total accidents occurring in these regions	90
Time in ground to pick-up patient (min)	10
Number of ground transport needing later transfer	10
How many weeks simulation time (for simulation 1 to 6)	30
How many weeks simulation time (for simulation 7 and 8)	52



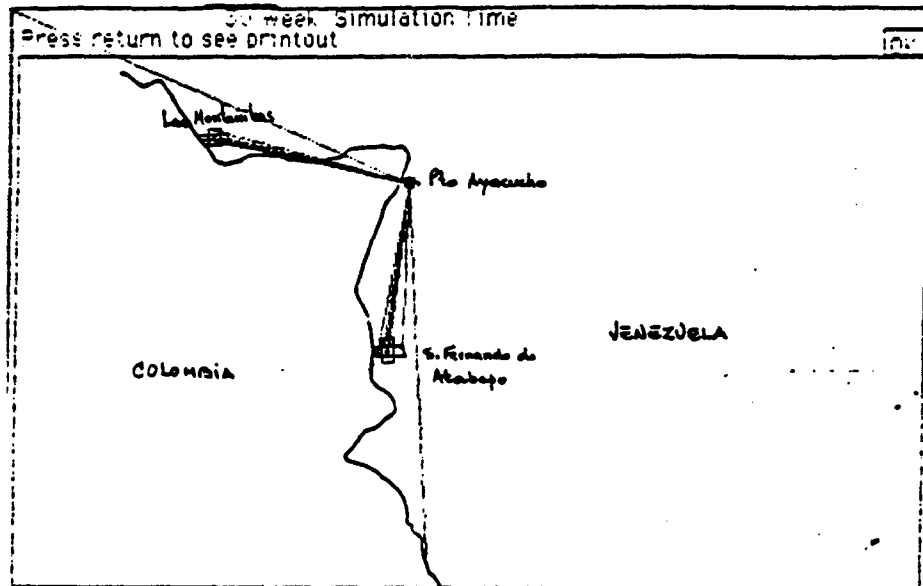
31 week simulation time  
(Preliminary Program Version)

Chr	Stat	Revd	Bird num.	Rnge	total	Av resc	Av wait	Flt Hrs
					flts	(min)	(min)	/week
1	3	11	1	300	11	116.5	58.3	0.6
			11			116.5	58.3	

There were 1 "out of range" cells and 0 "non-responses due to in-service" or "in-range"

Another Simulation? (Y/N)

Figure 7 Simulation 1



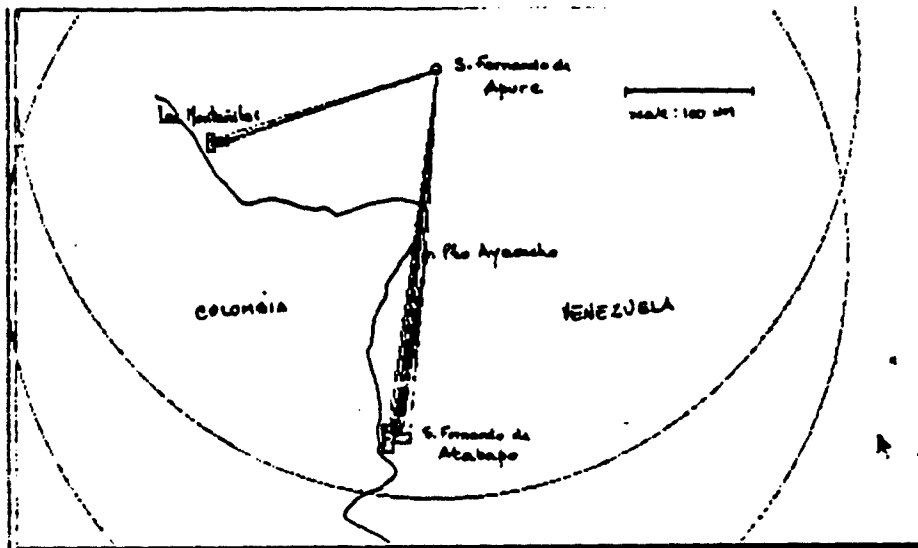
30 week Simulation Time  
 (Preliminary Program Version)

Center	Stations	Road	Birds	Range	Total	Av resp	Av wait	Fit Hrs
			num	km	flts	(min)	(min)	/week
3	12		1	520	12	86.4	44.2	0.4
	12					88.4	44.2	

There were 0 "out of range" calls and 0 non-responses due to "in-service" or "in-repair"

Another Simulation? (Y/N) :

Figure 8 Simulation 2



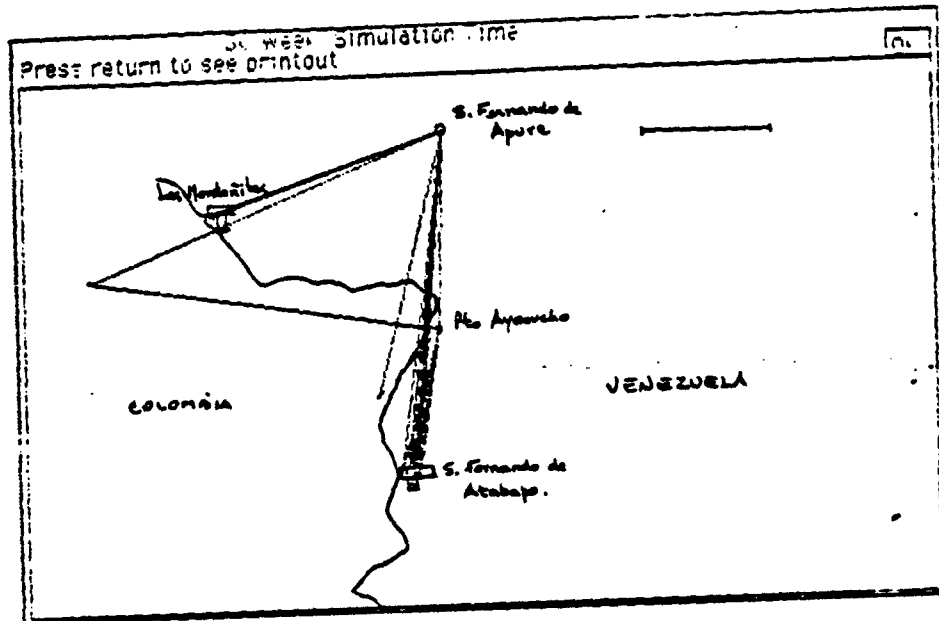
31 week simulation time  
(Preliminary Program Version)

Dist	Stat	Revs	Bird num	Rnds total	Av. resp (min)	Av. wait (min)	Fls /week
1	3	14	1	300	8	152.1	73.8
2	0	0	1	300	6	174.4	61.1
					151.7	68.4	

There were 1 "out of range" calls and 0 non-responses due to "in-service" or "in-need".

Another simulation? (Y/N) :

Figure 9 Simulation 3



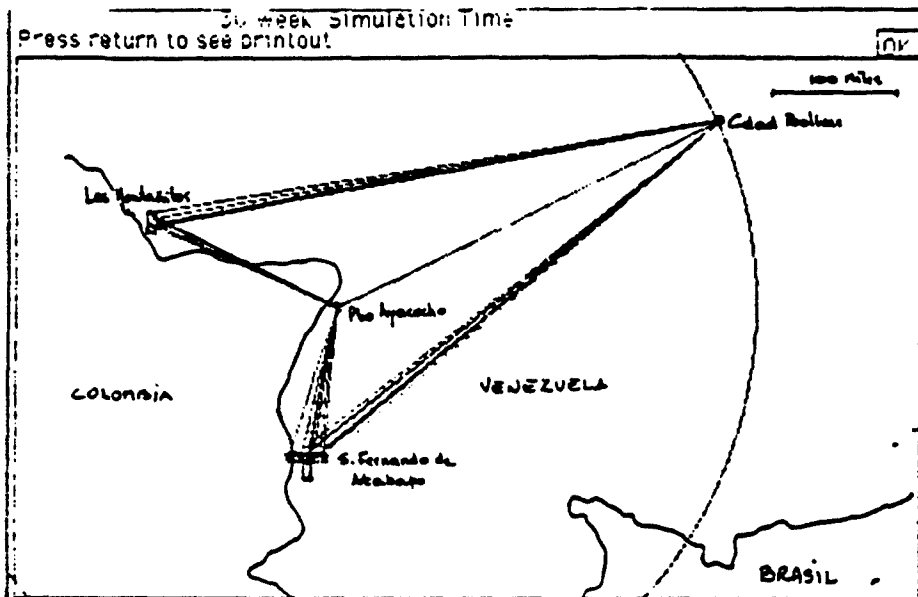
30 week simulation time  
(Preliminary Program Version)

Cont	Stat	Rows	Stnd num	Page	Total files	av resp (min)	av wait (min)	Flt Hrs /week
1	3	14	1	580	3	97.5	49.7	0.1
2	2	2	1	580	13	95.2	34.8	0.7
						94.0	37.6	

There were  "out of range" cells and  "non-responses due to in-service" or "in-repair"

Another simulation? (Y/N)

Figure 10 Simulation 4



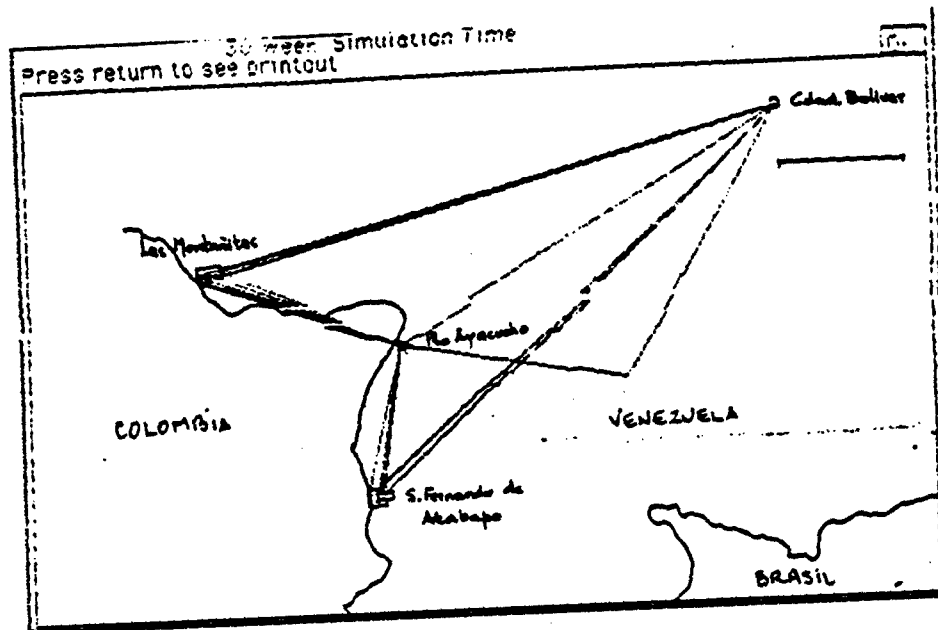
31 WEEK SIMULATION TIME  
 (Preliminary Program Version)

Cont. Stat	Povd	Birds	Ende notes	AV. resp	AV. wait	F/T Hrs	
		num.	bits	(min)	(min)	/week	
1	3	14					
2	0						
		1	300	14	217.0	55.1	2.4
		14			217.0	55.1	

There were 0 out of range calls and 0 non-responses due to in-schedule or in-rep bit

Another Simulation P. 47/31

Figure 11 Simulation 5



31 week Simulation Time  
(Preliminary Program Version)

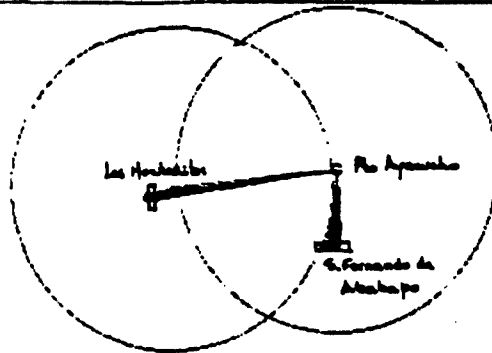
Center	Stations	Radio	Equip num.	Pages total	Avg resp. time (min.)	Avg wait (min.)	Films /week
1	3	11					
2	2		1	580	13	1193	357
			13			1193	35.7

There were 0 "out of range" calls and 0 non-responses due to in-service or in-repair

Another Simulation? (Y/N)

Figure 12 Simulation 6

52 Week Simulation Time  
 Press return to see printout



53 Week Simulation Time:  
 (Preliminary Program Version)

Tr	Stat	Acvd	Bird num.	Range	Total fits	Avg. resp. (min.)	Avg. wait (min.)	Fit Hrs. / week
P	3	38	1	230	20	225.9	153.4	1.2
P	1	0	1	230	18	195.3	37.8	1.6
			38			211.4	98.6	

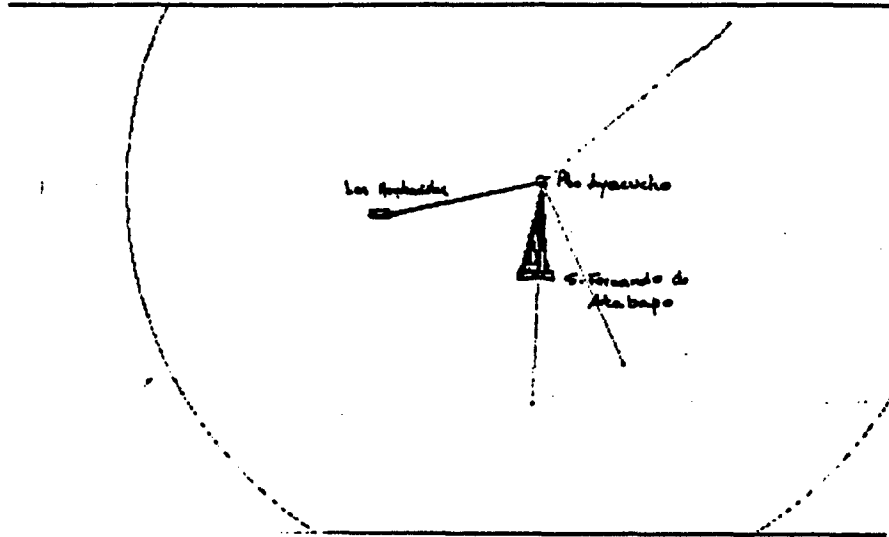
There were 1 "out of range" calls and 3 non-responses due to "in-service" or "in-repair"

Other Simulation Data:

Figure 13 Simulation 7



52 Week Simulation Time  
 ess return to see printout



53 Week Simulation Time:  
 (Preliminary Program Version)

nt	Stat	Acvd	Bird num.	Range	total flts	Avg. resc. (min.)	Avg. wait (min.)	Flt Hrs. /week
1	3	22	1	600	22	97.0	52.8	0.5
2	1	0						
		22				97.0	52.8	

There were 1 "out of range" calls and 2 non-responses due to "in-service" or "in-repair"

another Simulation ? IV NI :

Figure 14 Simulation 8

the case of a tilt-rotor aircraft. Although the tilt-rotor made one more rescue than the helicopter, its average rescue and wait time was 24% less than that of the helicopter. Also the flight hours per week was reduced by 33.3%.

In the third and fourth simulations a trauma center status 3 was located in San Fernando de Apure and other center status 2 was located in Pto. Ayacucho with one helicopter at each of these trauma centers in one case, and one tilt-rotor in the other case. The average rescue and wait time were reduced by more than 40% using the tilt-rotor. In the same fashion the flight hours per week was reduced by 38.5% even thus the tilt-rotor handled two additional rescues.

In the fifth and sixth simulations a trauma center status 3 was located in Ciudad Bolivar with no rotorcraft and other center status 2 in Pto. Ayacucho with a rotorcraft located in this hospital. The average rescue time was reduced by 45%, the average wait time was reduced 35.3% and the flight hours per week was reduced 55%.

In the last two simulations, two helicopters were compared against one tilt-rotor. The helicopters were based, one in Pto. Ayacucho and the other in a small hospital. The only tilt-rotor was based in Pto. Ayacucho for the second case. In these simulations the helicopters assisted 40% more rescues but the average rescue and wait time were 54% more than the tilt-rotor alone. The flight

hours per week of the helicopters were 72% higher than the tilt-rotor. The percentage of non-response due to "in service" or "in repair" was reduced using the tilt-rotor. Although these results are tentative and no firm conclusion should be inferred from this initial comparison, it does point out some advantages to be derived from the speed and range benefits of the tilt-rotor technology. The significantly larger range and higher speed of the tilt-rotor aircraft appears to offer important advantages in providing efficient emergency medical services in large, sparsely populated regions.

#### IV. COMPARISON BETWEEN THE MV-22 AND THE CONVENTIONAL HELICOPTER

##### A. POWER REQUIRED TO HOVER

When comparing the power required to hover with the power required at higher speeds as a helicopter and then as an airplane, the limiting fact for high speed of a helicopter is the rapidly increasing power required as speed increases due to the drag of the rotor as shown in Figure 15. [Ref. 10]

In a tilt-rotor the power required to hover is the same amount of power required for flight at 250 knots (at sea level) as an airplane and, as the airplane's speed increases, the incremental power required is much lower than the helicopter. Since power required is directly related to fuel consumed (Figure 16), this means that for a helicopter and tilt-rotor of the same weight, the tilt-rotor can fly about twice as fast, twice as far on the same amount of fuel that is used by the helicopter.

##### B. NOISE LEVEL

The noise level of many of today's helicopters at 500 feet during hover is shown in Figure 17. As indicated larger helicopters produce more noise than smaller helicopters. Compared to the CH-46 "Sea King," the "Osprey" while cruising at 100 feet [Ref. 11], is audible for only

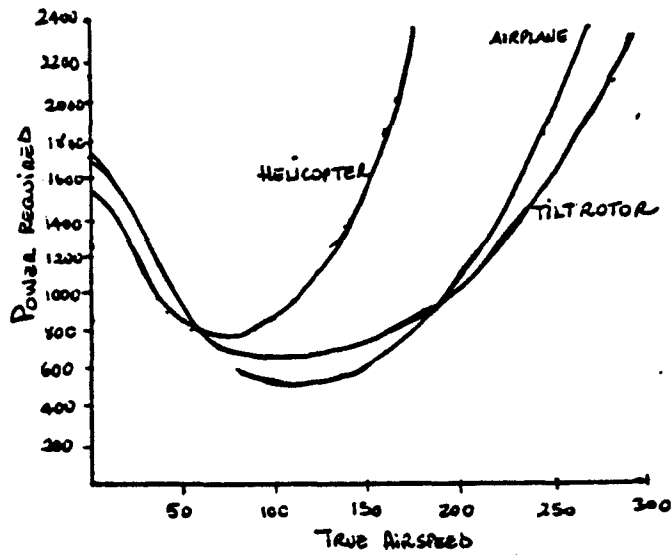


Figure 15 Curves of Power Required Versus Speed

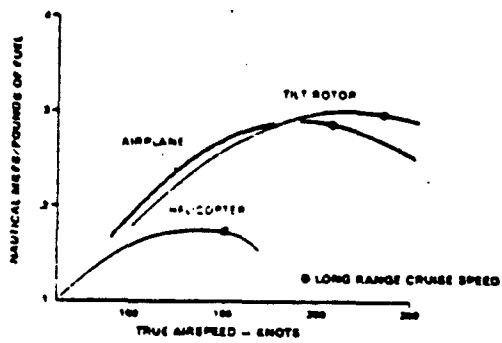


Figure 16 Fuel Consumption

one quarter of the time the CH-46 can be heard. This shortened timespan reduces V-22 detection distance by approximately 50%, which when combined with the V-22 twofold speed advantage over most helicopters, result in a 75% reduction in audible detection time. The V-22 reduced acoustic signature results primarily from its low rotor-tip speed in the airplane mode.

#### C. VIBRATION

The vibration levels measured at the crew station of the XV-15 in the helicopter mode, are similar to conventional helicopter values and increase with speed. However, as the aircraft converts to the airplane mode, the data shows reduced vibration at a specific airspeed or the ability to penetrate to higher speeds with the same level. In the airplane mode, measured vibration levels on the order of 0,05 G's have been recorded which provides a comfortable environment during the major portion of the operating envelope of the aircraft, in other words, the tilt-rotor aircraft operates in the helicopter regime of flight a very small portion of its total operating time. The XV-15 research aircraft can accelerate from hover to airplane cruise flight in 30 seconds. Conversion time is 12 seconds. In a civil operation approach and departure times would be lengthened to several minutes as dictated by airport and traffic control procedures, but still, helicopter time would be only a small portion of the total flight time. This

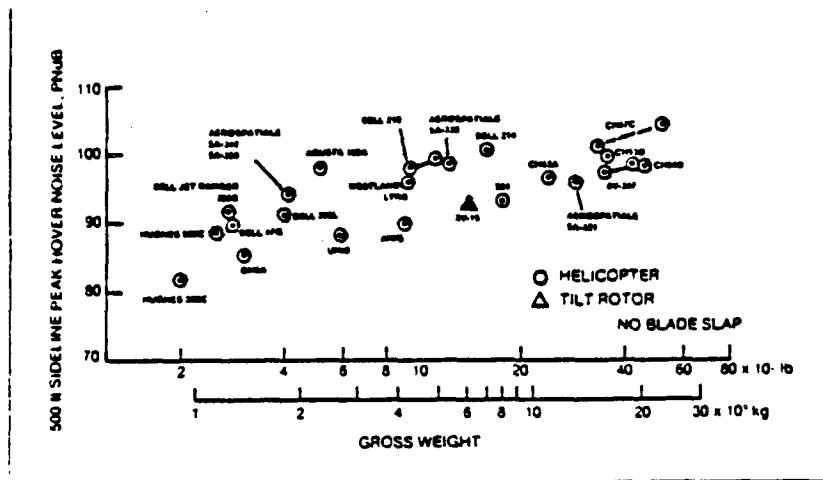


Figure 17 Rotorcraft Hover Noise Levels

means that the rotors and other components subject to vibratory and fatigue loading would have greatly extended time between failures and service lives in comparison to their counterparts on helicopters which are subject to these vibration loads for their total flight time. (Figure 18)

#### D. PRODUCTIVITY

The productivity in a basic mission may be defined as:

$$Pr = (Pm * Dm) / Cm \quad (1)$$

where,

Pm = mission payload

Dm = mission distance

Cm = mission direct cost

(Aircraft initial, maintenance, fuel and crew elements)

By substituting the variables which contribute to mission direct cost, the productivity expression becomes:

[Ref. 12]

$$Pr = \frac{Tl}{K1 * Cwa} * \frac{Pm * Dm}{(We + K2 * Wfm) * Tm} \quad (2)$$

where

Cwa = initial aircraft cost per pound of weight empty (\$/pound)

K1 =  $1 + \frac{\text{lifetime maintenance cost} + \text{lifetime crew cost}}{\text{Initial aircraft cost} + \text{lifetime fuel cost}}$

Tl = Aircraft life in flight (hours)

In the second bracket term, the productivity index, the new variables are:

Tm = mission time in flight hours (hour)

We = aircraft weight empty (pounds)

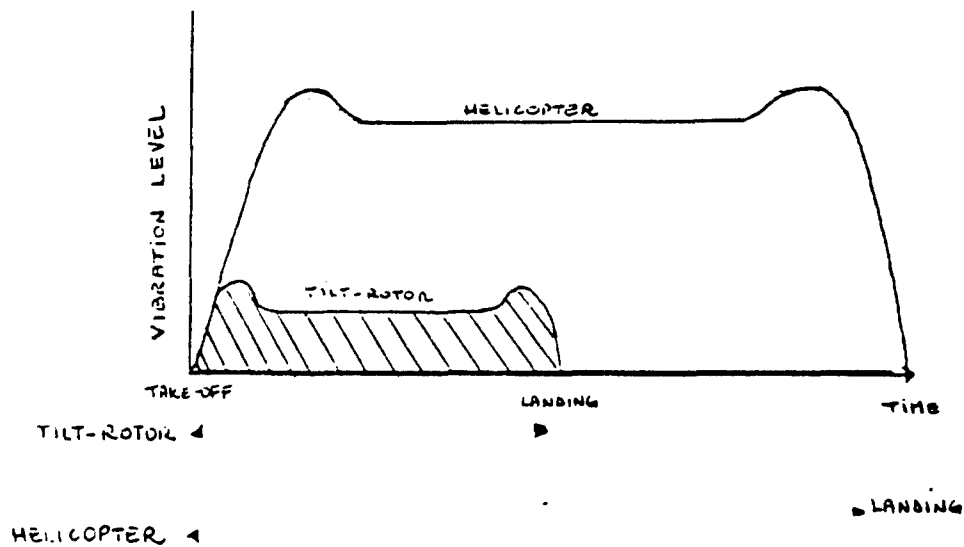


Figure 18 Vibration



Wfm = fuel needed for mission (pound)

and K2 is defined as:

$$K2 = \frac{\text{cost per pound fuel} * \text{aircraft life}}{\text{cost per pound of aircraft weight empty mission time}}$$

An approximation of K2 can be made for all V/STOL types by selecting a type of operation and assigning typical values.

For example:

Cost per pound of fuel ..... \$ 0.05 (33 cents per gallon)

Cost per pound of aircraft .. \$ 250.00

Aircraft life ..... 7,500 Hours

Average mission time ..... 1.5 Hours

therefore

$$K2 = 1$$

The productivity index simplifies to:

$$Pi(UTIL) = (Pm * Dm) / [(We + Wfm) * Tm] \quad (3)$$

For simplified linear productivity analysis, weight empty fractions and fuel flow fraction for a mission are assumed independent of gross weight. The payload, weight empty and mission fuel load in Equation (3) may be divided by gross weight then the productivity index becomes:

$$Pi(UTIL) = \frac{(Pm/Gw) * Dm}{(We/Gw + Wfm/Gw) * Tm} \quad (4)$$

where

$$Pm/Gw = 1 - ((We/Gw) + (Wfm/Gw))$$

Two simple missions were examined. One is a dash mission and the other is a simple range mission.

In the dash mission, a vertical take-off is assumed at sea level, 90°F conditions. The time at hover fuel flow is one minute plus a time allowance for climb to cruise altitude. The aircraft dashes out ten nautical miles, cruises back at best range speed and lands with 10% reserve fuel. Since this is a linear analysis (i.e., weight empty fractions, hover fuel flow fractions and cruise fuel fractions are independent of gross weight), no specific payload need to be designated. The results are shown in Figure 19 as productivity index versus response time to midmission.

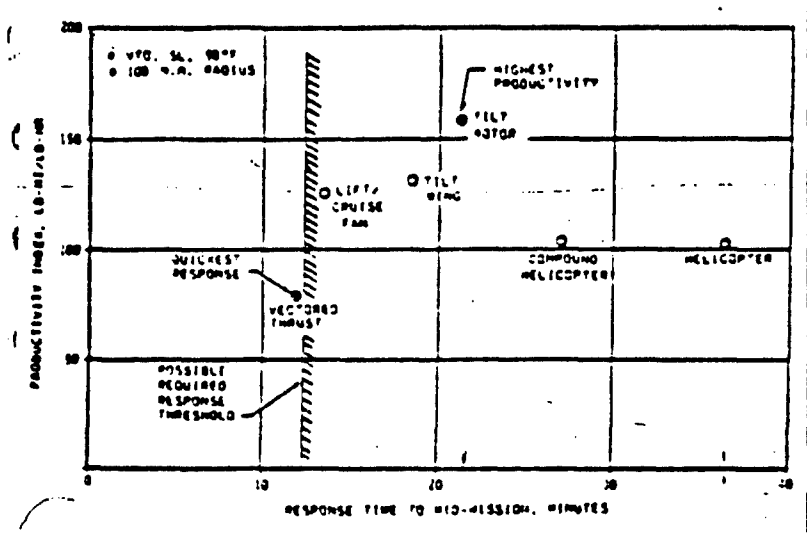


Figure 19 Productivity and Response Time for a Dash Mission

In the simple range mission, the aircraft hover fuel flow rate is applied for six minutes plus the time to climb to cruise altitude. The aircraft flies best productivity airspeeds (faster than best range speed) for various ranges up to their maximum consistent with a vertical take-off at sea level on a 90°F. Ten percent reserve fuel is maintained. Figure 20 shows the relative productivity and range capability of the types considered. Its productivity is better than the helicopter above ranges of approximately 50 nautical miles. In the same mission, if the payload were specified, Figure 21 shows that the tilt-rotor can be expected to require higher gross weights than the helicopter until the design range increases to approximately 500 to 600 nautical miles; primarily due to its higher weight-empty fraction. Also indicated in Figure 21 is the effect of an overload takeoff and cruise at 20,000 feet on tilt-rotor.

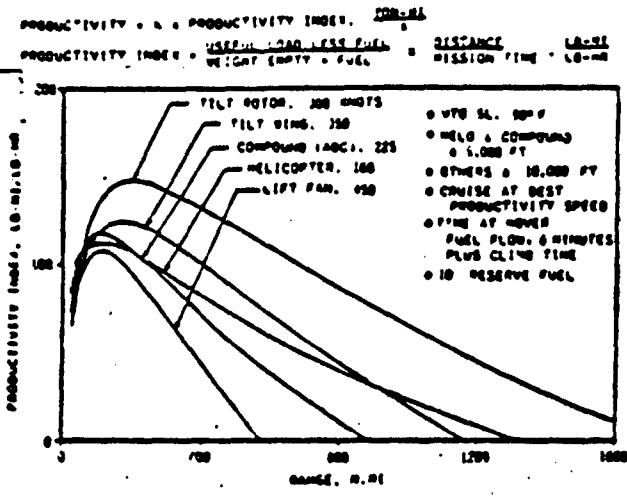


Figure 20 Productivity for a Simple Range Mission

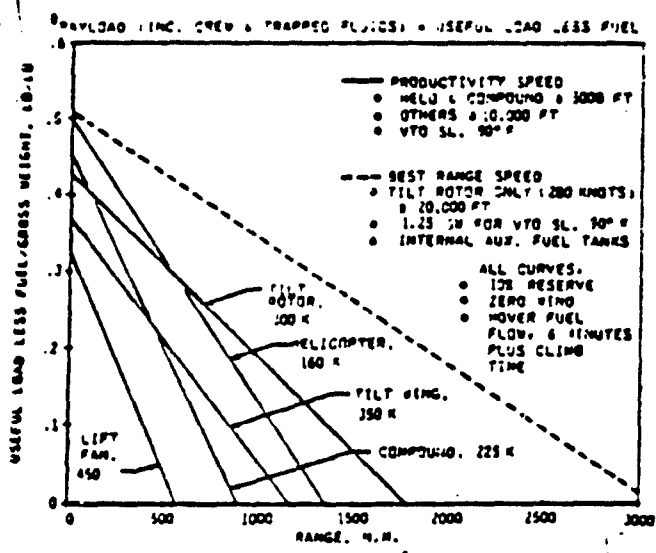


Figure 21 Payload Fractions for a Simple Range Mission

## V. LANDING SITE

### A. SITE SELECTION CRITERIA

Security is a primary consideration in the selection of a forward based military vertical landing site (vertiport). The site must guarantee the physical security of the aircraft and protection from small arms fire from insurgents operating in the region across the frontier river. These insurgents normally utilize small caliber weapons limited to 9mm and 7.62mm and should not pose a threat to the aircraft, based on its survivability characteristics.

Avenues of approach and departure should be oriented to insure that all ingress and egress routes are over friendly Venezuelan soil to minimize visual exposure and aural detection by the aforementioned insurgents. The vertiport's distance from the frontier will also be determined by the expected noise signature of the tilt-rotor.

The site itself must be clear of all trees and tall vegetation along with any other obstacles which might be hazardous to flight operations within 1000 square meters. Although the tilt-rotor can operate off inclined surfaces, an attempt should be made to provide level terrain with a hard surface and good drainage to prevent swamping or erosion of the landing site which would restrict operations during heavy rainfall. The rivers in the area frequently

overflow requiring that the vertiport and all access roads from the military outpost be elevated approximately 1.5 meters above the surrounding terrain.

The military outpost is composed of and electrical generator capable of servicing approach and landing site lights along with High Frequency and Ultra High Frequency radios for air-to-ground communications.

The average temperature at the military outpost is 88°F with a high relative humidity and light winds generally out of the north-east at eight knots. Figure 22 illustrates a possible military outpost area.



Figure 22 Possible Military Outpost Area

## B. NEW SITE PREPARATION

As we state earlier, the capacity of the MV-22 of landing or taking-off from small space, permits us to develop a prefabricated and fully portable vertical airfield which could be transported to any given point and quickly assembled to launch and recover this type of aircraft or helicopter using the Expeditionary Airfield Concept (EAF) [Ref. 13] which permits the construction of an expeditionary operating site 72 feet by 72 feet using AM-2 aluminum matting runway/pad. Many factors will influence the time and effort required to install vertical airfield such as site characteristics, type of aircraft to be supported, projected duration of operation, availability of local materials and weather conditions.

### 1. Vertical Airfield (72 x 72 feet)

Basically the VTOL airfield consists of two major items of equipment: a pad or runway and visual landing aids.

#### a. Runway

The runway consists of interlocking aluminum planks sections of AM-2 matting. A full section is 2 feet by 12 feet. Each pallet of matting contains 11 full panels and two half panels (6 feet) which provide enough matting for one 1/2 width of a standard EAF runway, or a total of 288 feet<sup>2</sup> of surface area per pallet. The half mats are used to stagger the rows in a "brickwork pattern" which

provides more strongly integrated surface. Each full section weights about 144 pounds and can be easily installed by two-man teams. An average laying rate for a team is 600 square feet per hour. The upper locking lip of a plank being installed is engaged along the full length of the locking groove of the preceding plank and then dropped into a fully locked, horizontal position (Figure 23). At the same time, the 2-foot end locking lip overlaps the locking edge on the end of the last section laid. This partial lock is completed by inserting a locking bar (Figure 24). Nearly 5200 square feet of matting will be required to surface a VTOL airfield 72 feet by 72 feet. The weight of the matting and resulting coefficient of friction inherent in a VTOL airfield are sufficient to prevent movement of the aluminum runway surface relative to the sub base. However, the high velocity jet stream from aircraft rotors may cause the mats to lift slightly. To combat this a special device known as an earth anchor is used as needed to fasten down any problem area.

The repair of the runway can be accomplished in several ways depending upon the extent of damage. Small holes may be patched with aluminum patches welded by an aluminum gun torch. Special replacement mats may be installed without disturbing adjoining mats. Whole sections may be replaced with standard mats by opening up the section at the special male/female key lock rows which are normally



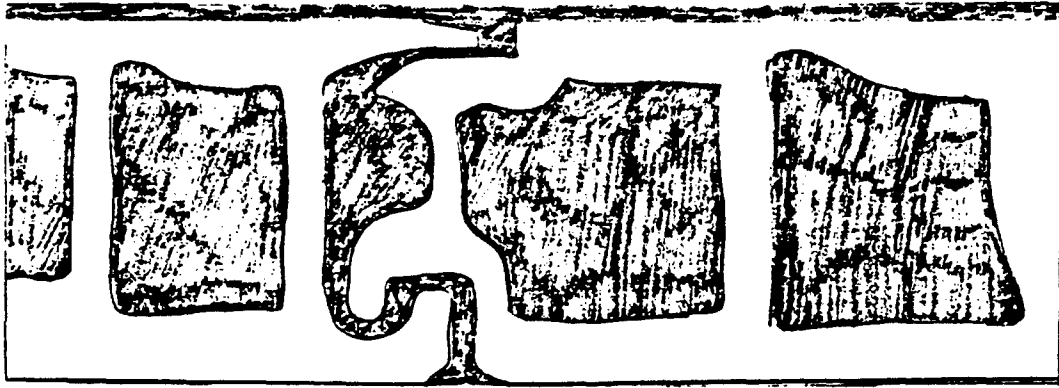


Figure 23 Locking Groove

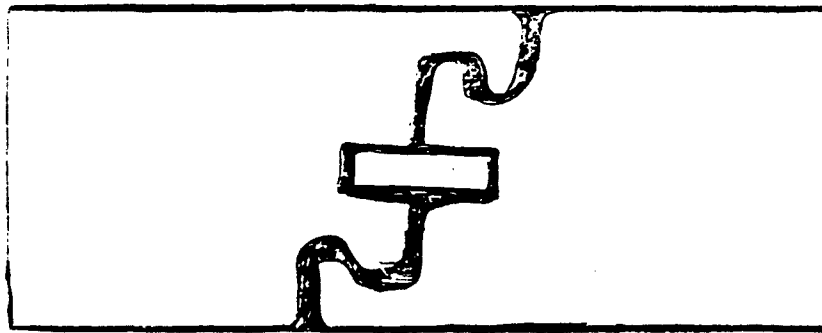


Figure 24 Completed Lock

installed at 50 feet intervals when the runway is first laid. These so called zippers allow the airstrip to be opened within a maximum of 25 feet from the damage section, thus resulting in minimum disturbance of undamaged matting.

b. Landing Zone Lighting

For this vertiport a landing zone lighting aid is considered to be used to assist the pilot in locating and identifying the landing zone and making a landing at night with the following characteristics:

1. Be visible to the pilot.
2. Identify an area free of obstacles and safe for hovering and landing.
3. Employ three or more lights at least 15 feet apart to prevent autokinetic illusion.
4. Provide orientation along an obstacle-free corridor for landing and takeoffs.

The type of landing zone lighting considered is the glide angle indicator light (GAIL). This is a helicopter portable lighting set (NAEC 515420-1) composed of one gail and eight airfield emergency portable marker lights. The set is normally used to assist helicopters in conducting safe landings over hazardous obstacles at night. GAIL is a battery-powered device which projects a tricolored beam to provide the helicopter with a glide path. It is intended to be used in conjunction with the eight battery-powered marker lights which mark the landing zone. GAIL weighs 30.5 pounds with battery and the entire set with carrying case weighs 167.5 pounds. Operating service and

repair instructions for the set are contained in NAVAIR 51-40-ACB-2. The range of the tricolored beam is three miles or greater at 20% atmospheric transmission. The intensity of the beam can be adjusted by a variable rheostat to improve beam acquisition and color contrast. GAIL incorporates a feature which permits ground to air coded signaling with the tricolored beam for identification and authentication purposes. The beam is illustrated and characteristics provided in Figure 25. [Ref. 14]

The green beam delineates the desired angle of descent and assures the pilot that he is clear of obstacles if he stays in the green sector. Clearance of obstacles is also assured if he flies in the amber sector, but his approach will be steeper and will require a greater rate of descent. Flying within the red sector indicates to the pilot that he is too low and may be in danger from obstacles on the approach path.

The glide angle can be adjusted from 25 degrees above the horizontal to 10 degrees below it. The reference point for measuring glide angle is the bottom of the green beam.

A landing zone lighting pattern considered for this vertiport is the standard "T" pattern which can be also be used without GAIL. Lights at the head of the "T" must be at least 5 paces apart and the lights in the stem must be

COLOR	MEANING	VERTICAL ANGLE (degrees)	BEAM HEIGHT (ft) (at 1/3 nm range)
AMBER	High approach	$8.5 \pm 1$	918/2754
GREEN	On glide path	$2.5 \pm .5$	270/810
RED	Low approach	$4.0 \pm .5$	432/1296

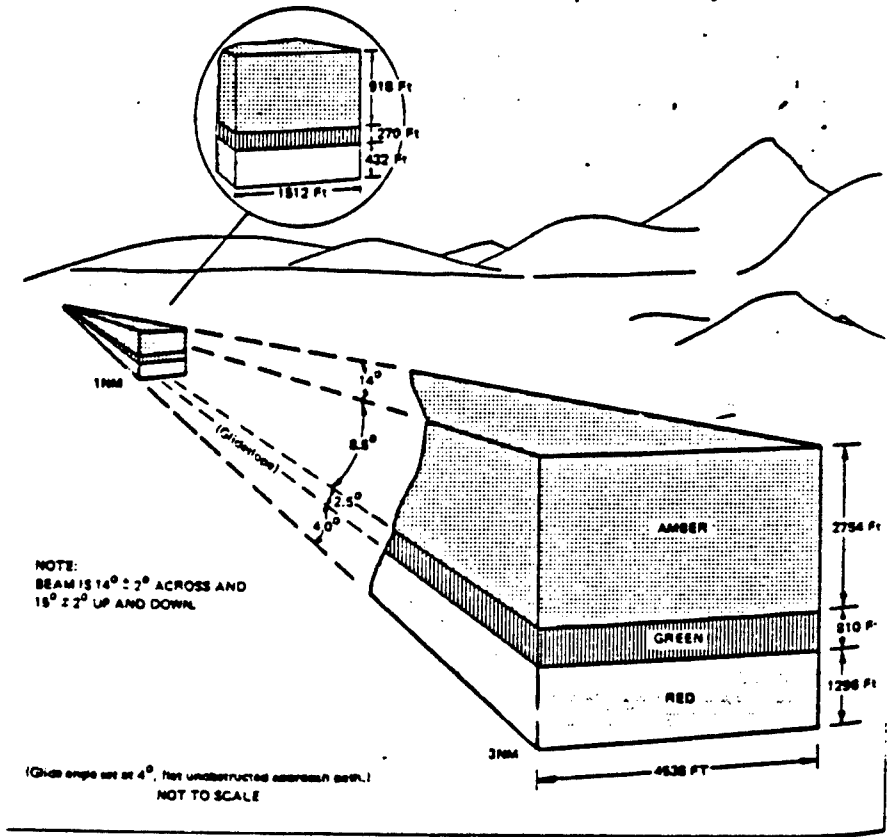


Figure 25 GAIL Beam Pattern

at least 10 paces apart. To indicate the windline, the head of the "T" should be positioned to the windward side and perpendicular to the steam. If GAIL system is used, it is set up 15 paces out from the head of the "T," centered, and aligned with the steam of the "T". (Figure 26) In this figure "X" represents the touch-down point.

c. Terminal Guidance

A portable instrument landing system (ILS) type of final approach electronics guidance can be used to provide the aircraft with an all-weather capability at this landing site. It will broadcast a sufficiently reliable precision glide slope so that the aircraft can descend through the overcast into the zone with minimal ceiling and visibility, which have precluded air support. It is light enough to be backpacked by two or three men who can transport it into the site and then put it into operation.

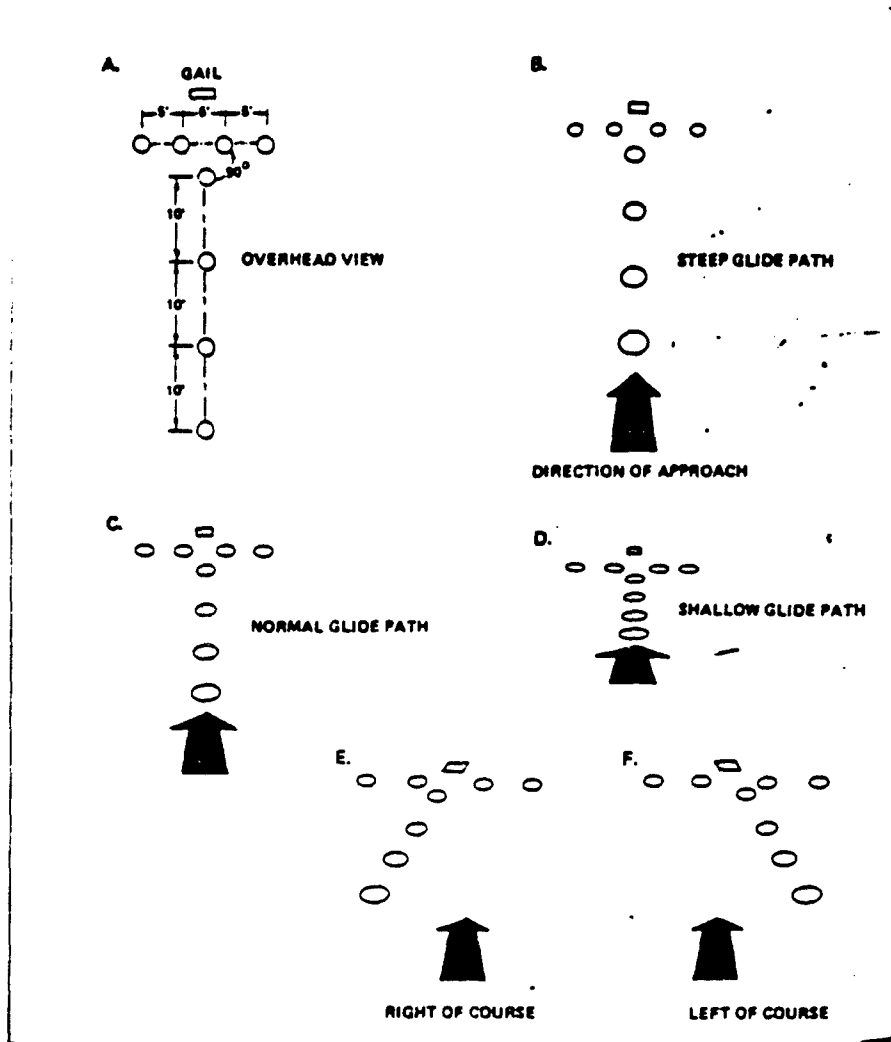


Figure 26 Approach to Lighted "T" Pattern in Landing Zone

## VI. CONCLUSIONS

Due to the capacities of the tilt-rotor aircraft, it could be utilized in Venezuela, even in places where there are not facilities of vertiports, like in the region considered for this study. Its versatility in a nap-of-the-earth flight insures good performance in the forestall region, and capable of slope landing which guarantees safe irregular terrain landing.

The payload which is actually transported by helicopters to the zone can be doubled and the time employed can be decreased by half if we use a tilt-rotor aircraft.

Due to its low noise signature, its auditive detection by insurgents in the border zone can be drastically reduced, which could make before hand planning of sabotage and guerrilla attacks against the flow of supplies to the area more difficult and in the event of its occurrence, a tilt-rotor aircraft could be less vulnerable to low caliber projectiles.

The tilt-rotor aircraft could perform missions like: search and rescue, logistic support, long range and aeromedical evacuation. In the latter mission it was determined the great advantages of the tilt-rotor over the helicopter not only in range and speed but that a tilt-rotor can accomplish the missions of two helicopters of

approximately the same size of a tilt-rotor. The survival rate of priority patients will considerably increase.

Creating a support infrastructure to operate a V-22 Osprey would not be necessary and in the event it did need it, it could be developed in the region by using the expeditionary airfield concept. The cost would be way below a permanent installation construction. This would permit also the disassemble and transportation to another location where an expeditionary vertiport for the operation of a V-22 would be necessary, that is, we could count with a portable vertiport that has emergency lighting system for night operations and portable terminal guidance.

The tilt-rotor is more cost-effective to operate than today's conventional helicopters.

The tilt-rotor aircraft would have a positive effect in the region because air transportation plays an important role in the economic progress of the developing regions.

Finally, in the cockpit of the V-22 will be a new type of pilot: one who understands the complexities and demands of fixed wing and rotary wing flight, who also feels comfortable at turboprop altitudes and airspeeds, and most important, who can easily transition from the hot, demanding, low level tasks of helicopter operation to the easy cruise of turboprop flight and back again.



The feasibility application of a tilt-rotor aircraft in Venezuela is imminent while the future is unlimited and excitement continues to grow.

## VII. SUMMARY

Venezuela has maintained through the years, physical presence by stationing personnel at its remote borders with Colombia and Brazil, but the flow of supplies to these areas, which would normally be done through rivers, helicopters and small airplanes that use remote unpaved landing strips, sometimes is limited by various reasons. Weather conditions do not permit flying and other times the drought season causes navigation through rivers of small boats impossible, that is, navigation is only done during the rainy season. Also, the problem of insurgents personnel exists at the borders with Colombia supported by international narcotic trafficking trying to stop the urban and economic development of the region. For all of these reasons, a study was undertaken with the objective of eliminating the flow of supplies and logistic support problems in the vast southern region of the country, by studying the advantages that a tilt-rotor aircraft offers by virtue of its capacities and characteristics and determining its feasibilities in future application of this system. The only aircraft available at this moment that utilizes this concept is the XV-15 Tilt-rotor which is the prototype of a future derivative that is the V-22 "Osprey" Tilt-rotor aircraft. This aircraft is being developed under Bell

Helicopter Textron Inc. and Boeing Vertol Company. A detailed description of the characteristics and capabilities of this airplane would offer.

A series of missions are examined like: a special long range logistical support mission from Pto. Ayacucho to San Fernando de Atabapo, also a 100 mile radius mission to Los Monjes Island from Pto. Fijo, and a comparison between a ship, a helicopter and a tilt-rotor aircraft. A very important mission like aeromedical evacuation is carefully examined and eight (8) simulations were done with the help of a computer program at NASA Ames Research Center in Moffet Field, California, giving interesting results in favor of the tilt-rotor aircraft and revealing the need to implement a national system of rotor aircraft based emergency medical centers and the need to improve the small and illequipped emergency facilities in the southern part of the country. Later, the advantages of the tilt-rotor in comparison with a conventional helicopter are examined in terms of power required to hover, noise level, vibration and productivity, with the tilt-rotor aircraft showing satisfactory results in missions of more than 50 nautical miles of radius. Finally, the site selection criteria for the construction of an expeditionary vertiport is determined that offers security at distances far enough from the river to avoid being hit by small caliber projectiles. Also describing the use of the landing zone lighting where the use of a GAIL (glide angle

indicator light) for night landings and an ILS (instrument landing system) as a portable terminal guidance.

Considering all of this, we conclude that the tilt-rotor can play an important role in the improvement of the logistic support system and in the existing health care in the region. So, the application of this kind of aircraft in the region offers only advantages.

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