NASA CR-166,266

NASA CONTRACTOR REPORT 166266

Community Rotorcraft Air Transportation Benefits and Opportunities

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CONTRACT NAS2-10798
December 1981

NASA

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Prepared for
Ames Research Center
under Contract NAS2-10798

National Aeronautics and
Space Administration

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N82-16008#

ACKNOWLEDGEMENTS

On October 1, 1980, the Helicopter Association International (then the Helicopter Association of America) entered into a contract (NAS2-10798) with the National Aeronautics and Space Administration, through its Ames Research Center, to perform a study which would assist professional transportation planners in assessing benefits and opportunities that can be derived from the use of rotorcraft (helicopter) transportation. The acknowledgements which follow relate to this project.

The Helicopter Association International acknowledges with appreciation the excellent work done by its support contractor, Vitro Laboratories Division of Automation Industries, Inc., and in particular, the outstanding contribution made by Vitro's support team lead, Darral J. Freund.

A Helicopter/Heliport Advisory Council was formed by the HAI program manager to assist in the preparation of this study. Several iterations were reviewed before the final text was completed. Appreciation is extended to all who participated in the Council (see Appendix F for complete roster).

Additionally, continuing liaison during the contract period was maintained by the HAI program manager and the Vitro support team leader with the NASA Technical Monitor, Jay V. Christensen, of NASA's Ames Research Center and his assistants, Dr. John Zuk and William Snyder. (Dr. Zuk became the Technical Monitor toward the end of the contract period). Their inputs were very helpful and are acknowledged with deep appreciation. Recognition also is extended to John Ward of NASA headquarters for his very helpful counsel during the performance of this project.

A conference on Planning for Rotorcraft and Commuter Air Transportation was held in Monterey, California, August 31-September 4, 1981, under the auspices of NASA and the American Planning Association (APA). Attendees numbered some 125 persons, including many key transportation planners from all over the United States. A draft of this study was distributed as part of the conference documentation, and inputs derived at the conference were very useful in completing this final study. The HAI congratulates the APA and NASA for the excellent manner in which the conference was conducted, and the HAI will serve in a coordinating capacity to maintain continuing dialogue between the rotorcraft (helicopter) industry and the planning community (through the APA).

Special acknowledgement is extended to Bell Helicopter Textron and Hughes Helicopters for making available a 222 and two 500D's, respectively, for flight demonstrations at Monterey on September 2. All planners flew at least once, and their reactions were unanimously very favorable! These flights provided an exceedingly important contribution to the success of this conference. Appreciation also is extended to the following helicopter manufacturers for providing technical data for this study: Aerospatiale Helicopter Corporation, Bell Helicopter Textron, Boeing Vertol, Hughes Helicopters and Sikorsky Aircraft.

On September 3, a Rotorcraft session at the Monterey Conference was conducted by HAI program manager, Glen A. Gilbert. Speakers and subjects were: Dr. Robert Winick (Montgomery County, Maryland, Planning Department), Intermodal Relationships; Jack Thompson (State of Ohio, Department of Transportation), Heliport Planning Guidelines; Charles Cox (Bell Helicopter Textron), Heliport Noise; Arthur Negrette (Flight Safety Institute), Rotorcraft Safety and Operational Reliability; David S. Lawrence (Sikorsky Aircraft), Rotorcraft Benefits and Opportunities in Urban Applications; Darral J. Freund (Vitro Laboratories), Opportunities and Benefits Overview; Marjorie Kaplan (Douglas Aircraft), panel member; and Edward Hall (City of Phoenix), panel member.

Rotorcraft presentations during the Conference were made at other sessions by Tom Stuelpnagel (American Helicopter Society), on Rotorcraft Technology Status and Projections, and Jack Thompson on Rotorcraft Regulatory Considerations.

All participants listed above contributed to various sections of this study. In addition, other individuals not previously mentioned in these acknowledgements who contributed to this project included: Jack Cafarelli, Byron Bond and Tirey Vickers, Vitro; Pete Parsinen, Hans Weichel, and Ron Reber, Bell Helicopter Textron; Dave Wright, Hughes Helicopters; and Jaan Liiva, Boeing Vertol. Also, Dick Stutz of Sikorsky Aircraft and John Meehan of Pan American are recognized for their hard work in chairing two of the ten conference working groups.

Sincerest appreciation on behalf of the Helicopter Association International is extended to all.

Robert A. Richardson
HAI Executive Director

Glen A. Gilbert
HAI Program Manager

December 1981

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I. INTRODUCTION

A. STUDY OBJECTIVE

This study was contracted by the National Aeronautics and Space Administration (NASA), Ames Research Center. The primary objective of the study is to provide information about rotorcraft (helicopters) that will assist transportation planners at all levels (e.g., community, regional, state, federal) in assessing and planning for the use of rotorcraft transportation. However, the study also is intended to provide information useful to helicopter researchers, manufacturers and operators concerning helicopter opportunities and benefits.

The three primary topics of the study are:

- To present the current status and future projections of rotorcraft technology -- and the comparison of that technology with other transportation vehicles.
- To describe community benefits of promising rotorcraft transportation opportunities, and
- To discuss integration and interfacing considerations between rotorcraft and other transportation vehicles.

The work was performed by the Helicopter Association International (HAI), with the support of Vitro Laboratories Division of Automation Industries, Inc., Silver Spring, Maryland.

A companion study was also commissioned by NASA. It was performed by the American Planning Association in association with System Design Concepts, Inc. (Sydec). It addresses the criteria needed for planning rotorcraft transportation services from the perspective of community planners. Thus, the APA study is intended to identify the information needed by planners, in considering helicopter transportation, and the HAI study is intended to answer that need for information.

The terms of reference set forth by NASA for performing this study were explicit. While there was a tendency to focus on the public transportation opportunities of helicopters in a conference of the type that was held in Monterey (see "Acknowledgements"), this study was charged with examining all helicopter applications in all operating environments. Accordingly, this report addresses Benefits and Opportunities for the following helicopter applications:

- Public Service
- Public Transportation
- Corporate Executive
- Energy Exploration
- Construction
- Cargo
- Agriculture/Forestry
- Other Commercial Businesses

in the following settings:

- Central Business District
- Suburban
- Small Community
- Remote Area
- Airport
- Ocean Area

B. HISTORY AND PROJECTIONS

Civil benefits from the use of helicopters have increased significantly since 1960 and are expected to continue to increase in response to new and growing transportation needs. These needs have already resulted in strong growth rates in helicopter fleets, in heliports (mainly privately owned), and in operators, with some years seeing growth rates of 10 to 18 percent in the helicopter fleet. For those applications where the helicopter is uniquely qualified, it has made and will continue to make, important contributions to society. The public service roles of fire rescue, medical evacuation and sea rescue are paramount examples.

Present helicopter designs have incorporated impressive improvements in performance, reliability, quietness, and vibration reduction over previous designs. For the first time, helicopters have been specifically designed for the civil markets and for civil environments and there will be increased near-term use of these rotorcraft for various transportation purposes. Rotorcraft capabilities should grow significantly during the next decade as continued improvements are made in performance, cost of operations and noise reduction.

Over the past decade, a number of commercial applications have also grown remarkably. The transportation of crews and cargo to offshore oil rigs is a primary example. Based almost entirely on the offshore transportation role, one company has grown to be one of the largest operators in the entire aviation field including the airlines. It has 400 helicopters of 16 types. It flies 1000 hours per day and carries 165,000 passengers a month. In the Gulf of Mexico, the total number of helicopters of all companies operating to offshore oil rigs is between 700 and 800 (1981).

In early 1981, Bell Helicopter TEXTRON, working under a NASA contract, completed a study (NASA CR-166161) of a 20-year historical analysis and 10-year forecast of United States and free-world helicopter markets.

Figure I-1 shows the number of deliveries made in the past, and forecast for the future, to the free-world countries, and clearly indicates the dominance of the U.S. market. It also shows the rapid growth in the decade of the 1970's representing an increase of over 200%.

Figures I-2 and I-3 show the number of these units that were manufactured (and expected to be manufactured) by the various helicopter companies. Figures I-4 and I-5 indicate the dollar value of those deliveries.

At the start of the 1980's, the helicopter growth in the United States has been about 15% per year for the preceeding few years. While much of this has come from the growth in the use of helicopters to support offshore oil operations, there have been definite increases in most of the modes of air transportation, such as business/corporate, public service, construction, and forestry.

Perhaps the primary reason for the overall rapid growth is the technical and operational improvements in helicopters. The reduction in noise

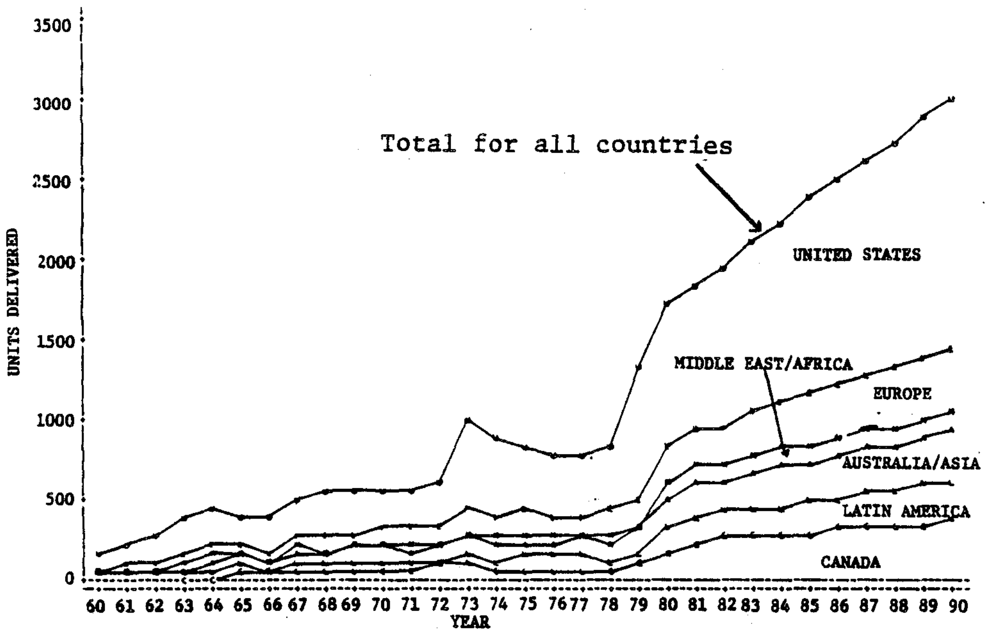


Figure I-1. Regional Civil Markets (Units)

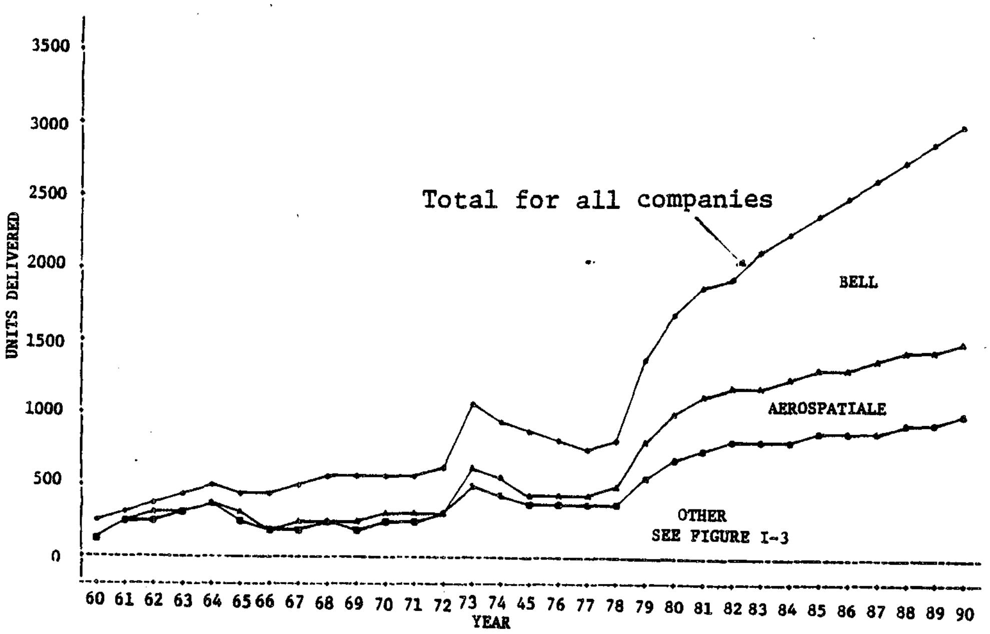


Figure I-2. Free World Civil Rotorcraft Production (Units)

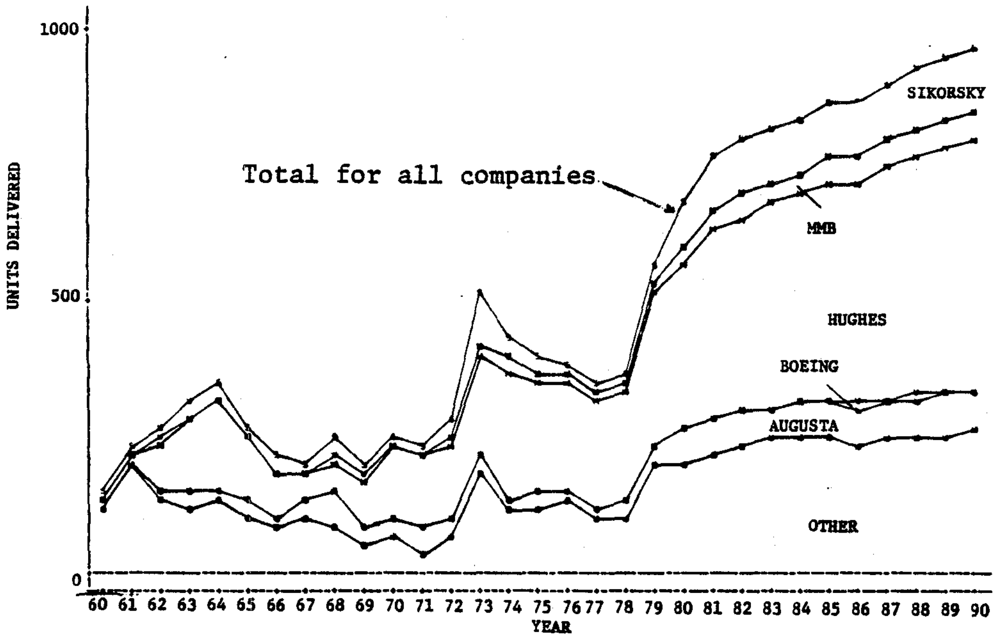


Figure I-3. Free World Civil Rotorcraft Production (Units)

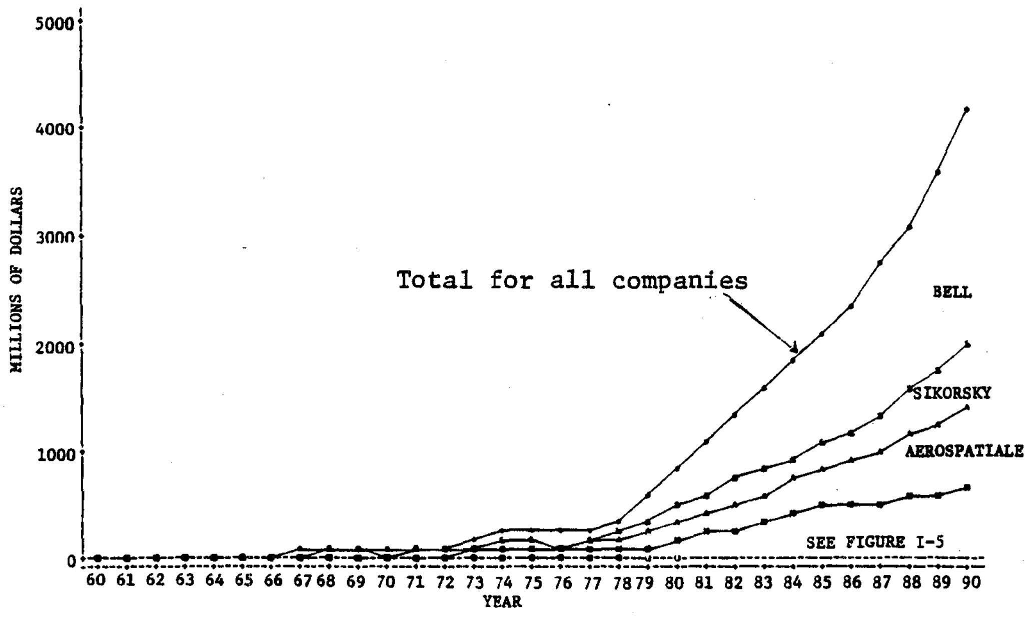


Figure I-4. Free World Civil Rotorcraft Production ($ Millions)

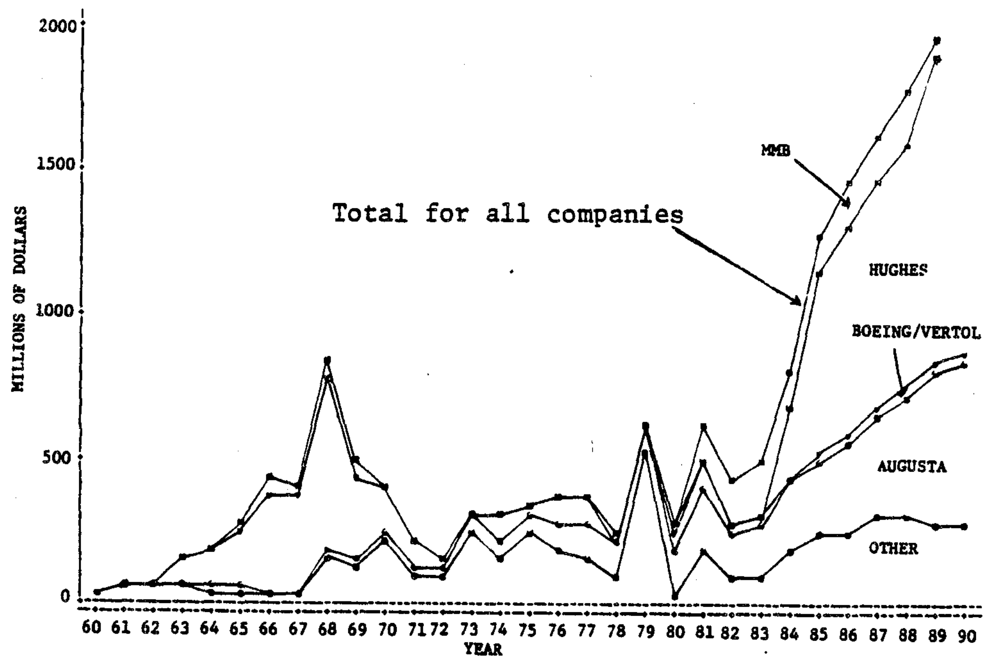


Figure I-5. Free World Civil Rotorcraft Production ($ Millions)

and vibration, the increase in performance (speed, comfort and safety), and the vastly improved instrument flying capability are all important contributors. In essence, the helicopter is rapidly becoming a viable and important means of transportation.

Additionally, some trends have been taking place in air transportation that may significantly improve the opportunity for the helicopter to be used for public transportation. It has been recognized for some time that there will be few if any new airports to service large urban centers. The real estate to build such airports is simply not available or the land costs are prohibitive. Furthermore, many of the present major hub airports are nearing their maximum air traffic capacity. Thus there are very few solutions for handling any dramatic increases in demand for air transportation using conventional fixed wing airplanes. Some of this demand may be accommodated by helicopters through the use of heliports within the communities themselves and dedicated heliports at conventional airports. In essence, the technology has improved to the point that the helicopter offers realistic alternatives for public transportation that can relieve some of the load at major airports.

One significant barrier to the achievement of this helicopter transportation solution is the lack of public-use heliports. In other forms of transportation (aircraft and cars), the needed services and facilities (airports and roads) were built in anticipation of increased traffic. This has not been the case for helicopters. It is possible, however, that if community planners, and the public in general, became more aware of the current and future improved capabilities and characteristics of helicopters, this situation may change. This could produce an environment leading to more public-use heliports and that, in turn, would enable the helicopter to fulfill some of the increased demand for transportation that is forecast.

II. EXECUTIVE SUMMARY

A. UNIQUE HELICOPTER CAPABILITIES

The helicopter has a number of unique capabilities that cannot be duplicated by conventional airplanes. They permit the helicopter to perform other tasks better or more competitively. These capabilities must be understood to fully appreciate the reason why the helicopter can carry out many unique tasks. The principal unique capabilities are:

Capability:	Therefore the Helicopter Can:
• Vertical takeoff and landing	• Land on small surfaces slightly larger than its rotor diameter (e.g., roof tops, parking lots, boats, wharves, airports.)
• Slow to zero velocity	• Land on unprepared surfaces (e.g., clearings, parks, lawns, mountain tops.)
• Hover and hover taxi	• Hoist and observe (e.g., sea rescue, fire rescue, police search, medical evacuation.)
	• Taxi around and over obstructions and traffic on airport (permits separate paths that do not interfere with airplane movements.)
• Slow Flight and Small turning radius	• Fly safer and slower in poor visibility.
	• Fly smaller patterns in air (e.g., shorter and segregated airport approach patterns, and smaller holding patterns that consume less airspace.)
• Steep approaches and departures	• Land at locations not accessible to airplanes.
• Cargo hoist	• Operate as crane.
	• Provide external lift of cargo of unwieldy size or at difficult locations (e.g., lumber hauling, pipe line laying, wire laying.)
• Less sensitivity to wind than airplanes	• Fly smoother in turbulent air.
	• Approach landing sites from any direction (up to about 35 kts). This permits separate helicopter patterns around airports; also flexibility in siting permanent landing areas.
• Can use skids, wheels or floats	• Land on any relatively smooth and level surface (e.g., on water, unprepared land, ship.)

B. HELICOPTER TECHNOLOGY STATUS AND PROJECTIONS

Civil rotorcraft technology advances in the 1980's and 1990's will be directed toward the following major objectives:

- Safe and quiet operation from city-center heliports
- Increased productivity, from higher speed and greater useful load
- Reduced fuel consumption and costs of operation
- Improved ride comfort
- Increased reliability
- Enhanced capability to operate routinely in poor weather and in/out of high traffic density areas
- Operate independently of and not in conflict with airplanes.

The primary technology thrusts that will enable achievement of these objectives are: extensive use of composite materials, advanced cockpits with simplified controls and computerized flight aids, advanced avionics including highly accurate navigation capability, low drag fuselages matched with aerodynamically optimized rotors, and high speed concepts such as the compound helicopter, Advancing Blade Concept (ABC), Tilt Rotor and X-Wing.

The compound helicopter has both a wing and an auxiliary propulsion to unload the rotor and provide speed capability up to 250 knots. The ABC has two stiff, coaxial rotors that provide lift without stalling at high speed, so no wing is required to cruise up to 300 knots. The tilt rotor is capable of approaching helicopter performance at low speed and aircraft performance at high speeds up to about 350 knots. In the X-Wing concept, the 4-blade rotor is stopped in cruising flight to form an X-shapped wing, and consequently rotor limitations to high speed are removed.

Future high speed, multi-engine rotorcraft will have power margins enabling them to hover with one engine inoperative. This will enhance safety and reduce heliport real estate requirements by allowing steeper approach and departure gradients and by eliminating the need for large clearway space to accommodate emergency roll-on landings.

Modern rotorcraft with moderate tip speeds are significantly quieter than earlier helicopter models. Advanced blade tip geometry and the steeper approach and departure gradients made possible by high power margins will further reduce the noise footprints of future rotorcraft. With formulation of realistic noise standards, this will permit even very large rotorcraft to operate directly into city centers. A comparison of the noise footprint of conventional aircraft, STOL aircraft and helicopters is shown in Figure II-1.

Cabin comfort of future rotorcraft will compare with modern airliner standards. Quieter transmissions and more efficient soundproofing will reduce internal noise. Structural tuning and advanced concepts such as higher harmonic blade pitch control will reduce vibration and wind gust sensitivity.

Advanced cockpits with improved pilot visibility, simplified controls, and automated flight aids including CRT's (cathode ray tubes) and voise interactive systems will permit dependable operation in bad weather. Takeoffs and landings from confined downtown areas in congested airspace can be routine. Combined with appropriate changes to current air traffic control regulations and procedures,

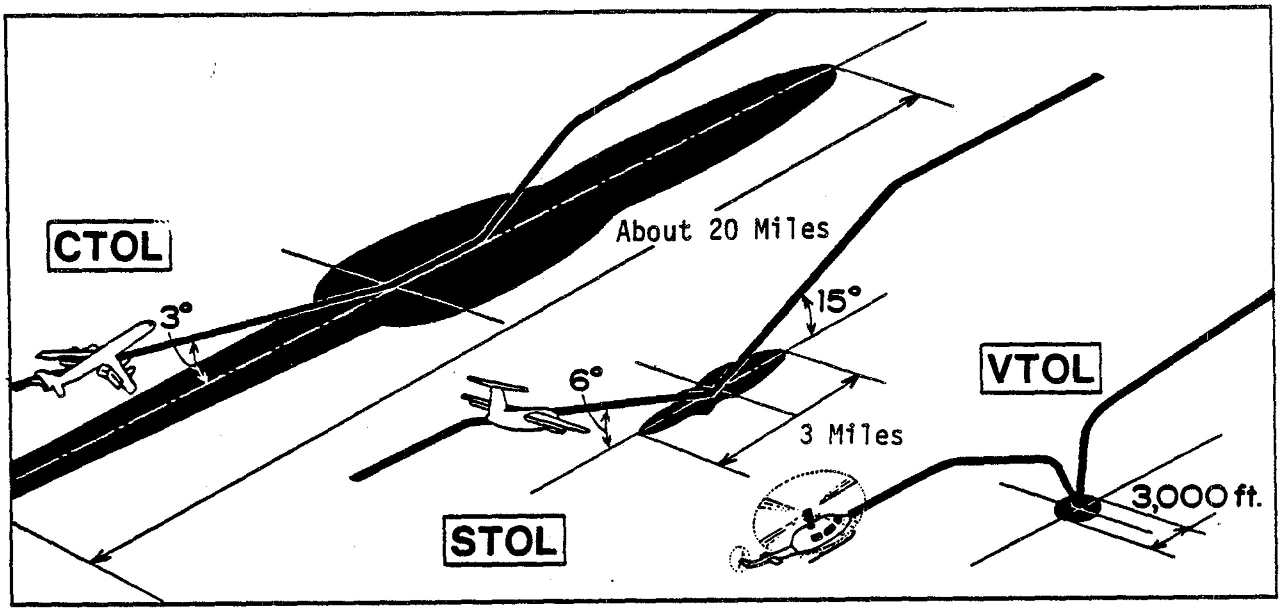


Figure II-1. Comparative Noise Footprints

this will enable rotorcraft to realize their potential for relieving airport and urban traffic congestion.

Fuel consumption will be markedly reduced by improvements in weight and drag effects, rotor blade geometry, trim control, and flight path management. The latter will be made possible by advanced avionics and flight controls, and by development of lightweight, fuel efficient gas turbine engines. For the higher speed concepts, advantage will be taken of the highly efficient propellers and fans being developed for small to medium-size fixed-wing transports. It is anticipated that by the year 2000, rotorcraft passenger-miles per gallon of fuel will be improved 50 to 75 percent.

Significant improvement in subsystem reliabilities will result from increasing use of solid state electronics, elastomerics and composites, and by reduced vibration. Corresponding reductions in maintenance burden of about 40 percent will contribute to substantial savings in operating cost.

There are virtually no technological constraints to the size of future rotorcraft. Maximum payload and range capabilities will be driven instead by the requirements of the marketplace. It is anticipated that payloads of up to 100 passengers and ranges of up to 600 miles will be available in rotorcraft of the 1990's. Higher speed rotorcraft in size using the ABC, tilt rotor, or X-Wing concept, will probably be somewhat smaller to satisfy the kind of missions for which speed itself, rather than payload or productivity, is paramount -- such as emergency medical service or search and rescue.

The safety of helicopter passenger transportation has improved substantially over the past decade. It varies by flying category, but in general is comparable to the safety of airplanes. There is the possibility that by the years 1990 and 2000 the safety performance will exceed that of airplanes because of the inherent safety advantage that arises from the ability to fly slowly (when desired) and to land on unprepared surfaces.

C. HELICOPTER OPPORTUNITIES AND BENEFITS

1. Applications and Scenarios

A number of years ago, the initial uses of helicopters in civil applications resulted from the unique capability of the helicopter to do something that could not be done in any other way. The rescue of an injured person on a remote mountain and the evacuation of a critically ill patient from an offshore oil production platforms are but a few examples.

Later, the helicopter came to be used more and more for jobs that could be done better or with less expense than by other methods. Examples of this are the agricultural spraying of chemicals on a small or hilly field surrounded by high obstacles, and the routine movement of offshore oil rig crews from shore to the rig and back again.

Finally, the helicopter has reached the stage in its development where it is directly competing more and more with other forms of transportation on the basis of time savings, cost savings and convenience. A basic and underlying trend that has made this possible is the substantial technical improvements that have been made in helicopters over the past decade in the following areas:

- Fuel efficiency
- Speed
- All-weather capability
- Comfort (quieter, more room, less vibration)
- Exterior noise reduction
- Improved safety and reliability

In this study, the full range of the applications that could be identified in the above categories were reviewed. From that set, 24 were selected as having the greatest potential for helicopter use. For those 24 applications, scenarios were developed and analyses performed that assessed the comparative performance of the helicopter (against other vehicles) in those scenarios. The list of scenarios selected is shown in the attached Table II-1.

Based on the knowledge gained in the analyses of the scenarios, an assessment was made of opportunities and benefits in various operating environments. A summary of the results of that assessment is provided below, together with a chart that shows the inter-relationships of: (a) helicopter applications, (b) helicopter operating environments and (c) opportunities and benefits.

2. Opportunities and Benefits

Figure II-2 indicates the primary helicopter applications where benefits are being derived. Benefits can be derived in the following environments:

TABLE II-1. PROMISING HELICOPTER SCENARIOS

1. PUBLIC SERVICE

   a. Law Enforcement Search
   b. Public Safety: Ambulance
   c. Public Safety: Fire Rescue
   d. Disaster Aid: Flood
   e. Disaster Aid: Snow Storm
   f. Disaster Aid: Large Scale Mountain Timber Fire
   g. Search and Rescue: Mountain Area

2. PUBLIC TRANSPORTATION

   h. Large Helicopters - Scheduled: To and From CBD's
   i. Medium Helicopters - Scheduled: Intra CBD
   j. Medium Helicopters - Scheduled: To and From CBD's
   k. Medium Helicopters - Scheduled: To and From Airports
   l. Large Helicopters - Unscheduled: To and From CBD's
   m. Small Helicopters - Air Taxi: Topographically Constrained Area

3. CORPORATE/EXECUTIVE

   n. Medium Helicopters: To and From CBD's
   o. Medium Helicopters: To and From Suburbs
   p. Medium Helicopters: To and From Airports

4. ENERGY EXPLORATION/PRODUCTION

   q. Offshore oil Production Support
   r. Powerline Laying; Remote Area; Coal Fields and Other Mining

5. CONSTRUCTION

   s. Crane: Intra CBD
   t. Pole Laying: Suburbs

6. CARGO

   u. External Lift: Ocean Area

7. AGRICULTURE/FORESTRY

   v. Grain Spraying: Rural Area
   w. Logging: Remote Area

8. OTHER BUSINESS/COMMERCIAL

   x. TV Reporting: Intra CBD
   y. Photography: Small Community

9. FLIGHT TRAINING

10. PERSONAL USE

OPPORTUNITIES AND BENEFITS

	TRANSPORTATION CATEGORIES							
	PUBLIC		PRIVATE		PUBLIC SERVICE		TOOL OF PRODUCTION	
	PEOPLE	GOODS	PEOPLE	GOODS	PEOPLE	GOODS	PEOPLE	GOODS
	Transport Charter	Cargo	Inter-Company Intra-Company	Parts	Police Fire Rescue Medical	Equipment Water Chemicals Supplies	Traffic Reports T.V. News Gathering	Construction Forestry Agricultural

TRANSPORTATION ENVIRONMENTS	B E N E F I T S			
URBAN	Transport □ ● Charter □ ●	Inter-Company □ ● Intra-Company □ ⊖	Police/Ambulance ⊟ ● Fire Rescue □ ● Disaster Relief □ ●	Traffic Reporting ⊟ ● TV News □ ● Crane □ ⊖
SMALL COMMUNITY	Transport ⊖ Charter ○	Inter-Company □ ○ Intra-Company □ ⊖	Disaster Relief ⊖	
RURAL		Intra-Company □ ○	Search & Rescue □ ○ Wildlife Mgmt. □ ○ Disaster Relief □ ●	Wire/Pole Laying □ ⊖ Spraying/Seeding ⊟ ● Surveys □ ⊖
REMOTE AREA			Search □ ⊖ Disaster Relief □ ● Aerial Surveys □ ⊖	Power/Pipe Lines □ ⊖ Aerial Surveys □ ⊖ Logging □ ⊖
AIRPORT	Transport ● Charter ⊟ ●	Inter-Company □ ●	Fire ⊟ ⊖ Ambulance ⊟ ⊖	Base of Helicopter Operations ⊟ ●
OCEAN	Charter ■ ●	Intra-Company ⊟ ●	Sea Rescue ⊟ ● Patrols ⊟ ●	External Lift Shore to Ship ⊖

CODE: Present Use: Hi ■ Med ⊟ Lo □ Potential Use: Hi ● Med ⊖ Lo ○ (National Scale)

Figure II-2

a. Urban Area

The urban area has a great diversity of helicopter opportunities. There is a potential for a high level of flying activity in: public transportation, private transportation, public service and as a tool of production.

A significant opportunity for a high level of public transportation is in flights between densely populated areas and their airports.

In private flying (mostly corporate) a high level of activity is possible in flights that involve inter-company contacts and communications.

Some of the needs of helicopters for public service are accentuated in the city. This is particularly true for fires in high rise buildings and for emergency medical transportation -- because of congested ground traffic.

The use of the helicopter for traffic reporting and TV news reporting has grown in many parts of the country. As a tool of production, the use of the helicopter as a crane is rapidly growing. On many occasions it can be the most cost effective means of doing the job.

b. Small Community

Under the right circumstances (in the relationship and location between small communities and densely populated areas), there would be a potential need for helicopter public transportation, both scheduled and charter in small communities. The other main opportunity area for helicopters is in private (mainly corporate) flying -- but this is mostly influenced by the needs and desires of corporations in selecting communities where they would like to locate their headquarters or manufacturing facilities.

c. Rural

The opportunities and benefits in rural areas are mainly in public service applications and as a tool of production.

Search and rescue, wildlife management and disaster relief are the principal public service opportunities.

As a tool of production the helicopter has already grown rapidly in the agricultural work of spraying and seeding. However, the laying of power lines and poles and the performance of aerial surveys is also done and has some growth potential.

d. Remote Area

The remote area is very similar to the rural area in the general categories of opportunities (public service, and tool of production).

However, remote areas are most vulnerable to disasters and they often have an urgent need for aerial services.

The logging work performed by helicopters in several remote areas of the Northwest has grown surprisingly and may have potential for substantial expansion.

e. Airport

The airport is a useful environment for helicopters, and many helicopter operations currently are based at airports. Flying to and from airports today is one of the most frequent types of trip for private (corporate) helicopters. This can be expected to continue to be true in the future, but with increased use of city center heliports, certain types of helicopter operations may not need to use airports.

f. Ocean Area

The expanding helicopter operations to offshore oil rigs over the past 10 years has accounted for an important percentage of the production of civil helicopters during that period. The speed of helicopter transport exceeds boat travel by a large margin. As a consequence, the ability to transport work crews efficiently and to move urgent cargo quickly has been an important contributor to the efficiency of oil exploration and oil recovery.

Rescue operations are the other principal contributor of helicopters in the ocean area. While these incidents do not occur frequently, they are important and helicopter rescue efforts save many lives.

D. INTERMODAL RELATIONSHIPS

In order to be successful in public transportation, new rotorcraft services need to: (1) add to people's existing transportation options, and (2) be integrated and coordinated with other types of transportation. New rotorcraft technology has the potential for being that special ingredient which significantly increases the choices of travelers and shippers. Several of the findings and conclusions related to providing integrated services are given in Figure II-3.

In the course of the study, a general concept of a functional classification of transportation was developed together with a description of how that classification applies to the assessment of integrated transportation services. Two scenarios were developed in which these concepts were applied.

The findings of the CBD to CBD scenario are summarized in Figure II-4. The time savings of rotorcraft reflect its more direct access, higher line-haul speeds and less roundabout travel. Those savings are most pronounced increasingly for trains, autos, and buses. The narrower time savings of fixed-wing make the marginal cost differences more of a determinant; but airport access cost can equalize the greater line haul cost of rotorcraft. In general, for the typical likely user, a person whose time is highly valuable, rotorcraft is the transportation option that may make the most efficient use of time in relatively short haul applications.

The second scenario is summarized in Figure II-4. For rotorcraft within urban areas, their best market is in relatively long intra-urban trips for business purposes. Heliport spacing and acceptable rates of helicopter acceleration are as important as increasing cruising speeds. In order to achieve time savings with rotorcraft service, the minimum spacing between heliports would be in a range of 10 to 15 miles. With such minimum spacing, it would probably take a metropolitan area of a million people or more to support a minimal community rotorcraft commercial intra-urban air transportation system.

Figure II-3. Summary of Conclusions and Recommendations

- The specific transportation functions provided by the different technologies are the proper focus for comparison.

- The transportation function of community rotorcraft service is to provide a high degree of travel accessibility.

- In making trips, people link different functional class roles whether using one type of transportation or more than one type.

- To integrate well with ground modes, community rotorcraft commercial air transportation service should be:

  - Limited stop service with published schedules
  - Operate on specific routes
  - Between specific destinations

- Using the Comparison Framework

  - No two modes serve the same trip length range
  - Rotorcraft could not completely substitute for any other mode
  - One needs to idetify the comparable transportation roles being provided by the other modes

Figure II-4. Summary of Findings of Interurban Scenario

- Rotorcraft have the best technological potential for increased transportation time savings between CBDs

- Time savings favorable to rotorcraft reflect its:

a) More Direct Access b) Relatively High Speeds c) Less Circuitous Travel	Most Pronounced for Trains, Autos and Buses in that Order

- Due to Narrower air travel time differences in short haul service between rotorcraft and fixed-wing, total portal-to-portal cost differences assume greater importance for that comparison.

- The travel that would be most cost effective would be relatively long trips (50-400 miles) for business purposes. (Note that future generation of high speed rotorcraft could greatly extend this cost effective range).

- Rotorcraft have relatively higher direct operating costs than conventional fixed-wing airplanes, but airport access costs can eliminate difference in the middle part of the distance range.

- For individuals whose time is monetarily valuable, rotorcraft can provide the most cost effective transportation service.

Figure II-5. Summary of Findings of Intraurban Scenario

- Due to relatively close heliport spacing in short haul applications, greater cruise speeds may not significantly improve the transportation benefits of community rotorcraft service.

- Public acceptance of high acceleration rates may be just as effective as increasing curise speeds with technological innovations.

- None of the other transportation options provide unique service connecting the activity places.

- The minimum spacing detween the heliports is in the 10-15 mile range.

- It would probably take a metropolitan area of about one million residents to have a minimal community rotorcraft commercial air transportation system.

III. UNIQUE ROTORCRAFT CAPABILITIES

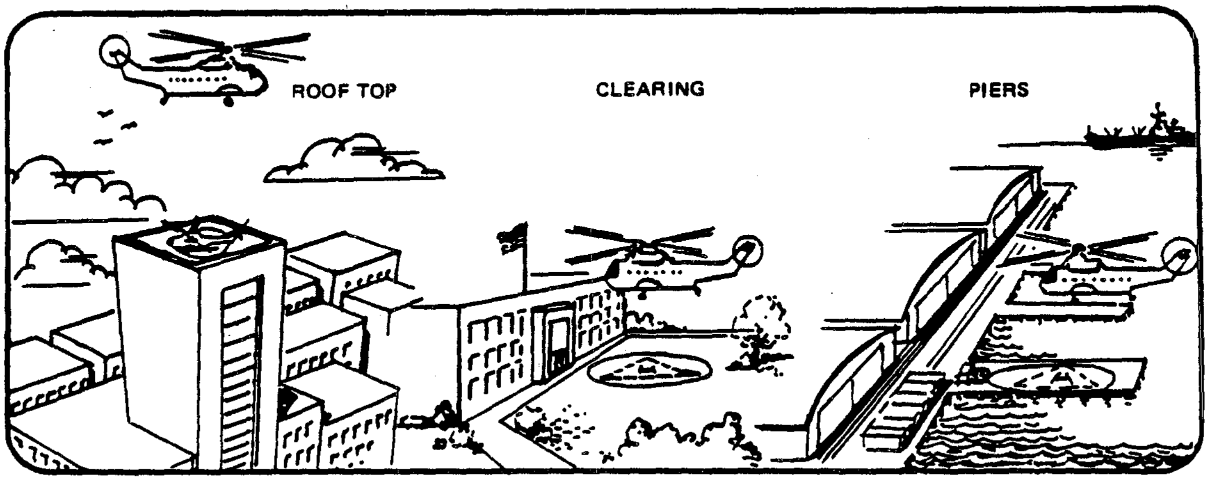
A. BACKGROUND

The helicopter has a number of unique capabilities that cannot be duplicated by conventional fixed-wing airplanes, and many of these capabilities are important to the transportation uses to which the helicopter can be applied. The purpose of this section is to probe somewhat deeper into these special helicopter characteristics and to show why and how they are important.

B. VERTICAL TAKE-OFF AND LANDING

During a typical final approach to landing, a helicopter decelerates from cruising speed and descends in altitude until it reaches a hovering condition just above the intended point of landing. If necessary, it can move sideways, forwards, backwards, or even rotate until it is positioned precisely for landing. Only then does it descend vertically for the final few feet to touchdown.

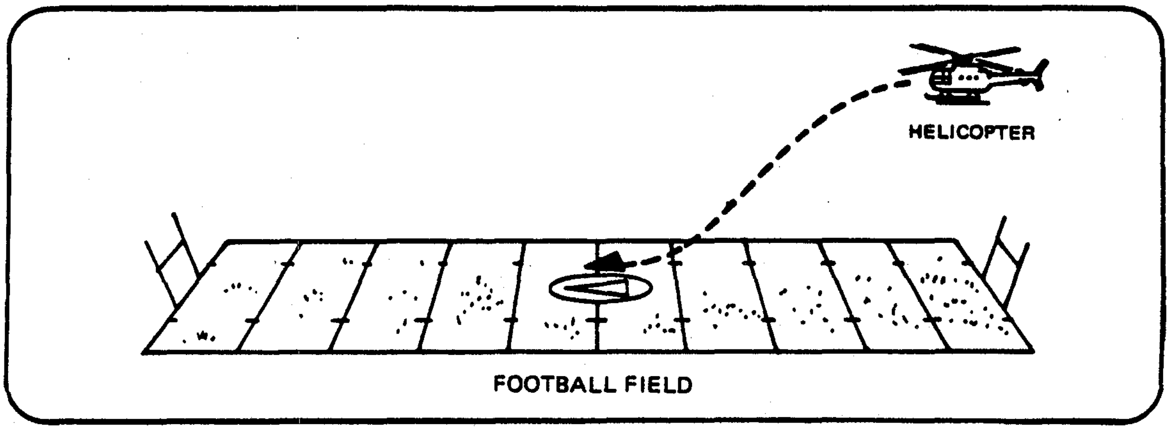
It has been said that an airplane lands and then stops, whereas a helicopter stops and then lands. The maneuvering flexibility close to the ground enables a pilot to land a helicopter with great precision. A minimum sized heliport need only be slightly larger than the rotor diameter of the largest helicopter expected to land there. As a result, there is great flexibility in selecting sites for heliports. For example, in the central business districts of large cities, a heliport can be located on top of buildings irrespective of their height, on small clearings on the ground, or even on piers or barges that are located on an adjacent body of water. (See Section VII.)



C. OPERATION ON UNPREPARED SURFACES

Helicopters are unique among aircraft in being able to operate from unprepared surfaces such as open fields. This enables helicopters to perform many missions that are not possible for other aircraft types. Other VTOL aircraft types such as the fan/jet have high velocity as well as high temperature downwash characteristics that require the aircraft to be operated from hard heat resistant surfaces such as concrete.

This ability to operate from unprepared surfaces provides the helicopter with an almost infinite choice of landing sites. While this is important in the flexibility of selecting departure and arrival points, it is also an important factor during aircraft emergencies. For example, if it is urgent that a landing be made quickly, the problems are likely to be less severe for a helicopter than an airplane. The airplane must find an airport (or at least a long flat road or pathway that is not being used). The helicopter need only find a small flat clearing.



D. HOVER AND HOVER TAXI

The ability to hover is the helicopter's most striking capability. It is an essential characteristic in many of the missions that the helicopter is called upon to perform. While the helicopter can remain motionless with respect to the air (i.e., hover), it is equally important that it can also compensate for wind and therefore remain motionless with respect to a point on the surface. It is this capability that makes the helicopter so useful in rescue missions such as at sea or at fires in high rise buildings.

There are two forms of hovering. One is called HIGE (hovering in ground effect); the other is called HOGE (hovering out of ground effect). Hovering out of ground effect requires high power and fuel consumption. However, if the helicopter is hovering at or below a height of about ½ the rotor diameter, (i.e., hovering in ground effect), the rotor downwash is partially trapped under the rotor, forming a cushion of air that decreases the power required to remain at a hover.

Larger helicopters, having wheel type landing gear, can taxi on prepared surfaces just as airplanes do. However, the large majority of helicopters have skid type landing gear and cannot taxi in the normal manner. Instead their "ground movement" must be done by Hover-taxiing a few feet off the ground. This turns out to be a tremendous advantage providing great flexibility in movements around an airport or heliport. For example, after making an instrument approach at an airport, a helicopter pilot can go from his minimum descent altitude directly to the helicopter landing site by hover-taxiing -- without interfering with the path of airplanes on the landing approach and without actually touching down on the runway and consuming valuable runway time. Also, a helicopter can avoid traffic lines on taxiways simply by hover-taxiing around the traffic.

E. SLOW FLYING

There are some combinations of low altitude and low airspeed that are avoided by helicopters so as to permit a single engine helicopter to make a forced landing (using "autorotation") in the event of engine failure. In a typical helicopter there are no restrictions in airspeeds above 40 knots -- and above 400 feet, there are no airspeed restrictions at all. Twin turbine engine helicopters, which are becoming the most prevalent type for business and public transportation purposes, are less limited by these restrictions because of their ability to continue flight using only one engine.

With these relatively minor restrictions, the helicopter may be operated at any speed from zero to its maximum cruising speed. This provides great flexibility for air traffic control purposes and substantial improvements in flight safety.

With respect to air traffic control, the slow flight permits a very short turning radius. This can result in shorter airport approach patterns that can be separated from airplane patterns. With the shorter turning radius helicopters can also fly smaller holding and maneuvering patterns that consume less airspace.

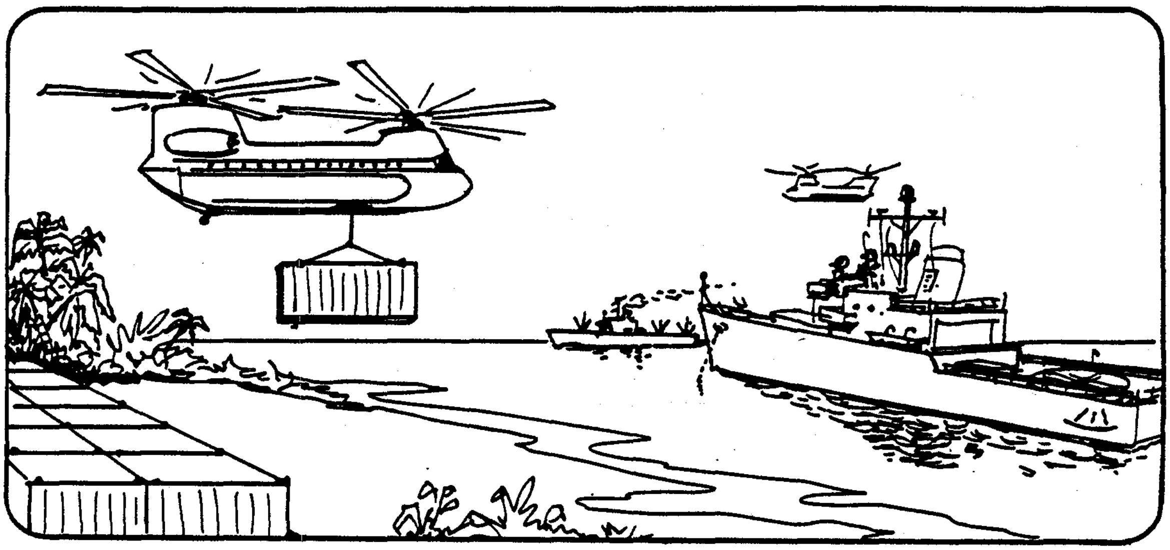
From a safety standpoint, the slow airspeeds that can be flown by helicopters, when it is advantageous to do so, are also important. High airspeeds have always been a problem for aircraft in making approaches and landings. They reduce decision time in the air and have all of the hazards of high speed operations on the ground. As the speed of the aircraft's flight decreases, the approach becomes progressively simpler and safer. Under conditions of poor visibility, the helicopter pilot can elect to fly at slower approach speeds and this gives him time to make adjustments in selecting and maneuvering to the specific landing site -- capabilities that airplanes do not have.

A number of helicopter applications in the field of public service, such as police work, also depend in part on the ability to fly low and slow. Agricultural spraying is another example in that the low speed capability provides advantages both in spraying close to obstacles, and in reducing the time and space required to turn around and start the next swath. Time is also saved by the ability to use loading sited close to the spray areas, including service trucks.

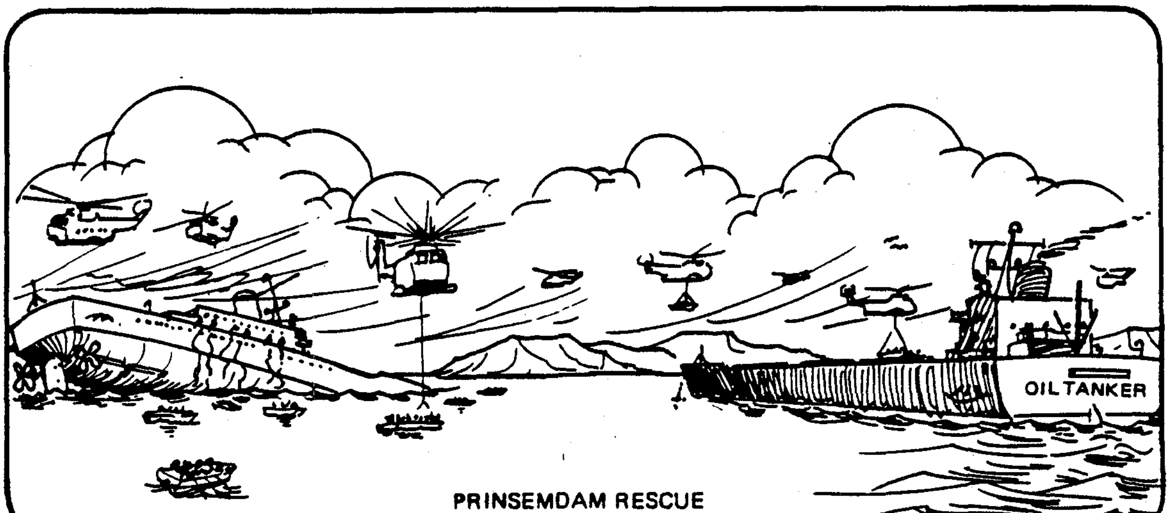
F. INSENSITIVITY TO MANY WIND CONDITIONS

The helicopter provides a smoother and more comfortable ride in turbulent or gusty wind conditions and is less sensitive to wake vortex and wind shear phenomena. This occurs because the rotor tends to integrate or filter the wind changes and thereby provide a smoother ride.

With respect to weight, helicopters are currently in production that can carry an internal or external load in excess of 25,000 lbs. (i.e., the Boeing 234, Chinook). Other helicopters are in the design stage that can carry 200 people or equally heavy external loads. A promising possibility for the future is the use of helicopters to load and unload cargo from ships that are standing off shore and consequently do not require deep draft port facilities. (This has already been done sucessfully in relieving port congestion at Jeddah, Saudi Arabia).



The hoist capability is an important element in making helicopters as useful as they are for rescue operations. A recent rescue mission that illustrates this important ability of helicopters took place when the cruise ship, Prinsemdam, sank (during 1980) 150 miles off the coast of Alaska. All 450 passengers were rescued without serious mishap despite cold weather and stormy seas. Of that total, 350 of the passengers were rescued by helicopters which hoisted them from the life boats into which they had escaped from the sinking ship. Coast Guard personnel who supervised this mission expressed the belief that most of the passengers would not have survived if helicopters had not been available.



PRINSEMDAM RESCUE

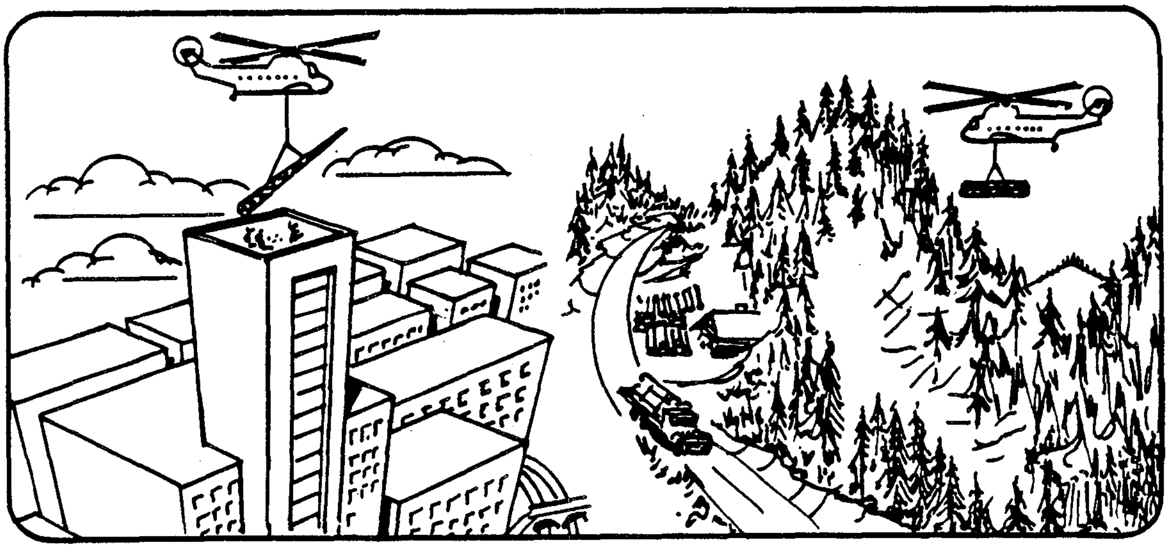
Another important characteristic of helicopters with respect to wind is that the helicopter does not have to fly on a long final approach path in the direction in which it will land. Typically an airplane will have a final approach path of from 3 to 10 miles or more in which it is lined-up with the landing runway. The use of a straight stable final approach path is an important element of safety in most conventional airplane approaches. A helicopter does not have this constraint. It can approach a landing site from any direction, irrespective of the wind direction, until a short distance from the landing site. Only then is it necessary to turn into the wind for the final landing. The importance of this characteristic is that it provides a mechanism to construct airport approach patterns that are separate and non-interfering with airplane patterns. Also in areas such as cities where there may be nearby buildings or other obstructions, it enables the helicopter to use patterns that avoid those obstructions. It should be noted in this connection that under conditions of high winds (i.e., about 35 knots or higher) helicopter operations may be discontinued--particularly at difficult landing sites.

G. APPROACH PROFILES

Because of its ability to fly slowly, the helicopter can make approaches to landing at considerably steeper approach angles than airplanes, without exceeding a safe rate of descent. This increases considerably the number of locations where a helicopter can make a safe landing. The maximum instrument approach angle for most airplanes is around six degrees and the normal approach around three degrees. A helicopter can operate comfortably up to about twelve degrees. Steep approaches are also important in their ability to reduce the noise footprint in the area of a heliport.

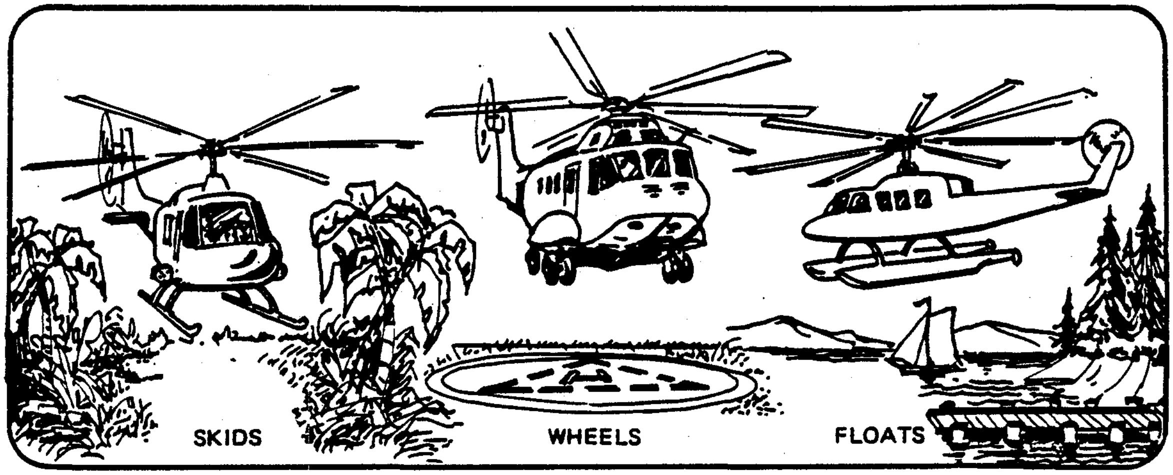
H. CARGO/HOIST

The helicopter is very effective in carrying external loads, the primary restriction being one of weight rather than shape or size. Two applications that illustrate this capability are the erection of radio and TV towers on the top of large high rise buildings and the use of the helicopter in logging operations where the terrain is too difficult for ground vehicles to be operated.



I. <u>LANDING GEAR</u>

In general, the lighter and smaller helicopters have used skids as their landing gear and the larger helicopters have used wheels. The dividing line has been in the range of 8,000 to 10,000 lbs. although many of the new high performance helicopters down to about 5,500 lbs. are now being equipped with wheels. The wheels provide the added flexibility to ground taxi, and to land at airports using the same air and ground patterns as those used by airplanes. Helicopters can also be operated on water, using floats.



IV. ROTOCRAFT TECHNOLOGY

(Section A below addresses the key technology aspects of helicopters, except for noise and safety which are addressed in separate sections (i.e. Sections B & C). Noise and safety are given special emphasis because they are of particular concern to community planners.

A. TECHNOLOGY STATUS AND PROJECTIONS

1. Background

This section of the study focuses on the current status of rotocraft technology and the projections of that technology to the years 1990 and 2000. However, it also provides some comparisons with other transportation vehicles.

The helicopter industry is large and diversified, with some 83 civilian helicopter models in current operation. There are 18 helicopter manufacturers world-wide, who have 47 models in production, and 12 models in development. About 30,000 helicopters are in use in the non-Communist world. This includes about 20,000 military and 10,000 civilian, most of which are in the United States and Canada.

It has been projected that by 1990, the civilian helicopter fleet will more than double, surpassing the military helicopter inventory in the process. This will involve the manufacture of some 20,000 new civil helicopters, for a projected 1990 total free-world fleet of 40 to 50 thousand civil helicopters!

2. Helicopter Classifications

In order to present pertinent information briefly, but with realistic values and comparability, six categories of helicopters have been established, based primarily on seating capacity, number, type and horsepower of engines, and acquisition costs. From among the myriad of types and models in use, typical currently-active helicopters are listed in each of the categories, and include both older models and current-production types.

CATEGORY 1: 2 to 5 seats; 150 to 300 hp; piston single engine.
Some typical active Category 1 helicopters: Aerospatiale 5A 342J; Bell 47G Enstrom 280C; Hiller UH-12E; Hughes 300C and Robinson R22.

CATEGORY 2: 5 to 7 seats; 350 to 650 hp; turbine single engine (light).
Some typical active Category 2 helicopters: Aerospatiale AS350D and SA341G; Bell 206B and 206L; and Hughes 500D and MBB BO-105CBS.

CATEGORY 3: 6 to 14 seats; 800 to 3000 hp; turbine single engine (heavy).
Some typical active Category 3 helicopters: Aerospatiale SA 360C; Bell 205 A-1 and 214 B-1; Kaman K-600-5; Sikorsky S-58T and S62A-C.

CATEGORY 4: 6 to 14 seats; 800 to 1300 hp; turbine twin-engine (light). Some typical active Category 4 helicopters: Aerospatiale AS365C; Augusta 109A; Bell 212 and 222; and MBB BK-117; and Sikorsky S-76.

CATEGORY 5: 15 to 28 seats; 2500 to 3200 hp; turbine twin-engine (medium). Some typical active Category 5 helicopters: Aerospatiale S330J; Boeing-Vertol 107 II and Sikorsky S61N MKII.

CATEGORY 6: More than 40 seats; more than 4000 hp; turbine twin-engine (heavy). Active Category 6 helicopter: Boeing-Vertol 234.

Within each of the categories above, characteristics representative of a typical currently operated 1980 helicopter have been synthesized by aggregating the data for the helicopters currently in use. These characteristics are shown on the accompanying Table IV-1.

3. Rotorcraft Status and Technology Trends

a. Background

While the helicopters described in Table IV-1 are a composite of older as well as new helicopters currently in use, the latest technology helicopters that have been and will be built as of the late 1970's are dramatically different from previous helicopters. They are streamlined and the fuselage looks very much like a typical airplane. Most have retractable wheels. These features have become necessary to reduce wind drag to allow speeds of about 150 to 180 knots where wind drag has become economically important.

These helicopters are also much quieter inside and outside. From the standpoint of the passenger they are more like a car, and normal conversations can be held without raising the voice. The vibrations are not noticable and not fatiguing. All of these features make the present state-of-the art helicopter very acceptable as a normal means of transport for people.

With respect to the 1990's and 2000's, conventional helicopters will improve in performance in a more evolutionary way. There will be many improvements in which each one may not be so noticeable to the passenger, but collectively they will have a great influence on performance, safety and cost effectiveness.

b. Principal Technology Objectives

Some of the main areas of present research and development that will impact the helicopters of the 1990's and 2000's are:

(1) Aerodynamics

With conventional helicopters, reduced drag, advanced rotor blade airfoils (combined with improved engines) will increase helicopter speeds from today's 150 knots to the order of 180 knots. Eventually speeds up to 200 knots may be achieved.

TABLE IV-1. CHARACTERISTICS REPRESENTATIVE OF A TYPICAL 1980 HELICOPTOR

Representative Characteristic	Category 1 Piston, single	Category 2 Turbine single, lt	Category 3 Turbine single, hvy	Category 4 Turbine twin, lt	Category 5 Turbine twin, med	Category 6 Turbine twin, hvy
Maximum Gross Wt. (lb)	2,500	3,500	10,000	10,000	20,000	50,000
Empty Wt. (lb.)	1,500	1,750	5,000	5,000	10,000	22,000
Useful Load, with full fuel (lb.)	750	1,200	3,000	4,000	7,000	20,000
Maximum External Load (lb.)	800	1,500	5,000	4,000	8,000	30,000
Seating Capacity	3	6	14	14	24	45
Rotor Diameter (ft.)	30	33	40	40	50	65
Overall Length (ft.)	35	38	50	50	60	100
Overall Height (ft.)	9	10	14	14	18	20
Normal Cruise (mph.)	90	130	130	150	160	160
State-of-the-art Cruise (mph.)		160	170	170		
Maximum Range, with full fuel (statute miles)	250	350	300	450	450	700
Maximum Endurance (hr)	3.5	3	3	4	4	4.5
Service Ceiling (ft)	13,000	14,000	15,000	15,000	15,000	15,000
Basic Price ($x1000)	100	275	800	1,500	3,000	9,000

(2) Composite Materials

New composites permit greater flexibility in design and protection. It is now possible to produce bearingless rotor heads and rotor hubs without hinges. These state-of-the-art hubs use only one-third as many parts as the older models which they replace. The use of composites, combined with other weight saving techniques, is expected to reduce the weight and cost of helicopters by about 25% by the year 2000. There will be greater reliability, less vibration and improved ride quality. The weight and speed improvements taken together will result in a 50% increase in productivity.

(3) Engines

Over the past decade a major improvement has been made through the switch from piston to turbine engines. The turbines have greater reliability and safety; they vibrate less; maintenance is simpler; and they are improving steadily in fuel efficiency and weight reduction.

(4) Automatic Pilots

Automatic pilots are continuing to be substantially improved. This work will result in improved stability of flight and the associated ride quality for passengers. For the pilot it will greatly reduce the complexity and workload of controlling the helicopter--particularly in instrument flight.

(5) Electronics

Improvements in the electronic field will affect many systems of the helicopter, just as they will with airplanes. Navigation and communication will be signigicantly improved. This is important to the helicopter because much of its flying is at low altitudes where it cannot receive the VHF line of sight signals transmitted by ground navigation facilities. Satellite navigation facilities will play an increasingly important role, both for helicopters and airplanes.

The new displays, control consoles and computers will make the pilot much more efficient and at the same time, reduce much of his workload. The pilot will shift more to being a commander of a vehicle than a manipulator of controls.

The computer may provide the most profound impact of all. It can be used to detect incipient maintenance failures in flight, it can make the navigation calculations for the pilot, and it can provide an instantly retrievable library of information that has not been available to the pilot before. It is likely that many future contributions of the computer have not even been identified yet.

Advanced cockpits with improved visibility, simplified controls, automated flight displays and control consoles, and voice interactive systems will permit dependable operation in bad weather conditions.

(6) Design For Reliability and Safety

A major effort has been made by the helicopter industry to make the helicopter the safest of transportation vehicles. One of the most important concepts in achieving this goal has been the use of multiple load paths in critical components, back-up systems and back-up operations. For example, it is possible to design a helicopter rotor so that there are multiple load paths for every critical element. Thus, the helicopter's rotor, which is its most critical and distinguishing feature as compared to other aircraft, can now be designed so that it is not a limiting factor in safety or reliability.

c. Impact on Passengers of Technology Improvements

A logical observation from the above discussion is: What does all of this mean from the viewpoint of the passenger?

Here are some of the answers:

- Improved Safety. People in the industry feel that the helicopter will become the safest type of aircraft. Through the technology just discussed, the helicopter will be as reliable mechanically as airplanes. But there are operational factors that give the helicopter a significant edge over other aircraft types. Since it can fly slow and since it can hover, the helicopter can land on virtually any flat piece of the earth that is not much larger than its rotor diameter. Also, because of its slow flight capability, the pilot can see obstructions and avoid them more easily in bad weather when operating at low altitudes, such as during landing approaches and departures. It is, therefore, possible to have many situations in which the helicopter is the safest type of aircraft.

- Reduced Noise and Vibration. External noise has been (and will continue to be) reduced through aero/acoustical technology, rotor blade design, and improved approach profiles. Internal noise and vibration will be substantially reduced by the same technology and by sound proofing. Present helicopters permit normal voice level conversations inside. Future helicopters will be even better. The outside noise will be at a level that is much more acceptable to the public.

- Improved Efficiency. As the helicopter improves in efficiency so that costs per seat mile are lowered it will be able to compete for more and more transportation application. It will be used by a broader range of economic classes of the public.

- Improved Reliability. Order-of-magnitude improvement in reliability will result from increasing use of solid state electronics, composites and by reduced vibration. Corresponding reductions in maintenance costs of about 40% will contribute to substantial savings in operating costs.

- Improved All Weather Capability. In the future, the helicopter will be able to fly in almost any kind of weather. The only exceptions are severe icing and severe turbulence -- the same limitations that apply to airplanes. Further, if anticipated improvements in self contained landing systems are realized, including use of inputs from satellites, the helicopter will be able to land in poor weather at small heliports and even unprepared landing sites that do not have sophisticated navigational aides. The eventual goal to be achieved is to be able to fly any route or flight profile in bad weather than can be flown when the weather is good.

- Speed. There is a direct relationship between the helicopter speed and its ability to compete in some transportation applications. The conventional helicopter has a practical upper limit of speed of around 200 mph. However, other forms of rotor-craft have greater speed potential. The tilt rotor, as an example,has an expected speed of about 350 mph; the compound helicopter speeds up to 400 mph; and the X-wing potential speds of around 550 mph.

d. Future Rotorcraft Configurations

(1) Conventional Helicopters. These are expected to be the dominant type of rotorcraft for as long as can be realistically seen in the future.

In the large helicopter category, they will appear internally very much like typical airliners. They will be able to seat as many as 200 or more passengers and have the same type of comfort facilities and furnishings. These helicopters will be directly competitive with the airlines in high density inter-city travel at distances that range from 100 to 300 miles, and possibly greater distances. Figures IV-1 and IV-2 project future improvements in cruising speeds, fuel efficiency and direct operating costs.

The mid-size and small-size helicopters will not appear much different in the 1990's and 2000's except for the tail rotor, which may be eliminated by some manufacturers through new techniques to control helicopter rotation. In other respects they will improve in most characteristics: speeds up to 250 mph, low noise level (inside and out), improvements in costs per seat mile, safer and more reliable.

(2) Tilt Rotor. This is a new class of rotorcraft, intended to operate at cruise speeds around 350 mph. These higher speeds are achieved without sacrificing vertical takeoff and landing capabilities, by using rotors in the overhead postion with rotor thrust directed downward for takeoff, and then tilting the rotors forward like large propellors for high speed forward travel. During landing approach, the rotors are again tilted to the overhead position as the tilt rotorcraft decelerates for landing.

Tilt rotorcraft have been under development and test for a good many years, and the concept has been successfully demonstrated through the Bell/NASA/Army XV-15 Tilt Rotor research aircraft program. Bell's D-326 Tilt Rotor, projected to cost about $12.4 million each (1981 $), will carry 30 passengers at 350 mph., costing about 30¢ per passenger seat mile. (See Figure IV-3).

(3) X-Wing. Another of the rotorcraft configurations being considered as a high-speed vehicle of the future is the X-Wing. The name is derived from the shape of the wing, which, when viewed from directly above or below, and not spinning, forms an "X". It is expected to have speeds of 550 mph and ranges of 600 statute miles. (See Figure IV-4).

The X-Wing spins and functions just like a helicopter rotor for vertical takeoff. Once the craft is airborne and exceeds certain speeds, the X-Wing locks in place to form a stationary wing for forward flight. Lockheed,

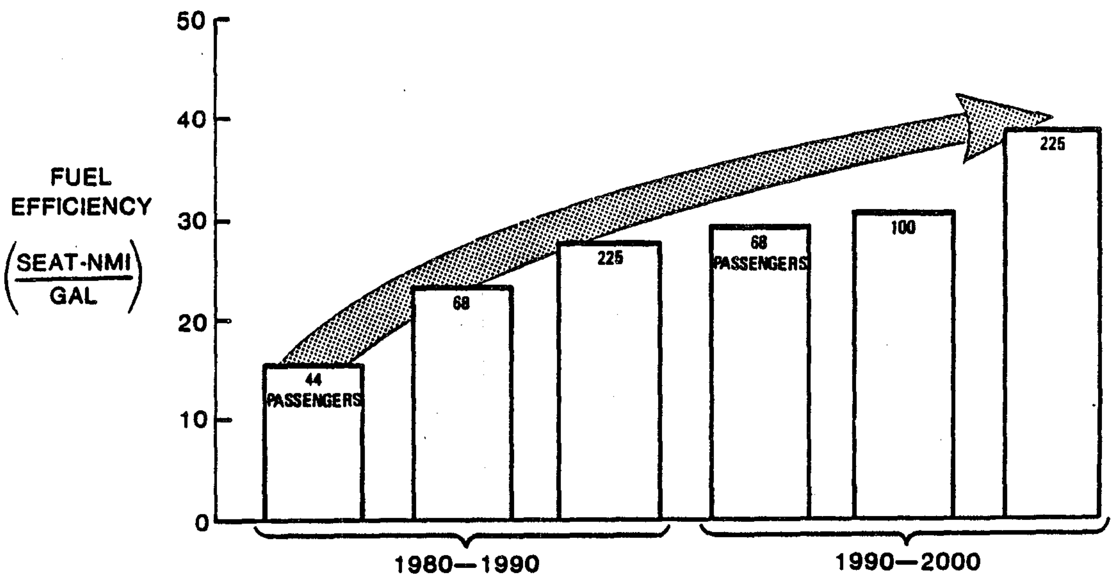


Figure IV-1. Helicopter Commuter Potential: Fuel Efficiency

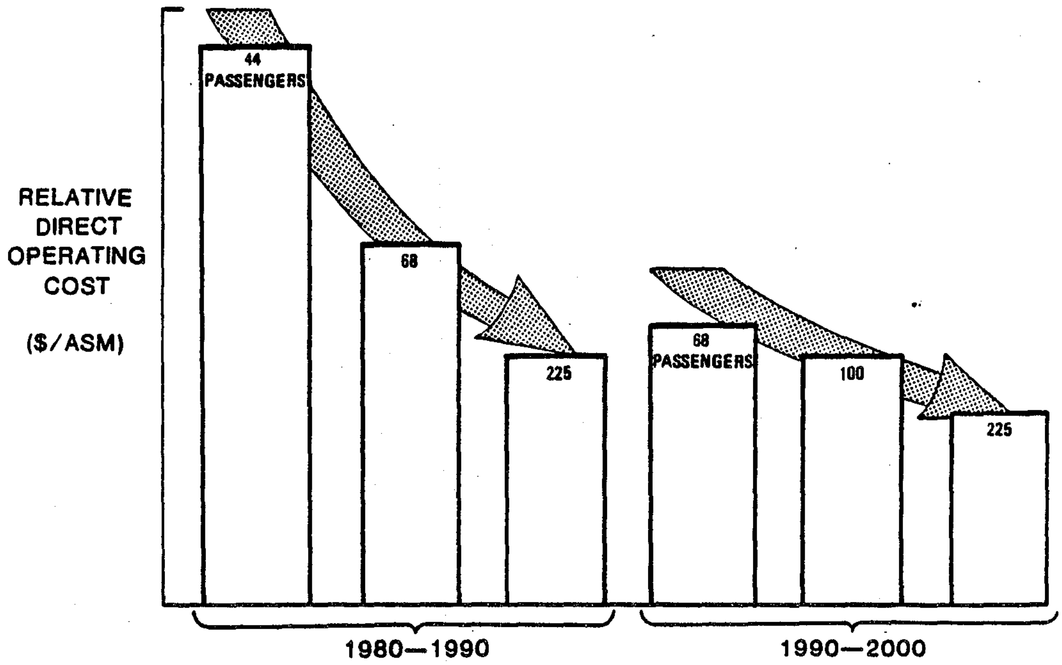


Figure IV-2. Helicopter Commuter Potential: Direct Operating Costs 100--300 NMI Stages

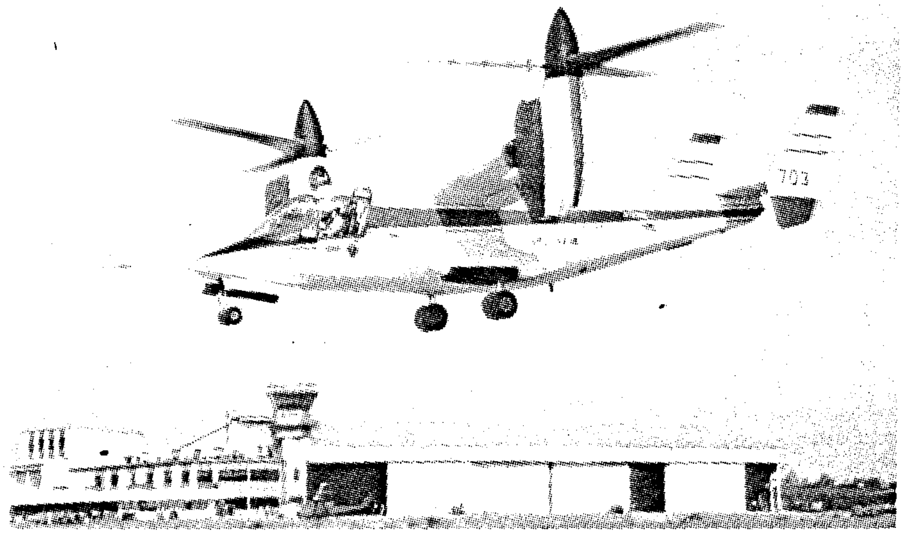


Figure IV-3. Tilt Rotor Helicopter

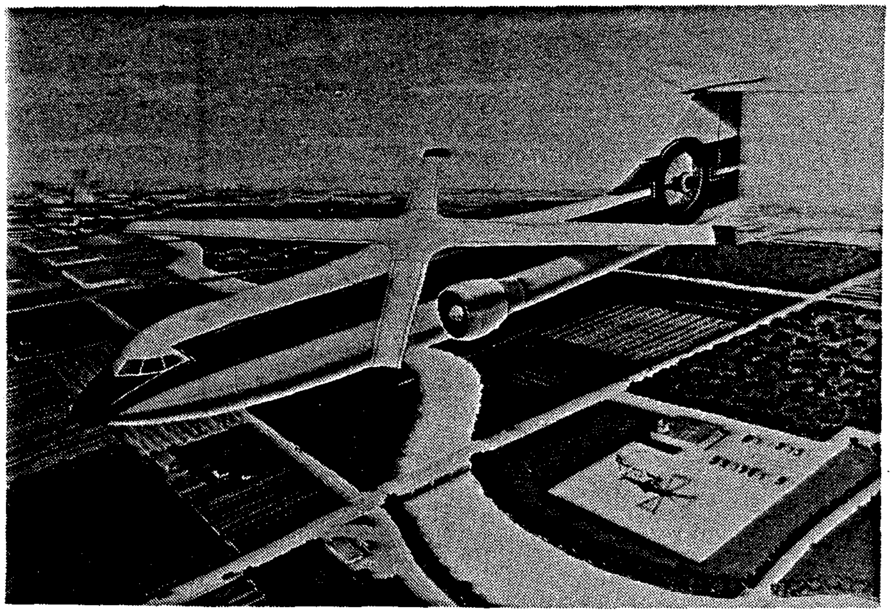


Figure IV-4. X-Wing Concept

with funding from the Defense Advanced Research Projects Agency, is designing an X-Wing.

(4) Advancing Blade Concept (ABC). Still another candidate configuration for high-speed rotorcraft is the Advancing Blade Concept (or ABC), shown in Figure IV-5.

In a conventional helicopter with one rotor on a single mast, the blade, being an airfoil, stalls when it is going around the trailing side of its rotational path. The severity of the stall increases at higher speeds and higher altitudes, considerably reducing the effective lift.

The ABC has two rotors, mounted on the same mast, and counterrotating on the same axis. Thus, there is an advancing blade on both sides of the aircraft, and stall from the retreating blade is not a limiting factor as much as drag is. Feathering the retreating blade reduces the drag.

Another advantage of the ABC's coaxial rotor system is that a tail rotor is not required to counteract the torque of the main rotor. Elimination of the tail rotor also reduces the helicopter's noise level considerably.

Sikorsky's ABC helicopter, a joint NASA/military program, has been through extensive altitude and speed testing, and has reached speeds of 300 mph in a shallow dive while at an altitude of 16,000 feet. The ABC has reached altitudes of almost 24,000 feet, during tests in late 1980.

Figure IV-5. Advancing Blade Concept

(5) Heavy Lift Helicopter (HLH). Future civil helicopter applications point to the desirability for further advances in size and capability, and studies of helicopters with gross weights of more than 300,000 pounds are in progress. (The largest helicopter in civil use in the Free World is about 50,000 pounds, at this time.)

Key to the feasibility of much larger helicopters are the propulsion system components (engines, drive, and rotors) and, in turn, their influence on configuration layout, empty weight, primary flight, and ultimately performance. Also, for reliability and to save weight, primary flight controls must be electronic, for "fly-by wire" (or through use of fiber optics).

A U. S. Army effort known as the HLH Advance Technology Concepts (ATC) Program demonstrated the feasibility of designing and manufacturing efficient large helicopter components. Civil derivatives of these military designs could produce a helicopter carrying 225 or more passengers. The lead of the military in initiating work on such designs is critical since the civil market is not sufficient by itself to justify development costs.

Civil applications for these technologically-feasible HLH's include logging, high voltage tower erection, resource exploration, numerous construction roles, and short-haul transport.

4. Economic and Technology Considerations of other Vehicles

(Note: In Section V on Helicopter Opportunities and Benefits, and in Section VI on Inter-Modal Transporation Relationships, comparisons are made between helicopters and other vehicles. Brief extracts of some of the data compiled for these comparisions are provided in this section.)

a. Commuter Airlines

A survey of 17 U. S. Commuter Airlines showed that their average direct and total operating costs for 1977-78 were as follows:

Stage Length, Statute Miles	Flight Time, Hours	DOC Per Flight Hr.	DOC Per Statute Mile	Total Cost* Per Statute Mi.
50	.208	$223.38	$.929	$1.403
100	.377	214.44	.808	1.220
200	.714	209.47	.748	1.129
400	1.388	206.77	.717	1.083

* Indirect costs amounted to 51% of the DOC

The Beech C-99, a 17 passenger turboprop commuter aircraft, has direct operating costs ranging from $341.69 per hour to $301.39 per hour, based on an annual utilization of 1500 to 2500 hours, respectively. At an average block speed of 220 knots (253 m.p.h.), this results in a DOC of $1.35 to $1.19 per mile, respectively, in 1981 dollars.

The DeHavilland Twin Otter, a 19 passenger twin turboprop commuter aircraft, costs approximately $1.2 million. Based on a 3000-hour annual utilization, direct operating costs range from $290 to $271 per hour and block speeds from 90 to 163 knots, for stage lengths of 30 to 300 nautical miles, respectively.

The DeHavilland Dash 7, a 50 passenger 4 enginine turboprop commuter aircraft, costs approximately $5.5 million. Based on a 3000-hour annual utilization, direct operating costs range from $1043 to $816 and block speeds of 106 to 200 knots, for stage lengths of 30 to 300 nautical miles, respectively.

The DeHavilland Dash 8, a proposed 36 passenger twin turboprop commuter aircraft, will cost approximately $4.5 million. Based on a 3000 hour annual utilization, its direct operating costs will range from $803 to $582 and block speeds from 120 to 225 knots for stage lengths from 30 to 300 nautical miles, respectively. Deliveries of this aircraft will commence in 1984.

Most of the commuter aircraft types used in the U. S. today are of foreign manufacture. There is a question whether the potential improvements possible with advanced technology will be applied to U. S. commuter transports due to economic reasons.

Significant improvements in fuel economy are anticipated through superior engines with high-efficiency propellers which have already reached a high state of development. New commuter aircraft designs will be optimized for high efficiency in climb rather than high cruising speed, as they will spend comparatively little time in cruise, but most of their time in climb and descent, due to their relatively short stage lengths.

Wings will be relatively high aspect ratio—also for efficiency in climb. Laminar-flow airfoils with excellent surface characteristics will provide a high ratio of lift to drag. The use of lighter materials will have a compounding effect on reducing weight and thus allowing increased payloads.

Turboprops will continue to be the main source of power.

b. Intercity Passenger Trains

With an average operating cost of 21 cents per passenger mile in 1979, Amtrak was not as efficient as bus transportation at 6¢ per passenger mile or airline transportation at 9¢ per passenger mile. At 45 passenger miles per gallon of fuel, Amtrak was not much more efficient than the private auto at 41 passenger miles per gallon.

The cost of railroad passenger cars is now $500,000; a Diesel locomotive, $600,000 per unit. An electric locomotive costs about $950,000, but its maintenance costs are about half that of a Diesel locomotive. Railroad electrification requires a huge capital investment; only lines handling more than 20 million ton-miles of traffic per year are considered candidates for electrification.

c. Bus

The bus is the most fuel efficient transportation available for intercity travel. In scheduled service, operating under 50% capacity, the bus averages 116 passenger miles per gallon of fuel. In tour and charter operations (which have higher load factors), the bus averages 208 passenger miles per gallon. The comparable figure for Amtrak was 47 passenger miles per gallon. Average utilization per vehicle is 8500 miles per month (about 326 miles per day for 26 days per month).

The typical intercity bus is powered by an 8-cylinder Diesel engine which gets 6 miles to the gallon of fuel. New supercharged 6-cylinder Diesel engines will be able to get almost 8 miles to the gallon. It is expected that this will become the standard bus powerplant over the next 20 years.

The most important changes in intercity buses during the next 20 years are expected in size rather than technology. Much will depend on whether present overall width limitations can be increased legally from the present 96 inches, to 102 inches. This would permit the use of a double-deck configuration with a correspondingly increased passenger capacity. Another possibility is to keep the same height and width but to increase length and passenger capacity by going to an articulated configuration, seating from 60 to 76 passengers in place of the present 47.

d. Rapid Rail Transit

This form of urban mass transportation, which includes subways, is justified for high density traffic corridors with high peak loads, as against 2000 passengers an hour for one lane of automobile traffic. However, it requires a very high capital investment. Subways now cost about $120 million per mile; a self propelled subway car costs $800,000.

It is expected that the trains will continue to be powered by electric motors for the foreseeable future, but that DC systems will be gradually changed over to AC. Stainless steel construction will be predominant. Radial steering trucks will reduce noise and wear on curved track, and will permit some savings in real estate by allowing the use of sharper curves.

Speed will remain in their present range and are not expected to exceed 75 m.p.h. on long stretches.

e. Light Rail Transit (LRT)

Compared to buses, trolley cars have no flexibility as far as routes are concerned as they are confined to a fixed track. They also can not overtake each other in case of a malfunction, or a track blockage, except where special switching arrangements are installed and parallel tracks are available.

To be efficient, LRT needs its own exclusive right-of-way, free of grade crossings and interference from other surface traffic. Where this is possible, LRT offers the advantage of being able to handle higher peak load densities than buses.

Ten cities are presently engaged in LRT construction projects. LRT will be a potential customer for all of the technological improvements previously discussed for rapid rail.

f. Intercity Motorbuses

The intercity bus industry consists of 1150 companies and operates 20,500 buses. 46 companies are classified by the Interstate Commerce Commission as Class I carriers, indicating that their annual revenues exceed $3 million.

In 1979, the bus industry served 14,600 communities, as compared to the airlines, who served 700 communities and AMTRAK, which served 550.

Of the 360 million passengers carried by bus companies in 1980, Class I carriers carried 37%; the remaining 63% were carried by Class II, Class III, and intrastate carriers. The Trailways system itself consists of 55 individual carriers, many of which are not Class I carriers.

An intercity motorbus costs about $140,000; this price is up from $125,000 in 1980. Both Greyhound and Trailways build their own buses through subsidiaries; Greyhound owns MCI (Motor Coach Industries) and Trailways owns Eagle. Both companies sell their products to other bus lines as well.

Average operating costs of intercity bus lines were $1.69 per mile in 1980, up from $1.35 the previous year. The 1980 costs included .97 per mile for labor and .16 per mile for fuel, which is still a minor item, although it was up from .08 the the previous year.

g. City Buses

Not being limited to rails, city buses have the advantage of great flexibility as compared to rapid rail or light rail transit; buses can overtake each other, and can drive around obstructions. Similarly, bus routes can be relocated as necessary with relatively little expense. A modern city bus costs $150,000 and can handle a seated load of about 36 passengers or a crush load (seated and standing) of 75 passengers. Without a dedicated right-of way, buses have to mix with city traffic; typical route speeds average less than 15 m.p.h. With an 8-cylinder 200 h.p. diesel engine, the typical city bus gets 3.5 miles per gallon of fuel, as compared to about 6 miles per gallon for interstate buses, because of frequent stops.

h. Automobiles

There are four general types of passenger automobiles in use in the U. S. today.

Type	Weight	Initial Cost	MPG	PAX	PAX MI GAL	TOTAL COST PER MILE
Standard	4000#	$8200	18	6	108	30¢
Compact	3000#	6800	20	4	80	27¢
Subcompact	2500#	4900	24	4	96	23¢
Van	5000#	13,200	13.5	14	189	45¢

Total cost listed above includes depreciation, maintenance, gas and oil, taxes, parking, tolls and insurance. Figures are based on a FHWA report, "Cost of Owning and Operating Automobiles and Vans, 1979", plus a 30% rise in initial cost and a 25% rise in total cost per mile due to inflation.

The most important trends in the design of U.S. automobiles have been forced by the rising costs of petroleum, and have resulted in the move toward smaller, lighter cars, with smaller and more efficient engines.

During the 1990's, it is expected that there will be a growing demand for two-passenger cars, particularly for use around urban areas, where parking space will become more of a problem.

In any case, there will be a growing use of plastics and other synthetics in order to decrease weight. Spinoffs of new materials developed for the aviation industry may be applied if production costs can be brought down to an affordable level. Lighter cars will allow smaller engines to provide the same acceleration characteristics, at a slightly lower fuel consumption.

Engine efficiency will continue to increase, aided by a growing use of superchargers and electronic controls. There will be an increasing demand for Diesel engines for better fuel economy, although Diesel may always be more expensive. The general adoption of Diesel power could be limited in future years by the adoption of more stringent pollution standards, especially with regard to the emission of particulates. Superchargers are especially useful on Diesels, and wide application is expected.

It is expected that reciprocating engines will continue to power the automobiles of the next two decades.

One of the most important trends in automotive design will be the increasing application of electronics, in controlling carburation or fuel injection to provide the optimum mixture of fuel and air under all conditions; in automatic shifting to match the transmission to the engine; in sensing fuel detonation and thus allowing the use of lower grade fuel; and in providing anti-skid braking.

i. Use of Real Estate

An important source of revenue for local communities is real estate taxes. Rotorcraft, which utilize airspace except for small landing pads, remove relatively little real estate from the tax rolls. All surface modes of transportation must have roadways, right-of-ways, etc. which reduce the amount of taxes that could be collected from the real estate in a given community.

B. NOISE

1. Background

The external noise of helicopters has been considered to be one of the most important characteristics influencing where and how helicopters can be used, particularly in urban areas. By nature, the helicopter is a low flying aircraft and as a result, it frequently comes within the audible range of people. Furthermore, the helicopter is the only type of aircraft that can take-off and land in a city environment. Therefore, even if the noise is at a relatively low level, it can take place in close proximity to where people live and work. This creates the paradox that in a number of helicopter applications, the features that make the helicopter uniquely useful, bring the helicopter close to people -- and this closeness accentuates the problems associated with external helicopter noise. Yet, in the end, helicopter noise must be controlled so that it is acceptable to the communities in which it operates.

The noise footprint of a helicopter during approach, landing, take-off, and departure is considerably less intense than that of an airplane. The smaller region associated with the helicopter can be attributed to two causes, i.e., the helicopter emits less noise than the airplane, and it can approach and depart its landing area at higher angles. However, the airplane noise footprint is normally associated with an airport which is typically (but not always) at substantial distances from population centers, whereas the helicopter noise footprint frequently is located within the confines of a community.

The helicopter noise, within the footprint region, is comparable to other sounds that are acceptable to the community, if only because of familiarity. Light trucks and city buses are examples of the helicopter noise equivalent, and these noise events normally occur with great frequency compared to helicopter noise events. (See Figures IV-6 and IV-7)

While helicopter noise is considerably less intense than aircraft noise, it has a unique signature that readily identifies its source. The dominant feature of this noise in many helicopters is a pulsating sound called blade slap. This sound is generated by the main rotor, and pulsates rhythmically at the blade passage frequency. The reduction of blade noise has been the subject of considerable study and research, directed at both rotor design and establishing flight profiles that minimize this particular noise. New blade shapes will also tend to reduce these pulsations. Furthermore, since blade slap caused by the strong interaction of the rotor blades with wake vortices is related to flight conditions, helicopter flight procedures and routings that avoid populated areas during approach and departure can be used to substantially reduce the effect of this phenomenon.

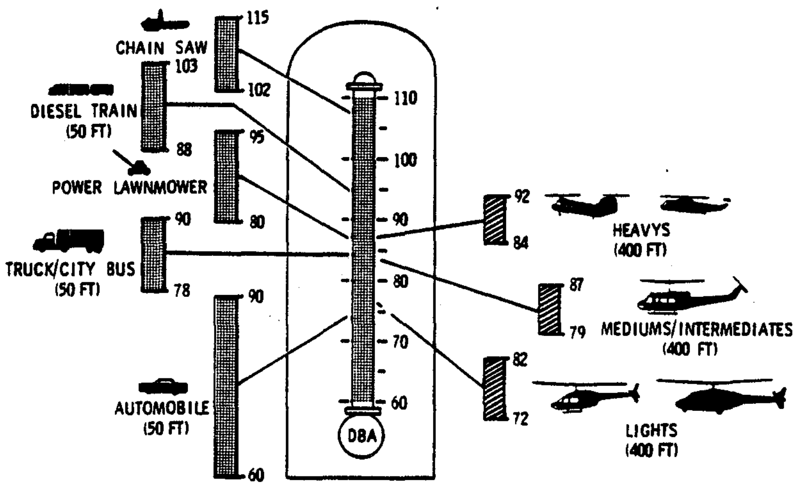


Figure IV-6. Comparison of Sounds

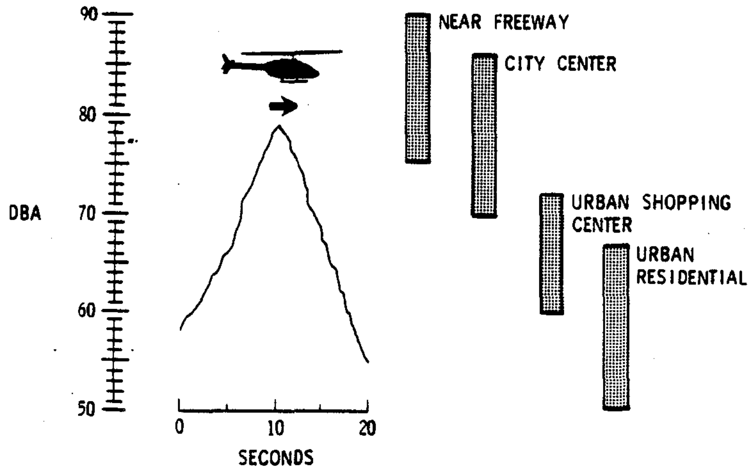


Figure IV-7. Comparison to Ambient Noise

2. Subjective Attitudes to Noise

The annoyance caused by noise has subjective attributes that are difficult to quantify. Nevertheless, they must be considered when establishing noise standards. Some of the main attitudes are:

- Feelings about the necessity or preventability of the noise. If people feel that their concerns are being ignored, they are more likely to feel hostility towards the noise.

- Judgement of the importance and value of the activity which is producing the noise. The importance and value of helicopter activities have been particularly evident in the public service functions, and particularly those related to the saving of life. There is some possibility that community awareness of these benefits will gradually relieve the apprehension about helicopter noise. After the helicopter rescue operation at the MGM Grand Hotel in Las Vegas, there was a dramatic change in community attitude to the establishment of new heliports in the city.

- Activity at the time an individual hears a noise. An individual's sleep, rest and relaxation have been found to be more easily disrupted by noise than his normal daytime activities.

- Feeling of apprehension associated with the noise. The apprehension associated with a particular noise is often pronounced when it is unique in character and unfamiliar. To some extent, this is the case with helicopter generated noise. The overcoming of this emotion will likely come about when the sound becomes more familiar and it is recognized that helicopter noise is not associated with a hazard. The fact that many helicopter operations are associated with rescue and public service activities may also assist in overcoming this emotion.

Factors affecting attitudes to noise are illustrated in Figure IV-8. Figure IV-9 illustrates some piloting techniques that also may affect these attitudes.

3. Helicopter Noise Regulations

The FAA is charged by Noise Control Act of 1972 (PL92-574) to prescribe standards for the control of aircraft (includes helicopters) noise which are economically reasonable, technologically practicable, and appropriate to the type of aircraft. A flow chart of the rule making process is shown by Figure IV-10.

The standards for the control of helicopter noise govern the issuance of new type certificates for helicopters for which application is made on and after the publication date of this notice. It applies to original, standard airworthiness certificates for restricted category certificates for helicopters which do not have any flight time before January 1, 1985. The standards proposed by the FAA are similar to the standards developed within the International Civil Aviation Organization (ICAO).

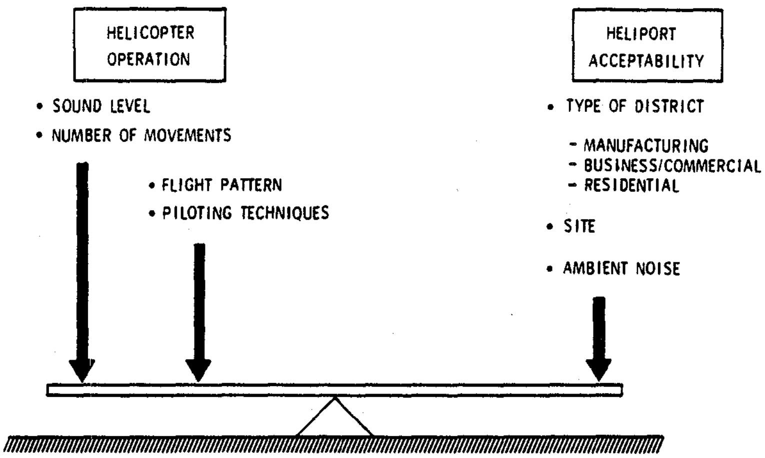


Figure IV-8 Factors Affecting Attitudes to Noise

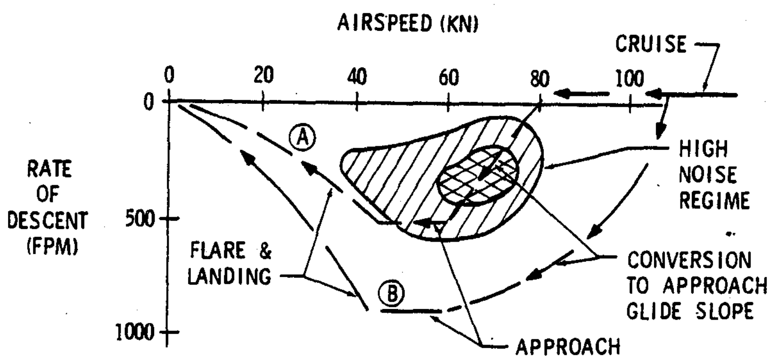


Figure IV-9. Piloting Techniques

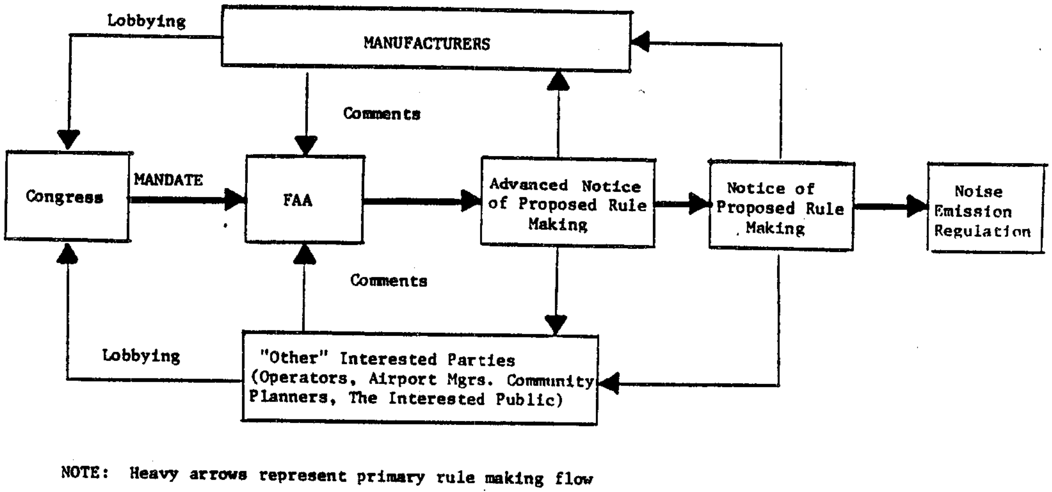


Figure IV-10. Evolution of Noise Standards for Helicopters

In addition to these noise emission standards, the FAA also is required by Congress to prepare, and is preparing, environmental response standards to control the total noise energy exposure to the community caused by aircraft operations. However, an interim rule was issued by the FAA on January 26, 1981, Development and Submission of Airport Operators Noise Compatability Planning Programs that specifically excluded heliports. This exclusion was made by the FAA at the specific request of manufacturers, who believed the inclusion of heliports would be premature at this time. However, helicopters using airports are included in the noise response regulations.

4. Noise Measurement Standards

Sound levels normally are measured in decibels relative to a reference sound pressure level. However, the annoyance of a sound is caused by its pressure and by several other factors such as spectral content, tonal qualities, duration and rapidity of the noise build-up.

The spectral content probably is the most significant contributor to noise annoyance. For example, the ear is considerably more sensitive to sounds centered near a frequency of 1000 cycles per second than to sounds of equivalent pressures at lower or higher frequencies. The tonal qualities also affect annoyance, since pure tones such as tail rotor whine are more disturbing than wide band noise of equivalent pressure centered on the pure tone frequency. The duration of the tone also affects annoyance, the longer the tone the greater the annoyance. The rise time of the noise is another annoyance factor, since a rapid rise in sound pressure causes a greater annoyance than a gradual rise.

Two measurement standards have emerged from a maze of candidates as the standards for helicopter noise measurement. These are the effective perceived noise (EPNdB) for vehicle noise emission, and the noise level corrected for daytime/nightime noise events (L_{dn}) for environmental response. The L_{dn} is the frequency weighted value of the noise spectrum emitted by the helicopter, identified as dB(A), corrected for the numbers and times of noise events occurance.

These standards, and the selection rationale, probably can best be understood from the following table that pairs each emission standard with its corresponding environmental response standard.

CANDIDATE NOISE MEASUREMENT STANDARDS

Emission Standard		Corresponding Environmental Response Standard
dB(A)	→	L_{dn}
PNdB	→	CNR
EPNdB	→	NEF

In each of these measurement standard pairs, the environmental response standard has its origin in the corresponding emission standard, but is corrected for the numbers of noise events and times of occurence. The composite noise response (CNR), and noise exposure forecast (NEF) are not expected to be widely used and therefore not further discussed.

The EPNdB provides a measure of certain characteristics of noise, namely the presence of tones and duration of the sound that is considerably more descriptive, than dB(A). Unfortunately, an EPNdB measurement instrument can cost about $5,000, while dB(A) can be measured with an instrument that costs less than $500! Helicopter noise certification using EPNdB test instruments is an extensive and costly process. The quantities of these instruments that would be required for noise measurements at small airports and heliports throughout the United States would make the use of EPNdB instrumentation for that purpose economically prohibitive. Furthermore, communities have measured noise from various transportation and other sources for many years using the dB(A) unit. Therefore, helicopter noise measured in this unit can be more easily compared to noise associated with other transportation vehicles.

EPNdB has been selected by the FAA as the helicopter noise emission standard, and L_{dn} which is computed from dB(A) measurements has been selected as the environmental response standard. These appear to be the best practical choice in both cases.

5. Helicopter Noise Measurement Profiles

The noise measurement tests proposed for helicopter certification are take-off, fly over, and approach. The flight profiles for the take-off and approach noise tests are illustrated by Figure IV-11 and IV-12. Three microphones connected to appropriate electronics, are located on level ground on a straight line and dispersed perpendicular to the flight path. The distance between microphones is 492 feet (150 meters). The helicopter is flown over the center microphone for each of the required flight profiles, at prescribed configurations, heights, and climb/descent angles. The sound spectrum is detected by each of these microphones, both frequency and amplitude versus time, and the data are processed to provide the noise levels in dB(A) or EPNdB units. The data are corrected to accommodate non-standard atmospheres and deviations from the prescribed flight path.

6. Noise Limits

The proposed noise level limits are about the same values for the three prescribed profiles, but vary considerably with gross weight. The noise level limits for helicopters having high gross weights are the noise equivalent of a jet flyover at about 1000 ft. The noise limits decrease as weight decreases, until at 1700 lbs. or less, it corresponds to a prop plane flyover at that altitude.

7. Helicopter Noise Sources

Helicopter acoustic technology is considerably more complex than that of fixed wing aircraft, since there are more noise sources as illustrated by Figure IV-13, and interactions among these sources.

a. Main rotor

A significant source of helicopter noise is the main rotor and is caused by variable loads, both periodic and random, on the rotor lifting surfaces. Blade interaction also provides a substantial noise contribution as a blade moves through the atmospheric disturbance caused by the preceding blade.

b. Tail rotor

The tail rotor, required only for single main rotor helicopters, is a substantial noise generator. Its spectrum includes narrow band tones, and also fluctuating noises caused by the interaction of the tail rotor and main rotor flow fields.

c. Power Plant

Piston engines, and gas turbines that produce strong compressor tones or exhaust noises, can be substantial noise sources.

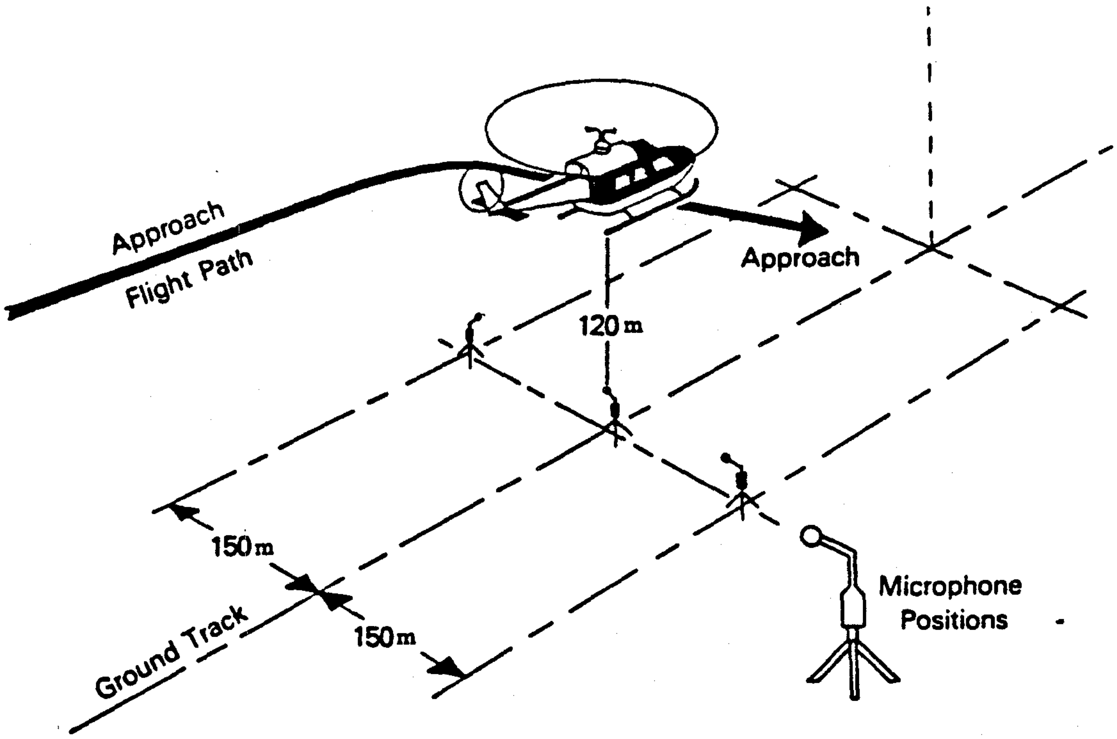


Figure IV-11. Helicopter Approach Noise Tests

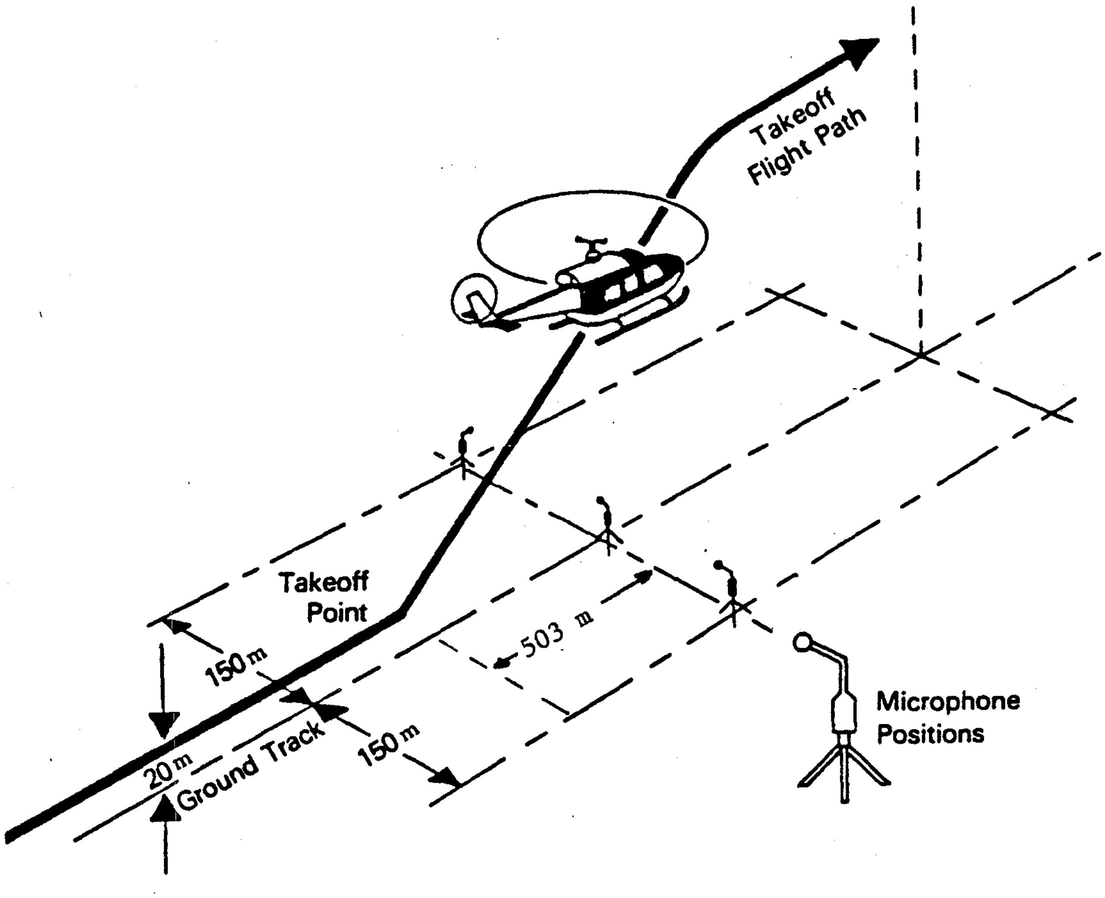


Figure IV-12. Helicopter Takeoff Noise Tests

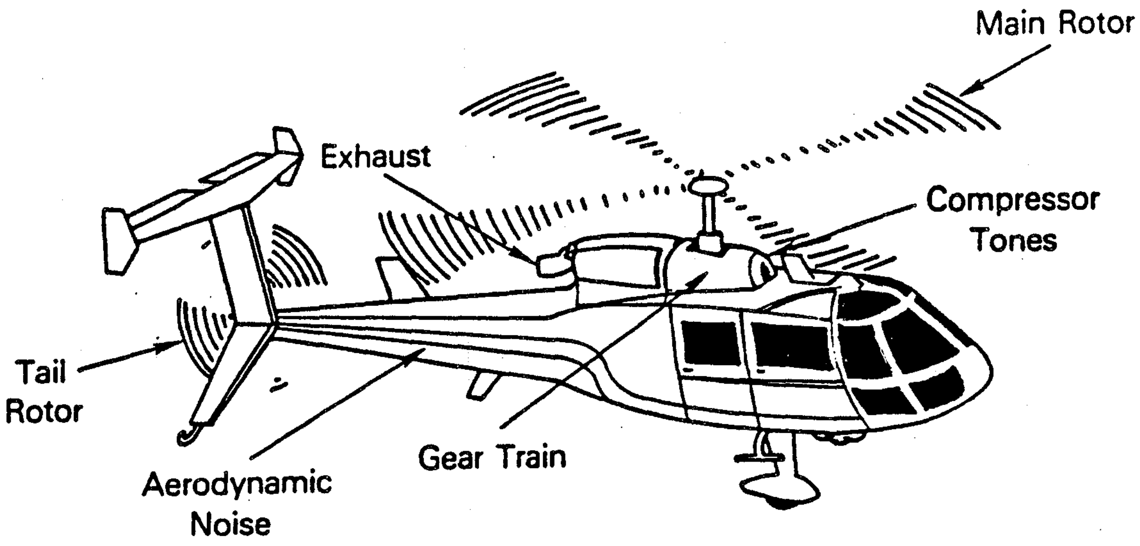


Figure IV-13. Helicopter Noise Sources

8. Helicopter Noise Reduction

The majority of today's helicopters operate in sparsely populated areas, and typically do not cause substantial noise problems. When operating in an urban environment, there are four approaches to the reduction of the environmental impact of helicopter noise annoyance. These are heliport location, scheduling, flight patterns, and acoustic technology. These approaches are not mutually exclusive, and all should be applied to achieve the desired results.

The scheduling should emphasize, where feasible, daytime operations, particularly when other environmental noises are high such as at maximum ground traffic times. The subjective aspects of noise annoyance are lowest during daytime activities, and also relate to the difference in level between the particular sound and the prevailing ambient level.

The flight profiles should be directed, where feasible, over ground regions having a high noise ambient level such as major highways, or over non noise-sensative areas such as rivers. For example, passengers in a car among normal vehicle traffic probably would not be annoyed by, and possible not even aware of, helicopter overflights. It should be understood that these noise reduction considerations apply essentially to low level flight in densely populated areas when visual reference to the surface is feasible, not to instrument (IFR) operations.

Main rotors are the most significant contribution to helicopter noise annoyance. Design features now being examined to decrease this noise are rotor radius, blade chord, blade numbers, and rotor speed. The operational implementation of noise reduction technology should be gradual, since each improvement must be weighed against performance requirements and life cycle costs.

9. Helicopter Noise Summary

While the noise footprints of helicopters normally are considerably smaller than those of airplanes, these footprints may occur in populated regions such as central business districts. Accordingly, the industry and government agencies are applying considerable technology and operational skills to further reduce noise emission. This represents a challenging task, particularly in view of the subjective aspects of noise annoyance.

Noise regulations are being formulated by the FAA that will impact the helicopter certification process. In the long run, these should result in reduced helicopter noise without economic penalty.

The noise measurement standard currently favored by the FAA for helicopter certification is the effective perceived noise level (EPNL), which considers most of the noise parameters that contribute to annoyance. However, the environmental response standard currently favored is the L_{dn} which is computed from a dB(A) measurement which does not consider as many noise annoyance parameters as does the EPNL. However, the dB(A) is an accepted standard and the measurements can be made with established shelf hardware. It permits ready comparison of noise between helicopters and other transportation vehicles.

Of the helicopter noise sources described in this section, the most significant sources are the main rotor, tail rotor and power plant. Much of the current work on noise reduction is directed at reducing this sound.

C. HELICOPTER SAFETY FACTORS AND CONSIDERATIONS

1. Introduction

The safety record for civil helicopters in the United States reflects an impressive improvement trend, i.e. from 35 accidents per 100,000 hours flown in helicopters in 1969 to 14 accidents per 100,000 hours flown in helicopters in 1979. This dramatic reduction in the helicopter accident rate for the 10 year period 1969-1979 occurred despite extremely rapid growth in both the number of civil helicopters and their scope of application.

These statistics are even more impressive when it is recognized that many helicopters operate in very unforgiving environments which include off-shore support of distant oil rigs and high-altitude/mountain operations where otherwise minor in-flight problems can quickly evolve to critical conditions. During this same time period, still other demands have been placed on the helicopter and its flight crew by expanding the helicopter's application into new areas.

Activities such as day and night law enforcement operations, environmental control programs which require long periods of hovering over harbors and rivers, agricultural spraying/seeding, and traffic and powerline patrols at low altitudes where considerable attention must be allocated to functions other than flying the aircraft, and the use of helicopters in response to major disasters, such as the MGM Grand Hotel fire in Las Vegas where helicopters operated in a high-risk environment to extricate people from a burning high-rise hotel, illustrate the varied and complex role civil helicopters perform currently. Thus, the overall accident rate of helicopters per 100,000 hours flown becomes very impressive when taking into consideration their many inherently dangerous activities and their routine exposure to extremely demanding environments.

Helicopter public transportation operations have even a better safety record than the overall accident rate. This is because such operations are conducted under more stringent Federal Aviation Regulations. Using NTSB data for the three year period 1977-1979, the accident rate for surveyed helicopter air taxi operators certificated under FAR Part 135 was 3.31 per 100,000 flight hours. This compares with the commuter air carrier accident rate of 3.44 per 100,000 flight hours.

As previously noted, the usual methodology for reporting accident rates is in terms of "accidents per 100,000 flight hours." An obvious consequence of this approach is to bias "comparative" accident statistics in favor of those aircraft operations which are of a long-haul, nonstop nature such as transcontinental flights.

Since accidents very often occur during either take-off or landing, additional insight into the helicopter's safety record vis-a-vis other types of aircraft can be gained by a comparison of the number of accidents per 100,000 departures. Figure IV-14 presents the findings of a recent analysis conducted by Bell Helicopter Textron wherein the accident rate per 100,000 departures was determined for three different groups of aircraft operators during the period 1977-1979 to include:

- U. S. certificated air carriers
- Helicopter air taxi operators
- Commuter air carriers

On the basis of accidents per 100,000 departures, the safety record of helicopter air taxi operators compares favorably with that of certificated air carriers and is significantly better than commuter air carriers.

Several factors account for the dramatic improvement in helicopter safety statistics in recent years to include:

- Increased use of turbine engines in the helicopter fleet
- Growing preference for multi-engine helicopters
- Acceptance of the helicopter in the IFR environment
- More sophisticated planning and control of helicopter maintenance, pilot proficiency/standardization and field operations.
- Improvements in the design, reliability and operation of critical helicopter components.

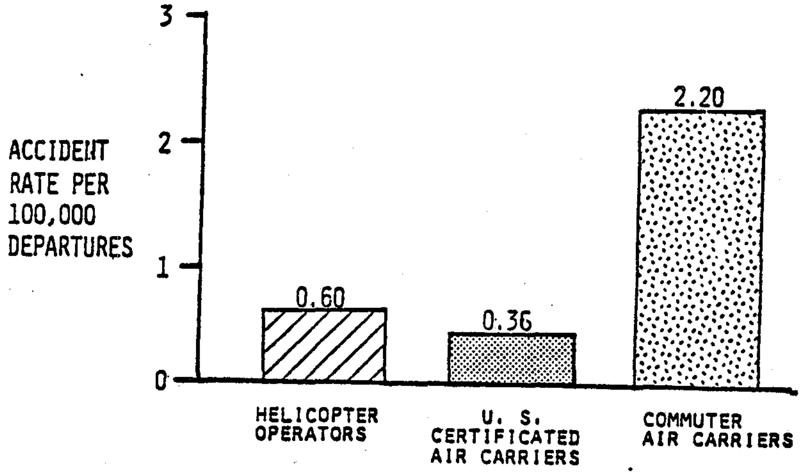


Figure IV-14. Accident Comparison for Helicopter Air Taxi Operators -- 1977 through 1979

- Enhanced layout, design and environmental control in the helicopter cockpit
- Exceptionally well-experienced and professionally-oriented flight crews and maintenance personnel.

While the civil helicopter accident rate has dramatically improved during the past 10 years due to the devleopments noted above, there is confidence in the industry that still further improvements can be expected as helicopter research/development by NASA, the FAA and the industry bears fruit in the decade of the 1980's.

2. Helicopter Safety Factors

a. Versatility and Controllability

Perhaps the most important factors contributing to helicopter flight safety are its recognized versatility and controllability. Unlike conventional fixed-wing aircraft, the helicopter possesses unique attributes which enable the pilot to precisely control various flight parameters. Thus, certain options and advantages are available to helicopter pilots which advance measurably the inherent flight safety of helicopters when compared to

e. Control of Maintenance, Training and Operations

While there has always been some control of helicopter maintenance, crew training and field operations by both management and the Federal fixed-wing aircraft. Such advantages include slow forward airspeeds in areas of reduced visibility or congested airspace, take-off and landings from totally unprepared areas, the ability to carry external sling loads which can be immediately released should circumstances warrant, exceptional visibility from the helicopter's cockpit, and the ability to land and take-off from very small or confined areas.

b. Utilization of Turbine Engines

A major factor contributing to the improved safety record for civil helicopters in the last 10 years is the expanding acceptance and utilization of turbine engines to power the helicopter in place of reciprocating engines. An analysis by Boeing Vertol Company of U. S. civil helicopter accidents during 1975 determined that the accident rate for all turbine-powered helicopters was 9.02 per 100,000 flight hours and 29.77 for all helicopters powered with reciprocating engines, a threefold increase over the turbine helicopter rate. Table IV-2 summarizes civil helicopter shipments by U. S. manufacturers for the five year period 1975-1979. During this most recent 5 year period, the number of helicopter shipments with reciprocating engines decreased slightly between 1975-1979 while the number of turbine-powered helicopter shipments increased significantly. The demand for turbine-powered helicopters is expected to increase in most major segments of the industry (off-shore, logging, corporate, air taxi, etc.) during the 1980's yielding a further improvement in the civil helicopter accident rate.

TABLE IV-2

CIVIL HELICOPTER SHIPMENTS

1975-1979

(RECIPROCATING-ENGINE v. TURBINE-ENGINE)

POWER SOURCE	1975	1976	1977	1978	1979
Reciprocating Engine	207 (24%)	225 (29%)	257 (30%)	270 (30%)	201 (20%)
Turbine Engine	647 (76%)	538 (71%)	591 (70%)	634 (70%)	818 (80%)
Total	854	763	848	904	1019

c. Multi-Engine Helicopters

The growing demand for turbine-powered helicopters has been accompanied by a strong interest in multi-engine helicopters. Off-shore operators in particular have shown a definite preference for, and in many cases are insisting upon multi-engine helicopters. As more manufacturers have included one or more multi-engine helicopters in their product line, the number of multi-engine helicopters in the civil fleet will continue to increase.

Table IV-3 summarizes accident statistical data for civil helicopters in 1975 as developed by Boeing Vertol Co. and illustrates clearly the lower accident rate enjoyed by multi-engine helicopters. During 1975, the accident rate for multi-engine (turbine) helicopters was only 3.92 accidents per every 100,000 flying hours, whereas the accident rate for single-engine (turbine) helicopters was 2 1/2 times greater at 9.95 accidents per 100,000 flying hours.

The demand for multi-engine helicopters is expected to increase significantly in the 1980's over that experienced in the previous decade. While flight safety is a motivating factor in many cases where a greater degree of redundancy/reliability is necessary, the growth in multi-engine helicopters is also expected to increase as new performance demands are placed upon helicopter operators which necessitate the greater "power availability" of multi-engine helicopters.

TABLE IV-3

CIVIL HELICOPTER ACCIDENTS AND FLYING HOURS

CALENDAR YEAR 1975

(SINGLE-ENGINE TURBINE v. MULTI-ENGINE TURBINE)

HELICOPTER CLASSIFICATION	FLIGHT HOURS	NUMBER OF ACCIDENTS	ACCIDENT RATE
Single-Engine (Turbine) Helicopters	693,285	69	9.95
Multi-Engine (Turbine) Helicopters	127,264	5	3.92
Total-Helicopter Turbine	820,549	74	9.02

d. Component Design, Reliability and Operation

Helicopter transmissions, shafts and other components of the power train have undergone constant refinement. Improved bearings, gears and seals which together with better surface treatment of splines and more effective lubrication systems combine to greatly reduce or eliminate in-flight failures of helicopter power train components.

Aerodynamic improvements resulting from recent rotor-system designs have improved helicopter autorotational performance and handling characteristics. While incorporation of these developments into production aircraft has enhanced safety in many ways, there has also been a recognizable advantage to aircraft performance, passenger comfort and reliability.

Crash resistant fuel systems are beginning to be introduced into the new generation helicopters. These systems protect the helicopter occupants and the surrounding area from a massive post crash fire.

e. Control of Maintenance, Training and Operations

While there has always been some control of helicopter maintenance, crew training and field operations by both management and the Federal Aviation Administration, the micro-computer has greatly assisted the helicopter operator in expanding and maintaining control in these areas. Currently a range of computer software is available to assist in monitoring and scheduling helicopter maintenance, managing pilot proficiency and standardization, and planning aircraft operations.

This use of computer technology allows management to more accurately plan and control helicopter operations with both a direct and indirect benefit to safety.

f. Instrument (IFR) Certification

The availability of IFR (Instrument Flight Rules) approved helicopters has enhanced flight safety considerably. Helicopter IRF certification has resulted in:

- The development of improved stability augmentation systems and autopilots. These systems reduce pilot workload and limit the potential for vertigo and orientation errors.
- Additional flight crew training and the obtaining of new pilot qualifications to operate IFR helicopters.
- The ability to file and fly IFR as an alternative to flying VFR (Visual Flight Rules) in instrument meteorological conditions.
- Greater utilization of FAA facilities and services (navigational aids, air traffic control services, weather reporting facilities, etc.) by helicopter crews during both IMC (Instrument Meteorological Conditions) and VMC (Visual Meteorological Conditions).

3. Local Government Planning Considerations for Helicopter Flight Safety

Although the safety record for civil helicopters has been advanced considerably during the last 10 years, the industry is seeking still greater accomplishments in the field of flight safety. While manufacturers, operators, pilots and maintenance personnel will strive to continue the trend of the 70's there is a growing and important role for "non-industry" professionals in fostering a safer environment for helicopter operations.

While many can help to improve the helicopter's operating environment, the professional planner is especially well trained and positioned to seriously assist in promoting a safer environment for helicopter operations, especially as the number of heliports (especially urban heliports) increases. During this decade, the routine use of helicopters in urbanized areas for medical evacuation, law enforcement, fire-rescue, news coverage and other public-oriented purposes will increase dramatically. It is expected that their use in urban public air transporation also will grow significantly.

The planner, by virtue of his/her position in the approval process of local government can insure that "planning consideration" is given early on to those factors affecting helicopter flight safety. City and regional planning considerations relating to helicopter safety should include:

a. Wires and Obstructions

Over 200 civil helicopter wire strike accidents were reported to the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB) between 1970-1979. A recent NASA sponsored study of civil helicopter wire strikes found that 208 helicopter wire strike accidents occurred over the ten year period 1970-1979, causing:

- 37 deaths and 52 serious injuries
- The destruction of 88 helicopters and substantial damage to an additional 120 helicopters at a cost of $11,108,000.

The city and regional planner can play an important role in reducing the magnitude of these accidents by carefully examining development plans, construction permits, zoning variances, and other land use applications to prevent the erection of wire and obstacles in the vicinity of helipads and known low-level corridors. Options available to the planner to mitigate potential helicopter wire strikes include re-location of the wire or obstruction, marking or illuminating the wire/obstruction, and notification of the proposed wire hazard/obstruction to FAA and local helicopter operators.

Practical and economic factors prohibit the marking of every wire and obstruction in the urban area, however, the planner can and should be critical of wires and unmarked obstructions proposed in the vicinity of known or potential heliports/helipads. As noted in Table IV-4 of the 208 helicopter wire strikes reported (1970-1979), 47 (23%) occurred during take-off, approach to landing, and landings. Many of these accidents could have been avoided by relocating the hazard during the design phase, marking the obstruction or giving notice to local operators.

TABLE IV-4

CIVIL HELICOPTER WIRE STRIKES

1970-1979

PHASE of FLIGHT	NUMBER OF ACCIDENTS (N=208)	% of TOTAL
Take-Off	22	11
Climb	10	5
Cruise	28	13
Low Pass	12	6
Approach to Landing	12	6
Hover	9	4
Approach to Swath Run	7	4
Swath Run	57	27
Pull-up from Swath Run	13	6

In-Flight Turn Around	17	8
Landing	13	6
Autorotation	8	4
	208	100%

b. Heliport Location and Layout

Although the heliocopter is an extremely maneuverable vehicle, the location and layout of the heliport/helipad should not escape detailed consideration by planners in sole reliance on the helicopter's inherent maneuverability. Safety factors to be considered by planners when reviewing heliport/helipad applications include:

- Obstructions to the navigable airspace serving the helipad/heliport
- Control of public access
- Location of approach and departure path
- Size of heliport/helipad vis-a-vis the type of aircraft expected to use the facility and the level of operations anticipated
- Alignment of arrival and departure tracks with prevailing winds
- Compatibility of surrounding land uses
- Availability of visual landing aids to include markings, lighting (if night operations are anticipated and wind direction indicators
- Availability of fire-fighting equipment and back-up resources
- Use of barriers or other planning techniques to prevent injury or damage from helicopter rotor-wash
- Proximity of other airports or heliports

c. Heliport Zoning

To protect both public and private investments in heliports and to concurrently further helicopter flight safety, zoning ordinances and/or land-use policy plans should be adopted for the heliport's environs. Heliport zoning objectives should focus on preventing noise sensitive encroachment on the heliport, regulating the erection of hazardous obstructions and controlling land uses which are likely to generate "foreign object damage" to helicopter rotors and engines or attract birds and gulls.

Figures VI-15 and IV-16 illustrate various bases for comparison of accidents as between helicopter operators, U. S. certified air carriers, and commuter air carriers. The data on helicopter operators were derived from a survey of eight Part 135 helicopter air taxi operators conducted by Bell Helicopter Textron covering the three year period January 1977 through December 1979. The data for the certified air carriers and commuter air carriers were derived from a special study conducted by the National Transportation Safety Board covering the same three year period. (The same data sources apply to Figure IV-14.)

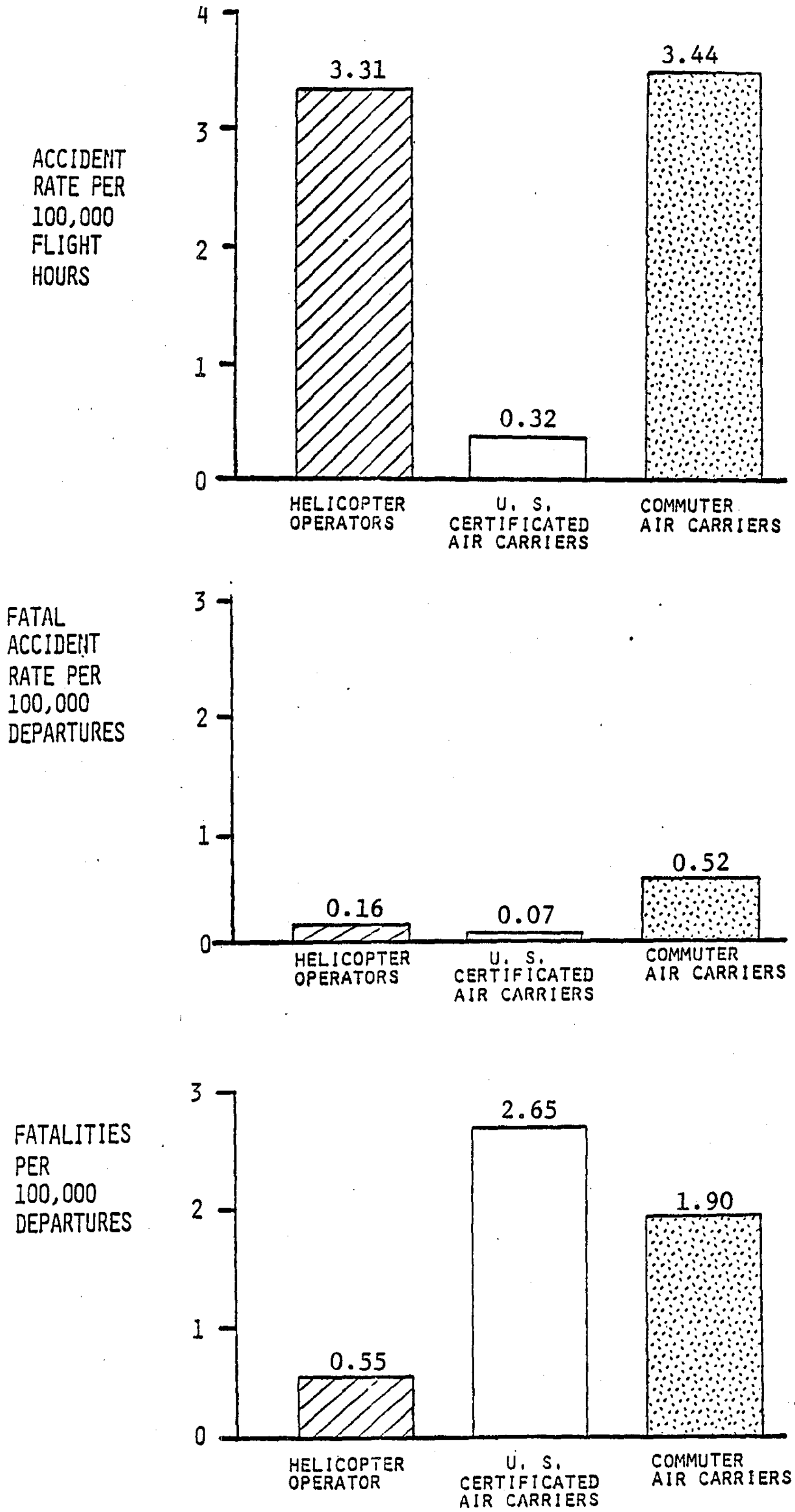


Figure IV-15. All Accidents

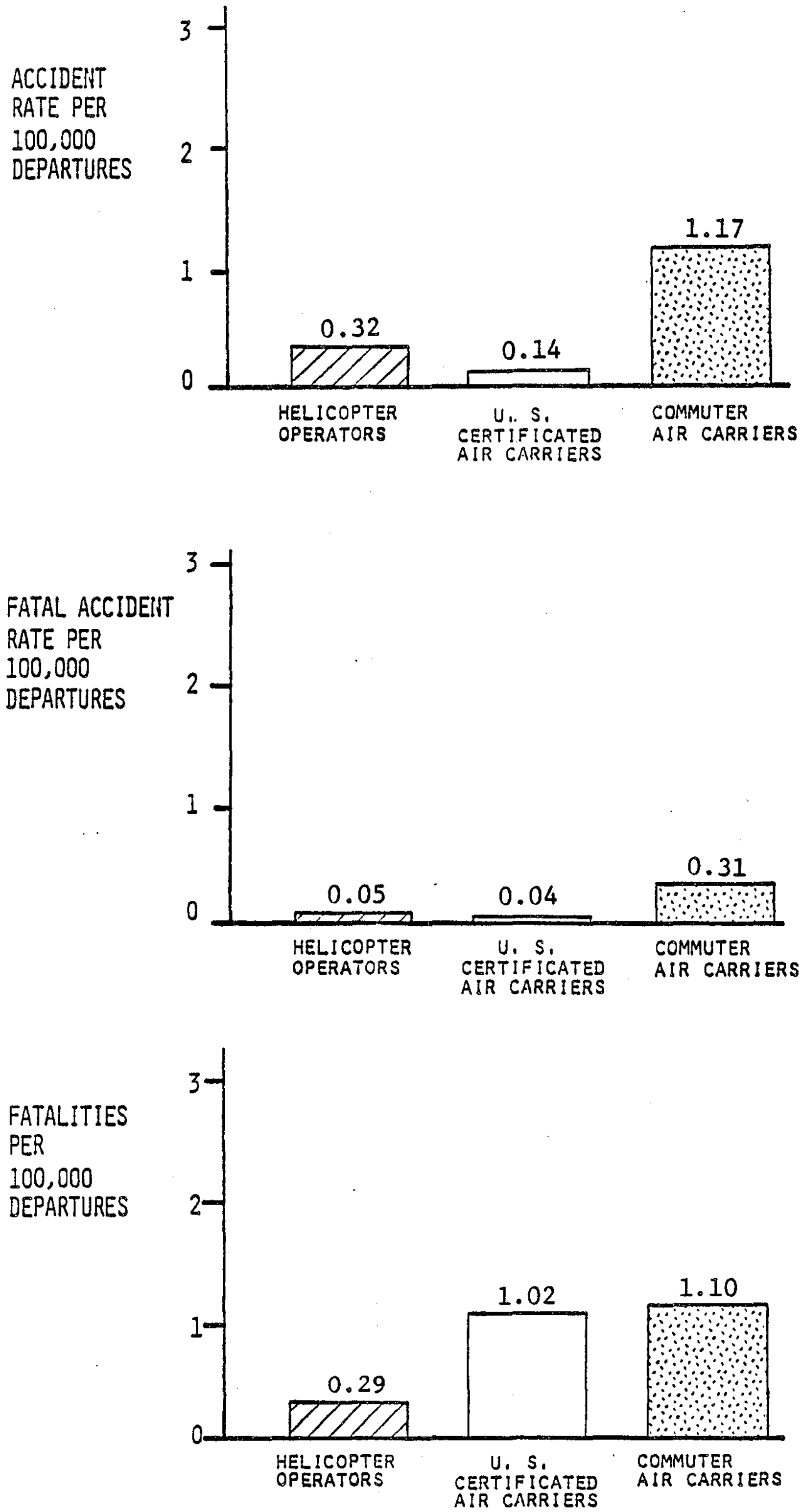


Figure IV-16. Pilot Error Accidents Only

V. HELICOPTER OPPORTUNITIES AND BENEFITS

A number of years ago, the initial uses of helicopters in civil applications resulted from the unique capability of the helicopter to do something that could not be done in any other way. The rescue of an injured person on a remote mountain and the evacuation of a critically ill patient from an oil rig are examples. Section III of this report (Unique Helicopter Capabilities) addresses the ranges of characteristics that give the helicopter special capabilities to perform new transportation tasks.

Later, the helicopter came to be used more and more for jobs that could be done better or with less expense than by other methods. Examples of this are the agricultural spraying of chemicals on a small or hilly field surrounded by high obstacles, and the routine movement of offshore oil rig crews from shore to the rig and back again.

Finally, the helicopter has reached the stage in its development where it is directly competing more and more with other forms of transportation on the basis of time savings, cost savings and convenience. A basic and underlying trend that has made this possible is the substantial technical improvements that have been made in helicopters over the past decade in the following areas:

- Fuel efficiency
- Speed
- All-weather capability
- Comfort (quieter, more room, less vibration)
- Exterior noise reduction
- Improved safety and reliability

However, the full potential of the helicopter cannot be realized until it has the availability of landing sites (mainly public use heliports) at the right locations. This means locations that are closer or more accessible to the passenger both at the point of departure and the destination. The fact remains that the direct line costs for specified distances are (and will continue to be) higher for helicopters than for other forms of transportation. However, with the proper selection of heliports, the actual distances from point of departure to destination and the time and cost of transit can be substantially less for the helicopter.

This section will present the range of helicopter applications in all operating environments that have been considered in this study. With that information as a start, the goal is to identify and assess the most promising opportunities for helicopters, and the benefit that can be derived from their use.

A. METHODOLOGY USED IN THE ANALYSIS OF OPPORTUNITIES AND BENEFITS

The approach that was taken in this analysis of benefits and opportunities involved the following steps:

- A review was made of the range of helicopter applications that could have an impact on community benefits. These were aggregated into ten categories. A list of both the categories and applications is shown on Table V-1.

- A preliminary assessment was then made of potential benefits that could accrue to individuals and to communities from the use of helicopters in the applications and environments listed. Figure V-1 shows the relationships of the applications, environments, and benefits as a three dimensional matrix.

The perspective gained from the above work made it possible to identify 24 scenarios that would be likely candidates to show important benefits to people or communities. These scenarios are listed on Table V-2.

Having identified a set of "promising" scenarios, criteria were then developed for assessing the helicopter and other vehicles in those scenarios. This was followed by the assessment process itself. (Note: A description of that assessment process is provided in Appendix A).

Upon completing the assessment of helicopter applications and scenarios, a review was made of all environments from the viewpoint of opportunities and benefits that could be derived. From a practical viewpoint, this was assisted by information gained from a study of literature in which authors had discussed helicopter opportunities and benefits.

The results of the methodology that has just been described are documented in the following two sections:

B. Analysis of Applications and Scenarios

C. Opportunities and Benefits.

In aggregating and discussing opportunities and benefits in Section C, it was decided to do so under the headings of the environments in which helicopters operate. Thus, benefits in an urban environment are assembled for all helicopters applications -- such as public transportation, public service, etc. In that way, a planner in an urban area (as an example) can see all of the benefits grouped together for that environment.

B. ANALYSIS OF APPLICATIONS AND SCENARIOS

This section will describe and illustrate the more important helicopter applications, and in selected cases, summarize the assessment scenario that was used.

1. Public Service Applications

a. Emergency Medical Service

(1) Background

The use of helicopters for medical evacuation began on a large scale during the Korean war and continued in the Viet Nam war. Many

TABLE V-1. HELICOPTER APPLICATIONS

1. PUBLIC SERVICE

   a. Law Enforcement
      - Drug
      - Security/Surveillance
      - Search
      - Patrol/Observation
      - Pursuit
      - Command Post/Crowd Control
      - Pollution Control
      - Transport (people)

   b. Public Safety
      - Ambulance
      - Fire Rescue/Fighting
      - Search (lost people)
      - Water Area Patrol
      - Traffic

   c. Disaster Warning/Relief/Rescue
      - Flood
      - Frost/Freeze/Snow
      - Large Scale Mountain Timber Fires
      - Shipwreck
      - Other: Hurricane, Tornado, Earthquake, Landslide, Avalanche, Drought, Volcano

   d. Search & Rescue
      - Mountain
      - Ocean
      - Aircraft Accidents

   e. Wildlife Management
      - Animals/Fish

   f. Environmental Surveys
      - Fish/Oil/Dams

   g. Environmental Transport
      - Poles/Wires/Pipe/Construction
      - Transport (people)

2. PUBLIC TRANSPORTATION

   a. Scheduled
      - Large
      - Medium/Small

   b. Non-scheduled
      - Large/Medium
      - Small (Air Taxi)

3. CORPORATE/EXECUTIVE TRANSPORTATION

   a. Part 91
      - People
      - Cargo/Mail

4. ENERGY EXPLORATION/PRODUCTION

   a. Offshore Support
   b. Pipeline Laying
   c. Powerline Laying
   d. Aerial Surveys

5. CONSTRUCTION

   a. Crane
   b. Cargo
   c. Wire Stringing
   d. Pole Laying

6. CARGO

   a. External Lift
   b. Internal Lift

7. AGRICULTURE/FORESTRY

   a. Spraying
   b. Seeding
   c. Logging
   d. Surveys

8. OTHER BUSINESS/COMMERCIAL

   a. Bank Record Transfer
   b. TV Reporting
   c. Photography
   d. Advertising
   e. Real Estate Evaluation
   f. Sight Seeing
   g. Mapping

9. FLIGHT TRAINING

10. PERSONAL USE

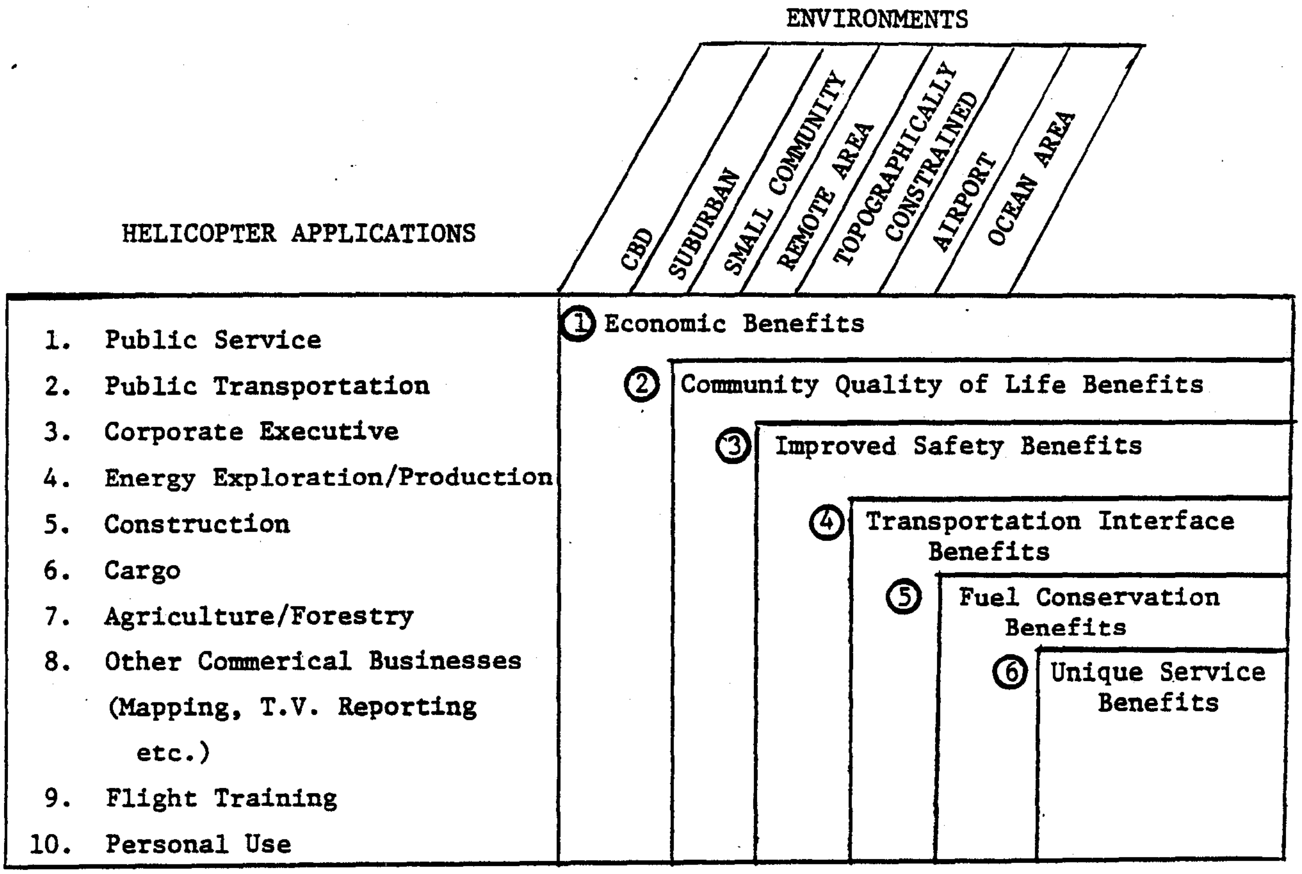

ENVIRONMENTS
CBD
SUBURBAN
SMALL COMMUNITY
REMOTE AREA
TOPOGRAPHICALLY CONSTRAINED
AIRPORT
OCEAN AREA
HELICOPTER APPLICATIONS
1. Public Service
2. Public Transportation
3. Corporate Executive
4. Energy Exploration/Production
5. Construction
6. Cargo
7. Agriculture/Forestry
8. Other Commerical Businesses (Mapping, T.V. Reporting etc.)
9. Flight Training
10. Personal Use
1 Economic Benefits
2 Community Quality of Life Benefits
3 Improved Safety Benefits
4 Transportation Interface Benefits
5 Fuel Conservation Benefits
6 Unique Service Benefits

Figure V-1

TABLE V-2. PROMISING HELICOPTER SCENARIOS

1. PUBLIC SERVICE

   a. Law Enforcement Search
   b. Public Safety: Ambulance
   c. Public Safety: Fire Rescue
   d. Disaster Aid: Flood
   e. Disaster Aid: Snow Storm
   f. Disaster Aid: Large Scale Mountain Timber Fire
   g. Search and Rescue: Mountain Area

2. PUBLIC TRANSPORTATION

   h. Large Helicopters - Scheduled: To and From CBD's
   i. Medium Helicopters - Scheduled: Intra CBD
   j. Medium Helicopters - Scheduled: To and From CBD's
   k. Medium Helicopters - Scheduled: To and From Airports
   l. Large Helicopters - Unscheduled: To and From CBD's
   m. Small Helicopters - Air Taxi: Topographically Constrained Area

3. CORPORATE/EXECUTIVE

   n. Medium Helicopters: To and From CBD's
   o. Medium Helicopters: To and From Suburbs
   p. Medium Helicopters: To and From Airports

4. ENERGY EXPLORATION/PRODUCTION

   q. Offshore Oil Rig Support
   r. Powerline Laying: Remote Area

5. CONSTRUCTION

   s. Crane: Intra CBD
   t. Pole Laying: Suburbs

6. CARGO

   u. External Lift: Ocean Area

7. AGRICULTURE/FORESTRY

   v. Grain Spraying: Rural Area
   w. Logging: Remote Area

8. OTHER BUSINESS/COMMERCIAL

   x. TV Reporting: Intra CBD
   y. Photography: Small Community

9. FLIGHT TRAINING

10. PERSONAL USE

thousands of lives were saved by getting patients under hospital care within minutes instead of hours. Because of helicopters, the time before surgery was reduced from nine hours in World War II to about one hour in Vietnam with a 5 to 1 reduction in fatalities.

Today, over 350 U.S. hospitals are equipped with helipads for receiving helicopters used in emergency medical services. Such helicopters pick up patients at accident sites and other locations for rapid evacuation to an appropriate hospital. The ability of the helicopter to avoid traffic congestion and terrain problems, while providing a very smooth ride, makes it an ideal ambulance. The capability to greatly reduce transit times makes it possible for hospitals to specialize in such fields as cardiology, burns, trauma, etc., as the various hospitals within a region may then be only minutes apart and the patient can safely be transported to the hospital equipped for the most appropriate specialized care.

It has been estimated that trauma kills 115,000 people per year, with associated costs to society of $41.5 billion annually. Helicopter technology can reduce response time by as much as 80% and reduce mortality by 50%.

As a means of further exploring new requirements and new helicopter designs in the field of emergency medical service (EMS), several symposiums have addressed these questions in the recent past. In October 1981, NASA conducted an EMS seminar in Washington, D.C. In July 1980, another NASA sponsored seminar was conducted on the range of public service applications of helicopters including EMS. Finally, an Advanced Technology Workshop, jointly sponsored by NASA and the Helicopter Association International (HAI) was held in Palo Alto, California in December 1980.

(2) Scenario: Helicopter Ambulance

A city hospital with ambulance service is 15 miles from a serious car accident. The accident is 30 miles from the desired location to take the accident victims -- a shock trauma unit.

The criteria considered important in this scenario were:

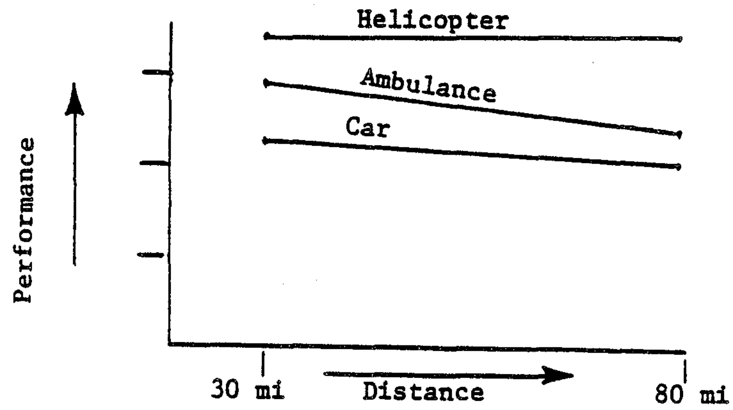
- Response time to scene of accident
- Transit time to trauma unit
- Life support capability in vehicle
- Service reliability of vehicle
- Cost

The alternative forms of transportation considered were:

- Ambulance
- Helicopter ambulance
- Car at scene of accident

A variation in the scenario was made that placed the trauma unit 80 miles from the scene of the accident.

The measure of performance of these alternatives is reflected in the chart below.



In general, the analysis of this scenario indicated the following:

- The helicopter is the highest cost option. However, the total time to the accident scene and then to the shock trauma unit is substantially faster. Also, the helicopter has the capability to carry full life support equipment. As the distance to the shock trauma unit increases, the time advantage of the helicopter also increases.

- The ambulance has, of course, an excellent capability but is not as fast as the helicopter. The costs, however, are substantially lower. At closer distances than those considered in the scenario, the ambulance would steadily increase in comparative performance.

- The car at the scene has a good response time (better than the ambulance) but has the major deficiency of not having a life support capability. The car may get to the shock trauma unit quickly but with a dead patient.

- A cost/benefit analysis of the accident history in any city and its structure of hospitals and ambulances would determine whether a helicopter ambulance service would be cost effective.

b. Fire Fighting

(1) Background

The U.S. Forest Service uses helicopters to fight forest fires. Besides flying in personnel and equipment, helicopters can fight spot fires by dropping water or fire suppressant directly on the blaze. Controlled backfires can be started by dropping flaming globs of petroleum jelly.

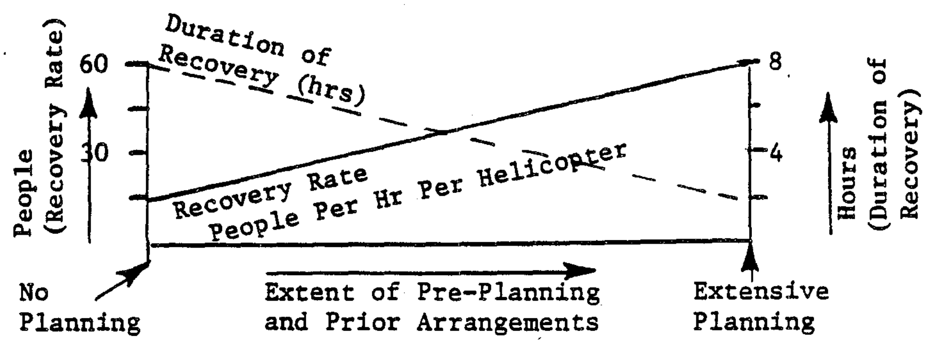
City fire ladders can typically extend only up to five to seven floors. In high-rise building fires, helicopters may provide the only escape route for victims above this level. Helicopters have saved hundreds of lives in recent high-rise building fires, by landing on the roof and ferrying victims to safety. In the recent MGM Grand Hotel fire in Las Vegas, helicopters also used winches to rescue victims from balconies.

(2) Scenario: Hotel Fire Rescue

A major fire takes place on the 10th floor of a 20 story hotel. Those people above the fire cannot escape to the ground and are above the height where they can be rescued by fire truck and ladder. Almost all of these people (about 400) can get to the roof of the hotel.

In the basic scenario, two six-place helicopters are available and arrangements had been pre-planned for their use in this type of circumstances. A helicopter landing site on the roof had also been pre-planned and is available. In a variant of the scenario, there is not a landing site available and preplanning had not been accomplished to use the helicopters. It was necessary for the helicopters to rescue the people by chair and hoist.

The relative performance in these alternatives is shown on the chart below.



There is no comparison with other vehicles because the helicopter is the only vehicle that can perform this task.

The estimates of recovery rates with and without the availability of a heliport is based on the judgment of people who have had experience in this type of operation. It also assumes that a recovery area is within a few minutes flight time from the hotel.

The assumed availability of helicopters for the condition of no pre-planning is one that could obviously vary considerably.

c. Law Enforcement

(1) Background

The use of the helicopters as aerial police patrol cars is particularly advantageous in patrolling wide areas with a small force. The ability of the helicopter to follow fugitives and speeding cars and to coordinate their observations with ground units via radio is an effective crime fighting combination. The fitting of police helicopters with powerful searchlights can be a strong deterrent to criminal activity.

The most sophisticated police helicopter produced so far is a Bell 222 which was delivered recently to the London Police Department. It is equipped with a Heli-Tele camera system which can be directed by the observer; color T.V. pictures can be transmitted either to the Scotland Yard operations room or to a mobile relay station parked in a strategic location. A powerful zoom lens can show details as precise as an auto license number.

A Decca Navigation System provides guidance to steer a direct course to any desired location; instrumentation provides continous information on heading, distance, and time to the selected destination.

Other equipment includes a rescue hoist, public address system, cargo hook, litters, Nightsun floodlight and stabilized binoculars. A complete radio communications systems permits direct coordination with patrol cars or walkie-talkies.

Other equipment such as an infrared camera can be fitted to the helicopter on short notice. This camera can detect a person hiding in underbrush or under camouflage; it can also detect a buried body.

(2) Scenario: Law Enforcement Search

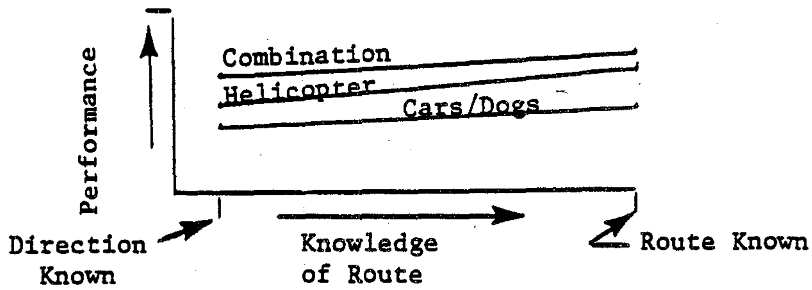
The Canadians have been very successful in combining the versatility of the helicopter with a detection device that was developed in the military but recently has been used more and more for civil uses. This is the forward looking infrared (FLIR) device that can distinguish a human from the surrounding terrain, day or night. This scenario is dependent upon that capability.

A fugitive has escaped from a city prison during the evening hours into the surrounding countryside. In the basic scenario the route of escape is known; in a variant, the route is not known. The criteria considered important in the best method of catching the fugitive are: probability of detection, probability of apprehension, ability to evacuate, and cost.

The alternative forms of transportation considered were:

- Helicopter (in daytime or at night with FLIR or searchlight)
- Police cars and dogs
- Combination of the above

The measure of performance of these alternatives is shown on the chart below.



d. National Disasters

(1) Background

National disasters do not occur frequently, but when they do they can have as important impact on society. They differ from the more normal helicopter rescue operations in the scale of the rescue effort that is required. There are about a dozen generally recognized disasters that can occur in the United States (i.e., flood, freeze, snow, fire, shipwreck, hurricane, tornado, earthquake, lanslide, avalance, drought, and volcano). Also, it has often been said that if a disaster can occur, eventually it will occur.

In most of these disasters the success of rescue and relief efforts is directly related to the extent of pre-planning that has been performed in anticipation of the disaster.

One major impediment to rescue efforts in the past has been the inability to move supplies and rescue teams to the site -- and the inability to evacuate people from locations where they cannot be reached by normal transportation means. The helicopter offers a great potential to improve relief and rescue in these circumstances.

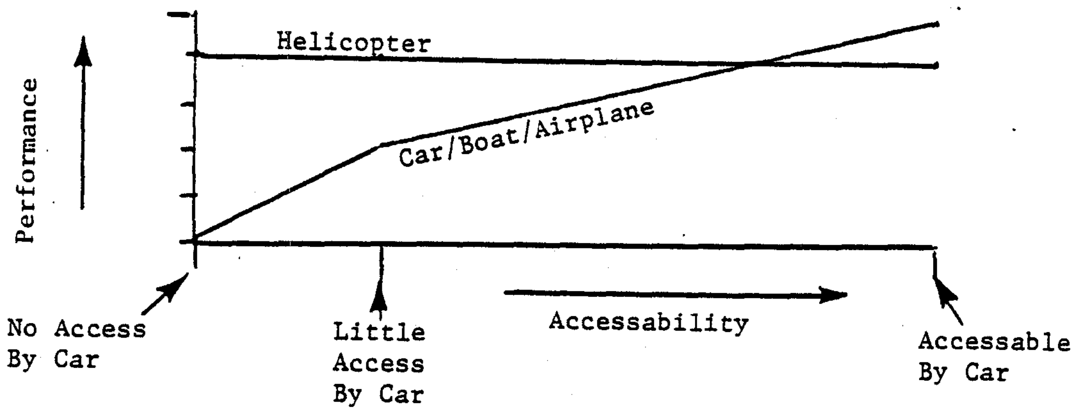
(2) Scenario: Flood Rescue

In this scenario a major flood disaster occurs over a sizeable area affecting several towns and small communities. It is not accessable for several days by normal transportation methods. There are many injured people and emergency medical supplies and emergency evacuation is needed. In a variant of the scenario some access to the scene is possible by ground vehicles and boats. Another major factor (although not treated in the scenario) is the extent to which pre-planning was done for this disaster and arrangements made for the availability of helicopters.

The alternative solutions considered were:

- Helicopter rescue and support
- Normal combination of ground vehicles, boats and airplanes

The performance attained in these alternatives is shown on the chart below.



The criteria for this scenario are considered to be valid. However, there is no set of data available to indicate the degree of accessibility that would exist in future flood situations.

It does appear, however, that there may be a wide range of flood situations in which helicopters could make a contribution in relief and rescue operations.

As in most cases of disasters or survival situations, the effectiveness of relief operations appear to be directly related to the degree to which contingency plans have been made for such an emergency.

(3) <u>Scenario: Large Scale Timber Fire in Mountainous Areas</u>

During the dry season, a fire takes place under windy conditions and affects large areas of two mountainous western states. The two variation in this scenario assume in one case that virtually no planning for a fire disaster of this magnitude had been accomplished; and in the other that extensive planning had been performed.

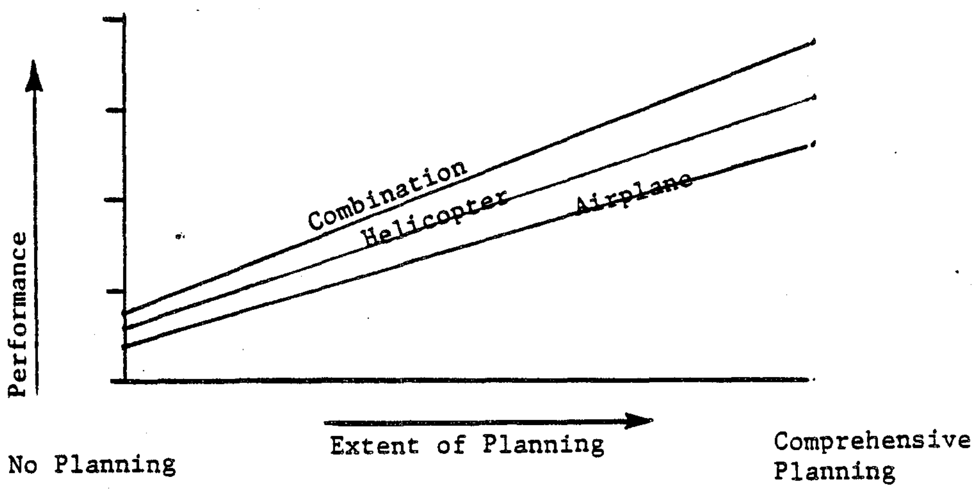
The criteria considered important were:

- Ability to identify large scale problems
- Ability to identify local problems
- Ability to evacuate emergency cases
- Ability to supply tools, equipment and medicines
- Ability to drop water and chemicals
- Ability to perform post-fire clean up

The transportation alternatives considered were:

- Helicopter
- Airplane
- Combination of helicopter and airplane

The performance attained through these alternatives is shown on the chart below.



This is another instance of a disaster in which the helicopter and the airplane, working together in providing relief, can do a better job than either vehicle separately.

The helicopter, because of its ability to fly low and slow, is better able to identify local problems and to supply tools and equipment. Also, it is the only vehicle that can land at unprepared small sites to evacuate people. In the post flight clean-up, it also has a unique capability. Smoldering fires can easily re-ignite and they are one of the main concerns after a major series of fires has been extinguished. The helicopter, by using forward looking infra-red (FLIR) sensors, can detect the latent smoldering fires and then take the necessary action to see that they are thoroughly extinguished.

The airplane is better in sizing up the large scale situation of a major fire because it can fly faster and higher. It also has a greater capacity to carry water and chemicals.

While no good measures are available for making a good assessment of capabilities to handle such a disaster if no prior planning had been performed, it seems obvious that the capability would be far less -- and almost reaching no capability in some circumstances. In scenario 2, an arbitrary value of a 20% capability was used.

e. Search and Rescue

The U. S. Coast Guard uses helicopters in combination with fixed wing aircraft and surface vessels, for search and rescue operations. The utility of the helicopter in this role has been greatly enhanced by the development of twin-turbine power. The effective range of helicopters has been increased by the installation of helipads on the surface vessels (Coast Guard cutters).

Where the initial search area is very large or very far offshore, fixed wing aircraft are used because of their greater speed and range. It is interesting to note that in Denmark, which has a relatively small area of ASR responsibility, helicopters have completely supplanted fixed wing aircraft for ASR missions.

Modern navigation equipment such as Loran-C enables aircraft and surface vessels to coordinate their actions precisely. When the navigation equipment is coupled to the autopilot, the aircraft can fly complex search patterns automatically, giving the pilots more time to concentrate on the actual visual search. The use of airborne radar greatly increases the effective range for detection of objects such as small boats or liferafts on the surface. This is especially valuable in low visibility or in night ASR operations. Once the survivors are located, the helicopter's unique ability to hover enables it to winch up the survivors to safety.

In September 1966, five Danish helicopters rescued all the passengers and crew from a sinking ferry off the north coast of Denmark. In October 1980, U.S. Coast Guard helicopters rescued 500 passengers and crew from the floundering cruise ship Prinsendam, in the Gulf of Alaska.

f. Wildlife Management

Helicopters are used for hunting predators such as coyotes. The National Park Service also uses helicopters for moving wild animals out of areas where their presence is objectionable, to remote or environmentally more desirable areas. Large animals are tranquilized first, and put in a cage or heavy net which is picked up and carried by the helicopter as an external load, then lowered gently to the ground at the destination. Burros have been moved out of the Grand Canyon; bears and beavers have been relocated to remote areas, using this method.

Helicopters are used for wildlife counts, where their ability to survey large areas of rough terrain in a short time, and to slow down and hover as necessary, make them ideal for the purpose. Using infrared surveillance, it is possible to count deer, even in dense underbrush.

Trout streams are restocked via helicopter using a dumpable tank which is attached to the bottom of the fuselage. The tank is filled with water and hundreds of fingerlings (young trout) at the fish hatchery. The tank installation is designed so that oxygen can be bubbled through it continuously in flight. Over the destination lake or stream, the helicopter is hovered 5 to 10 feet over the water surface and the tank is dumped.

The use of helicopters instead of fixed-wing aircraft for this purpose has resulted in less injury to the fish and has made it possible to stock very narrow mountain streams as the fish can be discharged very accurately so they will all end up in the water.

2. Public Transportation Applications

a. Airline Passenger Service

(1) Background

In 1980, New York Helicopter started scheduled passenger service between Newark , LaGuardia, and Kennedy Airports; and between Newark, LaGuardia and Manhattan (34th St. Heliport). The four nodes of this network are presently connected by 15 to 24 daily schedules in each direction on weekdays, and 8 to 14 daily schedules in each direction on weekends. Nine-passenger turbine-powered Dauphin helicopters are used. The longest scheduled leg (Newark to Kennedy) is 13 minutes; the shortest (34th St. to LaGuardia) is 6 minutes. Helicopters use the United Airlines terminal at Newark, the American Airlines terminal at LaGuardia and the TWA terminal at Kennedy.

Approximately 12 other scheduled passenger operations of this type are considered to be close to implementation within one or two years.

(2) Scenario: Scheduled Public Transportation Between CBD's (Using Medical Helicopter)

This scenario considers public transporation services between two CBD's that are 100 miles apart. The class of users considered for this service is upper and middle level business supervisors and managers. The airport at each CBD is 25 miles away, a public service heliport is located in the center of each CBD. Nonrush hours are assumed for the assessment.

The transporation options considered were:

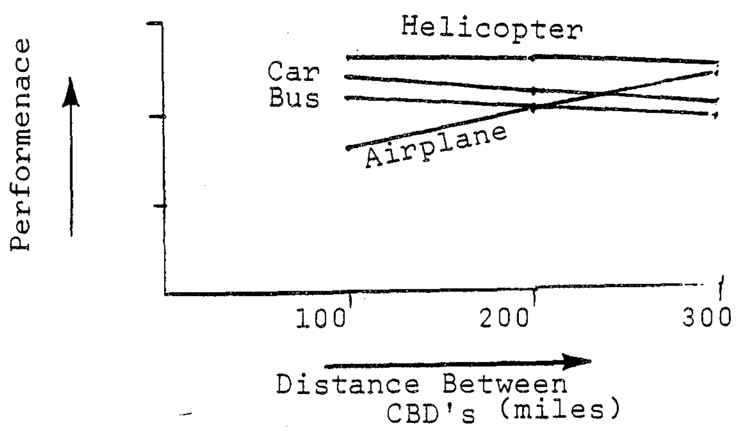
- Scheduled helicopter (4 flights per day available)
- Rental car
- Scheduled bus (6 trips per day)
- Scheduled air commuter and taxi (4 flights per day)

The assessment criteria considered important for this scenario are:

- Time efficiency
- Schedule convenience
- Service reliability
- Comfort (spaciousness)
- Annoyances (noise, traffic congestion, etc)
- Costs

Two variations of the scenario were assessed, i.e.: one with the distance between CBS's increased to 200 miles, the other with the distance increased to 300 miles.

A graph of the performance ratings of the four vehicles for the three scenarios is shown below:



b. Air Taxi

Helicopters provide important time savings for trips to and from urban areas particularly in areas where ground traffic is heavy or surface routes are devious, indirect, or blocked by shore lines. Such savings are even greater where urban heliports are available near the intended origin or destination. Many cities in the U. S. have helicopter air taxi service.

3. Private Flying Applications

The two primary applications in this category are corporate flying and off-shore oil support flying that is conducted by the oil company that is obtaining the support. The primary characteristic is that the transportation is used to fly personnel who are employees of the company operating the helicopters. The helicopters, however, are for transportation and not directly used in the primary function of the company (such as oil production).

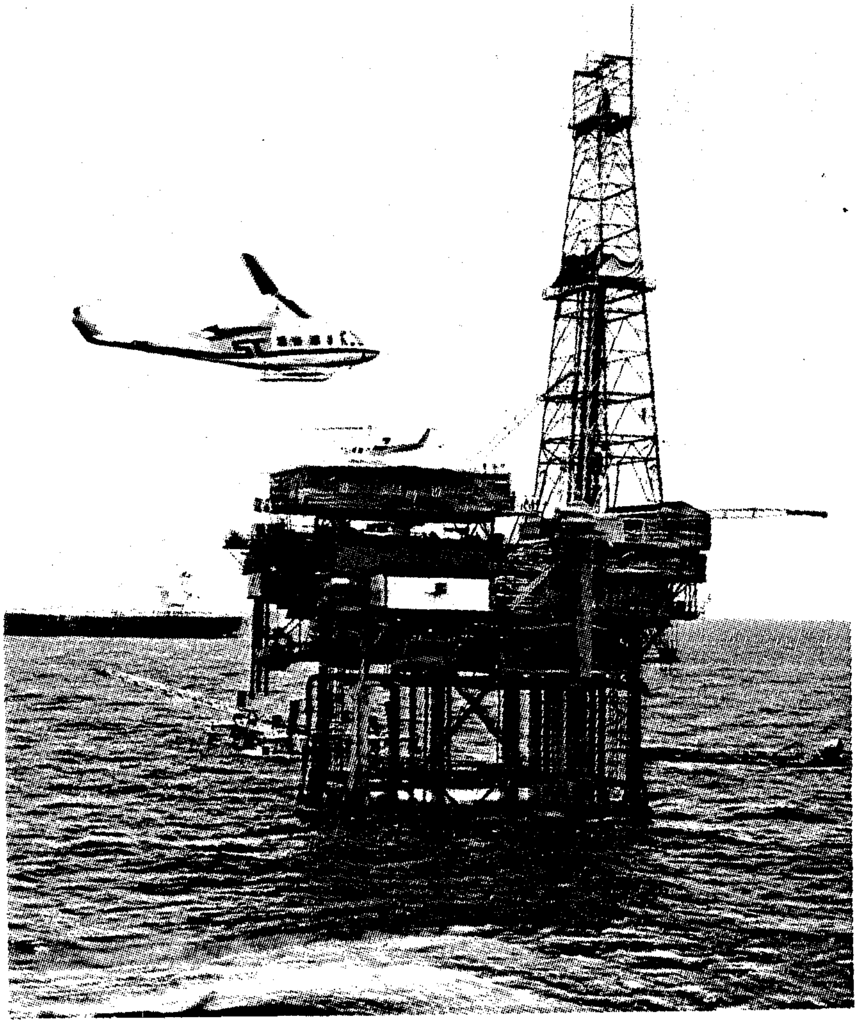
a. Corporate Transport

Time is money and the hourly cost of travel is very high where corporate executives are concerned. Thus many corporations particularly those which have a number of branches or offices scattered geographically over a large area, use their own helicopters for executive trips up to about 300 miles. The appointments and sound-levels of modern helicopters will permit executive conferences in flight. The high speed of helicopters in comparison to ground transport not only provides the ability for executives to stay personally in touch with more outlying company activities, but enables conferences with branch personnel to be scheduled with much less advance notice. The net result is increased executive productivity.

b. Offshore Oil Production Support

(1) Background

About 500 helicopters are now engaged in oil support operations in a 60,000 square mile area of the Gulf of Mexico. Over 1200 offshore platforms are equipped with helipads. Helicopters handle nearly all the crew changes for the 26,000 offshore personnel. Many of the platforms are between 50 and 125 miles offshore. The use of helicopters rather than boats provides a large savings in travel time, as the helicopters are up to 10 times as fast. Because the offshore workers are paid for travel time, the savings in travel time translates into an economic savings for the employers. In addition, workers arrive at their destination fresh and ready to go to work, rather than tired and possibly seasick.



Helicopter operations are not affected by high waves which can make personnel transfers between boat and platform difficult or even impossible. This is a morale booster for offshore workers, who know that if they are injured on the job, a helicopter can arrive within minutes, for a quick trip to a hospital on shore.

Helicopters also transport supplies and equipment to the offshore platforms. Down time is very expensive for a production platform which represents an investment of over twenty million dollars. If a breakdown occurs, helicopters can fly in emergency repair parts and personnel to get the unit back in operation as quickly as possible.

The largest U.S. helicopter operator is PHI (Petroleum Helicopters Inc.). They have been in business since February 1949 and have been flying offshore since 1950. Their fleet is comprised of 400 helicopters of 16 different types. PHI bases extend around the Gulf of Mexico from Corpus Christi, Texas to Bradenton, Florida. They also fly out of Hyannisport, Massachusetts to support drilling operations off the Georgian Banks in the North Atlantic. Their longest route extends 153 nautical miles (175 statute miles) offshore out of Hyannisport. PHI also operates Helicopters in Egypt, Trinidad, and Brazil. Their helicopter fleet now flies 1000 hours per day carrying 165,000 passengers per month. The total flying time of PHI's 32-year history is now approaching 4 million hours.

A typical PHI customer is Tenneco Oil. Tenneco has been operating in the Gulf of Mexico offshore area for 17 years. One of their platforms is 130 miles offshore, and has a working crew of 36 men. To change crews using a crew boat takes 32 hours and costs $22,000. Using an 18-passenger Puma helicopter, the crew change is completed in 4 hours and costs $5500. The crew boats are now used mostly for cargo and resupply operations. 90% of the crew changes are now handled by helicopter. Tenneco now has 25 helicopters under contract for offshore transportation. These helicopters are owned and operated by PHI.

(2) Scenario: Offshore Oil Rig Support

This scenario has two sets of options. One involves a normal crew change of an oil rig with the rig being 100 miles offshore in one case and 200 miles offshore in the second case. The other option involves two situations with an oil rig that is 100 miles offshore. In one case the flying weather is good and the sea state is smooth. In the second case, the flying weather is bad (i.e.,IFR) and the sea state is high. Also, in the second option, the purpose of the transportation is to evacuate an injured worker from the rig -- and time is critical.

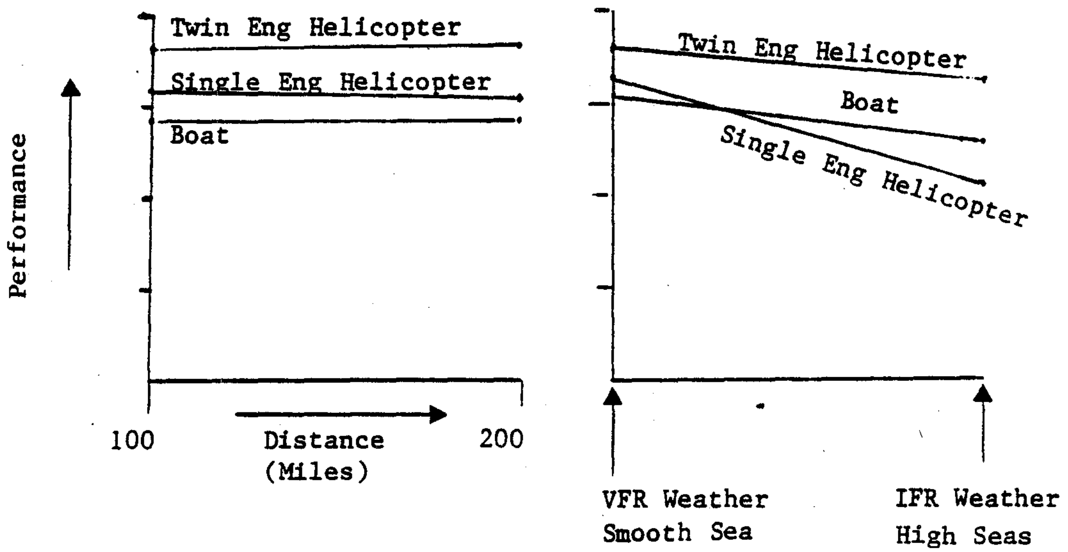
The vehicle options in this scenario are:

- Twin Engine IFR Certified Helicopter
- Single Engine VFR Certified Helicopter
- Boat

The criteria that were considered important were:

- Safety
- Reliability
- Speed
- Capacity
- Comfort
- Cost

The performance of the various vehicle choices under the various scenario options is shown on the charts below:



In the crew change situation, the helicopter rates substantially higher than the boat in speed and in schedule reliability. In most criteria, the twin engine helicopter is somewhat superior to the single engine helicopter.

In the case of the emergency evacuation during good weather and bad weather, the twin engine helicopter is a moderately better choice than either the single engine helicopter of the boat in good weather conditions. However, in bad weather, the twin engine IFR helicopter is a substantially better choice than either of the other vehicles.

4. Tool of Production Applications

The term "Tool of Production" refers to commercial business ventures where the helicopter is directly used for the primary works of the company or enterprise.

a. Agriculture

(1) Background

Helicopters have long been used for dusting, spraying, and seeding operations. Their chief competition has been the fixed-wing airplane. However, when operating in confined or contoured areas, the high maneuverability of the helicopter makes it superior to the airplane in providing better control of the delivery process. The latter is very important from the environmental standpoint in seeing that the material remains inside the desired application boundaries. While only 10% of the agricultural spraying fleet consists of helicopters, the acreage sprayed is about 20% of the total. This reflects the higher productivity of the helicopter.

In tall crops such as corn and fruit trees, the extremely strong downwash and vortex flow from a helicopter provides better penetration of the applied material through the leaves, than may be possible with fixed-wing agricultural applicators.

Because of the ability of the helicopter to take off and land vertically, the nurse trucks (tankers) can be brought to the fields being sprayed. To minimize loading and reloading time, the helicopter can be landed atop a special platform on the nurse truck. As soon as the loading operation is complete, the helicopter lifts off the truck and resumes spraying. This contrasts with the fact that an agricultural airplane may have to use an airstrip several miles away from the job site for loading. Besides the increased productivity due to the elimination of ferrying operations, having the loading done at the job site enables the farm owner to keep closer control over the entire operation.

The extreme maneuverability of the helicopter provides several other advantages over the use of an airplane for aerial application. Less time is lost in turns so the helicopter can start the next swath immediately. Also, the fact that less distance is required for turns keeps the neighborhood noise level down; an airplane makes a much wider turn before it can get back to start the next swath.

Besides the dusting and spraying of insecticides, herbicides, defoliants and fertilizer, helicopters are used for such other agricultural applications as white-washing nut trees to prevent damage from sunburn, and hovering over apple trees to shake down the apples. In western ranges, helicopters are used for herding livestock; in this application, the helicopter can do the work of 15 cowboys. Helicopters are also very effective in covering large areas in searching for lost livestock.

In Florida, on clear winter nights, helicopters are sometimes hovered over citrus groves to dry off the moisture from the growing fruit and thus prevent frost damage. Under such conditions, if a temperature inversion exists, the helicopter wake can draw down warmer air from higher levels to help inhibit frost.

An interesting agricultural operation is "double-cropping" in which a field of grain is reseeded by helicopter, several weeks before harvest. The air-reseeding operation takes place without damage to the growing grain. (It is estimated that a tractor would trample at least 5% of the crop if the reseeding were done from the ground). The reseeding is done at a time which allows the new plants to grow to a height just below the height at which the old plants will be cut for harvesting. Thus , the second crop will not be destroyed when the first crop is harvested. The staggering operation gives the second crop a head start of several weeks and thus allows two crops to be produced from the same field during a single season.

In conditions where fields are flooded or muddy, the ability to seed or spray fields from the air means the difference between doing the job and not doing it, as heavy farming equipment may bog down, or at least compact the soil and create ruts where water will collect. Where the soil is thus compacted, it sometimes requires three years to recover to where it will be productive again.

(2) Scenario: Agricultural Spraying

This scenario has the following three alternatives:

- A 40 acre grain field is to be sprayed. It is surrounded by trees. A helicopter nurse truck can be driven to the site. The airplane landing site with support facilities is five miles away.

- A 300 acre flat grain field is to be sprayed. It is surrounded by trees. The helicopter nurse truck can be driven to the site. The fixed-wing landing strip with support facilities is five miles away.

- A 100 acre grain field in rolling terrain is to be sprayed. The helicopter nurse truck can be drive to the site. The fixed-wing landing strip with support facilities is five miles away.

In all of these alternatives the choice of vehicles is between the helicopter and a fixed-wing spray aircraft. The use of group spraying equipment is ruled out because of soft ground and the probable loss of a substantial portion of the crop due to trampling.

The criteria considered important are the following:

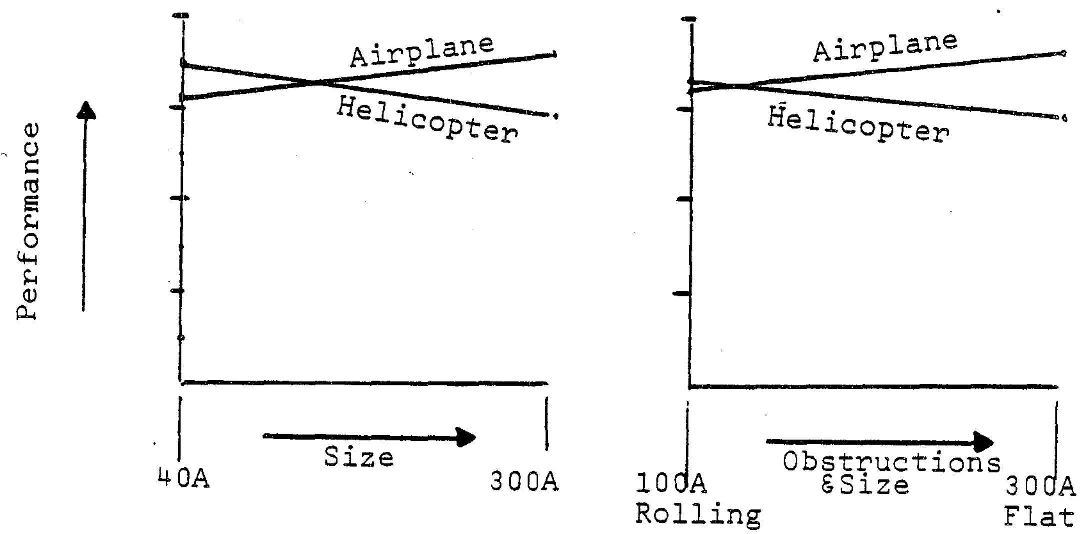
- Productivity per hour. This is dependent upon the nature of the field but is influenced, from the standpoint of the vehicle by its maneuverability, speed and capacity. The ability of the helicopter to fly low and slow is very effective in the accuracy of application and the penetration of application. This is most important in small fields or fields that have rolling terrain or high obstructions around the perimeter.

- Application hours required. This is essentially dependent upon the speed of the aircraft and its load carrying capacity.

- Support hours required. The helicopter which can land and be supplied from a nurse truck has a great advantage on this criteria.

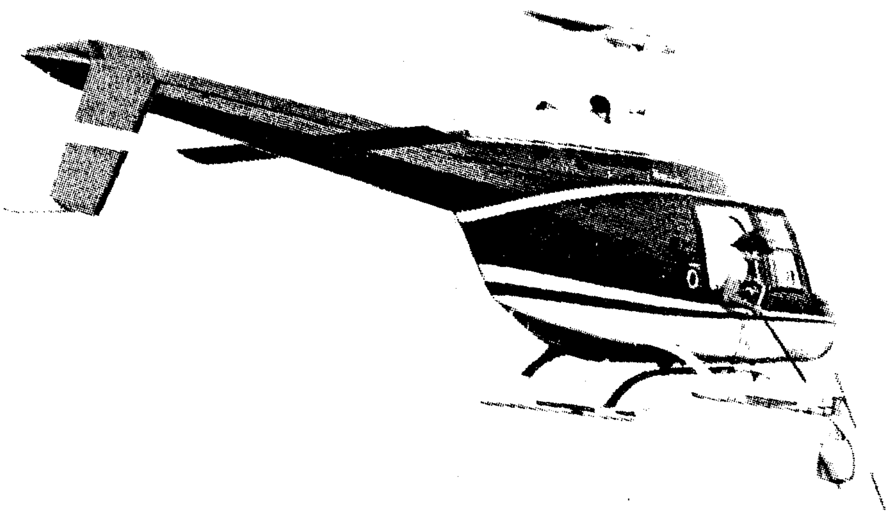
- Cost per hour. The helicopter direct costs are about one third higher than the airplane.

The charts below reflect the influence of these variations:



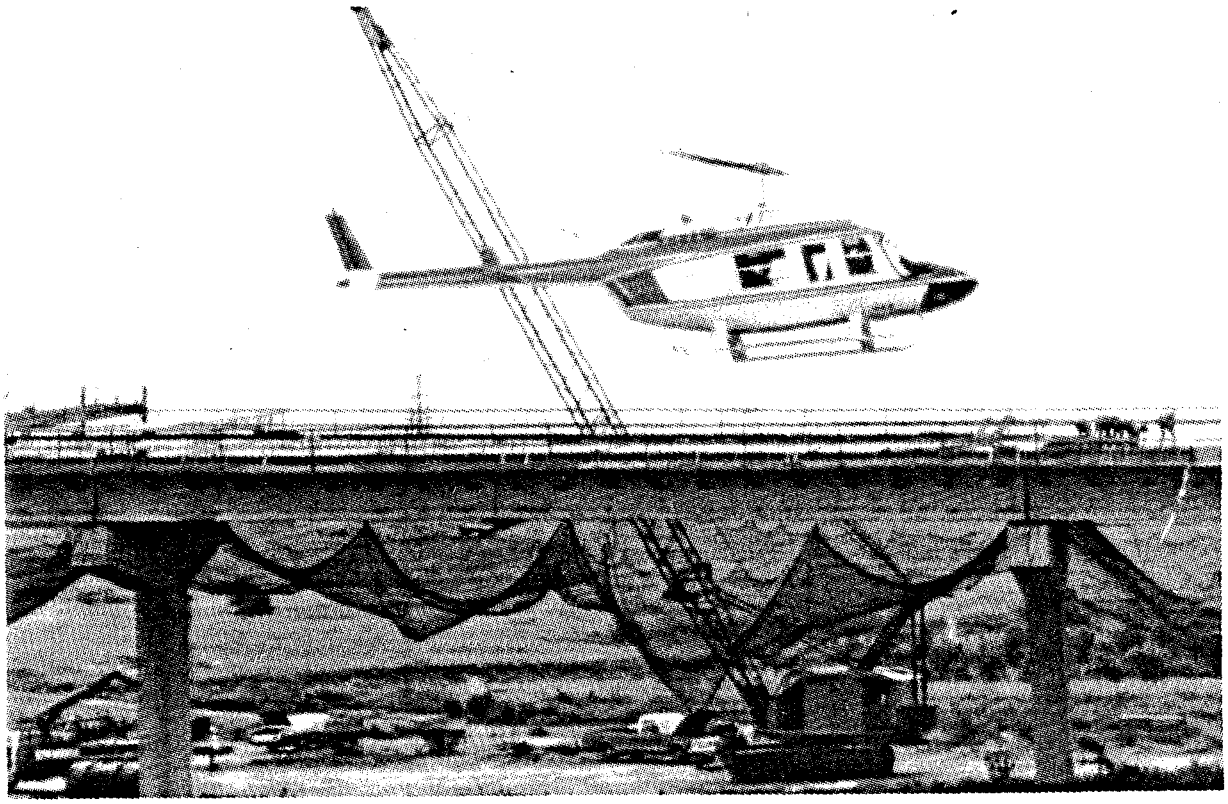
b. <u>Banking</u>

For years, certain banking chains have used helicopters for courier service and for the daily collection and delivery of business paper (checks, etc.). In such cases, the helicopter often does not land but hovers low over the roof for the pickup. With present interest rates, the use of a helicopter for delivering large checks is profitable as the money can sometimes be kept invested for an extra day or so and not paid out until the final due date. Banks with large geographical coverage often use helicopters for real estate inspection and site location. The ability of the helicopter to fly slowly if desired makes it an ideal platform for photographing real estate sites.



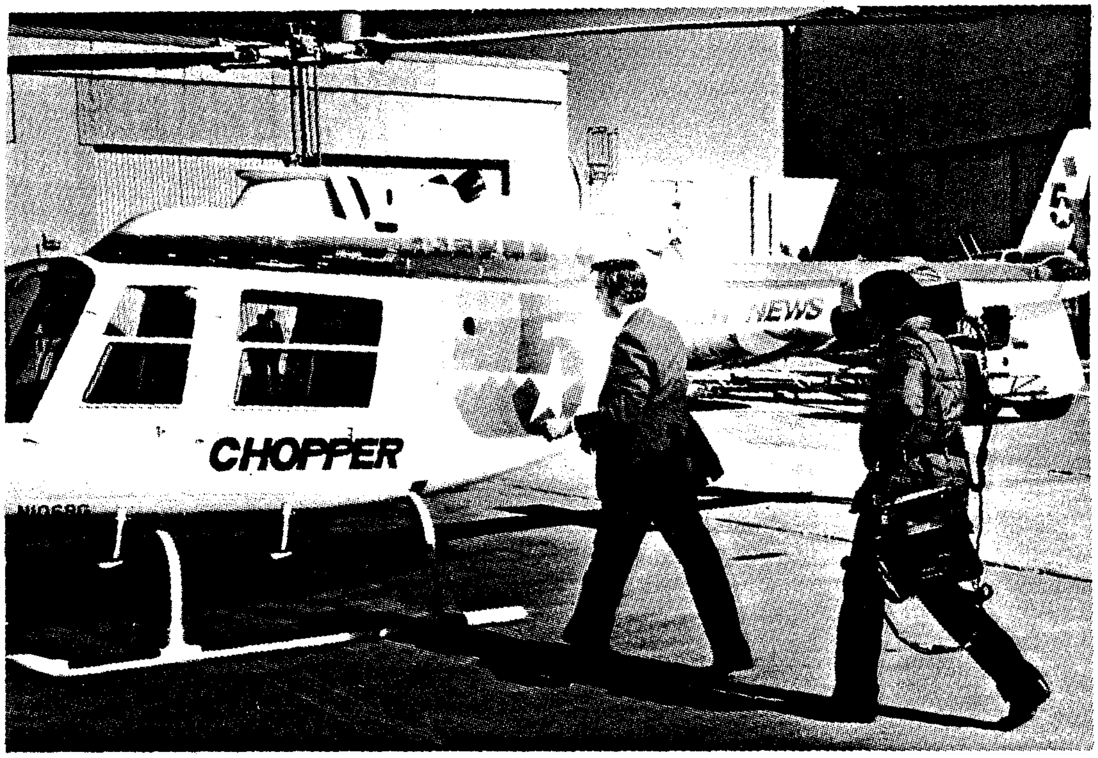
c. Construction

The construction industry uses helicopters for site surveys, photography, and corporate transportation. However, the ability of the helicopter to lift and carry large external loads either from a sling or a winch, provides the most important advantage in that the helicopter can do lift jobs that are impossible with a crane, such as lifitng a large air conditioning unit to the center of a large roof, where no crane could reach. The helicopter can save time in running new fences, utility lines, raising and positioning poles, towers, and other structures, or laying large pipelines across areas where no roads exist.



d. Electronic News Gathering (ENG)

Helicopters have long been used for still and movie photography where their ability to fly slowly is an advantage. A recent but fast-growing activity is the combination of helicopter and video camera, television coverage of news stories. The further addition of a microwave transmitter to this combination makes it possible to provide live coverage of the event without waiting for the helicopter to land. This capability is desirable for television stations in their race for ratings.



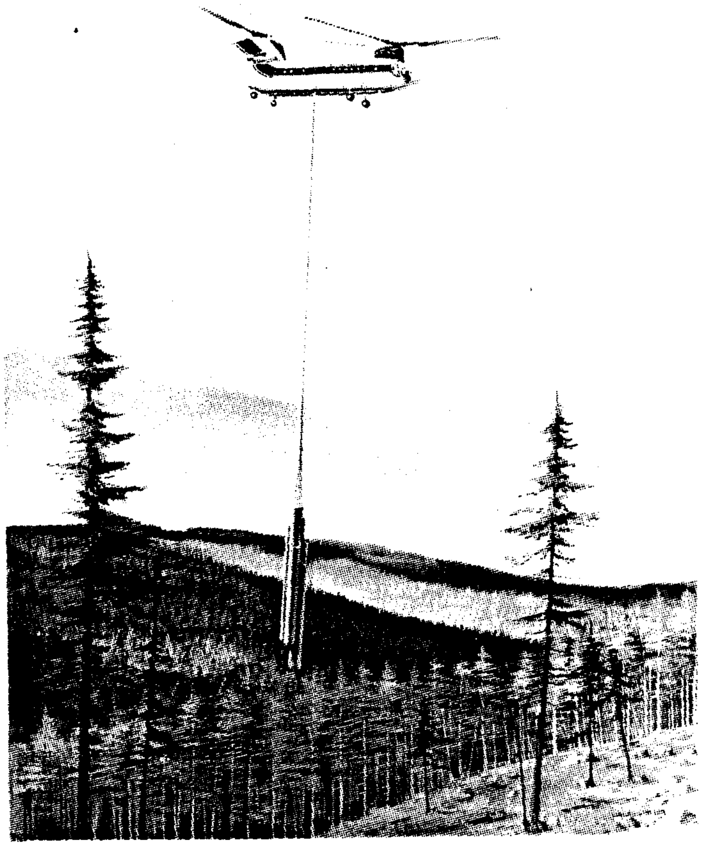
e. Fishing

Helicopters are used in fish spotting to save time and increase productivity of commercial deep-sea fishing trawlers. The advantage of using a helicopter instead of a fixed-wing aircraft for this purpose is that the helicopter can operate from a helipad on the ship.

f. Logging

Particularly in the Pacific Northwest, the heavy-lift helicopter has been found to be a tremendous labor-saver in transporting logs from the forest to a central trucking site from which they are taken to the mill. The helicopter logging lift is advantageous from the environmental standpoint, as it obviates the need for cutting roads through the wilderness. In addition, it allows the harvesting of logs from sites which would otherwise be too difficult to get to with any form of ground transport. Usually two or three logs are cabled together to make a bundle of about 11,5000 pounds. The helicopter picks up the bundle, carries it to the trucking site, and deposits it on a rack, from which a fork-lift tractor can subsequently load the logs on a truck. One helicopter can keep three ground crews busy preparing the bundles.

The largest helicopter logging company in the U.S. is Columbia Helicopters, with headquarters in Oregon. It has eleven Boeing V-107-II tandem rotor helicopters which can carry over 20,000 pounds externally. Experience indicates that tandem rotor helicopters have greater stability and maneuverability when carrying external sling loads.



g. Photography

The helicopter makes an excellent platform for low-altitude oblique photography, and has long been used for both still and movie photography. Applications include news gathering, pollution monitoring, wildlife counts, crop surveys, real estate appraisal, tax surveys, community planning, and environmental assessments, besides the making of films for theatre and television. Special applications include the recording of wake patterns in tests of an experimental hydrofoil vessel.

h. Public Utilities

Heavy-lift helicopters are used extensively in power line constuction, as they can erect poles and transmission towers and string wires and cables in a fraction of the time that would be required if the entire job had to be done by equipment and personnel on the ground. These advantages are even more pronounced where river crossings or rough terrain is involved, or where the ground is too soft to permit access by heavy construction equipment.

Similarly, heavy-lift helicopters are used in pipe-line construction, to carry large pipe sections into position for welding, in otherwise inaccessible terrain.

Helicopters make ideal vehicles for the patrol of power lines and pipe lines. They can fly slowly enough to get a good look at mechanical details, and hover long enough to complete such jobs as spraying insulators. The ability to land nearby for discussion with ground maintenance crews provides another advantage which is not possible with fixed-wing aircraft.

Power companies spend a great amount of money each year keeping their right-of-way clear of encroaching vegetation. Helicopters are used to spray herbicide for this purpose; they can do a much faster job than a ground crew. Compared to an airplane, the helicopter can fly closer to the power cables and do a more thorough and accurate job of depositing the spray just where it is needed.

i. Shipping

An ocean-going ship represents a very large investment; idle time is very expensive in terms of interest, rental charges, and crew salaries. When seaport docking facilities become bogged down (as at Jeddah during a long period a few years ago), the cost of ship delays becomes astronomical. Heavy lift helicopters can be used to unload ships anchored in the harbor away form the docks, quickly carrying the cargo to convenient storage yards on shore. Loose cargo such as sacks of cement can be transported in a cargo net slung under the helicopter; containers and pallets can be hooked to an external sling for the short flight to shore.

In other shipping applications, helicopters are used in delivering harbor pilots to ships about to enter the harbor, and in picking up pilots from outbound ships. If the ship does not have a helipad, a winch is used. Other time-saving applications include the delivery of harbor documentation to inbound ships several hours before docking, so that all the paperwork can be completed by the time the ship is ready to unload. This procedure minimizes delays at the docks, saving dockage charges for the ship owner, and increasing the capacity of the dock facilities by reducing the servicing time.

j. Traffic Reporting

Helicopters are used extensively for urban traffic reporting by commercial broadcast stations. Reasons for selecting a helicopter rather than a light plane for this job include: (a) by not being constrained to fly at higher speeds and altitudes, the helicopter can operate in visual flight in lower ceiling and visibility conditions; (b) by not requiring much room for takeoff and landing, the helicopter could be based close to the station offices (assuming that a heliport were available) rather than being forced to use a more distant airport. A nearby base would permit faster reaction to breaking news events if the station also used the helicopter for news gathering purposes.

C. OPPORTUNITIES AND BENEFITS

The environments in which benefits have been assembled and discussed in this report are:

- Urban
- Small Community
- Rural
- Remote
- Airport
- Ocean

Section VI of this report, INTERMODAL RELATIONSHIPS, contains a functional classification of transportation services (See Figure VI-1) which will be used in the discussion of benefits. Under that classification each transportation environment will be discussed as one grouping, and will provide the structure for assessing benefits in each of the categories of helicopter use or application.

1. URBAN BENEFITS

The urban setting has a greater diversity of potential helicopter use than any other environment. It is the only location where there appears to be a large potential in the near future for helicopter use in public transportation. In addition, it has an intensified need for helicopters in public service work such as fire rescue, anbulance, and law enforcement. It is a natural environment for at least one of the terminals in much of the corporate/executive type of flying. Finally, a number of the applications in which the helicopter is used as a tool of production are found in the city (e.g. TV News, Construction, Traffic Reporting, Bank Mail Transfer). Each of these applications will be discussed separately.

a. Public Transport

Present helicopters (as defined in Section IV) are more acceptable to the public and more competitive in time/cost effectiveness than helicopters available in the 1970's and before. They are much quieter, (both inside and outside), more comfortable, faster, more reliable and less costly than before. The condition has now been reached where it is timely to assess once again the use of this type of helicopter for public transportation. These public transportation markets may be expected to be those associated with urban areas and their conventional airports, intraurban, and inter-urban including large-large, large-small and small-small community service.

Each form of public transportation (cars, buses, trains, airplanes) has had some similarities in the growth patterns of its markets. For example, each vehicle initially provided some special convenience or appeal that was desirable -- but it was costly and therefore available only to a limited market. The first passengers to ride in each of these vehicles during the early stages of its development were the more affluent members of society. The helicopter is somewhat in that same stage today. It is more like the taxi or limousine than the bus. Also, it is likely to experience similar patterns of increased efficiency and lower costs. This will be accompanied by a broadening of the public market that will use the helicopter. The helicopter generally will find its role (in public transportation) where shorter routings and shorter times can be achieved through the use of landing and take-off areas that are situated for the convenience of the passengers. The ranges where the present helicopter can compete are:

- Intra-city — Distances exceeding 10 to 15 miles

- Inter-city — Distances between 50 and 300 miles. (As the helicopter is further improved and as improved configurations such as the tilt rotor are developed, the latter maximum range will be extended beyond 600 miles).

In this regard, a pertinent illustration is provided by a study made by Boeing Vertol on the potential use of tandem rotor helicopters for inter-city use in Europe at ranges between 100 and 300 miles. This study indicated that during the 1990's, ratios of about 30 passenger seat miles per gallon of fuel can be achieved in versions of the helicopter that seat 68, 100, and 225 passengers. With spearate heliports located in the central business districts at both terminals, such a helicopter can achieve competitive total trip costs (compared to airline/taxi fares) and, additionally, make significant savings in time. In the process, it can relieve some of the congestion at the major airline hubs in the same cities. This capability to relieve congestion at airports can be an important factor in preventing zero-growth air transportation for the many cities that are expected to have saturated airline airports during this decade.

Helicopter charter operations, available to the public, have been successfully conducted in a number of cities. They provide an important service in many types of emergency or urgent transportation needs when no other form of transportation can provide the service within the time constraints imposed. In a typical case of this type, cars may be too slow and airline routings or schedule may not match the passengers needs.

The two scenarios (inter-urban and intra-urban) examined in Section VI, INTERMODAL RELATIONSHIPS, provide further insights on the parameters that are important in assessing the role of the helicopter in public transportation.

(1) Individual Benefits

For the individual traveler in an urban setting, a public helicopter service has the potential to provide time savings, cost savings, reductions in the uncertainties of travel time during rush hours, and added convenience. In some cases there will not be absolute savings in costs but the time/cost effectiveness for the individual traveler will be great enough for choosing the helicopter. As the helicopter continues to be improved in efficiency and performance, and as a structure of heliports is established, an increasing number of people will find it advantageous to make the same choice.

(2) Community Benefits

At the present time, helicopter travelers do not typically transfer from helicopter to buses or trains. Instead, interconnections are normally made with airplanes, taxis, limousines or cars. This pattern will tend to be from the upper and middle level income brackets. The implication here is that many of the passengers in helicopters will be among the middle and upper level managers of the industry of the nation. The degree to which their time can be used more efficiently will affect (with great leverage) the efficiency of the corporations that they lead.

One of the service points for many helicopter public transportation trips will be the airport. The contribution that the helicopter can make here is to reduce congestion and overloading of the airport terminal building. This is true also for the road traffic leading to and from the airport, for the parking of cars, and for the movement of passengers within the terminal. With respect to the movement of passengers, the helicopter has the capability of taking passengers directly to the airline gate. This could be accomplished either by landing on the roof of the terminal building or on the aircraft parking area by the loading piers.

The helicopter has the potential to benefit the airport in another important way. This potential exists because the airline industry is facing a serious problem in the overloading of the airports and airport terminals. An indicator of this problem is shown in Figure V-2, a forecast made in 1978 on air carrier airport saturation.

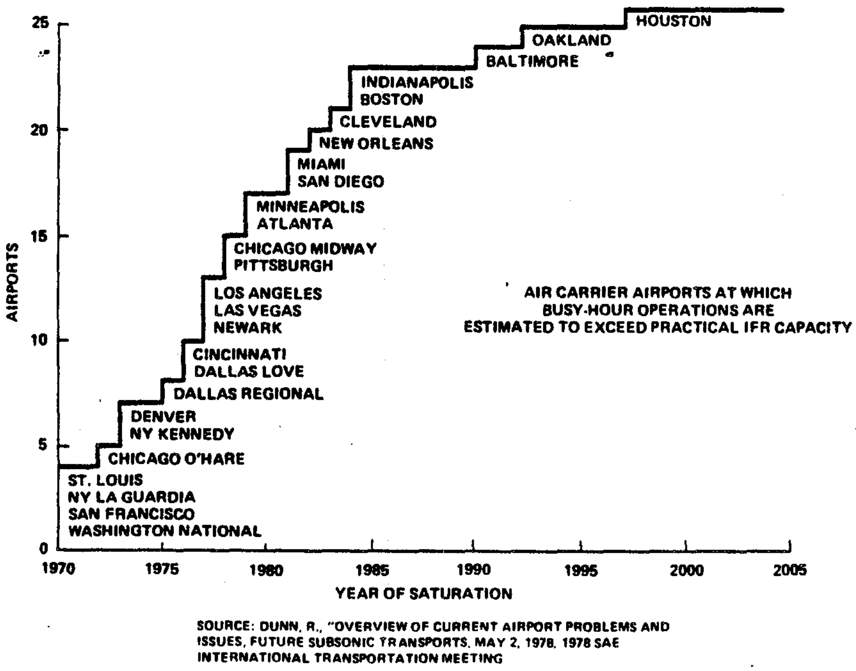


Figure V-2. Forecast Air Carrier Airport Saturation

That study indicates that 25 major city airports will be saturated by the year 2000. This problem is compounded by the fact that there will be few, if any new major airports to serve the large metropolitan areas. The real estate required is not available and the costs of construction are too high. This situation provides an opportunity for the helicopter (and the commuter airline) to provide service between some metropolitan areas and small communities that would relieve the congestion at the major airports.

Many of the benefits from helicopter public transportation will be indirect in nature. Middle and upper level businessmen will be able to move with greater flexibility and speed between activity centers in and surrounding the city -- and to and from the central business districts. Flights to small communities and to other cities within a radius of 250 miles may also be available. This transportation will have an impact on many life activities of people. Individually the benefits will not appear to be of major importance -- but collectively they will. In general, the helicopter will provide a new degree of freedom and flexibility to move about the city (and between cities) and to do so with speed and convenience.

b. Private Transport

Helicopter private transport in the urban area can be divided into two logical types, i.e. corporate/executive flying and air charter operations.

A number of large companies in the U.S. have established helicopter flying organizations within the company or in a subsidiary. These tend to be highly professional operations that use experienced pilots, well equipped and modern helicopters, and professional flight managers. These operations tend to have a level of reliability and safety that is comparable to flying on the airlines.

The most frequent pattern is for these helicopters to be used on a reservation basis by upper level managers. Many of these helicopters have executive interiors so that normal business activites and communications can be conducted while in flight. These passengers can get to their destination quickly and in comfort -- and have the added benefit of being able to work while doing so. These executives can often take a trip and return home in one day when it would take an overnight trip by some other means of transportation. Sometimes a meeting will unexpectedly extend well into the evening hours. For these travelers, it doesn't make much difference. The helicopter can fly at night and under instrument flying conditions and deposit the passenger near his place of work or his home.

When an urgent meeting is scheduled on short notice at a location that may be as far as 250 or 300 miles away, the helicopter may be the only means of getting there on time. This tremendous range of capabilities and the associated flexibility of movement depends in large measure on the ability of the helicopter to land near points of business.

Many helicopter operations are conducted from established airports and heliports that are conveniently located or have been especially constructed to serve a company on that particular route. However, a significant portion of helicopter flights involve a landing at a pre-arranged site (with approval of the property owner) that is an open field, a parking lot, or a road or driveway. The regulations on helicopter landings in most parts of the country permit the occasional landing of helicopters at sites that are not established heliports. This is a powerful and effective adjunct to the use of the helicopter. It is also the reason why helicopters can be so effective in many of their rescue and emergency flights.

Another pattern of use in the corporate category is the single helicopter, single pilot operation. Often, the pilot is also the owner of the company or a key manager. This type of use is similar to what has taken place with light general aviation type airplanes. Many doctors, lawyers and businessmen have used Cessnas, Beechcraft and others as an important adjunct to their professional work.

A third pattern of use has been adopted by several large companies. The business has been moved to a suburban setting and a scheduled airline-type operation has been established to move employees to subsidiary plants, to adjacent cities, and to airports. The passengers here tend to be workers or managers at any level of the company who have a business need to travel.

(1) Individual Benefits

For the corporate passenger, the helicopter can provide a profound improvement in the flexibility and convenience of travel. It can save time in the travel itself; it can overcome the waste of time at airport terminals or on congested roads; and it enables flights to locations (and under schedules) that are not possible in any other way. It directly supports the growing policy among corporations that face to face communications between workers and managers at all levels of a company are cost/effective.

(2) Community Benefits

The corporate helicopter can provide many benefits to the urban community. In many cases , it can provide an important alternative to a major corporation as to where its corporate headquarters and plants can be located. On the one hand , it can provide the flexibility and ease of transportation in the city to retain a headquarters there. On the other hand , it can provide the speed and convenience of transportation in the suburbs and small communities to support the desires of the corporation that desires to locate in the outlying areas and decentralize its operations.

In general , however, if transportation is used, and if its use steadily increases, this is a clear indication that it is making a contribution. Where the contribution takes place is often hard to identify because it can be diffuse in nature. It is analogous to the contributions made by the telephone or by the automobile. The contribution is clearly there, but is difficult to fully identify, assess and quantify.

An important corollary contribution of corporate helicopters is that each new helicopter adds to the reserve fleet of helicopters that is available for emergency rescue and relief in the city.

c. Public Service Benefit

The areas where public service use of helicopters is applicable in the community are listed below -- with those of greatest present value indicated by asterisks (*).

- Law Enforcement: Patrol, Command Post, Polution Control, People Transport*

- Public Safety: Ambulance*, Fire Rescue*, Traffic Control

A tabulation prepared by the president of Sikorsky Aircraft for Vertiflite, September/October 1980, showed almost one million people saved by helicopters from life threatening situations over the past 40 years. Of these, more than

60,000 were by commercial and government helicopters--which is substantial. Most of the remainder were military rescues.

Perhaps more significant is the implication of these statistics. If more helicopters and more heliports were available, these statistics might be increased many fold. Yet it is not realistic to expect a major increase in the availability of helicopters in communities to come from government facilities such as law enforcement offices or the military. The answer seems to lie in the use of helicopters that are used commercially in the city but can be available in an on-call basis to help in emergencies. In the past , many if not most operators have been fully cooperative in providing this type of service -- usually at their own expense. It is not unreasonable to expect this to continue in the future.

It would appear desirable, therefore, for communities to encourage helicopter operations in and near the urban area, and to provide for landing sites at many locations. In this connection, it should be noted that an austerely equipped site for helicopter landing on an "occasional" basis is very inexpensive -- perhaps a few hundred dollars. All that is needed is a firm flat space, on the ground or on top of a building -- a square that is 40 feet on a side is usually adequate. It must have reasonable flight path approaches, it should have printed markings on the surface, and it should have at least a wind sock. (Note: The state of Ohio has made excellent use of inexpensive heliports and claims to be the only state where every major city has a public-use heliport.)

There seems to be no question that the helicopter has made an important contribution to society by performing rescues that cannot be accomplished in any other way. The challenge, then, is to provide a receptive environment for operators and the availability of landing sites that will greatly increase that contribution.

d. Tool of Production Benefits

The helicopter serves as a tool of production in urban areas both in the transport of people and goods.

Helicopters have been used for traffic reporting for many years and most large cities take advantage of that use of the helicopter. TV news gathering is a more recent use and is growing rapidly. The ability to transport a TV camera to a news scene while the action is taking place, adds another dimension to the realism and timeliness of the reporting. Typically , the helicopter has a means of relaying to the TV studio the scene as it is being photographed -- so the action is live. The helicopter has a decided advantage over a TV truck in the speed with which it can get to the scene and in the accessibility to the location where the news event is taking place.

In the transport of goods for production purposes in the city, the primary examples are: construction (crane operators), bank record transfer and advertising. One potential application in the future is the removal of cars and trucks from the scene of an accident so that the highway can resume its normal traffic unobstructed.

In each of these applications, the amount of use of helicopters is not presently great but there is potential for growth. Also, new applications will undoubtedly emerge in the future. Twenty years ago, for example, who would have envisioned the use of the helicopter for the transfer of bank records by roof top pick-up and where, in many cases, the helicopter does not even touch-down for a landing. Another important application is the helicopter operating as a crane. There are many instances where cranes cannot or have not been used at the heights required to install roof-top air conditioners or TV station antennas.

e. Urban Summary

Figure V-3 provides a summary indicator of the areas where there are current benefits and potential future benefits from the use of helicopters in the urban environment.

There is a wide diversity of uses and some of them have a high potential in terms of utility and the volume of activity.

Three areas that potentially have great impact on society are the public transportation, the corporate and the public service applications.

The public transportation role can improve the quality of life of the public at large by making transportation more convenient and more accessible.

The corporate use of helicopters is likely to have a major impact on business. This can be similar to the impact on business in the changeover in the U.S. from trains to airplanes.

The public service role can be a major contributor in urban areas -- and this role could be provided economically since it can be achieved through on-call use of helicopters that are based near the city center but are basically used for some other prupose.

(Note: For a discussion of disaster relief, see paragraph 4. Remote Area Benefits, page V-40.)

f. Problem Areas

There are a number of problem areas affecting the achievement of the potential of the helicopter in the urban area. Three primary areas are listed below. Each will be discussed separately:

- Need for increased public acceptance of helicopters
- Need for more public use helicopters
- Need for all-weather flying capability

(1) Need for Increased Public Acceptance of Helicopters

As previously discussed, there is still a reluctance on the part of the general public to accept helicopters. Mainly this stems from the perception of unusual noise and from the closeness to which the helicopter comes to people, to homes and to offices in much of its flying. Several trends are taking place that may alleviate this problem in time. First, helicopters are becoming much quieter. Second, increased exposure and familiarity to the unique helicopter sound may increase the public acceptability and tolerance. Finally, there is an opportunity to educate the public about helicopters and how they have changed and improved in safety and other respects over the years.

(2) Need for More Public Use Heliports

As was mentioned earilier, highways were built in anticipation of increased automobile traffic and airports were also built on the expectation of greater airplane activity. This availability of essential capital facilities was in itself a substantial spur to the increased use of automobiles and airplanes. There is no reason to believe that this same pattern would not work with helicopters. If more public use heliports were available, increased flying of helicopters would be encouraged.

In this connection, it is significant that the capital investment of heliports is very small in relation to total helicopter travel costs when compared to airplanes (that require airports), cars (that require roads) and trains (that require tracks).

(3) Need for All-Weather Flying Capability

One of the essential capabilities of airplanes that was needed for growth was to provide reliable all weather landing capabilities. Today the occasions are rare when an airplane fails to reach its destination because of weather.

Each conventional airport capable of supporting instrument flight operations has on array of navigation and communications equipment that is needed for such operations. While this equipment is costly, the expense is warranted because of the size of the airport and the volume of traffic (basically scheduled air carrier) it handles.

Heliports are not expected to have this same volume of traffic, so other solutions to all-weather landing may be needed to be cost effective at heliports.

This situation is even more difficult for the helicopter in flying to the suburbs, to small communities and to remote areas. Expensive ground facilities cannot be provided for the many heliports at which the helicopter is capable of landing. The extreme situation is the occasional landing site where a helicopter may land just a few times a year. In cases of emergencies, (e.g., accidents, trauma cases, natural disasters), it is impossible to predict the need for a helicpter to make an all-weather approach and landing.

A solution must eventually be found for this problem. The value of the helicopter is directly related to the extent to which it can fly the same routes and patterns in bad weather that it can in good weather. With the airplane, the solution was relatively simple and inexpensive because the number of airports are few. With the helicopter, because of the virtually infinite number of landing sites involved, new solutions must be found. The current VOR/DME navigation system, nor ILS/MLS meet this need.

Nevertheless, a promising concept has emerged in the techniques that have been developed to make instrument (bad weather) landing approaches on oil rigs. The technique developed was to use a ground mapping radar in the airplane so that the pilot could "see" the oil rig. The concept was to put the essential equipment in the helicopter -- not on the ground.

The ability of the helicopter to fly slow and hover when used in conjunction with airborne sensors should enable the helicopter in the reasonably near future to land on instruments at almost any site where it can land in good weather.

2. SMALL COMMUNITY BENEFITS

Small communities do not typically have the population density nor the restrictions to ground vehicle movement to support extensive public service uses of helicopters nor their use as a tool of production.

One potential use of helicopters in small communities is in situations where there is a heavy flow of traffic to a neighboring city and its airports. The distances and transit times for other vehicles must be inconvenient because of routings, schedules, or topographical problems, and the city must have helicopter service to its airport and other small communities or suburban areas. As the number of cities having helicopter service increases, more situations of this type will exist.

Another possiblity is where a large corporation has located its offices in the area and needs fast, flexible transportation to plants that are in dispersed locations. A number of coal companies in Appalachia are in this category. They make extensive use of helicopters and some are based in centrally located small communities.

Unless there is some reason why helicopters are based in a small community for other commercial reasons such as agriculture spraying, or logging, the opportunities for helicopters in small communities, in the near term, are somewhat limited.

The tabular summary in Figure V-3 summarize the more provisioning opportunities for helicopters in small communities.

3. RURAL AREA BENEFITS

The largest opportunity for helicopter use in rural areas is in support of agriculture, forestry and construction work.

In agriculture, the spraying and seeding of crops has grown to be a substantial industry. The helicopter has an advantage over the airplane when the fields are relatively small (less than 100 acres), when there are high trees or other obstructions on the periphery, and when the terrain is rolling or hilly. The greater maneuverability and slow speed capability of the helicopter enable it to be more efficient under those conditions.

In construction work, the helicopter has power to be cost/effective in pole laying, power line stringing, and in the erection of power line towers. This is particularly true in cases where the ground is mountainous or rough and not easily accessible by car and truck.

In the public service category, helicopters are used in rural areas for search and rescue and for wildlife management. (Note: For a discussion of disaster relief, see paragraph 4, Remote Area Benefits).

Figure V-3 summarizes the main applications of rural area helicopter benefits.

4. REMOTE AREA BENEFITS

As a tool of production in remote areas the helicopter has proven to be effective in a number of applications. Notable examples of this are in construction and in forestry work. The construction work is mainly in the laying of power lines and pipe lines; in the lifting, transport and erection of power line poles; and in aerial surveys. In forestry work, the transport of timber and logs from sites that are not easily accessible by road has grown remarkably in the past few years. One company on the West Coast (i.e., Columbia Helicopters) has a fleet of 11 heavy lift tandem helicopters devoted solely to logging work. Also, that work comprises two thirds of its entire helicopter commercial operations.

In public service activities, there are some important contributions that the helicopter can make. Some of the main areas are:

Disaster relief and rescue
Search and rescue of people and downed aircraft
Wildlife management
Environmental Survey

The area of disaster relief and rescue deserves some special comment because it has not been planned for extensively in connection with helicopters. Also, it should be noted that the use of the helicopters for disaster relief is applicable to all environments (urban, small community, rural, airport, ocean area and remote area) but is somewhat accentuated in remote areas (and ocean areas) bacause of the distance and isolation from normal facilities.

Natural disasters differ from the more normal helicopter rescue operations in the magnitude and scale of the rescue effort that is required. There are about eleven generally recognized types of disasters that can occur in the United States:

Flood	Earthquake
Snow (frost/freeze)	Landslide
Large Scale mountain timber fires	Avalanche
Shipwrech	Drought
Hurricane	Volcano
Tornado	

Also, as in most other life activities, if an event can occur-eventually it will occur. The recent volcano of Mount St. Helens, and the vast fires in California are examples.

Perhaps the most important factor leading to success of rescue operations is the extent to which contingency plans have been made and arrangements made for the use of the necessary resources when the disaster occurs. If helicopters are important tools of rescue, pre-planning for their use must be accomplished.

One major impediment to rescue efforts in the past has been the inability to move supplies and rescue teams to the site -- and the inability to evacuate people from locations where they cannot be reached by normal transportation means. The helicopter offers a great potential to improve relief and rescue in these circumstances. The ability to drop-off and pick-up fire fighters behind the fire, the ability to rescue people from the roof of a building surrounded by water, the ability to take an injured person to medical facilities -- these are all examples.

By being in the air above the scene, by being able to hover and fly slow, the helicopter has a perspective to size up a situation and the flexibility of maneuver that is not possible in any other way. Also, the helicopter can use sensors that are not as useful in any other vehicle. A good example is the forward looking infra-red (FLIR) detector. It is a passive detector that can sense objects that are at a higher temperature than the environment. A human is clearly invisible at night in an open field. FLIR enables helicopters to locate people for rescue or law enforcement purposes. Another highly important use of the FLIR is in fire prevention. After a major timber fire has been extinguished, there still remains a serious threat of the fire re-starting from smoldering embers. The helicopter with the FLIR is used very successfully to detect these hot spots, after which the fire fighters are deposited on the scene to extinguish them for good.

Figure V-3 summarizes the main applications of helicopters in remote areas.

5. AIRPORT AREA BENEFITS

The normal interface at the departure or arrival of a helicopter flight is with a car, taxi, limousine, or airplane. Thus, transportation to international or hub airports is one of the natural opportunities for helicopter use.

This is well understood, and all of the past attempts to establish scheduled helicopter public transportation service in New York, Los Angeles, San Francisco, etc. have focussed on traffic between a major city and its airports. This is expected to be an excellent test of the viability of present generation helicopters to provide a useful and economically successful service.

Air Taxi operations have constituted another major category of flights leaving from or terminating at airports. Most air taxi operators base their helicopters at an airport.

Corporate flying has been one of the primary categories of helicopter flights to and from airports. A number of large corporations base their helicopter operations at an airport because it is one of the frequent end points of a trip, because service facilities are available and because the airport has the navigational aides and air traffic services that permit departures and arrivals in bad weather. As corporate flying increases, the usage of airports will increase in direct proportion, with increasing use of discrete helicopter arrival/departure route structures. Many of these airports may be in outlying areas of a city or in small communities that do not have airline service.

In the public service category there has been extensive use of helicopters for fire fighting and medical evacuation. This will clearly continue in the future.

In general, airports have been the natural home base of most helicopter operators, irrespective of what the basic work activity of their helicopters may be. (Note: For a discussion of disaster relief, see Remote Area Benefits, page V-40).

The benefits that helicopters can provide to airports in the future are substantial. This is true both on the air side and on the ground side.

On the air side, one of the important potential contributions is in the relief of the congestion that is expected in the future at the major air terminals of the country. This can occur through helicopter operations between small communities that are more direct than the airline routings. Another possibility is the acceptance of passengers at the airports who would otherwise have transferred to other trunk line routings for the continuation of their travel.

On the ground side, there is also a possibility that the helicopter can relieve some of the congestion of ground traffic that is moving to and from the airport. To make a contribution in this area would require a large volume of helicopter traffic. This could be fostered if the helicopter operation provides some additional advantage to the passenger such as termination of the flight at or near the airline gate rather than the airport terminal. This could be either on the roof of the terminal or on the airline taxi ramp area.

Figure V-3 summarizes the main areas where benefits from helicopter service are attainable in the airport area.

6. OCEAN AREA BENEFITS

In the ocean area, the primary helicopter uses are: (1) to provide transportation to and from off-shore oil rigs, and (2) to perform rescue missions at sea. Both of these applications are well accepted and very successful.

Over the past few years, the number of helicopters purchased by off-shore oil operators has exceeded any other single category of use. Overseas, in the North Sea, where the oil rigs and platforms are larger than off the U.S. shores, the British Aircraft Co. will soon be using large tandem rotor helicopters that can seat 44 passengers, and cruise at 150 miles per hour. Commercial flying to the oil rigs is a booming area of business and is expected to continue its expansion for some time.

In the Gulf of Mexico, most of the rigs are within 100 miles of the shore line. However, plans are underway for drilling at distances of 200 miles and greater. This will amplify the utility of the helicopter -- and at the same time will require use of the larger types of helicopters that carry 15 to 25 passengers. This same pattern of oil exploration at greater distances is also taking place in the Atlantic ocean east of New England.

A portion of the flying to the oil rigs is done by flying subsidiaries of the oil companies themselves, rather than by charter. This flying therefore falls into the category of coporate (private category) rather than public. The flying itself is almost identical to that performed by the charter companies and the same type of helicopters are used.

The U. S. Coast Guard does most of the helicopter search and rescue work off the coastal shores. It does obtain support from the Navy and Air Force when needed. The rescue, last year, of 350 survivors from the Cruise ship, Prinsendam, that sank off the coast of Alaska, is the most recent example of the success in this type of disaster.

Figure V-3 summarizes the main helicopter opportunities in the ocean area.

OPPORTUNITIES & BENEFITS

TRANSPORTATION CATEGORIES							
PUBLIC		PRIVATE		PUBLIC SERVICE		TOOL OF PRODUCTION	
PEOPLE	GOODS	PEOPLE	GOODS	PEOPLE	GOODS	PEOPLE	GOODS
Transport Charter	Cargo	Inter-Company Intra-Company	Parts	Police Fire Rescue Medical	Equipment Water Chemicals Supplies	Traffic Reports T.V. News Gathering	Construction Forestry Agricultural

TRANSPORTATION ENVIRONMENTS	B E N E F I T S			
URBAN	Transport □ ● Charter □ ●	Inter-Company □ ● Intra-Company □ ⊖	Police/Ambulance ⊟ ● Fire Rescue □ ● Disaster Relief □ ●	Traffic Reporting ⊟ ● TV News □ ● Crane □ ⊖
SMALL COMMUNITY	Transport ⊖ Charter ○	Inter-Company □ ○ Intra-Company □ ⊖	Disaster Relief ⊖	
RURAL		Intra-Company □ ○	Search & Rescue □ ○ Wildlife Mgmt. □ ○ Disaster Relief □ ●	Wire/Pole Laying □ ⊖ Spraying/Seeding ⊟ ● Surveys □ ⊖
REMOTE AREA			Search □ ⊖ Disaster Relief □ ● Aerial Surveys □ ⊖	Power/Pipe Lines □ ⊖ Aerial Surveys □ ⊖ Logging □ ⊖
AIRPORT	Transport ● Charter ⊟ ●	Inter-Company □ ●	Fire ⊟ ⊖ Ambulance ⊟ ⊖	Base of Helicopter Operations ⊟ ●
OCEAN	Charter ■ ●	Intra-Company ⊟ ●	Sea Rescue ⊟ ● Patrols ⊟ ●	External Lift Shore to Ship ⊖

CODE: Present Use: Hi ■ Med ⊟ Lo □ Potential Use: Hi ● Med ⊖ Lo ○ (National Scale)

Figure V-3

VI. INTERMODAL RELATIONSHIPS

A. INTEGRATED SERVICES

In comparing integrated services and modes of travel between helicopters and other vehicles,it is the specific transportation functions and not the vehicle technology that should be integrated or compared.

Each mode tends to organize the services it provides into functional classes and they usually form a hierarchy of service as shown in Figure VI-1.

TRANSPORTATION ROLES		Highway Functional Classification (for Urbanized Areas	Aviation Functional Classification	Aviation Trip Geography
Travel Mobility	Access to Property			
high	-	Principal Arterials	Trunk Routes	National & International
medium	low	Minor Arterial Streets	Regional Service	Connects smaller urban areas or to hub airports
low	medium	Collector Streets	Commuter Service	Transfer from smaller areas or to hubs
-	high	Local Streets	Community Service	Within urban areas or between nearby smaller areas

Figure VI-1. Transportation Functional Classification Applied to Aviation

The transportation roles of "travel mobility" for people and "access to property" or places define different functions for an aviation functional classification. The two larger classes on the hierarchy: commuter service and community service, are the focus of this overall study of intermodal relationships. For community service, there is a strong concern for access to places and less for serving through-travel. Rotorcraft are well noted for their ability to provide accessibility to almost any place on earth -- in fact, they can go many places where even the automobile can not go.

Several principles of integrated service can be derived from the concept of functional classifications, namely:

- Good integration is highly valued by users of transportation services.

• Functional classes of service need to be integrated within a transportation type and between types of transportation.

• Integrated service can be provided by different private companies or public agencies operating different classes of service.

The application of these principles has the following implications. For integration with a system of rotocraft service, practical limitations on having "point-to-point" service will result in a hierarchy of service requiring integrated transfers. For integration with longer-haul aviation, rotorcraft have been providing connections for travelers between nearby airports as well as having complementary or competitive commuter and ground access functions. To integrate well with ground modes requires service with published schedules and operations on specific routes between specific places.

A framework for comparing community rotorcraft service was developed in this study that highlights the functions and applications that are favorable to rotorcraft. It is partly based on a functional class hierarchy for each mode and the different relative transportation roles provided by each class of service. It is also based on trip lengths favorable to rotorcraft.

Figure VI-2 graphically shows this framework.

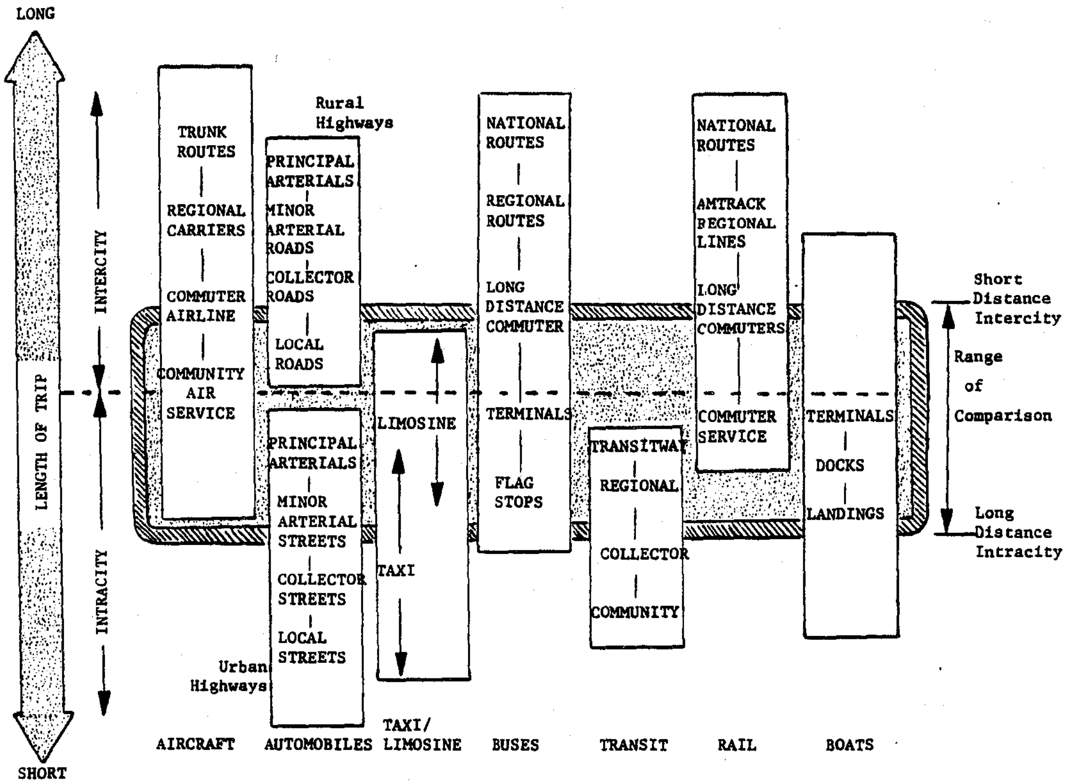


Figure VI-2. Framework for Comparing Community Rotorcraft Service.

The arrow on the side indicates the relative length of the travel. There are individual vertical representations for several transportation modes with terms generally categorizing the functional class hierarchy within each mode. A horizontal range of comparison is highlighted that cuts across each mode, which is bounded by long distance inter-urban trips and short distance intra-urban trips. Several observations can be made from this comparison framework:

First, the relative vertical position of the box for each mode indicates the typical trip lengths for those modes. The framework shows that no two modes serve the same range of trip lengths.

Secondly, each of the transportation modes provides a range of service, expressed in terms of trip length, which extends beyond the range of comparison being focused on in this study. A major implication of that observation is that rotorcraft should not be expected to completely substitute for or replace any other mode, but rather would complement or enhance other modes.

Thirdly and last, reading across the diagram, it can be seen that within the range of comparison, different parts of the functional hierarchies of the different modes provide the transportation functions analagous to community rotorcraft service. That means that, in making specific comparisons with another mode, rotorcraft service can provide the same or better combination of transportation roles, degree of mobility and access provided by that mode.

B. INTERURBAN ROTORCRAFT SERVICE SCENARIO

There are many downtowns, also termed "Central Business Districts" (CBDs), which are relatively close to those of other urban areas. There is a significant amount of interaction between the CBDs, primarily among business related activities, by people vacationing in both areas and in the transportation of small packages. In this situation, there are several alternative transportation choices, i.e., rotorcraft, short-haul fixed-wing, automobiles, intercity buses and intercity trains.

This scenario uses a distance range of 50 to 300 miles as the range of comparison. An important characteristic is the circuitous travel paths that exist for each mode (See Figure VI-3). This results in unequal distances by the different modes, with the rotorcraft being the base distance measuring the separation between the CBDs.

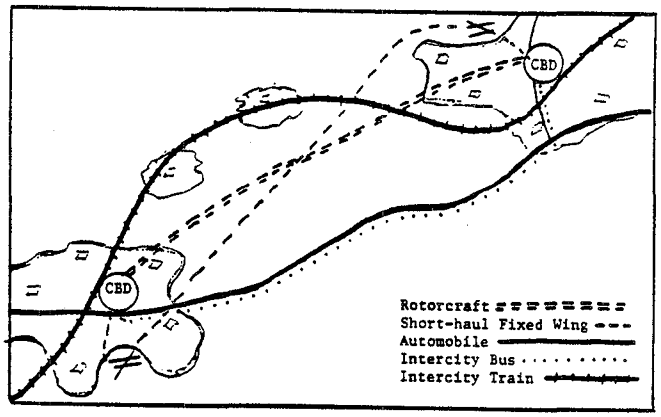
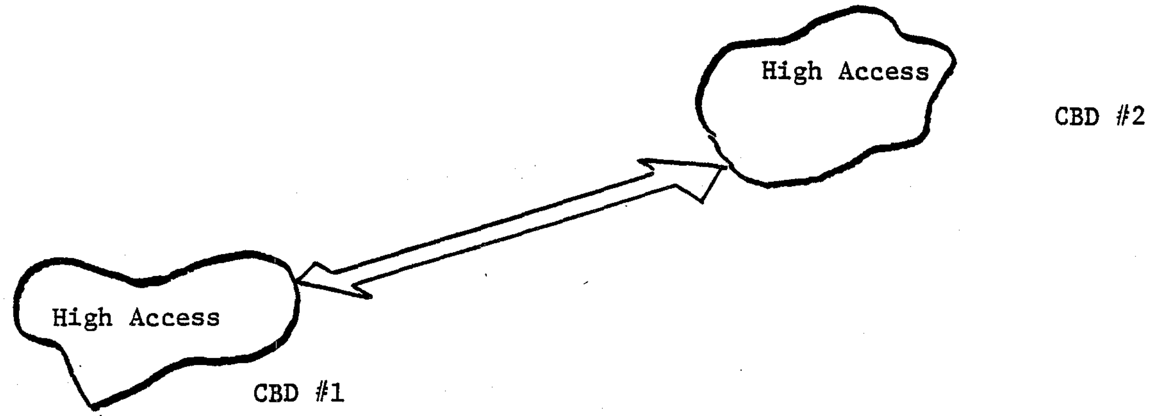


Figure VI-3. Transportation Options

The transportation function being provided by this scenario is high access to each CBD and mobility improvement limited to people who work in one of the CBDs and have some business to conduct in the other CBD. The connections for other modes may represent a different access/mobility balance; for example, rail service may have several intermediate stops giving added access to those places and mobility to other travelers.



The average speed of the line-haul portion of each of the transportation options is an important technological characteristic. This range of speeds for each mode over its respective distance between CBD pairs is the result of different classes of service and changes in technology. With the exception of improved high speed rail in selected corridors, the major technological speed innovation which could be applied in connecting any pair of nearby CBDs is through the use of rotorcraft.

Figure VI-4 shows the component parts of a trip when traveling on different modes between CBDs which are 150 miles apart.

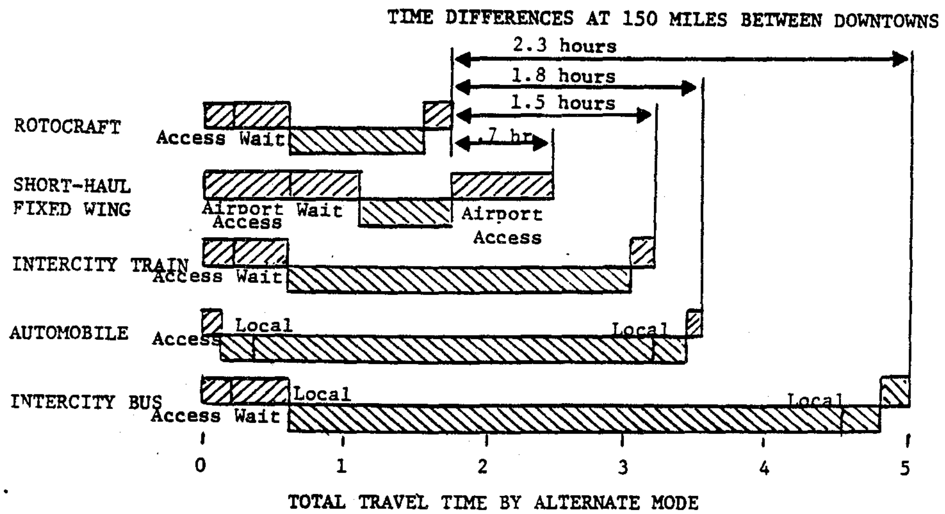


Figure VI-4. Component Parts of a Trip.

The chart shows the total travel time as well as the amount for each component. The line-haul portion of each mode requires some sort of local access or circulation to the terminals, usually by a different mode. In this scenario, short-haul fixed wing CBD-CBD service has different access requirements than the other modes, reflecting the airports each being located some significant distance from the CBDs.

Figure VI-5 gives the total CBD-CBD travel time differences (expressed in hours) between rotorcraft and the other modes for the various distances considered in the scenario (50-300 miles). The time differences which are favorable to rotorcraft reflect the combination of a) more direct access, b) relatively higher line-haul speeds, and c) less circuitous travel. The chart also shows that compared to trains, autos, and buses, rotorcraft has increasing time savings the further apart the CBDs (within the range shown). Compared to fixed wing short-haul aircraft, there is generally decreasing benefit with increasing separation except in the lower distance range for fixed-wing propeller aircraft. The magnitude of the time savings is sensitive to the various assumptions used in the scenario.

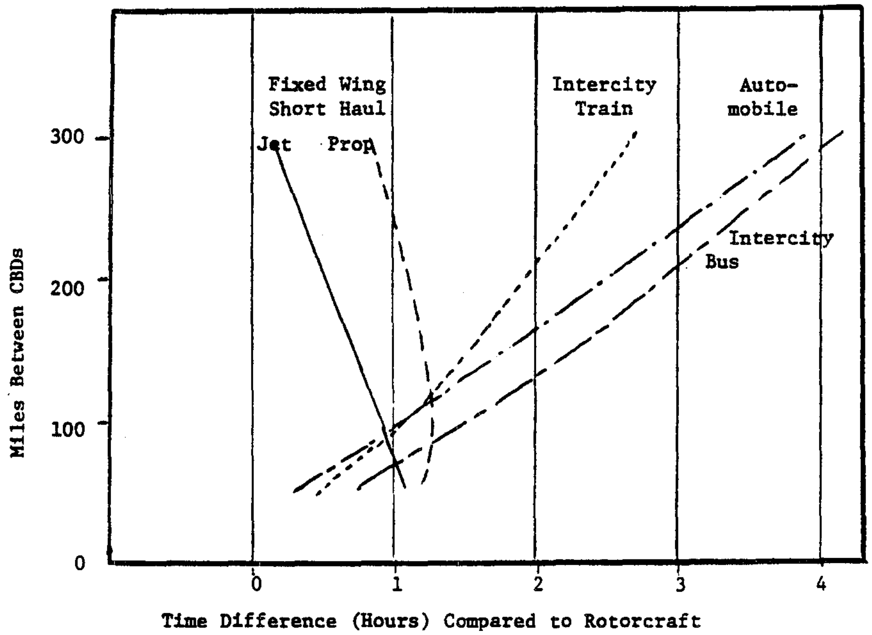
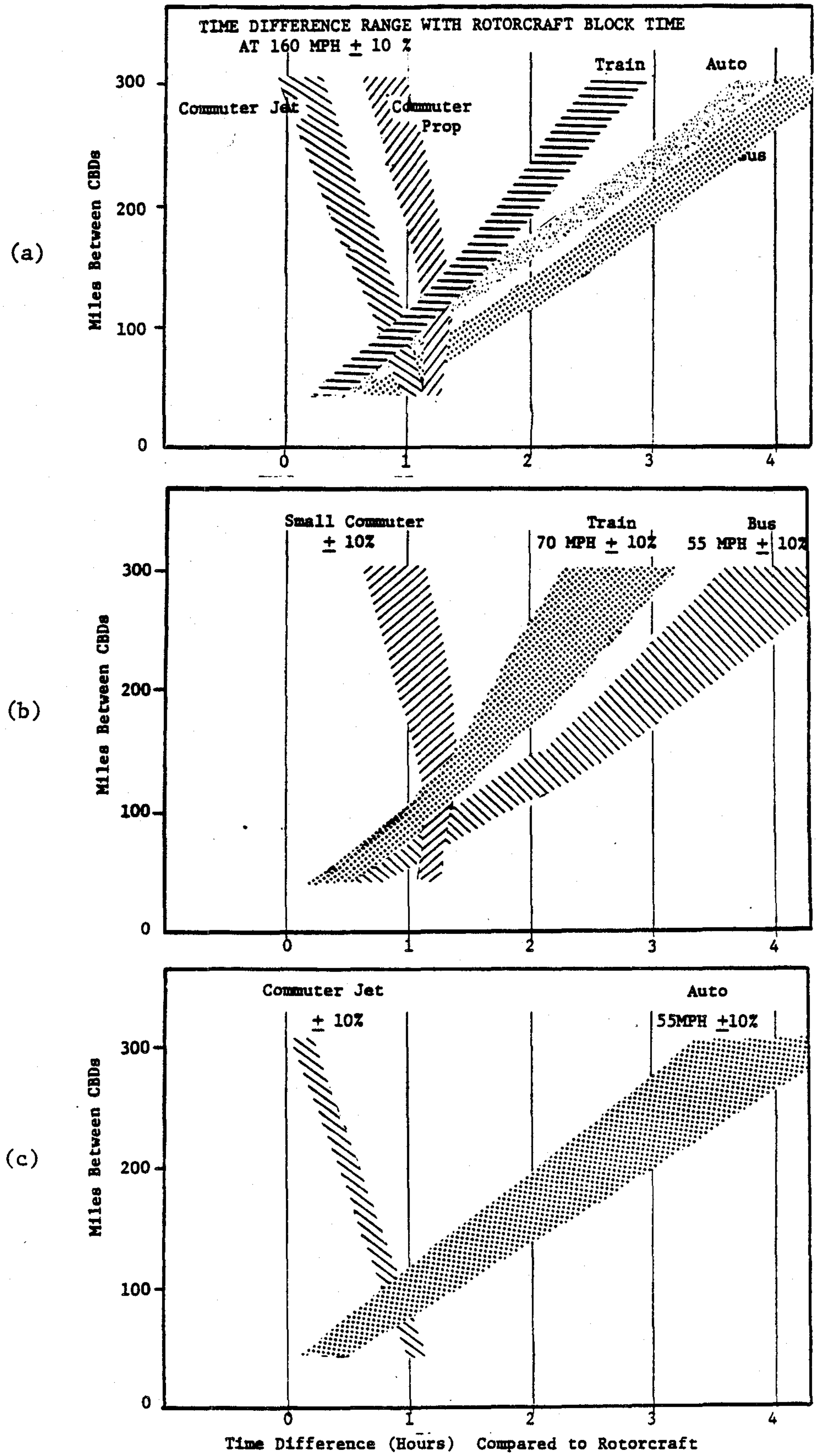


Figure VI-5

Figure VI-6 is a series of sensitivity graphs. The top comparison shows the effect of changing rotorcraft speeds 10 percent higher or lower than the basic assumption of 160 mph. Relatively, the sensitivity is low and shows differences of 10 to 15 minutes. The middle and lower comparisons in Figure VI-6 show much greater time difference sensitivity for ten percent variations in the speeds of each of the other modes (except for short-haul fixed-wing jet aircraft). Variations of one half to three quarters of an hour are shown. Local service for one of the other modes can increase the time difference by 15 to 20 minutes per stop.



(a)
TIME DIFFERENCE RANGE WITH ROTORCRAFT BLOCK TIME
AT 160 MPH ± 10 %
Commuter Jet
Commuter Prop
Train
Auto
Bus
Miles Between CBDs
300
200
100
0
0
1
2
3
4
(b)
Small Commuter
± 10%
Train
70 MPH ± 10%
Bus
55 MPH ± 10%
Miles Between CBDs
300
200
100
0
0
1
2
3
4
(c)
Commuter Jet
± 10%
Auto
55MPH ±10%
Miles Between CBDs
300
200
100
0
0
1
2
3
4
Time Difference (Hours) Compared to Rotorcraft

Figure VI-6

The two different patterns of time differences illustrated above (VI-6(b) and (c)) indicate that relative cost differences should be more important to the traveler when comparing rotorcraft to the fixed-wing aircraft option. Figure VI-7 shows estimates of direct operating cost over various distances for rotorcraft and fixed-wing short-haul aircraft. Generally, current generation medium size rotorcraft have two to three times the direct operating cost of fixed-wing short-haul aircraft on a seat mile basis. Larger capacity rotorcraft have less of a cost difference. However, for fixed-wing aircraft, the cost of departure airport access involving cab fare, limousine service, or driving and parking ones car, plus access costs at the destination airports, can easily add twenty dollars or more to the fixed wing cost. Over the mid part of the distance range, those access costs can eliminate the difference of the higher line-haul rotorcraft costs.

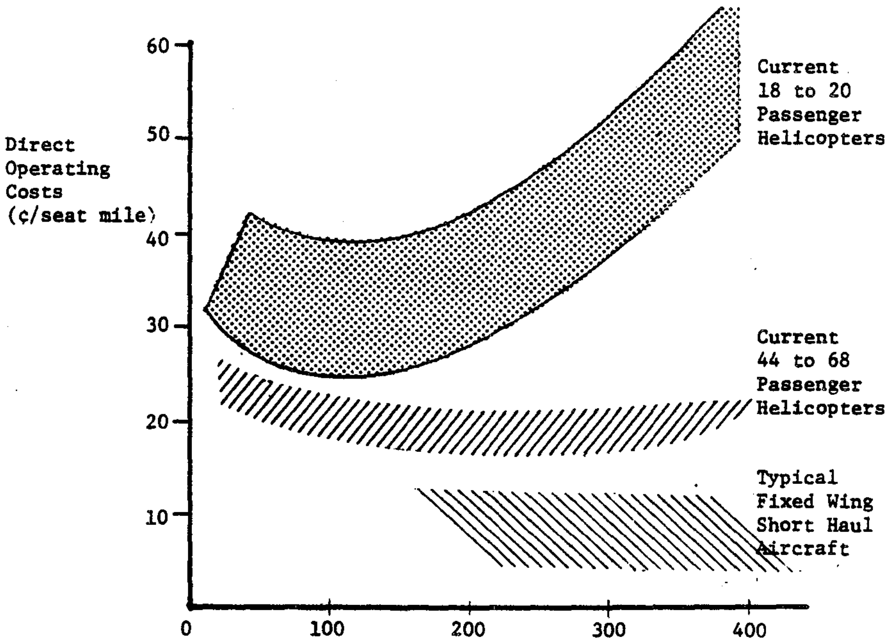


Figure VI-7

Time efficiency and cost avoidance are two indirect benefits of rotorcraft in this scenario. Figure VI-8 shows that the rotorcraft option makes the most efficient use of an executive's time for the distance range of the scenario. At the longer distances, the aviation choices enable the executive to more easily avoid the costs associated with an overnight stay.

C. INTRAURBAN ROTORCRAFT SERVICE SCENARIO

The framework given earlier identified several transportation modes as options for longer distance intraurban trips: rotorcraft, automobiles, taxis or limousines, and public transit. This scenario uses a distance range of 5 to 50 miles for the range of comparison. Figure VI-9 illustrates how the transportation options typically relate to one another. One typical feature which is important to consider in the scenario is the relative circuitry of the various options. The flight distances of the rotorcraft is used as the base measure of travel distance and the other options are assigned relatively longer travel distances between the same start and end points.

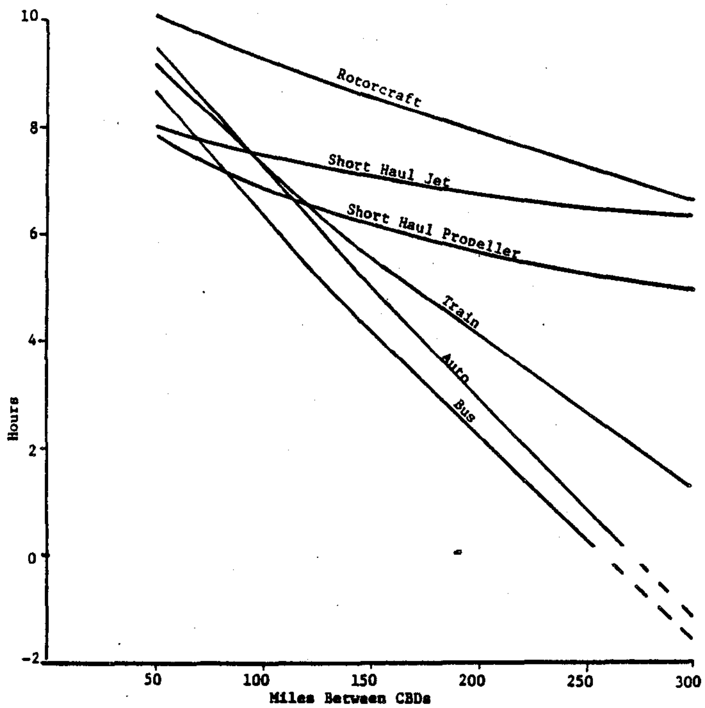


Figure VI-8. Hours Available for Business on a One-Day Trip With A Twelve Hour Time Budget

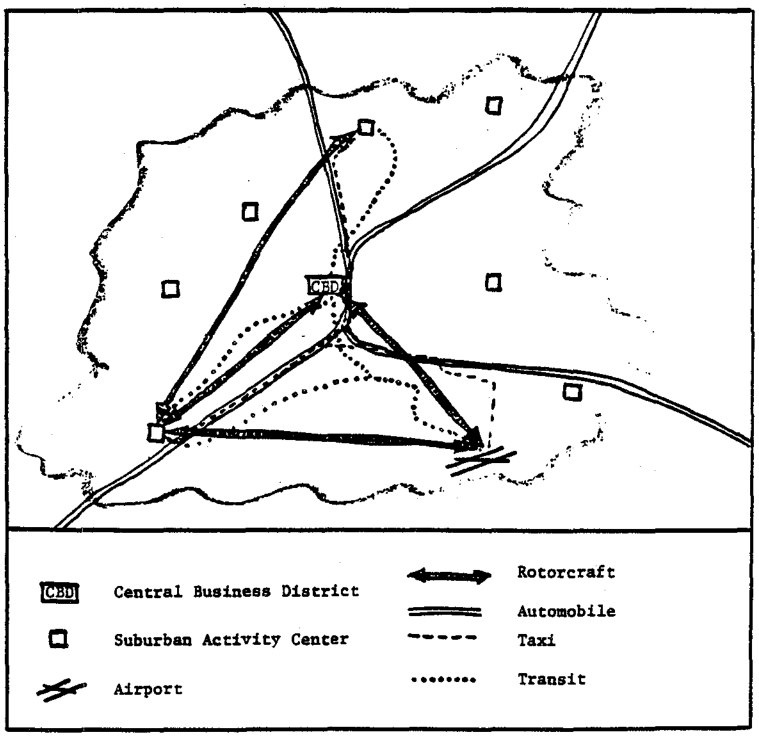


Figure VI-9

In this scenario, the rotorcraft provides a function analogous to principal and minor arterial highways. Therefore, the combined transportation function for rotorcraft should be to have a medium to high degree of through-movement of urban trips while providing direct access to suitable activity places. Suitable activity centers include: central bus-
serve other nearby places. Suitable activity centers include: central business districts, large shopping centers, hospitals, universities, or office and industrial parks, and lastly, airport and outlying intercity terminals. A strategic location within each activity center can have many travelers within a walking distance of 2000 feet, an area of about 300 acres. There is also a need for necessary and sufficient access facilities for taxi, automobile drop-off or parking, local transit and pedestrian connections.

As in the Down-town to Down-town scenario, the line-hual speed is an important technological factor. In this scenario, rates of acceleration and deceleration acceptable to the traveling public are also important. The range of speeds used for the other options reflects different classes of service being operated. In Figure VI-10 the average speed for rotorcraft is shown as a function of distance, due primarily to the time it takes to accelerate to cruise speed of 180 mph to an average speed of 145 mph for a ten mile flight, and it drops to 125 mph for a five mile flight. This is analagous to the "station spacing" effect in transit planning, with the more frequent and closer the stops, the lower the average speed along a route. Therefore, depending upon "heliport spacing" distances, greater cruise speeds may not significantly improve the transportation benefits of community rotorcraft service in this scenario. Sensitivities to variations in cruise speed and acceleration rates show that for trips of 15 miles or less, there is greater variation in average speed due to the range in acceleration rate assumptions.

There are four basic ways to connect the three activity centers in the scenario: 1) CBD to airport, 2) CBD to suburban activity center, 3) suburban activity center to airport, and 4) suburban activity center to suburban activity center. Each of these basic connections has different characteristics such as terminal times, relative speeds, and relative circuitry. The assumptions for each of the basic connections were selected in a consistant manner and are reflect in the time chart in Figure VI-11. The estimates of line-haul travel time were calculated by combining assumptions of the average speeds over various distances with assumptions as to the relative circuitry for those distances which ranged from 5 to 30 percent more circuitous than rotorcraft travel.

Figure VI-12 shows the total travel time differences expressed in minutes between rotorcraft and each of the other modes for the range of distances in the scenario. There is one chart for each of the basic connections between activity places. One observation is that each graph has a similar pattern implying that no other mode provides a unique transport service. A second observation is that each graph shows a cross-over point of equal travel time that ranges from 7 to 17 miles separation between places. This reinforces the presumption that Community Rotorcraft Service would tend to serve longer distance intraurban trips. A third observation is that rotorcraft have increasing time savings, but at a decreasing rate, as the separation between activity centers increases. A fourth observation is that for travel connected to the CBD, taxis or limousines are the next fastest while for travel to suburban activity centers it is the automobile. A final observation is that in each graph transit is shown as the least competitive while it provides its best relative service for CBD to airport service.

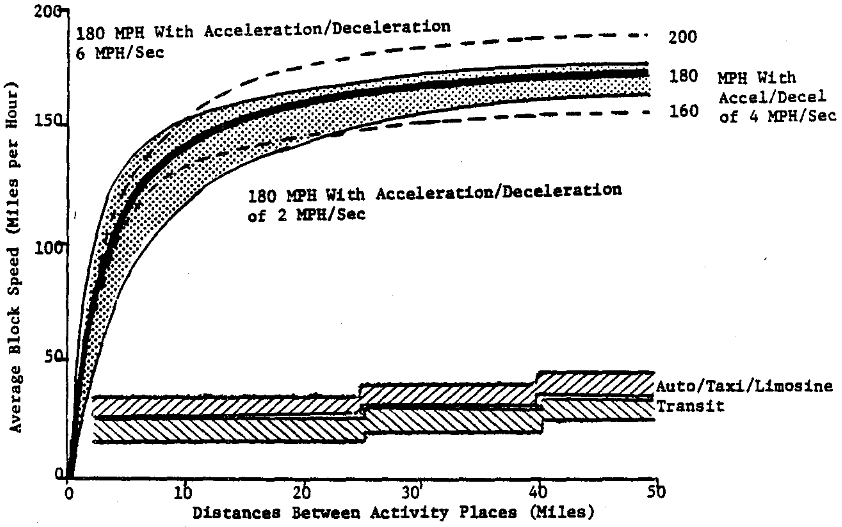
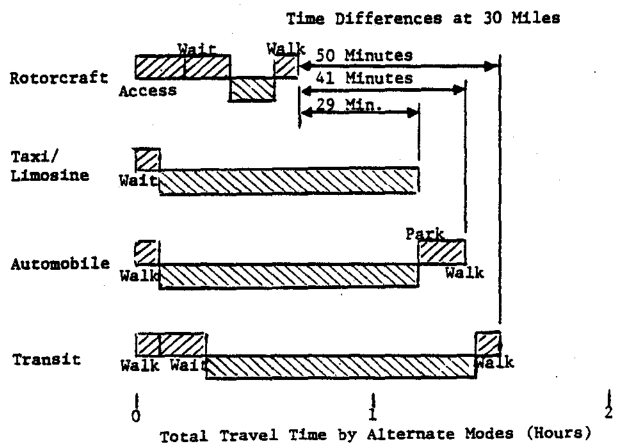
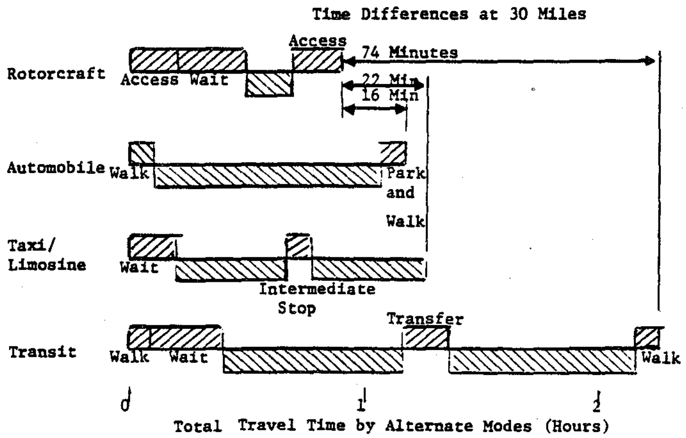


Figure VI-10. Current and Future Technology

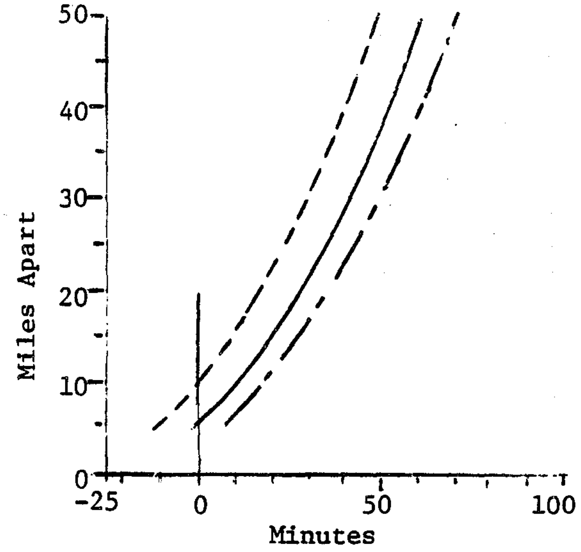


(a) Central Business District to the Airport

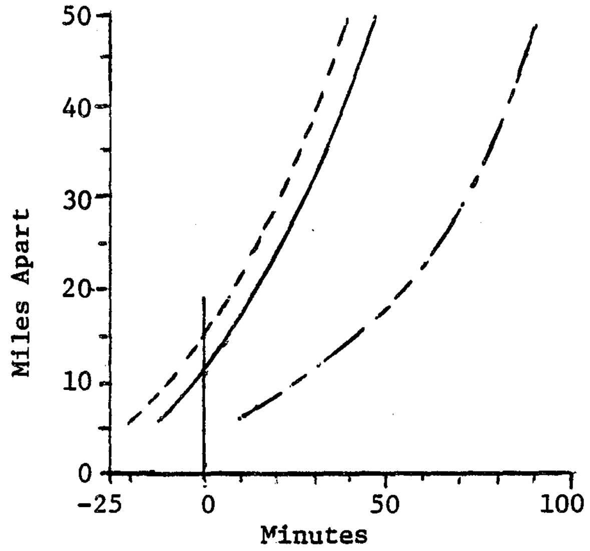


(b) Suburban Activity Center to Suburban Activity Center

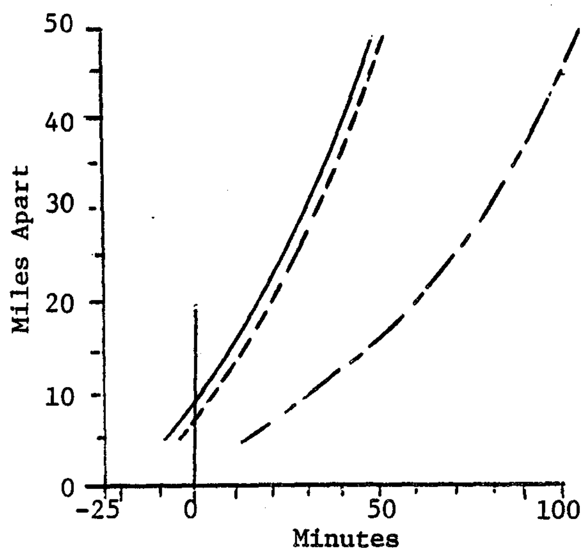
Figure VI-11



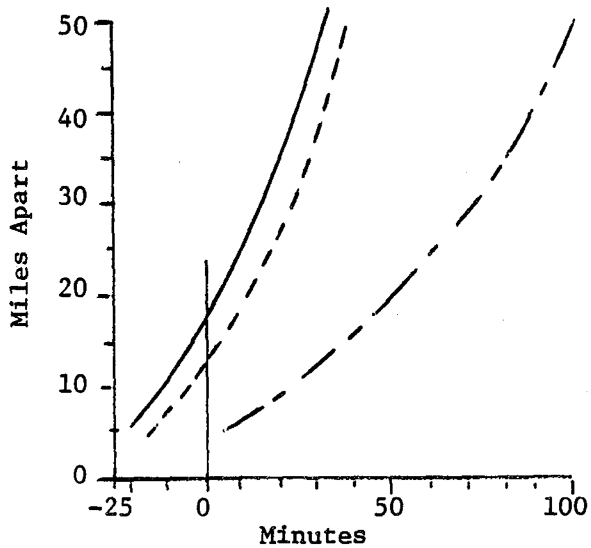
(a) CBD to Airport



(b) CBD to Suburban Activity Center



(c) Suburban Activity Center to Airport



(d) Suburban Activity Center to Suburban Activity Center

——— Automobile

- - - - Taxi

—— - —Transit

Figure VI-12. Time Difference Charts

These graphs and cross over points give a general indication of the minimum spacing between heliports to have an effective Community Rotorcraft System for the assumptions and scenarios considered, i.e.; about 10 miles between CBD and airport and CBD and suburb, and 15 miles between suburb to suburb. If one were to tie together a network of two or three suburban activity centers ringed around the CBD at these distances, such a system would probably correspond to an urban area covering 300 to 400 square miles. Typically, population densities would be about one million people or more. In order to have a system serving many activity centers, the urban area would probably have to be substantially larger than one million people.

VII. HELIPORT PLANNING GUIDELINES

According to the 1981 Directory of Heliports (Published by Aerospace Industries Association of America and Aviation Week and Space Technology), there are 3,985 heliports in the United States, Canada and Puerto Rico. This is a 16% increase over the 1977 total. However, of the current total, there are only 348 public use heliports, whereas there are 3,637 heliports for private or prior permission use.

The small number of public use heliports is considered to be one of the major impediments to the growth of helicopter transportation in urban areas. This is particulary true for heliports that would be used for public transportation and by corporate helicopters.

The purpose of this section is to provide guidelines for the planning of heliports so that there will not be a lack of information in the hands of planners who may wish to consider helicopter service in their areas.

A. HELIPORT TERMINOLOGY

The foundation of, or reasons for categorizing heliports in federal, state and local regulations, lies primarily in the protection of the general public, whether as a passenger in the helicopter or a resident or worker in the structures in close proximity to the heliport.

However, there is little standardization or uniformity in types of heliports except at the federal level. Other than those heliport classifications found in the Federal Aviation Administration (FAA) Advisory Circular "A/C 150/5390-1B, Heliport Design Guide," enormous variations exist at most state and local levels. Furthermore such descriptions as "helistop" and helipad", and other nonstandard names contribute greatly to the confusion of state and local development of standardized terms. They tend to confuse heliport size or available facilities (which is an unnecessary categorization of heliports) with type of use (which is an appropriate and useful form of classification).

With respect to heliport size or available facilities, the highly descriptive term "heliport" can be used to accurately describe all of the permanent helicopter operating areas in use today. A very simple yet effective method of distinction would be:

- Heliport, with services

A helicopter operating area at which is found one or more of the following:

Refueling services

Maintenance

Helicopter storage

Operations base for commercial purposes

- <u>Heliport, without services</u>

A helicopter operating area at which none of the amenities listed for "heliport, with services" is found.

B. <u>MAJOR CLASSIFICATIONS</u>

With respect to type of use, the major classifications of the Heliport Design Guide are widely used and accepted and are described briefly below:

1. <u>Personal Use Heliport</u>

Any heliport used exclusively by the property owner, or one having legal access to the property, such as a lessee or tenant.

The size and frequency of use are occasionally dictated by state and local regulations.

2. <u>Private Use Heliport</u>

A heliport, beside being used by the owner and/or lessee, may be used by other persons through invitation by the owner and/or lessee. Generally, public service agency heliports, i.e., police, fire, etc., are classified in this category. Additionally, most hospital heliports fall in this category.

3. <u>Public-Use Heliport</u>

A heliport open to the general flying public for which prior permission and/or authorization is not required.

4. <u>Federal and Military Heliports</u>

Heliports intended for the exclusive use of the controlling agency.

One other type of helicopter operating area that is sometimes ambiguously classified and quite often confuses the lawmaker or planner is the temporary or occasional landing site. Examples of occasional landing sites are: temporary construction locations where the helicopter may be called upon to land infrequently on an irregular schedule, or a clearing beside a highway where a helicopter must land to evacuate an accident victim. Sufficient latitude must be incorporated in state and local helicopter regulations to allow for these and other legitimate uses of the helicopter on an occasional or irregular basis. The term heliport generally identifies permanent landing facilities and should not be used to describe the occasional landing site. Furthermore, temporary and/or occasional landing or operating sites should not be covered by the regulations controlling permenent heliports.

C. <u>LOCATION CRITERIA</u>

The following identifies the primary factors to be considered in the siting of a public-use heliport.

1. Demand

The helicopter is still a relatively new transportation vehicle, particularly in terms of public transportation. As a consequence the demand or need for a heliport is often difficult to assess properly. One indicator may be the growth or development of limited or private-use heliports in a particular locale inasmuch as historically corporate or private heliport growth is indicative of a developing trend for broader use of helicopters.

Other issues are:

- The number of helicopters operating with a distance of 200± miles.
- Specific activities, i.e., executive transportation, air, taxi or shuttle service, public safety.
- An expressed need or desire for alternate transportation methods.
- A metropolitan or regional airport experiencing capacity problems, both airside and streetside.
- A geographically isolated area.
- Accelerated industrial/commercial growth.

2. Airspace Considerations

Airspace considerations fall into two categories: the federal concern and responsibility regarding potential conflicts with other existing or proposed air traffic, and local concerns regarding the planned construction of high-rise buildings or other physical barriers.

- Federal

A fundamental but essential aspect of heliport siting concerns an existing or potential conflict with airplane traffic operating from nearby airports.

- Local

The proposed development surrounding or adjacent to a heliport is a significant concern. In many cases an elevated or roof-top heliport is the most appropriate in a city center environment. There is less likelihood that real estate demands will require its removal at a later date and it has fewer problems of acceptable flight patterns. There is an important exception that is quickly becoming an attractive alternate: the waterside heliport. The island of Manhattan and St. Louis have enjoyed very successful results with waterside heliports. The benefits include virtually unrestricted approach and departure paths with little potential for permanent obstructions being developed that would interfere with helicopter operations. Many cities are adjacent to rivers and other bodies of water and should consider this attractive option.

3. Transportation Interfacing

The traditional helicopter passenger does not arrive or depart on a bus, train or subway. Historically a taxicab, limousine or private automobile is used.

The interfacing of helicopters with other forms of air transportation is an entirely different issue. The shuttle concept which employs helicopters between city centers and airports is one of the most attractive options available for passenger carrying commercial helicopter operators. This aspect of helicopter transportation offers the most immediate potential in many metropolitan areas for using the helicopter in a public transportation role.

4. Surface Access

The large, capital intensive considerations required for surface transportation facilities are all but absent in the development of heliports. The surface access requirements, beyond curbside access for taxicabs, limousines and private automobiles, are minimal.

The competition for available real estate in most urban areas tends to constrain if not eliminate any possibility of ground level heliport development. Accordingly, the elevated heliport offers the greatest promise in most cities. The elevated heliport also avoids many logistical concerns with regards to surface access, assuming that reasonable streetside accomodations are provided.

5. Environmental

The facility should be sited in a location that is either currently, or soon to become, environmentally compatible. Waterfront or elevated heliports represent the most attractive approach, should either be centrally located. It is most probable that a compromise location will be selected using the best or most desirable features of both.

6. Site Availability

It is highly improbable that a municipality will sanction the consumption of potentially valuable downtown real estate for a ground level heliport for at least two reasons: (1) the potential tax revenue from a high-rise office or residential buildings that could or would occupy the site; and (2), the current requirement for federally funded aviation projects to be retained as aviation facilities for a period of twenty years, thus restricting future development potential. There are, however, highly localized situations where city center ground level space is both desirable and easily adaptable to heliport siting. Examples are railroad yards, freeways, golf courses, parks and water courses.

Because of the constant change in political as well as real estate development issues peculiar to cities, the continued operation of a particular city center heliport cannot always be assured. As a consequence, the development of interim sites is often a viable option. The need for immediate helicopter facilities can be accommodated by developing low-cost interim sites that are programmed for development for other purposes within a reasonably short period of time. At the same time concurrent planning can be underway toward a more permanent site. The key point is that interim heliports can often be established at remarkably low cost--measured in hundreds rather than thousands of dollars.

Some metropolitan areas, particularly those of large expanse, will find it advantageous to establish a primary mid-town heliport as well as smaller satellite heliports. A heliport at one or more airports serving the city may be considered a satellite heliport. Additionally, industrial sites also may be suitable candidates for heliports.

Heliports that are needed for public service, hospital or corporate use have much less demanding requirements and the costs are very low. Typically, roof-tops provide suitable heliport sites.

7. Physical Obstruction

The almost constant alteration of the physical characteristics of most metropolitan areas requires close monitoring by transportation planners and particularly by the heliport planner. For example, the construction of an obstruction sufficient in size to interrupt or curtail the operation of a heliport can be some distance from the heliport.

Buildings, overhead transmission lines, smoke stacks, cooling towers, and antennas are obvious examples of physical obstructions that may prevent the siting of a heliport or constrain the operations of existing heliports.

8. Meteorological Concerns

Wind velocity, except in the rarest of circumstances, while important, should not be an overriding factor in heliport siting. In many heliport environments, wind direction is not an important factor.

D. MECHANICS OF PROCESSING

1. Variations in Political Jurisdictions

The information as well as the suggested and/or recommended approach to regulatory processing contained in this section should be considered as typical and general guidelines. There are significant variations in both the level and extent of regulations affecting heliport development not only between state boundaries but within the subordinate political divisions within the states as well. The laws and attendant rules and regulations for heliport siting and construction are uniform only at the federal level.

The extent of involvement of a minor political subdivision such as a city or town is usually with highly centralized issues. Zoning boundaries, structural and fire codes, access road widths and drainage and curb cuts are typical of local concerns and authority levels.

The scope of regulation is generally determined by the proposed use of the heliport. Heliports classified as private use are understandably less regulated at the state and local level than the heliport intended to accommodate the general flying public.

2. Identification of Type of Heliport

The identification of the type or classification of a heliport will vary at most levels of authority below that of the federal. About fifty percent of the states assume some role in heliport regulation, as well as a number of cities and towns. It is at these levels that a significant variation exists in heliport classification.

- Public or Government Heliports

These heliports are for the exclusive use of public agencies and are undoubtedly the least difficult to process.

It is not unusual to find that regulations normally applicable to the general public are not applicable to elements of the state and other political agencies or departments.

- Private-Use Heliports

These heliports are used by businesses, corporations and private citizens. The heliports can only be used by the property owner or those having legal access to the property.

- Personal-Use Heliports

As defined at the beginning of this Section, the personal-use heliport differs from the private heliport only slightly, with many state and local requirements remaining similar if not identical to the private-use heliport.

- Public-Use Heliports

Because this heliport is available for use by the general public, the minimum safety and operating standards are usually quite high at all levels of authority. It is important to point out that those recommendations contained in the Federal Aviation Administration Advisory Circular #150/5390-1B, "Heliport Design Guide," become mandatory requirements if federal funds are used in the construction of a public-use heliport.

It remains to the advantage of the heliport developer or designer to closely approximate the minimum requirements of the federal "Heliport Design Guide," for at least the reason that state and local authorities have historically adopted regulations patterned after the recommendations found in the Guide.

Local concerns (and on occasion some state concerns) normally focus on standards and/or minimum criteria concerning affecting noise, aesthetics, zoning, building codes and fire safety. The operational aspects, such as approach and departure routes, heliport size, and lighting are usually left to the aeronautical authorities, either state, federal, or local.

The following heliport processing checklist is a useful guide but should be used with caution because of the enormous variation in minimum requirements between the state and local regulatory agencies.

3. Preliminary Heliport Assesment

(1) Prepare initial site plans, establishing site location and intended use.

(2) Acquire and examine local bylaws, codes and/or ordinances to determine probability of siting approval.

If prohibited or forbidden, determine waiver granting probability. If local approval is feasible:

(3) Prepare detailed site plans.

- For aeronautical and/or operational safety concerns, consult:

  Federal Aviation Administration

  State Aviation Agency

  Local Aviation Agency

  Helicopter Operator

  Helicopter Association International

  Helicopter Manufacturers

- For nonaviation or ground safety concerns and/or requirements consult:

  State and local building codes

  State and local fire codes

  National Fire Protection Association Manuals

- For environmental, aesthetics and other concerns, consult:

  State and Local Environmental Protection Agency
  State and Local Historical Agencies
  U. S. Army Corps of Engineers
  (If heliport is waterborne on navigable waterways)

- Detailed site plans should include:

  Location by geographical coordinates
  Size
  Marking
  Lighting
  Fencing or other restrictive barriers
  Location and type of wind direction indicator
  Location and type of shelter
  Location, type and capacity of firefighting equipment
  Location of emergency exits (if elevated)
  Helicopter approach and departure paths
  Structural considerations (if elevated)
  Other requirements as directed by affected agencies

NOTE: Proper and thorough planning and preparation is key to achieving problem-free regulatory agency processing. It is absolutely essential that heliport planners identify the regulatory agencies involved and become familiar with the specific requirements of the agency.

4. Processing of Applications

Prior to submitting applications, it is sometimes possible to request a preliminary review of the proposed heliport site from the federal, state and, if one exists, local controlling agencies. Although it is not a common practice of these agencies to do site evaluations prior to the heliport proponent submitting the notification or application forms, on occasions one or more of the agencies will often accommodate this request. (It should be mentioned that most of these agencies have a dual role or obligation of the promotion as well as the regulation of aviation.)

- Obtain approval. In most cases, it is desirable that local (zoning and/or planning boards) approval be in hand prior to submitting federal and state aeronautical applications.

- Prepare and submit Federal Aviation Administrative form 7480-1, "Notice of Proposed Construction."

- Prepare and submit state and local aviation agency forms (as appropriate).

- If heliport is mounted on a structure, detailed construction plans should be submitted to zoning, planning board, or local building authorities as applicable.

- For floating heliports on navigable waterways, prepare U.S. Army Corps of Engineers application.

5. General Requirements

Usually maps, sketches, drawings and sometimes photographs of the proposed site are required when submitting applications or notification forms. Drawings, plans and other renditions of the proposed site should be carefully prepared so as to portray the site exactly as planned. Current aerial photographs, enlarged sufficiently to show the detail required, although not specifically requested, should accompany all application submissions. The photograph should depict the proposed flight routes to and from the heliport as well as any schools, auditoriums or locations at which large numbers of people congregate. The distance from these locations to the proposed site should also be indicated. It is strongly recommended that no major capital expense be made until all approvals are received from the agencies involved.

Additionally, should the proposed heliport be programmed for use by a government agency other than a regulatory agency, as in the case of a hospital heliport used by local or state police helicopter ambulances, written approval of the site should be on hand from the using agency prior to a capital expense commitment. Although not a common requirement, in some instances notification of local neighborhood or citizen groups or committees is sometimes required by the proponent. Usually the responsibility to notify these groups is with the public agency, not with the heliport proponent. Wherever the responsibilities lie, it is usually in the best interest of the proponent to insure the citizen group is aware of the proposal and understands the entire scope of the proposed operation.

E. REGULATORY PERSPECTIVES

This section will provide an overview of the regulatory environment for all aviation transportation planning in general. However, emphasis is placed on those specific agencies, laws and regulations that affect heliport development planning in particular.

1. Federal Authorities

The United States Department of Transportation is the cabinet level office charged with developing national transportation systems and conducting research programs to advance safety in transport.

These functions are administered by various agencies within the Department of Transportation that deal directly with specific transportation systems such as highways, railroads, waterways, urban mass transit and air.

The DOT agency charged with the responsibility of promoting, developing and regulating civil air commerce and aviation in the United States is the Federal Aviation Administration (FAA). The FAA promotes and regulates air safety and governs use of federal airspace. An additional role of the FAA is the certification of aircraft and pilots.

The FAA also supervises the publication of aeronautical charts, instructional materials and reports, including Advisory Circulars (ACs).

As initial points of contact for the heliport planner, the FAA has Regional Offices located throughout the country. Each Regional Office, in turn, maintains Airport District (or Field) Offices, known as ADOs and General Aviation District Offices, known as GADOs, throughout its geographical area of responsibility. These offices serve as the "grass roots" level interface of the FAA with the local aviation community, airport and heliport proponents and the general public.

General Aviation District Offices conduct air safety programs relating to certification, insepction and surveillance of general aviation operators, agencies and related airmen; aircraft airworthiness; air taxi operators; aerial applicators and rotor-craft external load operators; and conduct inspections of general aviation flight operations and maintenance to assure compliance with safety requirements.

2. Federal Laws and Regulations

The U.S. Department of Transportation was established by the Department of Transportation Act of 1966 which was enacted on October 15th of that year as Public Law 89-670 under Title 49 United States Code (USC) - Transportation, which forms the statutory basis for all U. S. law relating to transportation. This act, among other things, specifically transferred the functions, powers and duties of the old Federal Aviation Agency, which had been an independant agency since 1958, to the Secretary of Transportation and created the Federal Aviation Administration within the DOT to handle them.

The FAA receives its statutory charter from the Federal Aviation Act of 1958, enacted on August 23, 1958 as Public Law 85-726. It establishes the legal basis for the Federal Aviation Regulations (FARs) which are codified under Title 14 Code of Federal Regulations (CFR) - Aeronautics and Space, Chapter I, parts 0 - 199. FAR Part 157 is of particular interest to heliport planners as it deals with the requirement for notice of construction and activation of airports (and heliports) to the FAA.

The FAA's series of Advisory Circulars (AC) are, as the name implies, only advisory in nature. Unless incorporated into a regulation by reference, the contents of an Advisory Circular are not binding on the public. However, since the ACs are issued by the federal government in a numbered-subject system corresponding to the subject areas of the Federal Aviation Regulations, the tendency is to accept their contents as relatively binding guidelines.

Another piece of federal legislation that has had a significant effect on airport planning is the Airport and Airway Development Act of 1970 (Public Law 91-258). The FAA developed and implemented the Airport Development Aid Program, known as ADAP, to carry out the provisions of that act which authorized grants of federal funds to sponsors of airport development in order to bring about the establishment of a nationwide system of public airports adequate to meet the present and future needs of civil aeronautics. The statutory definition of "airports" includes heliports. Thus, heliports are eligible for federal funding under ADAP.

3. State Authorities

Most states have a department of transportation analogous to the federal DOT in function, organization and scope to manage state transportation systems and to levy various taxes related to transportation in order to provide funding for their programs. The state DOTs also serve as an interface with the federal DOT to coordinate and administer joint funding of transportation projects.

As a general rule, those states with a DOT have some form of aviation division within that organization similar to the FAA in function on the state level, but usually to a far less degree of complexity; some states have a staff of only two or three persons.

In other cases, a state will have an independant aeronautics commission comprised of board members associated in some way with the aviation industry that meets regularly to establish policy and to give direction to the state's aviation programs. Heliport planners should always contact the appropriate state aviation agency, if there is one, for information and assistance.

4. State Laws and Regulations

The "supremacy clause" in the Constitution of the United States states that the "Constitution and the laws of the United States ...... shall be the supreme law of the land." Aviation is so much under federal regulation that we tend to see federal law as always supreme, thereby preemptive over state law. Indeed, some federal law regarding aviation does take precedence over state law, such as in regulating air carriers (in interstate commerce), aircraft ownership and supersonic flight over the United States. However, the Constitution also specifically declares that all rights not held by the federal government shall revert to the various states. States' rights are jealously guarded by the states on the premise that a local government is closer to the people governed and more in touch with their needs. Naturally, each state has its own set of laws or code, most with a specific section or title dealing with transportation in the general code, or with a separate, distinct law for transportation matters. Some states even have specific laws for aeronautics alone. These laws usually have some sort of provision for the creation and authority of an aeronautics commission or other agency to administer the state's aviation programs and also provide the statutory basis for the state aviation rules and regulations, if there are any.

About three-fifths of the states rely wholly on the Federal Aviation Regulations to enforce their own laws as well, which are usually so structured as to correspond to the Federal Aviation Act of 1958 more or less exactly. This further tends to foster the impression the FARs are supreme, as discussed earlier. The other two-fifths of the states do have their own aviation regulations. Some are highly structured, but most seem to be fairly flexible and are imposed more in the interest of promoting aviation and safety.

Most states also have some form of an Airport System Plan for the systematic development of aviation and airports within the state. Some such plans even have provision for state funding, either in whole or in part, for aviation facility development. Generally, however, the word "heliport" does not even appear in these documents. The supposition that the term "aviation facility" includes heliports is usually left to the interpretation of the state officials concerned. Autonomy is at the state level, in any case, for it is there that the applications and planning for "aviation facilities" begins.

Some state aviation agencies publish information booklets, much in the same way the FAA publishes its Advisory Circulars. These publications are also non-regulatory in nature and are issued to inform the public of state standards either directly or peripherally related to aviation planning or serve to acquaint the planner with some unique condition found within that state. A good example of this is the Louisiana Office of Aviation and Public Transportation's information publication entitled "Off-shore Heliport Design Guide" (No. OAPT 5100), which is a reflection of that state's heavy involvement in offshore oil exploration.

5. Local Authorities

Transportation planners will ultimately find themselves working in a specific local area. Generally, to be most effective, proposed heliports will have to be located in an urban or industrial environment where stiff competition for land use is the rule and population density is high. Planners should be aware of the various forms of local authority having jurisdiction over any given area and should take them into consideration when formulating a plan of action for heliport approval. Often, the local authorities can be a source of assistance and encouragement. Planners should keep in mind that more often local officials will not be helicopter oriented and will probably have many preconceived notions, usually erroneous, about heliports and helicopter operations.

Most likely, there will be a zoning agency having jurisdiction at the county, township or municipal level on land use for the area in which a heliport proposal is made. Other local agencies that may have an influence on heliport plans include, but are not limited to, the transportation section of the regional planning commission, the county commissioners, or the township board of trustees. Municipal councils or similar governing bodies as well as civic planning departments, community or economic development departments, public safety departments (police, fire, etc.), building commissions, port authorities, municipal airport or aviation divisions, local environmental protection agencies, and even historical preservation commissions or societies should be taken into consideration. Additionally, the good auspices of the local chamber of commerce and the various civic associations and service clubs can be very helpful in gaining community approval for a heliport.

6. Local Laws and Regulations

Planners should keep in mind that state and/or federal approval of a heliport proposal does not preempt local laws or zoning restrictions. Primarily, the state and federal approval process is based on aeronautical and safety considerations only. Local laws and regulations, when applied to aviation facilities, are more concerned with land use, environmental protection, and other "quality of life" considerations that have a direct effect on the local citizenry.

Generally, gaining local approval for a heliport proposal will be the most difficult aspect of the entire project. Heliport planners should be thoroughly familiar with all applicable laws and regulations. Zoning laws and ordinances, and requirements and procedures for obtaining variances will usually be of primary concern. Local environmental protection standards, particularly those relating to aural pollution or noise control, but also air and water quality and even visual or aesthetic quality preservation, may be applied to the approval process. In the case of rooftop heliports, local building codes will have requirements for structural loading, access routes, wiring, and plumbing. In all cases, compliance with public safety regulations, chiefly for fire protection, will have to be planned for.

Some cities may have airport and even heliport establishment regulations. Another regulatory aspect to possibly consider is the existence of historic building or site and "community character" preservation laws.

7. Non-Regulatory Associations

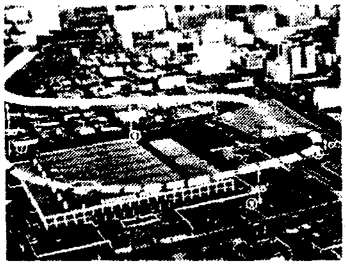
There are a number of national and regional organizations that have an interest in and an influence on aviation and heliport development, and can provide information and assistance to transportation planners. They are non-regulatory in nature but have developed standards and technical criteria that are often incorporated by reference into laws, ordinances, regulations, administrative orders and other similar instruments.

The National Fire Protection Association (NFPA) is one such organization whose published standards have had a significant impact on building codes in general and on heliport fire protection in particular. The NFPA was organized to promote the science and improve the methods of fire protection and prevention; to obtain and circulate information on those subjects; and to secure the cooperation of the public in establishing proper safeguards against loss of life and property to fire.

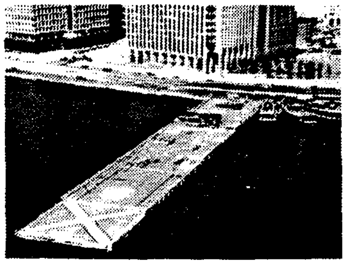
There are other national associations related to the aviation and helicopter industries that can be a valuable source of information and assistance to the heliport planner. Chief among them are the Helicopter Association International (HAI), the American Helicopter Society (AHS), the Aerospace Industries Association of America (AIA) and the National Business Aircraft Association (NBAA), all headquartered in Washington, D.C.

Helicopter pilots in various states and regions of the country have formed professional associations. The members of these associations have specific knowledge of the heliport situation in their respective areas and what needs to be done in the way of further heliport development. These pilots can usually be counted on to lend enthusiastic support and expertise to heliport planning activities.

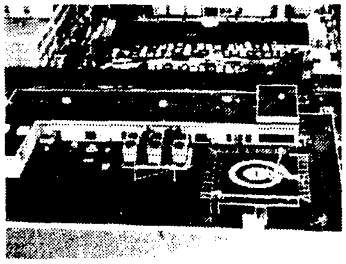
The Helicopter Association International, in cooperation with several other helicopter-oriented, organizations, has entered into a cooperative program with the American Planning Association (APA) to stimulate heliport planning and assist planners at the local level in relation to heliport development.



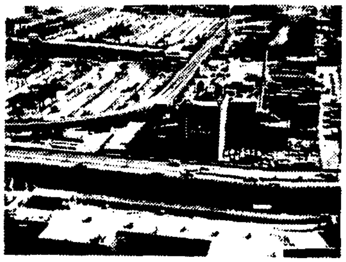
CONVENTION CENTER
LOS ANGELES



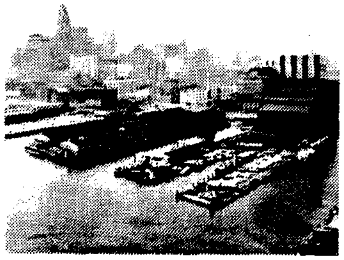
WALL STREET
NEW YORK



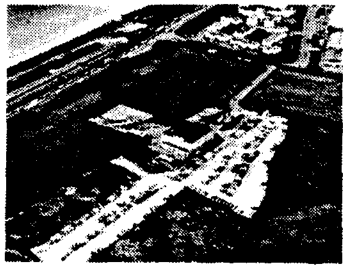
FIRST PENNSYLVANIA BANK



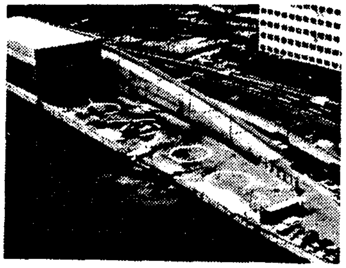
THIRTIETH STREET
NEW YORK



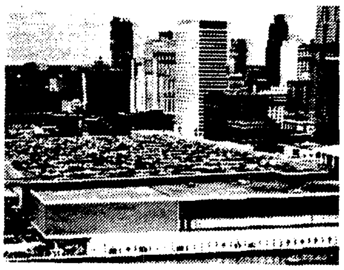
PIER NO. 4
BALTIMORE



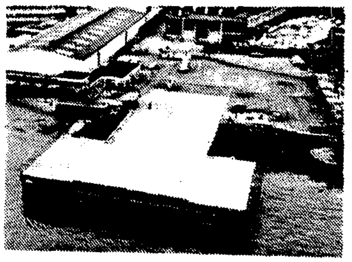
PENZANCE HELIPORT
PENZANCE, U.K.



SIXTIETH STREET
NEW YORK



COBO HALL
DETROIT



BATTERSEA HELIPORT
LONDON, U.K.

EXAMPLES OF DIFFERENT TYPES OF HELIPORTS

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. ROTORCRAFT TECHNOLOGY

Civil rotorcraft technology advances in the 1980's and 1990's will be directed toward the following major objectives:

- Safe and quiet operation from small city-center heliports.
- Increased productivity, from higher speed and greater useful load.
- Reduced fuel consumption and costs of operation.
- Improved ride comfort.
- Increased reliability.
- Enhanced capability to operate routinely in bad weather and congested terminal areas without conflict with and in discrete operations from fixed-wing air traffic.

The primary technology thrusts that will enable achievement of these objectives are: extensive use of composite materials, advanced cockpits with simplified controls and computerized flight aids, low drag fuselages matched with aerodynamically optimized rotors, high speed concepts such as the compound helicopter, Advancing Blade Concept (ABC), tilt rotor, X-Wing, and advanced avionics.

The compound helicopter has a wing and an auxiliary propulsion to unload the rotor and provide speed capability up to 250 knots. The ABC has two stiff, coaxial rotors that provide lift without stalling at high speed, so no wing is required to cruise up to 300 knots. The tilt rotor is capable of approaching helicopter performance at low speeds and aircraft performance at speeds up to about 350 knots. In the X-Wing concept, the 4-bladed rotor is stopped in cruise to form an X-shaped wing, and rotor limitations to high speed are removed.

Future high speed, multi-engine rotorcraft will have installed power margins enabling them to hover with an engine inoperative. This will enhance safety and reduce heliport real estate requirements by allowing steeper approach and departure gradients and by eliminating the need for large clearway space to accommodate emergency roll-on landings.

Modern rotorcraft with moderate tip speeds are much quieter than earlier helicopter models. Advanced blade tip geometry and the steeper approach and departure gradients made possible by high installed power margins will reduce the noise footprint of future rotorcraft still further. With formulation of realistic noise standards, this will permit even very large rotorcraft to operate directly into city centers.

Cabin comfort of future rotorcraft will compare with modern airliner standards. Quieter transmissions and more efficient soundproofing will reduce internal noise. Structural tuning and advanced concepts such as higher harmonic blade pitch control will reduce vibration. Automated trim and stabilization systems will minimize fuselage attitude variation and gust sensitivity.

Advanced cockpits with improved pilot visibility, simplified controls, and automated flight aids including CRT's and voice interactive systems will permit dependable operation in bad weather, and routine take-offs and landings from confined downtown areas in congested airspace. Combined with appropriate changes to current air traffic control regulations and procedures, this will enable rotorcraft to realize their potential for relieving airport and urban traffic congestion.

Fuel consumption will be reduced by improvements in weight and drag, by optimization of rotor blade geometry, by trim control and flight path management made possible with advanced avionics and flight controls, and by development of lightweight, fuel-efficient gas turbine engines. For the higher speed concepts using auxiliary propulsion, advantage will be taken of the highly efficient propellers and fans being developed for small to medium-sized fixed wing transports. It is anticipated that by the year 2000, rotorcraft passenger-miles per gallon of fuel will be improved 50 to 75 percent.

Order-of-magnitude improvement in subsystem reliabilities will result from increasing use of solid state electronics, elastomerics, and composites, and by reduced vibration. Corresponding reductions in maintenance burden of about 40 percent will contribute to substantial savings in operating cost.

There are virtually no technological constraints to the size of future rotorcraft; maximum payload and range capabilities will be driven instead by the requirements of the marketplace. It is anticipated that payloads of up to 100 passengers and ranges of up to 600 miles will be available in rotorcraft of the 1990's. Higher speed rotorcraft using the ABC, tilt rotor, or X-Wing concept will probably be somewhat smaller to satisfy the kind of missions for which speed itself, rather than payload or productivity, is paramount, such as for emergency medical service or search and rescue.

B. NOISE

Noise footprints for helicopters are considerably smaller than for airplanes. However, typically the helicopter flies closer to people and buildings.

Helicopter noise has been a problem because:

- It has a unique sound
- The noise source is often close to people and buildings

Special flight patterns and steep approaches can reduce noise exposure in sensitive areas.

The noise measurement standard correctly favored for helicopter certifications is the effective perceived noise level (EBNdB); the standard correctly favored for environmental measurements is the noise level corrected for daytime/nighttime events (L_{dn}).

The main sources of helicopters are: main rotor, tail rotor, and power plant.

Helicopter manufacturers have made significant strides in reducing both internal and external noise. This is expected to continue in the future.

C. SAFETY

The safety of helicopter passenger transportation has improved substantially over the past decade. It varies with category of flying, but in general is comparable to the safety of airplanes.

The primary reasons for the improvement , which are also the major areas of focus for improvement in the future, are:

- Increased use of turbine engines--more reliable
- Increased use of two (or more) engines
- Improved maintenance
- Improved flight controls
- Improved aerodynamics
- Better crew comfort--less fatigue
- Increased maturity of industry
- Increased instrument (all-weather) flying capability

Other future trends that will impact safety are:

- Flight training with simulators
- Computer assisted design analysis
- New materials

D. OPPORTUNITIES AND BENEFITS

The following material summarizes the more important helicopter applications where benefits are being derived and can be derived in six categories of environments. Figure V-3 provides this information in chart form.

1. Urban Area

The urban area has a significant diversity of helicopter opportunities. There is a potential for a high level of flying activity in: public transportation, private transportation, public service and as a tool of production.

A promising opportunity in the near future for a high level of public transportation is in flights between densely populated areas and their airports.

In private flying (mostly corporate), a high level of activity is possible in flights that involve inter-company contacts and communications.

Many of the needs for helicopters in public service are accentuated in the city. This is particularly true for fires in high rise buildings and for emergency medical transportation--because of congested ground traffic.

The use of the helicopter for traffic reporting and TV news reporting has grown in many parts of the country. The use of the helicopter as a crane has not been extensively used, but on many occasions it can be the most cost effective means of doing the job.

2. Small Community

Under the right circumstances (in the relationship and location between small communities and densely populated areas), there would be a potential need for helicopter public transportation, both scheduled and charter. Another opportunity area for helicopters is in private (mainly corporate) flying--but this is mostly influenced by the needs and desires of corporations in selecting communities where they would like to locate their headquarters or plants.

3. Rural

The opportunities and benefits in rural areas are mainly in public service applications and as a tool of production.

Search and rescue, wildlife management and disaster relief are principal public service opportunities.

As a tool of production the helicopter has already grown rapidly in the agricultural work of spraying and seeding. However, the laying of power lines and poles and the performing of aerial surveys is also done and has growth potential.

4. Remote Area

The remote area is very similar to the rural area in the general categories of opportunities (public service, and tool of production).

Furthermore, remote areas are vulnerable to disasters and they often have an urgent need for aerial services.

The logging work performed by helicopters in several remote areas of the Northwest has grown surprisingly and may have potential for substantial expansion.

5. Airport

The airport is the most natural environment for helicopters and most helicopter operations are based at airports at this time.

Flights between cities and their airports offer an important potential for helicopter growth. Flying to and from airports is one of the most frequent types of trip for private (corporate) helicopters. This can be expected to continue to be true in the future.

6. Ocean Area

The expanding helicopter operations to offshore oil rigs over the past 10 years has accounted for an important percentage of the production of civil helicopters during that period. The speed of helicopter transport exceeds boat travel by a large margin. As a consequence, the ability to transport work crews efficiently and to move urgent cargo quickly has been an important contributor to the efficiency of oil exploration and oil recovery.

Rescue operations are the other principal contributor of helicopters in the ocean area. While these incidents do not occur frequently, they are important and helicopter rescue efforts can save many lives.

E. HELIPORT PLANNING

In planning a heliport the following factors should be considered with respect to heliport location:

- Demand
- Airspace requirements
- Surface access
- Environmental considerations
- Availability of space
- Physical obstructions
- Meteorology and Climatology

The distinctions between the following types of heliports are significant:

- Public-use heliports
- Private-use heliports
- Personal-use heliports
- Government heliports
- Occasional landing sites.

In planning for heliports and helicopter use, it is essential that the division of authority between the various levels of government be thoroughly understood. Also, direct contacts and communications with people at these levels should be established early in the planning process.

F. SPECIFIC RECOMMENDATIONS FOR PLANNERS

Commercial helicopters provide an excellent source of helicopters for many emergencies such as fires and rescue missions. Generally, helicopter operators willingly cooperate in such emergencies. Their support can be significantly improved if many small, inexpensive heliports are established at the proper locations, such as at the top of high rise buildings.

In many cities the availability of at least one well equipped public-use heliport would encourage helicopter operations by corporations, charter operators and possibly scheduled operators.

National disasters do not occur frequently, but rescue work in most of them would be considerably improved if helicopters were available. Contingency plans should be established that make arrangements with operators for such support.

G. SPECIFIC RECOMMENDATIONS FOR MANUFACTURERS AND RESEARCHERS

The growth in airline transportation was directly related to the extent to which the aircraft could operate reliably most of the time. This infers the ability to operate safely in most weather conditions. Today, the airlines operate with very high reliability and they use a complex system of navigation aids and communications at the terminal airports to do so.

The problem is more complicated for the helicopter because, instead of having a few large centralized landing sites, it has an almost infinite selection of small sites. Furthermore, only a few large city heliports can afford instrument landing systems (or microwave landing systems).

The offshore helicopter operators have developed a concept that offers potential to solve this problem, namely more of the landing system should be located in the aircraft and less (or none) at the landing site. The satellite based NAVSTAR GPS very well may be the fundamental answer to this question.

Some new sensors are needed, such as a low-speed omnidirectional speed indicator. Also, a highly accurate navigation system may be needed in some situations -- perhaps radar using corner reflectors, forward looking infrared (FLIR) or a differential GPS monitor. Some inexpensive system is needed to probe the ground characteristics prior to the final hover-descent from 100 feet or so in altitude. This is particularly important if the landing is at an unplanned and remote destination. Even here, the technical problem in developing such a sensor can be solved. It would appear that the data for such a sensor can be derived from a system as simple as the radio altimeter.

The emphasis placed in these recommendations stems from the realization that major increases in helicopter use will take place when the helicopter on a constantly expanding basis can do under IMC (instrument meteorological conditions) what it can now do under VMC (visual meteorological conditions). It therefore appears that emphasis in development work that will solve that need is warranted.

H. FINAL RECOMMENDATIONS

This study has pointed out that many actions and developments are underway which will increase the viability of the helicopter (rotorcraft) as a transportation tool in the years ahead. However, the planner must not wait for all these advancements to take place before he plans for community heliports. The current generation of helicopters provides many community benefits and opportunities. Thus, the planner should provide now for heliport programming, not only to take advantage of the current generation helicopters, but also at the same time, to anticipate the enhancements which can be derived from future generation helicopters and plan accordingly.

APPENDIX A

ANALYSIS PROCESS USED IN ASSESSING OPPORTUNIITES AND BENEFITS

The discussion of opportunities and benefits in the basic HAI report focuses on the results and conclusions that were reached. It does not provide details on the manner in which various scenarios were analyzed and how the results of those analyses were used. The purpose of this section is to provide some of the details relating to how the analyses of scenarios were conducted.

The initial assessment consisted of identifying all meaningful helicopter applications -- in terms of this study. This came to 10 categories and 55 individual applications (see Figure A-1). The next step was to make preliminary judgmental estimates of the benefits that would be derived from each of the 55 applications in each of the operating environments. This was done by a group of six people, experienced in fields related to helicopter operations and community planning. The tabulations shown in Figure A-1 show the results of those estimates.

With this material in hand, 24 specific cases were singled out for more detailed analysis. The criteria for this selection was simply to pick the most promising applications in which helicopters are being or can be used. The ones selected are identified on Figure A-1 by a circled letter.

Next, a process was devised to evaluate the benefits and costs of each of the selected helicopter uses and to make a comparison (whenever possible) with the accomplishment of the same transportation application by other candidate vehicles. This process is shown in Figure A-2. It involves the description of a scenario, the determination of criteria and weighing factors and the comparative assessment of each candidate vehicle. It is important to note that these assessments were made by a group of experts in helicopter/ community planning and related fields. This process was devised as a means of focusing diverse expert opinion on the analyses in a way that would permit a review of many scenarios within the limited resources available.

CODE

Benefits

E. Economic
Q. Community/Segment Quality of Life
S. Improved Relative Safety
I. Interface with Other Transportation
F. Fuel Conservation
U. Unique Service

	INTRA CBD	CBD TO & FRO	INTRA SUBURBS	SUBURBS TO & FRO	AIRPORT TO & FRO	SMALL COMMUNITY TO & FRO	INTRA RURAL REMOTE AREA	RURAL/REMOTE AREA TO & FRO	TOPOGRAPHICALLY CONSTRAINED	OCEAN AREA
1. PUBLIC SERVICE										
a. Law Enforcement										
• Drug		EQ					EQ	EQ	EQU	EQU
• Security/Surveillance	EQU	EQU	EQU	EQU	EQU	EQU				
• Search			EU	EU			EQU (a.)	EQU	EQU	
• Patrol/Observation	EU	EU					EU	EU		
• Pursuit	EU	EU		EU		EU	EU	EU		
• Command Post/Crowd Control	EU	EU								
• Pollution Control										EQFU
• Transport (people)	E	E	E	E	E	E	E	E	E	
b. Public Safety										
• Ambulance	ES (b)	ES		ES		ES				
• Fire Rescue/Fighting	ESU (c)						ESU	ESU	ESU	ESU
• Search (lost people)							ESU	ESU	ESU	ESU
• Water Area Patrol										ESU
• Traffic	EU	EU								
c. Disaster Warning/Relief/Rescue										
• Flood	EST	ESU				ESU (d.)	ESU	ESU	ESU	
• Frost/Freeze/Snow						ESU	ESU	ESU (e)	ESU	
• Large Scale Mountain Timber Fires							ESU	ESU (f)	ESU	
• Shipwreck										ESU
• Other: Hurricane, Tornado, Earthquake, Landslide, Avalanche, Drought, Volcano	ESU	ESU	ESU	ESU	ESU	ESU	ESU	ESU	ESU	

Figure A-1. Applications Matrix

CODE

Benefits

- E. Economic
- Q. Community/Segment Quality of Life
- S. Improved Relative Safety
- I. Interface with Other Transportation
- F. Fuel Conservation
- U. Unique Service

	INTRA CBD	CBD TO & FRO	INTRA SUBURBS	SUBURBS TO & FRO	AIRPORT TO & FRO	SMALL COMMUNITY TO & FRO	INTRA RURAL REMOTE AREA	RURAL/REMOTE AREA TO & FRO	TOPOGRAPHICALLY CONSTRAINED	OCEAN AREA
1. PUBLIC SERVICE (cont.)										
d. Search & Rescue										
• Mountain							ESU	ESU (g)	ESU	
• Ocean										ESU
• Aircraft Accidents							ESU	ESU	ESU	
e. Wildlife Management										
• Animals/Fish							ESU	ESU	ESU	ESU
f. Environmental Surveys										
• Fish/Oil/Dams							ESU	ESU	ESU	ESU
g. Environmental Transport										
• Poles/Wires/Pipe/ Construction							ESU	ESU	ESU	
• Transport (people)							ESU	ESU	ESU	ESU
2. PUBLIC TRANSPORTATION										
a. Scheduled										
• Large		EQI (h)								
• Medium/Small	EQI (i)	EQI (j)		EQI	EQI (k)				EQI	
b. Non-scheduled										
• Large/Medium		EQI (l)			EQI	EQI			EQ (m)	
• Small (Air Taxi)	EQI	EQI		EQI	EQI	EQI		EQI	EQI	
3. CORPORATE/EXECUTIVE TRANSPORTATION										
a. Part 91										
• People	EQIU	EQUI (n)	EQIU	EQIU (o)	EQIU (p)	EQIU	EQIU	EQIU	EQIU	EQIU
• Cargo/Mail	EQIU	EQIU	EQIU	EQIU	EQIU	EQIU	EQIU	EQIU	EQIU	EQIU

Figure A-1. Applications Matrix (Continued)

CODE

Benefits

E. Economic
Q. Community/Segment Quality of Life
S. Improved Relative Safety
I. Interface with Other Transportation
F. Fuel Conservation
U. Unique Service

	INTRA CBD	CBD TO & FRO	INTRA SUBURBS	SUBURBS TO & FRO	AIRPORT TO & FRO	SMALL COMMUNITY TO & FRO	INTRA RURAL REMOTE AREA	RURAL/REMOTE AREA TO & FRO	TOPOGRAPHICALLY CONSTRAINED	OCEAN AREA
4. ENERGY EXPLORATION/PRODUCTION										
a. Offshore Support										EUF (q.)
b. Pipeline Laying							EUF	EUF	EUF	
c. Powerline Laying							EUF (r.)	EUF	EUF	
d. Aerial Surveys								EF	EF	
5. CONSTRUCTION										
a. Crane	EU (s.)	EU	EU		EU		EU	EU	EU	
b. Cargo	EU	EU	EU		EU		EU	EU	EU	
c. Wire Stringing				EU						
d. Pole Laying				EU (t.)						
6. CARGO										
a. External Lift	EU	EU							EU	EU (u.)
b. Internal Lift	EU	EU							EU	EU
7. AGRICULTURE/FORESTRY										
a. Spraying						EUQ	EUQ (v.)	EUQ	EUQ	
b. Seeding						EUQ	EUQ	EUQ	EUQ	
c. Logging						EUQ	EUQ w.	EUQ	EUQ	
d. Surveys						EUQ	EUQ	EUQ	EUQ	
8. OTHER BUSINESS/COMMERCIAL										
a. Bank Record Transfer	EU	EU								
b. TV Reporting	EU (x.)	EU	EU	EU	EU					
c. Photography	EUQ	EUQ	EUQ	EUQ	EUQ	EUQ (y.)				
d. Advertising	E	E	E	E		E				
e. Real Estate Evaluation	EU	EU		EU	EU	EU		EU	EU	
f. Sight Seeing	EUQ		EUQ			EUQ				
g. Mapping							E	E	E	

Figure A-1. Applications Matrix (Continued)

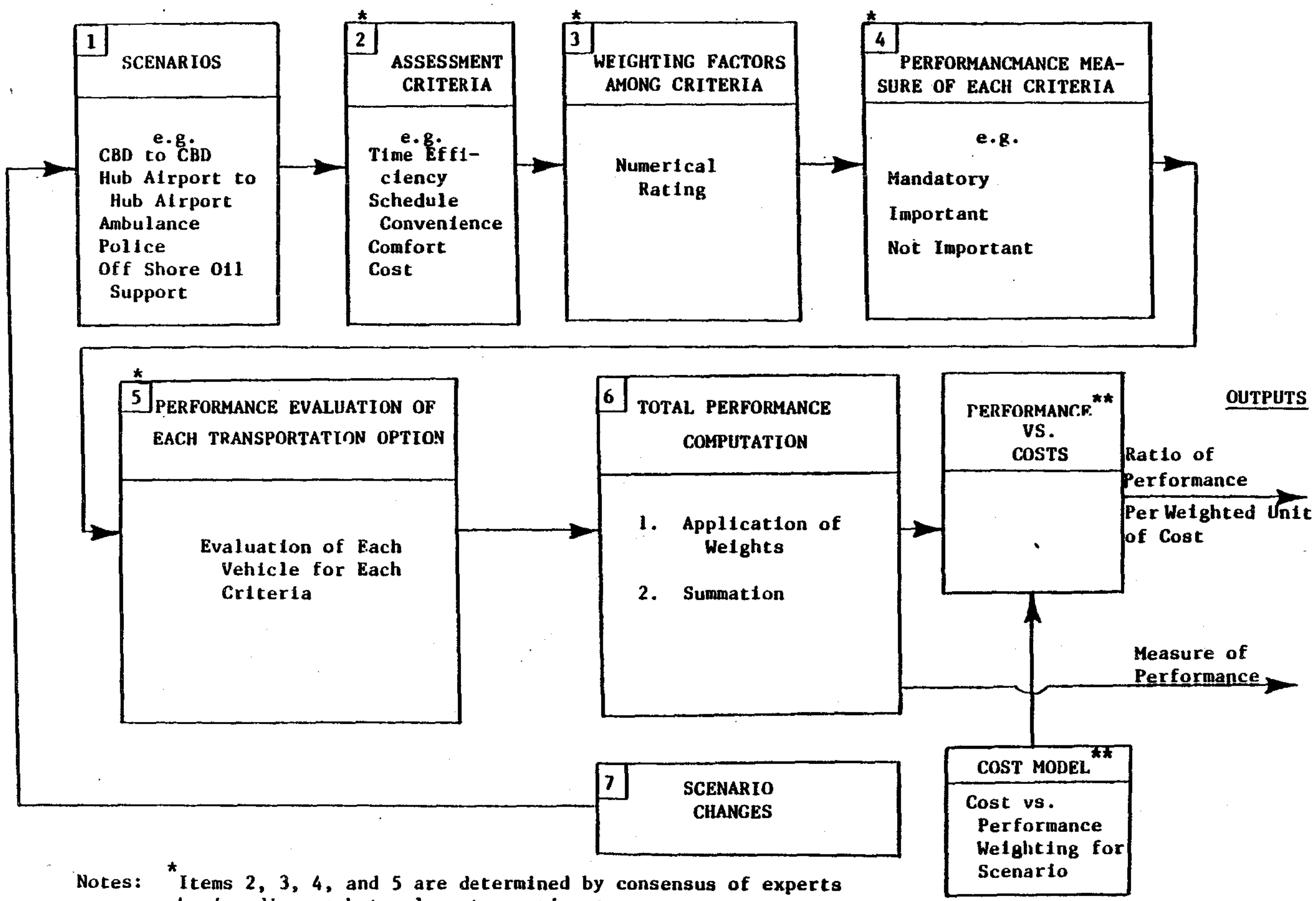
CODE

Benefits

E. Economic
Q. Community/Segment Quality of Life
S. Improved Relative Safety
I. Interface with Other Transportation
F. Fuel Conservation
U. Unique Service

	INTRA CBD	CBD TO & FRO	INTRA SUBURBS	SUBURBS TO & FRO	AIRPORT TO & FRO	SMALL COMMUNITY TO & FRO	INTRA RURAL REMOTE AREA	RURAL/REMOTE AREA TO & FRO	TOPOGRAPHICALLY CONSTRAINED	OCEAN AREA
9. FLIGHT TRAINING	E	E	E	E	E	E		E		
10. PERSONAL USE	EQ	EQ	EQ	EQ	EQ	EQ		EQ	EQ	

Figure A-1. Applications Matrix (Concluded)



Notes: *Items 2, 3, 4, and 5 are determined by consensus of experts having diverse but relevant experience.
** Cost model used where relevant.

Figure A-2. Evaluation Model

It is obvious that the assumptions and judgements used by the experts have a direct effect on the results obtained -- and that other experts might arrive at different absolute results. Nevertheless, it is not the aboslute values of the results that are important but the trends from considering alternative scenarios. It is these trends that are used for the final conclusions that are formed. The analysis process also identified the more significant criteria that could be used for more in-dept analyses in the future.

The final step in the analysis was to take the results of the individual scenarios and relate them (in the aggregate and separately) to community benefits. In doing this, a distinction had to be drawn between direct benefits and indirect benefits. Direct benefits are illustrated by the case of the saving in human life through helicopter useage in a high rise building fire (i.e., a life is saved). An illustration of an indirect or derived benefit is the case of a corporate decision to keep its headquarters in a Central Business District (CBD) or alternatively to decentralize its operating plants over the countryside, because of the added capability and convenience provided by the use of helicopters. The determination of these indirect benefits is more judgmental, more qualitative and less amenable to measurable proof. Nevertheless, the indirect benefits do exist, and they can be important.

The results of this last step in the study and analysis of opportunities and benefits is continued in Section V of the basic report.

APPENDIX B

SUPPLEMENTARY ROTORCRAFT TECHNOLOGY INFORMATION

Section IV of this study contains the rotorcraft technology information considered to be of greatest interest to planners. The supplementary information contained in this Appendix provides representative additional data on several models of helicopter manufacturers that are in production or planned for the future.

The statistics in this Appendix were provided by the manufacturers during the first half of 1981. The purchase price was a published figure. The costs of operation, however, were estimates. Helicopter operators have pointed out that: 1) constant inflation has a severe effect on operating costs; 2) certain costs of operation have not been included, and 3) it is rare, except in scheduled service that a helicopter operates 1200 hours per year in an urban environment; consequently, the denominator or divisor can be considered high. As a total result, these figures should be used as indications only. It should be understood that the operating costs shown are direct (DOC) and do not include indirect costs.

AEROSPATIALE HELICOPTER CORPORATION
(Category 4: Reference Table IV-1, Page IV-3)

MODEL: SA 365N DAUPHIN 2

PRICE: (1981) $1,760,000

EQUIPMENT LIST: STANDARD

COST PER HOUR: (1200 FLIGHT HOURS PER YEAR)

FIXED OPERATING COST: 294.42 (60,000/yr pilot & co-pilot
(See Comment, Page B-1) (119,100=6%/yr. on 1.985M
(174,107 Dep/yr for 7 years

MAINTENANCE AND SPARES: 246.33

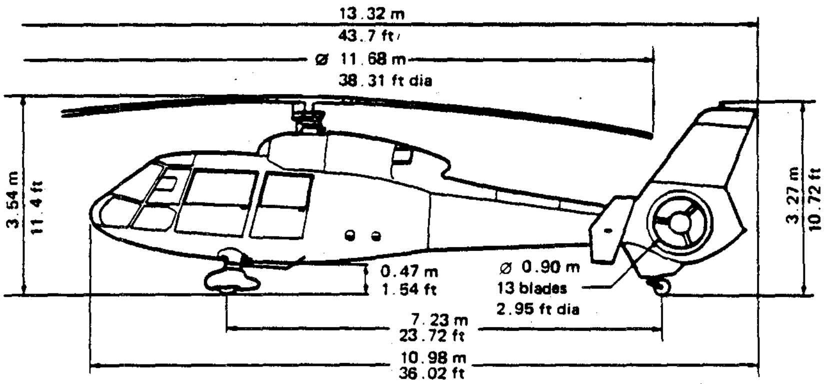
CONSUMABLES COST: $1.61/gal
95 gasl/hr 154.95
+2.00 for oil

TOTAL HOURLY COST: 695.70

FUEL EFFICIENCY: BASED ON A CRUISING SPEED OF 182 MPH

STAGE LENGTH:	50 MI	100 MI	200 MI	400 MI
PAX. SEAT MI/GAL.,	16.3	16.3	16.3	12.7

PASSENGER COMFORT: 22.07 CU. FT. PER PASSENGER IN AFT CABIN



MODEL SA 365 DAUPHIN 2 Engines: Two Turbomeca Arriel

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
670	7495	3354	245	3000	170

NOTES: Twin-engine version with 14 seats. Essentially similar to SA 360C in external appearance but with better performance in several categories. Skid gear optional.

AEROSPATIALE HELICOPTER CORPORATION
(Category 3: Reference Table IV-1, Page IV-3)

MODEL: AS 350D ASTAR

PRICE: (1981) $370,000 (BASIC)

EQUIPMENT LIST: STANDARD

COST PER HOUR: (1200 FLIGHT HOURS PER YEAR) (27,000/yr pilot salary (24,000 Ins.=6%/yr on 400,000 (40,000 dep./yr for 7 years.)

FIXED OPERATING COST: 75.83
(See Comment, Page B-1)

MAINTENANCE AND SPARES: 96.69

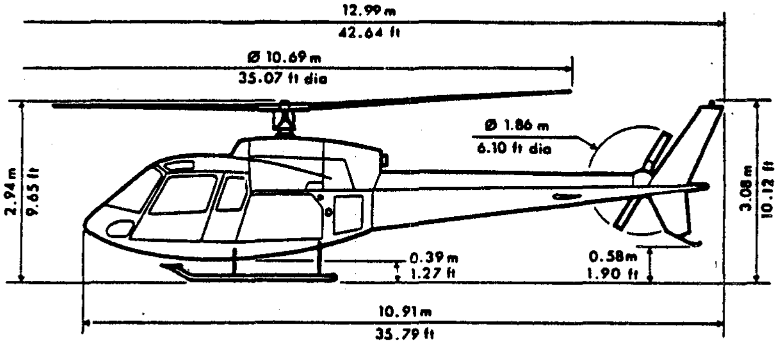
CONSUMABLES COST $1.61/gal 38gasl/hr +1.00 for oil: 62.18

TOTAL HOURLY COST: 234.70

FUEL EFFICIENCY: BASED ON A CRUISING SPEED OF 144 MPH

STAGE LENGTH:	50 MI	100 MI	200 MI	400 MI
PAX. SEAT MI/GAL.,	18.0	18.0	18.0	14.4

PASSENGER COMFORT: 21.17 CU. FT. PER PASSENGER IN AFT CABIN



MODEL AS 350-D Engine: Avco Lycoming LTS 101-600A2
ASTAR

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
615	4190	1830	427	1650	147

NOTES: Six-place light turbine aircraft for executive and commercial markets worldwide. Outside North American markets, AS-350-B uses Turbomeca engine and name "Ecureil" (Squirrel). Employs advanced technology three-blade main rotor and other systems. Skid landing gear and foldina main rotor.

AEROSPATIALE HELICOPTER CORPORATION
(Category 4: Reference Table IV-1, Page IV-3)

MODEL: AS 355F TWINSTAR

PRICE: (1981) $673,000

EQUIPMENT LIST: STANDARD

COST PER HOUR: (1200 FLIGHT HOURS PER YEAR) (29,000/yr. pilot salary; 46,380=6%/yr on 773,000; 77,300 dep/yr for 7 yrs.)

FIXED OPERATING COST: 127.23
(See Comment, Page B-1)

MAINTENANCE AND SPARES: 142.25

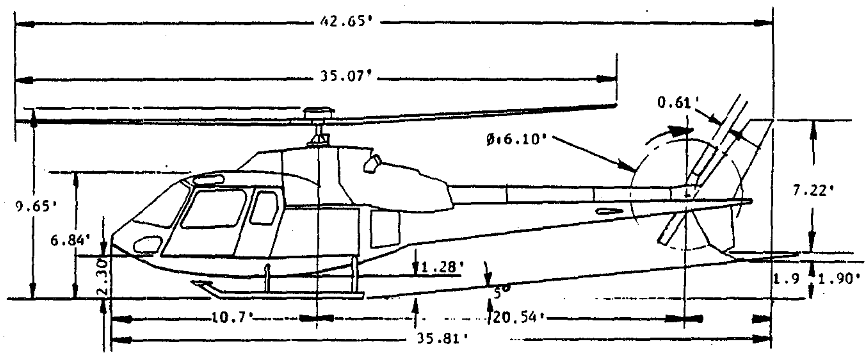
CONSUMABLES COST: $1.61/gal, 63 gals/hr, +2.00 for oil: 95.38

TOTAL HOURLY COST: 364.86

FUEL EFFICIENCY: BASED ON A CRUISING SPEED OF 144 MPH

STAGE LENGTH:	50 MI	100 MI	200 MI	400 MI
PAX. SEAT MI/GAL.,	11.6	11.6	11.6	9.3

PASSENGER COMFORT: 21.18 CU. FT. PER PASSENGER IN AFT CABIN



MODEL AS 355E Engines: Two Allison 250-C20F

TWINSTAR

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
420	4630	1918	436	2000	129

NOTES: Developed in response to customer demand, the AS 355E is expected to be certificated in late 1980. Estimated pricetag is $581,000 for 1981 delivery in VFR configuration, and $560,000 for 1982 deliveries. Airframe, rotor system and cabin are essentially the same as the AS 350D AStar.

AEROSPATIALE HELICOPTER CORPORATION
(Category 4: Reference Table IV-1, Page IV-3)

MODEL: AS 332L SUPER PUMA (STRETCHED)

PRICE: (1981) Not available in 81 - 1982 price is $4,822,000

EQUIPMENT LIST: STANDARD

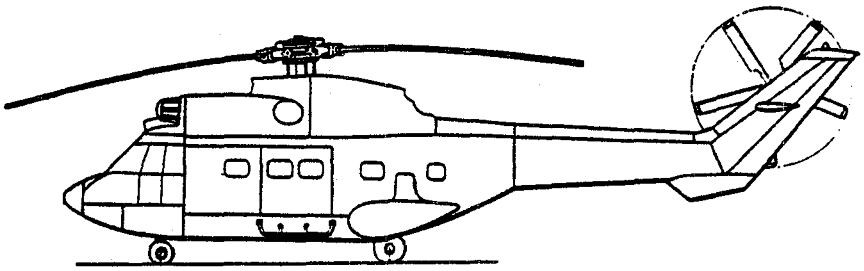
COST PER HOUR: (1200 FLIGHT HOURS PER YEAR)

FIXED OPERATING COST: (See Comment, Page B-1)	687.45	(75,000/yr pilot & co-pilot ~~(362~~,040 ins=7%/yr. on 5.172M)
MAINTENANCE AND SPARES:	530.38	(387,900 Dep/yr for 10 yrs)
CONSUMABLES COST: $1.61/gal. 157gasl/hr +5.20 for oil	257.97	
TOTAL HOURLY COST:	1475.80	

FUEL EFFICIENCY: BASED ON A CRUISING SPEED OF 178 MPH

STAGE LENGTH:	50 MI	100 MI	200 MI	400 MI
PAX. SEAT MI/GAL.,	22.23	22.23	22.23	20.20

PASSENGER COMFORT: 21.53 CU. FT. PER PASSENGER IN AFT CABIN



AS 332 Engines: Two Turbomeca Makila

SUPER PUMA

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
1800	16,750	N/A	347	N/A	157

NOTES: Referred to by many as a "European UH-60", the AS 332 uses a considerable amount of fiberglass and composite material to gain performance over the SA 330L Puma. It was developed to fill a French army requirement for a transport helicopter. Certification tests began in Spring 1979. The aircraft reportedly has excellent performance for its weight class and is expected to completely replace the SA 330 Puma as the core of Aerospatiale's helicopter lineup. First flight was in September 1978.

Bell Helicopter TEXTRON
(Category 2: Reference Table IV-1, Page IV-3)

MODEL: 206B

1981 Prices - Base Price: $295,000.

Equipt. List:
- High Skid Gear
- Deluxe Vinyl Interior
- Soundproofing Kit
- Heavy Duty Battery
- Dual Controls
- Flight Instrument Group
- Heater
- Litter Kit
- Engine Particle Separator
- Rotor Brake Kit
- ADF - King KR-87 with Antenna
- Audio Switch Panel - Collins
- VHF Transceiver/VOR
- OMNI/LOC Indicator
- Transponder

Equipped Price: $ 355,000.

Per hour costs based on 1,200 flight hours per year:

Fixed operating costs (incl. crew, insurance, depreciation)	$ 74.
Maintenance and spares cost	52.
Consumables cost (fuel and oil)	40.
Total Hourly Cost:	$ 166./Hr.

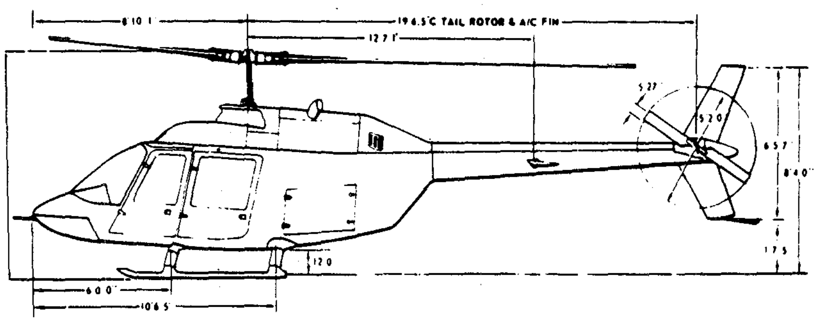
Productivity: 5 working days/week, 100 flight hours/month = 4.6 Hr./Day

Cost/Pax Seat Mile = $.30/Pax Seat Mile

Fuel Efficiency: Based on cruise speed of 138 mph (120 kts).
Includes fuel for warmup and takeoff.
Includes time and fuel to climb to 1,500 ft. cruise altitude and descend to land.

	50 mi.	100 mi.	200 mi.
Pax Seat Mi/Gal.	17.6	18.7	19.4
@ 1.50/Gal. - $/Pax Seat Mi.	.085	.080	.077

Passenger Comfort: 13.3 cu. ft. per passenger in aft cabin.



MODEL 206B Engine: Allison 250-C20B

JETRANGER-II

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
420	3200	1620	297	1500	122

NOTES: Model 206A is Army OH-58A, 206B has uprated engine but is flat rated to transmission limit of 317 shp. 206B is a five-place aircraft and is the most popular light turbine helicopter in the world.

Bell Helicopter TEXTRON
(Category 3: Reference Table IV-1, Page IV-3)

MODEL: 206L-1

1981 Prices - Base Price: $445,000.

Equip. List:

High Skid Gear	Rotor Brake
Soundproofing Kit	King ADF - KR-87 with Antenna
Dual Controls	Collins Audio Panel with VHF
Flight Instrument Group	VHF Transceiver - King KX 170B
Heater	OMNI/LOC Indicator
Litter Installation	KT-76 Transponder

Equipped Price: $ 498,000.

Per hour costs based on 1,200 flight hours per year:

Fixed operating costs (incl. crew, insurance, depreciation)	$ 96.
Maintenance and spares cost	83.
Consumables (fuel and oil)	49.
Total Hourly Cost:	$ 228./Hr.

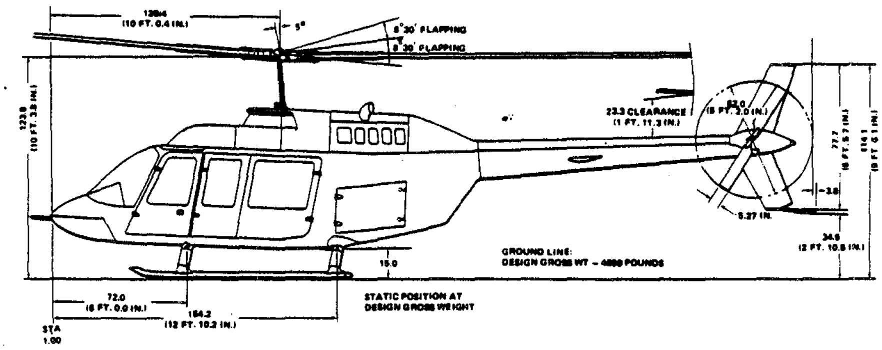
Productivity: 5 working days/week, 100 flight hours/month = 4.6 Hr./Day

Cost/Pax Seat Mile = $.28/Pax Seat Mile

Fuel Efficiency: Based on cruise speed of 134 mph (116 kts).
Includes fuel for warmup and takeoff.
Includes time and fuel to climb and descend to 1,500 ft. (cruise altitude).

	50 mi.	100 mi.	200 mi.
Pax Seat Mi./Gal.	21.0	22.3	22.9
@ 1.50/Gal. - $/Pax Seat Mi.	.071	.067	.066

Passenger Comfort: 15.0 cu. ft. of space per passenger in rear cabin.



MODEL 206L-1 Engine: Allison 250-C28B

LONGRANGER-II

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
500	4050	1894	297	2000	130

NOTES: Seven-place aircraft with nodal suspension system for reduced vibration. A development of the 206B model, the 206L has improved performance in most categories, including high altitude and hot davs.

Bell Helicopter TEXTRON
(Category 5: Reference Table IV-1, Page IV-3)

MODEL: 412

1981 Prices - Base Price: $1,725,000.

Equip. List:	
Rotor Brake	Transponder
Dual Controls	Marker Beacon
Heater	VOR/LOC/GS
3-Axis Gyro (Req'd w/Duals)	Fixed Step (Into Aft Cabin)
ICS	Litter Kit
ADF	Co-Pilot Instrument Group

Equipped Price: $ 1,833,000.

Per hour costs based on 1,200 flight hours per year:

Fixed operating costs (incl. crew, insurance, depreciation)	$ 295.
Maintenance and spares cost	127.
Consumables Cost (fuel and oil)	171.
Total Hourly Cost:	$ 593./Hr.

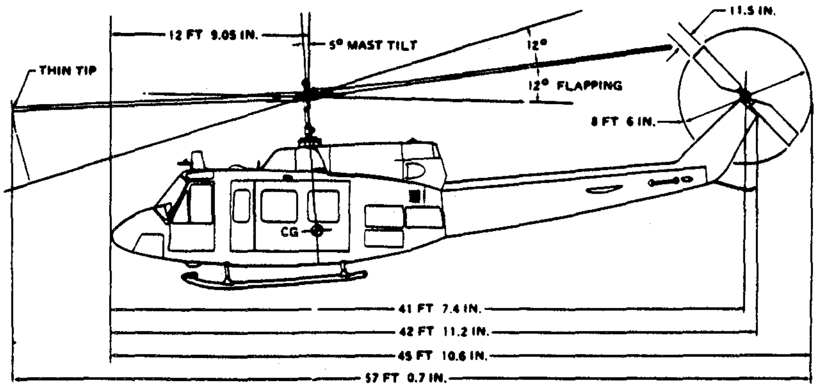
Productivity: A realistic one-shift operation can operate efficiently at 1,200 hours/year or 4.6 useful hours per week day - A full 24-hour, 7-day operation can operate successfully to 1,800-2,000 hours/year or 5.5 useful hours per day on a year-round schedule (365 days).

Cost/Pax Seat Mile = $.29/Pax Seat Mile

Fuel Efficiency: Based on a cruise speed of 145 mph (126 kts). Includes fuel for warmup and takeoff. Includes time and fuel to climb to 1,500 ft. cruise altitude and descend to land.

	50 mi.	100 mi.	200 mi.
Pax Seat Mi./Gal.	15.5	16.6	17.2
@ 1.50/Gal. - $/Pax Seat Mi.	.097	.090	.087

Passenger Comfort: 16.9 cu. ft. per passenger in aft cabin.



MODEL 212 Engines: Two P&W PT6T ("Twin Pac")

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
900	11,200	5332	227	5000	107

NOTES: 15-place IFR-certified aircraft with engines derated to 1290 shp takeoff power. Equipped with dual hydraulic, electrical and fuel systems. Military designation is UH-1N.

Bell Helicopter TEXTRON
(Category 4: Reference Table IV-1, Page IV-3)

MODEL: 222

1981 Prices - Base Price: $1,195.000.

Equip. List: Eight-Place Deluxe Interior
Litter Kit
Heater
Co-Pilot Instruments & Controls
VHF Transceiver w/Antenna
Communications Control Panel
#2 VHF
VOR/GS
ADF
Rotor Brake
Transponder

Equipped Price: $ 1,322,000.

Per hour costs based on 1,200 flight hours per year:

Fixed operating costs (incl. crew, insurance, depreciation)	$ 140.
Maintenance and spares cost	165.
Consumables cost (fuel and oil)	117.
Total Hourly Cost:	$ 422./Hr.

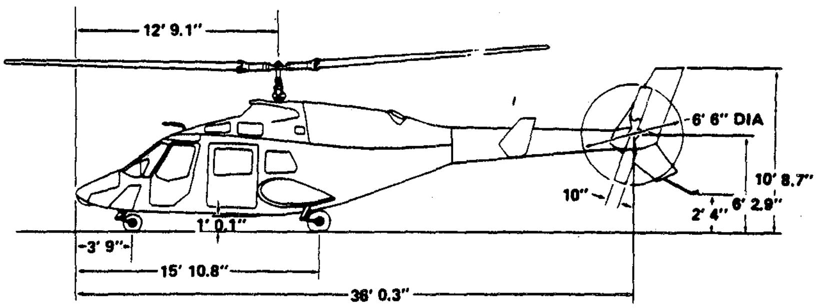
Productivity: 5 working days/week, 100 flight hours/month = 4.6 Hr./Day

Cost/Pax Seat Mile = $.39/Pax Seat Mile

Fuel Efficiency: Based on a cruise speed of 155 mph (134 kts).
Includes fuel for warmup and takeoff.
Includes time and fuel to climb to 1,500 ft. cruise altitude and descend to land.

	50 mi.	100 mi.	200 mi.
Pax Seat Mi./Gal.	12.1	13.0	13.5
@ 1.50/Gal. - $/Pax Seat Mi.	.124	.115	.111

Passenger Comfort: 21.6 cu. ft. per passenger in aft cabin.



MODEL 222 Engines: Two Lycoming LTS-101-650C-2

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
650	7650	3100	344	3500	160

NOTES: Ten-seat-maximum executive transport and commercial aircraft, with double the range of the Model 206B JetRanger II. IFR certification, nodal suspension, dual hydraulic and electrical systems, retractable tricycle gear.

Bell Helicopter TEXTRON
(Category: Not Applicable)

MODEL: D-326 Tilt Rotor

1981 Costs based on 1,200 hours flight time per year.

Acquisition cost (IFR configuration in commuter transport configuration) $ 12,400,000.

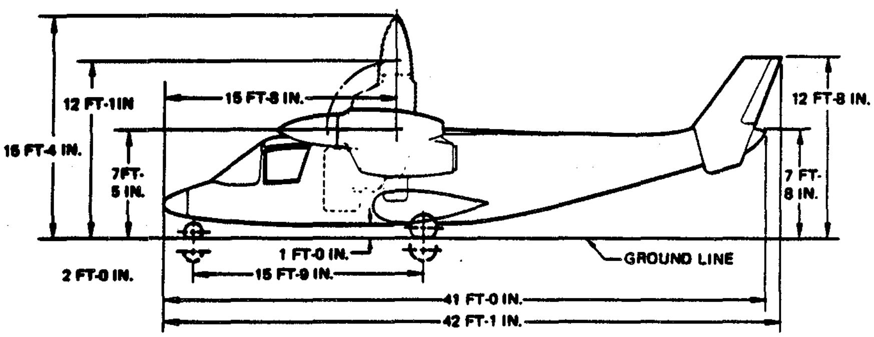
Operating costs (incl. crew, insurance, financing)	$ 2,030./Hr.
Maintenance and spares costs	795./Hr.
Consumables costs (fuel and oil)	480./Hr.
Total Hourly Cost:	$ 3,305./Hr.

Productivity (30 Pax @ 330 mph (287 kts)) = $.33/Pax Seat Mile

Fuel Efficiency: Based on average cruise speed of 330 mph (287 kts).
Includes fuel for warmup and takeoff.
Includes time and fuel to climb to most efficient cruise altitude and descend to land.

	50 mi.	100 mi.	200 mi.	400 mi.
Pax Seat Mi./Gal.	19.5	26.0	28.4	29.8
@ 1.50/Gal. - $/Pax Seat Mi.	.077	.058	.053	.050

Passenger Comfort: Comparable to DHC-7 turboprop commuter.



MODEL 301 Engines: Two Lycoming T-53

XV-15

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
1550	13,000	N/A	N/A	—	330

NOTES: A tilt-rotor VTOL transport in cooperative development with NASA and the Army Research and Technology Laboratories. Capable of vertical lift and descent and jet speeds in horizontal flight.

BOEING VERTOL COMPANY
(Category 6: Reference Table IV-1, Page IV-3)

MODEL: BV234LR PASSENGER TRANSPORT

1981 PRICES -

Base Price:	$ 12,373,500
Optional Avionics:	1,263,500
Equipped Price:	$ 13,637,000

PER HOUR COSTS BASED ON 1800 FLIGHT HOURS PER YEAR

Fixed Direct Operating Costs (Crew, insurance, depreciation):	$ 1,396
Maintenance and Spares Cost:	463
Consumables Cost (Fuel and Oil):	432
Direct Cost Per Flight Hour:	$ 2,291

PRODUCTIVITY

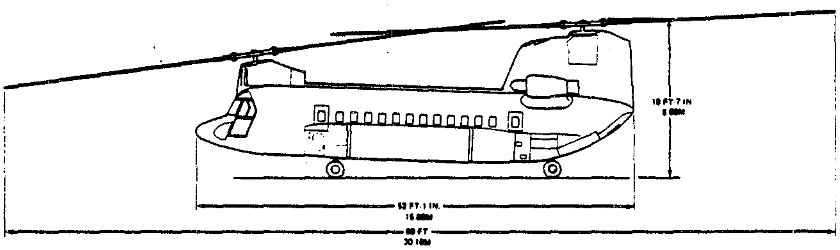
With 44 available seats, 135 knot block speed and 1800 flight hours per year utilization rate on 520 n. mile leg

Seat N. Miles per Week:	205,600
Cost Per Available Seat N.Mile:	$ .39

FUEL EFFICIENCY

Based on block speed of 135 knots, Pax seat n. mile per gallon	14.4
At $1.50/gallon, fuel $/seat n. mile	$ .104

PASSENGER COMFORT: Cu.Ft. Per Passenger: 26



MODEL 234 Engines: Two Lycoming AL5512

COMMERCIAL CHINOOK (LONG RANGE)

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
2957	47,000	22,551	740	28,000	165

NOTES: Boeing Vertol has gambled considerable expense on a civil certification program to capture the long-range offshore support and medium-lift civil utility markets. First versions were sold to British Airways Helicopters, with U.S. operators following suit. The utility version of the Model 234 has somewhat different performance than the long range version. Model 234 price to BAH for three aircraft was $33 million with spares. Certification is expected in 1981. Estimated operating cost is understood to be $755 per flight hour.

BOEING VERTOL COMPANY
(Category 6: Reference Table IV-1, Page IV-3)

MODEL: BV234UT UTILITY HELICOPTER

1981 PRICES -

Base Price:	$	9,689,300
Optional Cargo Equipment:		122,800
Optional Avionics:		327,400
Equipped Price:	$	10,139,500

PER HOUR COSTS BASED ON 1800 FLIGHT HOURS PER YEAR

Fixed Direct Operating Costs (Crew, insurance, depreciation):	$	1,144
Maintenance and Spares Cost:		463
Consumables (Fuel and Oil):		432
Direct Cost Per Flight Hour:	$	2,039

PRODUCTIVITY

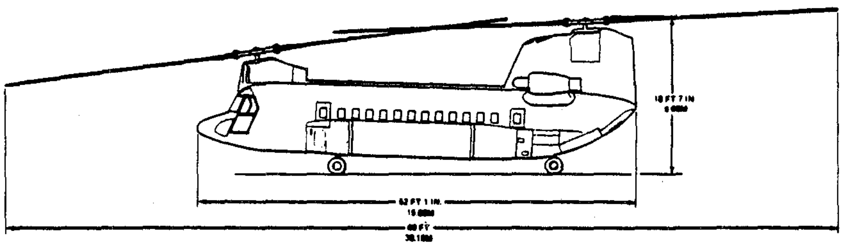
Tons delivered per hour one way on a 10 n. mile radius at 80% load factor:		57
Cost per Ton N. Mile:	$	3.58

FUEL EFFICIENCY

Based on 413 gal/hr, ton n. mile per gallon	$	1.38
At $1.50 per gallon, fuel $ per ton n. mile	$	1.09

Triple Hook System for load stability

Maximum payload, tons	14



MODEL 234 Engines: Two Lycoming AL5512

COMMERCIAL CHINOOK (LONG RANGE)

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
2957	47,000	22,561	740	28,000	165

NOTES: Boeing Vertol has gambled considerable expense on a civil certification program to capture the long-range offshore support and medium-lift civil utility markets. First versions were sold to British Airways Helicopters, with U.S. operators following suit. The utility version of the Model 234 has somewhat different performance than the long range version. Model 234 price to BAH for three aircraft was $33 million with spares. Certification is expected in 1981. Estimated operating cost is understood to be $755 per flight hour.

SIKORSKY AIRCRAFT
(Category 5: Reference Table IV-1, Page IV-3)

MODEL: S-76

Base Price: (December 1980) $1,676,000.

Equipment List:

Airframe

Fully Retractable Landing Gear, Main and Nose Wheel Type
Four Hinged Cabin Doors
38-Cubic Foot (1.08 cu.m.) Baggage Compartment
Cockpit and Cabin Engine Bleed Air Heating System
Windshield Defogging System
Dual Windshield Wipers and Washers
Pilot and Co-Pilot's Seats with Shoulder Harnesses
Twelve-Passenger Seats with Belts
Soundproofing and Upholstered Interior
Removable Carpeting
"Fasten Seat Belt" and "No Smoking" Signs
One First Aid Kit
Two Hand-Held Fire Extinguishers
Map Case
Ash Trays for Pilots and Passengers
Jacking Pads (3)

Powerplant

281-Gallon (1064 l.) Fuel Capacity in Two Tanks
Engine Fire Detection and Extinguishing Systems
Engine Inlet Icing Protection
Gravity Fueling Fillers for Each Tank
Low Level Fuel Warning System

Rotor and Controls

Single Pilot Controls
Co-Pilot's Flight Control Provisions
Space and Structural Provisions for S.A.S. or A.F.C.S.
Two Independent Servo Flight Control Systems
Blade Flap Restrainers
Bifilar Vibration Absorbers

Avionics

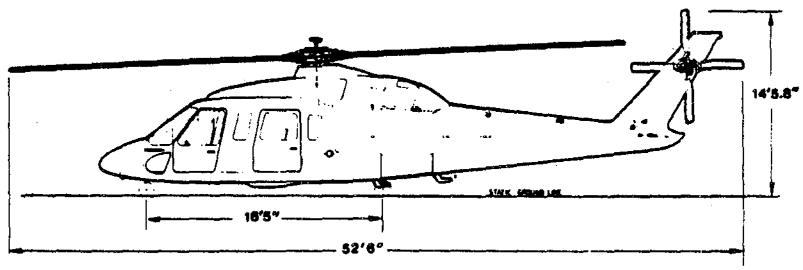
Single VHF Collins VHF-20A Transceiver
Intercom, Andrea, A301-61A

Electrical

Two 200-Ampere D.C. Starter Generators
17-Ampere Hour Nickel-Cadmium Battery
Position Lights
Anti-Collision Light (Strobe-Type)
Fixed Landing Light
Interior Cockpit Cabin and Instrument Lights
D.C. External Power Receptacle
Battery-Operated Self-Contained Cabin Emergency Light

Instruments

Airspeed Indicator
Triple Tachometer
Dual Torquemeter
Vertical Speed Indicator
Clock
Barometric Altimeter
Self-Contained Attitude Gyro Indicator
Self-Contained Heading Gyro Indicator
Self-Contained Turn and Slip Indicator
Magnetic Compass
Outside Air Temperature
Pitot Static System
Gas Generator Tachometer (2)
Power Turbine Inlet Temperature (2)
Fuel Pressure (2)
Engine Oil Temperature & Pressure (2)
Main Transmission Oil Temperature & Pressure
Hydraulic Pressure (2)
Fuel Quantity (2)
Caution/Advisory System
Master Warning System
Landing Gear Warning System



SPIRIT Engines: Two Allison 250-C30

MODEL S-76

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
650	10,000	4727	404	4000	155

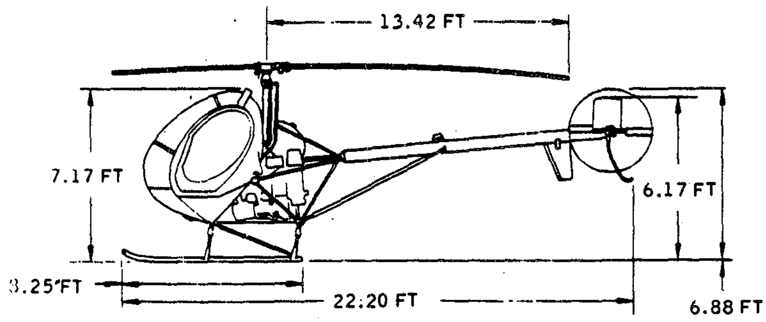
NOTES: Executive transport and offshore support aircraft for up to 13 passengers and one crew in VFR configuration or 12 and 2 in IFR configuration. The S-76 is Sikorsky's first purely civil helicopter venture. Considerable S-70 technology is included in the S-76 design.

Hughes Helicopters Inc

	MODELS			
	300*	500 **	600X	2000 ***
Prices:				
Basic price	$115,000			
Total direct oper cost/hr	56.51	116.26		
Total Fixed cost/hr	37.38	58.80		
Total cost/hr	93.81	175.06	210	
Passenger seat mi/gal			24.25	
Dollars per ton mi			3.50	
Performance:				
Max payload with fuel	1004	1030	791	
Cruise speed (SL)(mph)	85	160	157	
Maximum range (SL)(mi)	224	300	446	

Future Technology:				
Cost/seat mi				.058
Passenger seat mi per gal				22
Cruising speed (mph)				165
Max range				
Full payload (mi)				700
Min payload				880
Max payload				
Min fuel (lbs)				8600
Full fuel				4500
Productivity (ton mi/hr)				735
Comfort (cu ft per passenger)				35
Passengers				14-26

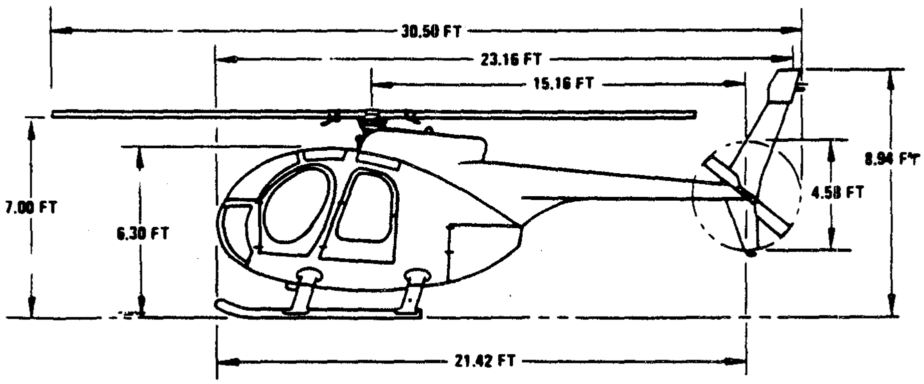
* Category 1, Reference Table IV-1, Page IV-3
** Category 2, Reference Table IV-1, Page IV-3
*** Twin Engine



MODEL 300C Engine: Lycoming H10-360-D1A

HP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
190	2050	1004	200	850	91

NOTES: Three-place light piston-engine helicopter for utility patrol, law enforcement or agriculture applications, as well as training. Army training designation for similar model is TH-55A.



MODEL 500 D Engine: Allison 250-C20B

SHP per Engine	Max Gross Weight (lbs)	Useful Load (lbs)	Range N.M.	External Load (lbs)	Max Speed (kts)
420	3000	1660	252	2115	153

NOTES: Similar Army model designated OH-6A with different engine. Five-place 500D went into full production late in 1976. At 70 kts, the 500D has an endurance of three hours.

APPENDIX C

HELIPORT PLANNING GUIDELINES

An important part of the planning for heliports is knowing the proper reference documents to use and right regulatory offices to contact. The set of references contained in this Appendix is intended to assist in this matter. The references have been grouped into the categories shown below:

- Category A: FAA Advisory Circulars (ACs) of interest and importance to heliport planners.

- Category B: State Aeronautics Commissions/Divisions, with addresses and telephone numbers.

- Category C: Airport Departments/Commissions of larger terminal cities in the United States.

- Category D: National Fire Protection Association Standards pamphlets.

- Category E: Trade Organizations

CATEGORY A: A reference list of FAA Advisory Circulars (ACs) of interest and importance to heliport planners.

Title / Subject	AC Subject Number
Advisory Circular Checklist	AC 00-2( )
Status of Federal Aviation Regulations	AC 00-44( )
Basic Helicopter Handbook	AC 61-13B
Airspace Utilization Considerations in the Proposed Construction, Alteration, Activation and Deactivation of Airports	AC 70-2D
Obstruction Marking and Lighting	AC 70/7460-1F
Proposed Construction or Alteration of Objects that may Affect the Navigable Airspace	AC 70/7460-2G
IFR Helicopter Operations in the Northeast Corridor	AC 73-2
Hazards of Rotating Propellers and Helicopter Rotor Blades	AC 91-42B
Address List for Regional Airports Divisions and Airports District / Field Offices	AC 150/5000-3( )
Citizen Participation in Airport Planning	AC 150/5050-4
Airport-Land Use Compatibility Planning	AC 150/5050-6
Planning the Metropolitan Airport System	AC 150/5070-5
Airport Master Plans	AC 150/5070-6
Federal-aid Airport Program-Procedures Guide for Sponsors	AC 150/5100-3A
A Model Zoning Ordinance to Limit Height of Objects Around Airports	AC 150/5190-4
Heliport Design Guide (plus Change 1)	AC 150/5390-1B
The Planning Grant Program for Airports	AC 150/5900-1B

CATEGORY B: A reference list of State Aeronautics Commissions/ Divisions addresses and telephone numbers.

ALABAMA DEPARTMENT OF AERONAUTICS
Room 627, State Hwy. Bldg.
11 South Union Street
Montgomery, AL 36130
(205) 832-6290

ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES
Pouch 6900
Anchorage, AK 99502
(907) 266-1470

ARIZONA AERONAUTICS DIVISION
205 South 17th Ave.
Phoenix, AZ 85007
(602) 261-7778

ARKANSAS DIVISION OF AERONAUTICS
Adams Field
Old Terminal Bldg.
Little Rock, AR 72202
(501) 376-6781

CALIFORNIA TRANSPORTATION COMMISSION, Aeronautics Subcommittee
1120 N Street
Sacramento, CA 95814
(916) 445-1690

COLORADO STATE PATROL AIRCRAFT
4201 E. Arkansas Ave.
Denver, CO 80220
(303) 757-9522

CONNECTICUT BUREAU OF AERONAUTICS
Drawer A
24 Wolcott Hill Rd.
Wethersfield, CT 06109
(203) 566-5498

DELAWARE TRANSPORTATION AUTHORITY, Aeronautics Section
Box 778
Dover, DE 19901
(302) 736-4597

FLORIDA AVIATION BUREAU
Division of Public Transportation Operations
605 Suwannee Street
Tallahassee, FL 32301
(904) 488-8444

GEORGIA BUREAU OF AERONAUTICS
5025 New Peachtree Rd., N.E.
Chamblee, GA 30341
(404) 393-7393

HAWAII STATE DEPT. OF TRANSPORTATION
869 Punchbowl Street
Honolulu, HI 96813
(808) 548-4711

IDAHO DIVISION OF AERONAUTICS & PUBLIC TRANSPORTATION
3483 Rickenbacker Street
Boise, ID 83705
(208) 334-3183

ILLINOIS DIVISION OF AERONAUTICS
Capital Airport
Springfield, IL 62706
(217) 753-4400

INDIANA AERONAUTICS COMMISSION
Suite 801, State Office Bldg.
100 North Senate Ave.
Indianapolis, IN 46204
(317) 232-3794

IOWA AERONAUTICS DIVISION
State House
Des Moines, IA 50319
(515) 281-4280

KANSAS AVIATION DIVISION
State Office Bldg.
Topeka, KS 66612
(913) 296-3566

KENTUCKY DIVISION OF AERONAUTICS & AIRPORT ZONING
419 Ann Street
Frankfort, KY 40601
(502) 564-4480

CATEGORY B (Continued)

LOUISIANA OFFICE OF
AVIATION & PUBLIC
TRANSPORTATION
Box 44245, Capitol Sta.
Baton Rouge, LA 70804
(504) 342-7504

MAINE BUREAU OF AERONAUTICS
Transportation Bldg.
Child Street
Augusta, ME 04333
(207) 289-3185

MARYLAND STATE AVIATION
ADMINISTRATION
Box 8766
Baltimore/Washington Int'l
Airport, MD 21240
(301) 787-7060

MASSACHUSETTS AERONAUTICS
COMMISSION
Boston-Logan Airport
East Boston, MA 02128
(617) 727-5350

MICHIGAN AERONAUTICS
COMMISSION
Capital City Airport
Lansing, MI 48906
(517) 373-1834

MINNESOTA AERONAUTICS
DIVISION
Room 417
Transportation Bldg.
St. Paul, MN 55155
(612) 296-8202

MISSISSIPPI AERONAUTICS
COMMISSION
500 Robert E. Lee Bldg.
Box 5
Jackson, MS 39205
(601) 354-7494

MISSOURI HIGHWAY AND
TRANSPORTATION DEPT.
6th Floor, Broadway Bldg.
Box 1250
Jefferson City, MO 65101
(314) 751-4922

MONTANA BOARD OF AERONAUTICS
Box 5178
Helena, MT 59601
(406) 449-2506

NEBRASKA DEPARTMENT OF AERONAUTICS
Municipal Airport
Box 82088
Lincoln, NE 68501
(402) 471-2371

NEVADA PUBLIC SERVICE COMMISSION
Kinkead Bldg.
505 East King Street
Carson City, NV 89710
(702) 885-4180

NEW HAMPSHIRE AERONAUTICS
COMMISSION
Municipal Airport
Concord, NH 03301
(603) 271-2551

NEW JERSEY DIVISION OF AERONAUTICS
1035 Parkway Ave.
Trenton, NJ 08625
(609) 292-3112

NEW MEXICO AVIATION DIVISION
Box 579
Santa Fe, NM 87503
(505) 827-5511

NEW YORK STATE AIRPORT
DEVELOPMENT SECTION
1220 Washington Ave.
Albany, NY 12232
(518) 457-2820

NORTH CAROLINA DIVISION OF
AVIATION
Box 25201
Raleigh, NC 27611
(919) 733-2491

NORTH DAKOTA AERONAUTICS
COMMISSION
Municipal Airport
Box U
Bismarck, ND 58505
(701) 224-2748

CATEGORY B (Continued)

OHIO DIVISION OF AVIATION
2829 West Granville Rd.
Worthington, OH 43085
(614) 889-2533

OKLAHOMA AERONAUTICS COMMISSION
424 United Founders Tower
Oklahoma City, OK 73112
(405) 521-2377

OREGON AERONAUTICS DIVISION
3040 25th Street, S.E.
Salem, OR 97310
(503) 378-4880

PENNSYLVANIA BUREAU OF AVIATION
Harrisburg Int'l Airport
45 Luke Drive
Middletown, PA 17057
(717) 787-8754

RHODE ISLAND DIVISION OF AIRPORTS
T.F. Green State Airport
Warwick, RI 02886
(401) 737-4000

SOUTH CAROLINA AERONAUTICS COMMISSION
Drawer 1987
Columbia, SC 29202
(803) 758-2766

SOUTH DAKOTA DIVISION OF AERONAUTICS
Pierre, SD 57501
(605) 773-3574

TENNESSEE BUREAU OF AERONAUTICS
Box 17326
Nashville, TN 37217
(615) 741-3208

TEXAS AERONAUTICS COMMISSION
40 East 5th Street
Austin, TX 78701
(512) 475-4768

UTAH DIVISION OF AERONAUTICAL OPERATIONS
135 North 2400 West
Salt Lake City, UT 84116
(801) 328-2066

VERMONT AGENCY OF TRANSPORTATION
State Administration Bldg.
133 State Street
Montpelier, VT 05602
(802) 828-2828

VIRGINIA DEPARTMENT OF AVIATION
4508 South Laburnum Ave.
Box 7716
Richmond, VA 23231
(804) 786-3685

WASHINGTON STATE DIVISION OF AERONAUTICS
Boeing Field
8600 Perimeter Rd.
Seattle, WA 98108
(206) 764-3141

WEST VIRGINIA STATE AERONAUTICS COMMISSION
Kanawha Airport
Charleston, WV 25311
(304) 348-3790

WISCONSIN DIVISION OF TRANSPORTATION ASSISTANCE,
Bureau of Aeronautics
Box 7914
Madison, WI 53707
(608) 266-3351

WYOMING AERONAUTICS COMMISSION
State of Wyoming
Cheyenne, WY 82002
(307) 777-7481

CATEGORY C: A reference list of Airport Departments/Commissions of larger terminal cities in the United States.

ATLANTA, GA

City of Atlanta
Dept. of Aviation
Atlanta Int'l Airport
Atlanta, GA 30320
(404) 766-2772

BOSTON, MA

Massachusetts Port Authority
99 High Street
Boston, MA 02110
(617) 482-2930

BUFFALO, NY

Niagara Frontier Transportation Authority (NFTA)
181 Ellicott St.
Buffalo, NY 14205
(716) 855-7300

CHICAGO, IL

Dept. of Aviation
Room 1111
City Hall
Chicago, IL 60602
(312) 744-6886

CINCINNATI, OH

Greater Cincinnati Int'l Airport
Box 75000
Cincinnati, OH 45275
(606) 283-3151

CLEVELAND, OH

City of Cleveland
Dept.- Port Control
Cleveland Hopkins Int'l Airport
Cleveland, OH 44135
(216) 265-6000

COLUMBUS, OH

Columbus Metro Airport & Aviation Commission
Port Columbus Int'l
Columbus, OH 43219
(614) 239-4000

DALLAS / FT. WORTH, TX

Dallas/Ft. Worth Regional Airport Board
Drawer DFW
Dallas/Ft. Worth Airport, TX 75261
(214) 574-6720

DENVER, CO

City & County of Denver
Stapleton Int'l Airport
Denver, CO 80207
(303) 398-3844

DETROIT, MI

Detroit Airport Dept.
11499 Conner
Detroit, MI 48213
(313) 527-1112

HOUSTON, TX

City of Houston
Aviation Dept.
Houston Int'l Airport
Box 60106
Houston, TX 77205
(713) 443-4361

INDIANAPOLIS, IN

Indianapolis Airport Authority
Indianapolis Int'l Airport
Indianapolis, IN 46241
(317) 247-6271

JACKSONVILLE, FL

Jacksonville Port Authority
Box 18097
Jacksonville, FL 32229
(904) 757-2261

KANSAS CITY, MO

Aviation Dept.
Kansas City Int'l Airport
Box 20047
1 Int'l Sq.
Kansas City, MO 64195
(816) 243-5200

CATEGORY C (Continued)

LOS ANGELES, CA

Los Angeles Dept.
of Airports
Los Angeles Int'l
Airport
One World Way
Los Angeles, CA
90009
(213) 646-5252

LOUISVILLE, KY

Louisville & Jefferson
County Air Board
Standiford Field
Box 21176
Lee Terminal Bldg.
Louisville, KY 40221
(502) 368-6524

MIAMI, FL

Dade County Aviation
Dept.
Miami Int'l Airport
Box 592075 AMF
Miami, FL 33159
(305) 526-2300

MILWAUKEE, WI

Milwaukee County
Airport Dept.
Gen. Mitchell Field
5300 So. Howell Ave.
Milwaukee, WI 53207
(414) 747-5300

NASHVILLE, TN

Metropolitan Nashville
Airport Authority
Box 17208
Nashville, TN 37217
(615) 367-3000

NEW ORLEANS, LA

New Orleans
Aviation Board
Moisant Field
Box 20007
New Orleans, LA
(504) 729-2591

NEW YORK, NY

The Port Authority
of New York & New
Jersey
One World Trade
Center
New York, NY 10048
(212) 466-7000

OAKLAND, CA

Port of Oakland
Authority
65 Jack London Sq.
Oakland, CA 94607
(415) 444-3188

OKLAHOMA CITY, OK

Will Rogers World
Airport
Box 59937
Oklahoma City, OK
73159
(405) 681-5311

OMAHA, NE

Omaha Airport
Authority
Eppley Airfield
Box 19103
Omaha, NE 68119
(402) 422-6800

PHILADELPHIA, PA

Division of Aviation
Dept. of Commerce
City of Philadelphia
Philadelphia Int'l
Airport
Philadelphia, PA 19153
(215) 492-3000

PITTSBURGH, PA

County of Allegheny
Dept. of Aviation
Greater Pittsburgh
Airport
Room M, 134 Terminal
Bldg.
Pittsburgh, PA 15231
(412) 771-2500

ST. LOUIS, MO

Missouri-St. Louis
Metro Airport Authority
Suite 239, Plaza One
514 Earth City Plaza
Earth City, MO 63045
(314) 739-2450

SAN DIEGO, CA

Port of San Diego
Box 488
San Diego, CA 92112
(714) 291-3900

SAN FRANCISCO, CA

Airports Commission,
City & County of San
Francisco
San Francisco Int'l
Airport
San Francisco, CA 94128
(415) 761-0800

CATEGORY C (Continued):

SEATTLE, WA

Port of Seattle
Commission
Box 1209
Seattle, WA 98111
(206) 382-3200

TUCSON, AZ

Tucson Airport Authority
Int'l Airport
Tucson, AZ 85706
(602) 294-3411

WASHINGTON, DC

Metropolitan Washington
Airports
Federal Aviation Administration
Washington National Airport
Washington, D.C. 20001
(703) 557-1155

CATEGORY D: A reference list of National Fire Protection Association Standards pamphlets.

Title	Pamphlet Number
Portable Fire Extinquishers	NFPA 10
Foam Extinquishing Systems	NFPA 11
Standpipe and Hose Systems	NFPA 14
Deluge Foam - Water Sprinkler and Spray Systems	NFPA 16
Central Station Signaling Systems	NFPA 71
Auxiliary Protective Signaling Systems	NFPA 72B
Remote Station Protective Signaling Systems	NFPA 72C
Proprietary Protective Signaling Systems	NFPA 72D
Life Safety Code	NFPA 101
Aircraft Rescue and Fire Fighting Services at Airports	NFPA 403
Aircraft Hangars	NFPA 409
Roof-Top Heliports	NFPA 418

Category E: A Reference List of Trade Organizations.

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

AIA
T-63
1725 DeSales St., N.W.
Washington, DC 20036
Telephone—202 347-2315
TWX: 710-822-0134
Pres. & Gen. Mgr.— Karl G. Harr
V. P. & Secy.— Samuel L. Wright

AIRBORNE LAW ENFORCEMENT ASSOCIATION, INC.

T-72
Suite 920
500 Newport Center Rd.
Newport Beach, CA 92660
Pres.— Robert L. Brooks , Jefferson County Sheriff Dept., 716 N. 21st. St., Birmingham, AL 35203
V. P.— Jim Simpson, Portsmouth Police Dept., 5198 W. Military Hwy., Chesapeake, VA 23321
(Organization to encourage communications & liaison between law enforcement agencies & aviation interests)

AIRCRAFT OWNERS & PILOTS ASSOCIATION

AOPA
O-320
Air Rights Bldg.
7315 Wisconsin Ave.
Washington, DC 20014
Telephone—301 654-0500
Telex 89-8468
TWX 710-824-0095
Cable Address: AOPA

Chrm.-Bd — J. B. Hartranft, Jr.
Pres.— John L. Baker
Sr. V. P.-Opns. & Intl. Aviation Theft Bureau— Ralph F. Nelson
Sr. V. P.-Mktg. & Assoc. Publisher— Harmon O. Pritchard, Jr.
Exec. Dir.-Mktg. Services— Laurel A. Smith
Membership Processing & Servicing— Katherine Post
Gen. Counsel— Alfred L. Wolf
Treas.— John J. Serrell
Sr. V. P.-Pub. Rel.— Charles Spence
Sr. V. P.-Policy & Tech. Planning— Rob Warner
Sr. V. P.-Fiscal/Int. Opns— William S. Brassel
Washington Counsel— John S. Yodice
V. P.-Data Research— Robert E. Monroe
Dir.-Fed. & Leg. Affairs— Lawrence Graves
V. P.-Adv.— John Gorsuch
Asst. V. P.-Admin. Of AOPA Air Safety Foundation— Jeanne Jackson
Airports— Jeffery H. Gilley
Asst. V. P.-Opns.— Michael Santangelo
Dir.-Tech. Planning Dept.— C. Dennis Wright
Flight Planning, Domestic/Intl.— Catherine V. Howser
Dir.-Flight Instructor Dept.— John J. Sheehan, III
Insurance Plans— Richard F. Busch
Opns. & Safety— Russell S. Lawton
Pilot Service— D. Koranda
Intl. Activities (IAOPA)— Victor J. Kayne

Publications Div.,
Editor-The Pilot & Handbook for Pilots & Airports - Edward G. Tripp
Creative Dir.-Publications-Art Davis
Group Travel Tours-Joanne M. Jensen
Comptroller-Lawrence E. Peters

Official Publications:
Aopairport Report
AOPA'S Airports U.S.A.
AOPA Aviation Fact Card
AOPA Guide to Congressional Contacts
AOPA Pilot
AOPA Handbook for Pilots
Yesterday's Wings
AOPA Newsletter
General Aviation National Report
The Flying club
Places to Fly Vol. 1, 2 & 3
See O-1360 for AOPA Air Safety Foundation

AIR FREIGHT ASSOCIATION OF AMERICA

T-106
Suite 607
1730 Rhode Island Ave., N.W.
Washington, DC 20036
Telephone—202 293-1030
Pres.— Harvey Pittluck, Pres., Profit by Air, Box 90897, Los Angeles, CA 90009
Exec. V. P. & Counsel— Louis P. Haffer, 1730 Rhode Island Ave., N.W., Washington, DC 20036

AIRLINE PASSENGERS ASSOCIATION, INC.

APA
T-134
(Mail: Box 220074
Dallas, TX 75264)
800 W. Airport Frwy.
11th Fl.
Irving, TX 75061
Telephone—214 438-8100
Chrm. & CEO— Tom Mathews

Washington Office:
WASHINGTON, DC 20006: Suite 300, 1919 Pennsylvania Ave., N.W. (Tel. 202 293-3815; Telex: 89-474)

Official Publications:
Apace Newsletter
First Class Magazine

AIR LINE PILOTS ASSOCIATION, INTERNATIONAL

ALPA
American Federation of Labor-Congress of Industrial Organizations (AFL-CIO)
T-143
1625 Massachusetts Ave., N.W.
Washington, DC 20036
Telephone—202 797-4000

Pres.— John J. O'Donnell, (EAL)
1st V. P.— Gerald A. Pryde, (UAL)

Official Publication:
Air Line Pilot
Editor— C. V. Glines

AIRPORT OPERATORS COUNCIL INTERNATIONAL, INC.

AOCI
T-174
Suite 602
1700 K St., N.W.
Washington, DC 20006
Telephone—202 296-3270
Cable: AOCIHQ

Pres.—Caesar B. Pattarini, Dir.-Aviation, The Port Authority of New York & New Jersey, One World Trade Center, Rm. 65W, New York, NY 10048
Exec. V. P.— J. Donald Reilly
V. P.-Fed. Affairs— J. J. Corbett

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Business Mgr.— Robert J. Lehman
Asst. V. P.-Fed. Affairs— Joann B. Faley
Gen. Counsel— Sidney Goldstein, Apt. 6A, 1172 Park Ave., New York, NY 10028

Official Publication:
Airport Highlights

AIR TRAFFIC CONTROL ASSOCIATION

O-760
Suite 410
2020 N. 14th St.
Arlington, VA 22201
Telephone—703 522-5717

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Exec. Dir.— Gabriel A. Hartl

Official Publications:
Atca Bulletin
Journal Of Air Traffic Control
Air Traffic Control

Editor— Tirey K. Vickers

AIR TRANSPORT ASSOCIATION OF AMERICA

ATA
T-189
1709 New York Ave., N.W.
Washington, DC 20006
Telephone—202 626-4000
ARINC: WASXYXD

Pres. & Chief Exec. Officer— Paul R. Ignatius
Exec. V. P.— Norman J. Philion

Official Publications:
Facts & Figures
Quarterly Review
World Airline Suppliers Guide

ALLIED PILOTS ASSOCIATION

T-208
Box 5524
Arlington, TX 76011
Telephone—817 261-0261
Pres.— Robert H. Malone
V. P.— Frederick R. Vogel

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

T-218
1515 Massachusetts Ave., N.W.
Washington, DC 20005
Telephone—202 467-4400

Pres.— D. Allan Bromley
Publisher & Exec. Officer— William D. Carey

Official Publications:
Science
Science 81

AMERICAN ASSOCIATION OF AIRPORT EXECUTIVES

AAAE
T-223
2029 K St., N.W.
Washington, DC 20006
Telephone—202 331-8994
Pres.— John D. Salomon, Dir.-Aviation, McCarran Intl. Airport, Box 11005, Airport Sta., Las Vegas, NV 89111
Exec. V. P.— F. Russell Hoyt, Washington, DC

THE AMERICAN HELICOPTER SOCIETY, INC.

T-248
Suite 103 John Zugscwert, Ex. Dir.
1325 18th St., N.W.
Washington, DC 20036
Telephone—202 659-9524

Chrm.— William F. Paul, Sr. V. P.-Engrg. & Dev., Sikorsky Aircraft Div., N. Main St., Stratford, CT 06602 (Tel. 203 386-4202)
Pres.— John N. Kerr, V. P.-Engrg. & Dev. Research, Hughes Helicopters, Bldg. 305, Centinela & Teale Sts., Culver City, CA 90203 (Tel. 213 305-5439)

Official Publications:
The Journal of The American Helicopter Society
Vertiflite

AMERICAN INSTITUTE OF AERONAUTICS & ASTRONAUTICS, INC.

AIAA
O-1060
1290 Ave. of the Americas
New York, NY 10019
Telephone—212 581-4300

Pres.— Dr. George E. Mueller, Chrm. & Pres., System Dev. Corp., 2500 Colorado Ave., Santa Monica, CA 90406 (Tel. 213 829-7511)
Dir., Immediate Past Pres.— Prof. F. A. Cleveland, V. P.-Engrg., Lockheed Corp., Dept. 03-20, 2555 N. Hollywood Way, Burbank, CA 91520 (Tel. 213 847-1988)
Pres.-Elect.— Dr. Artur Mager, Group V. P., The Aerospace Corp., Box 92957, Los Angeles, CA 90009 (Tel. 213 648-5577)

Official Publications:
Astronautics & Aeronautics
Editor-in-Chief— John Newbauer

AIAA Bulletin
Editor— Christine Krop

AIAA Journal
Editor-In Chief— Dr. George W. Sutton

Journal of Aircraft
Editor-In-Chief— Dr. Thomas W. Weeks

Journal of Energy
Editor-In-Chief— Dr. William H. Heiser

Journal of Guidance & Control
Editor-In-Chief— Dr. Donald C. Fraser

Journal of Hydronautics
Editor-In-Chief— Dr. John P. Breslin

Journal of Spacecraft & Rockets
Editor-In-Chief— Paul F. Holloway

Progress in Astronautics & Aeronautics
Series Editor— Dr. Martin Summerfield

AIAA Selected Reprint Series
Editor-In-Chief— Dr. Robert A. Gross

AIAA Student Journal
International Aerospace Abstracts

AMERICAN PETROLEUM INSTITUTE

API
T-266
2101 L St., N.W.
Washington, DC 20037
Telephone—202 457-7000
Pres.— C. J. DiBona
Dir.-Mktg.— B. W. Cecil

APPALACHIAN HELICOPTER PILOTS ASSOCIATION, INC.

T-312
Box 8953
South Charleston, WV 25303
Pres.— Michael Stephan, 135 Morrington Dr Pittsburgh, PA 15236 (Tel. 412 787-7500)
V. P.— Roger W. Mitchell, Jr., Rt. 1, Box 24 Ronceverte, WV 24970 (Tel. 304 645-6768)

ASSOCIATION OF LOCAL TRANSPORT AIRLINES

ALTA
T-364
11th Floor
1015 18th St. N.W.
Washington, DC 20036
Telephone—202 659-1050
Chrm.— Glen L. Ryland, Pres. & Chief Exec Officer, Frontier Airlines Inc., 8250 Smith Roac Denver, CO 80207
Exec. Dir.— John L. Zorack

AVIATION SAFETY INSTITUTE

ASI
T-404
Box 304
Worthington, OH 43085
Telephone—614 885-4242

(Toll free anonymous safety reporting: Tel. 800 848-7386; in Ohio—Tel. 614 885-4242 collect. Use name of Capt. X)
Pres.— John B. Galipault
V. P.— Thomas R. Clevinger

Official Publications:
Monitor
Anonymous Safety Reporting System

(Computer storage & retrieval of FAA service difficulty reports & NTSB accident & incident reports. Anonymous safety reporting, hazard summaries & analyses; aircraft & opns. safety audits; crash/fire/rescue; accident investigation; large scale emergency preparedness studies; crew physiological & psychological studies; human factors, aircraft design analyses)

AVIATION/SPACE WRITERS ASSOCIATION

AWA
T-408
c/o William F. Kaiser
Cliffwood Rd.
Chester, NJ 07930
Telephone—201 879-5667
Pres.— Robert L. Parrish, Business & Commercial Aviation, 3432 Foxford Tr., Arlington, TX 76014
V. P.-Membership— Ben H. Scarpero, The Garrett Corp., 9851 Sepulveda Blvd., Los Angeles, CA 90009

COMMUTER AIRLINE ASSOCIATION OF AMERICA

CAAA
T-463
Suite 700
1101 Connecticut Ave., N.W.
Washington, DC 20036
Telephone—202 857-1170
Pres.— Duane H. Ekedahl
V. P.-Govt. Rel.— Steve Smith

CONVERTIBLE AIRCRAFT PIONEERS (VTOL, STOL & RVTOL)

T-469
Newcomen Rd.
Box 212A
Chester Springs, PA 19425
Telephone—215 827-7478
Pres.— Haig Kurkjian, Box 212A, Newcomen Rd., Chester Springs, PA 19425
Exec. Secy.— E. Burke Wilford, Pres., Wilford Aircraft, 102 Goodbrothers Bldg., Narberth, PA 19072 (Tel. 215 664-1220)

EUROPEAN CIVIL AVIATION CONFERENCE

ECAC
T-508
3 bis, Villa Emile Bergerat
92522 Neuilly-sur-Seine Cedex
France
Telephone—745.13.26
Pres.— E. Willoch, Dir. Gen., Norwegian Civil Aviation Dept., Box 8124, N-Oslo 1, Norway
Secy.— M. Doz

EUROPEAN ORGANIZATION FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL
T-514
72, rue de la Loi
Brussels
Belgium 1040
Telephone—02 233.02.11
Telex: 21173

The Permanent Commission Of Ministers
Lord Trefgarne, Parliamentary Under Secy. of State, Dept. of Trade, 1 Victoria St., London, England SWIR OET
Josy Barthel, Minister of Trans., Central Administration of Porte-Nueve, Boulevard Royal, Luxembourg

Air Traffic Services Agency; Committee of Management:
Pres.-France— R. Aucouturier
V. P.-UK— A. White

EUROPEAN SPACE AGENCY

ESA
T-340
8-10, rue Mario Nikis
Paris Cedex 15
France 75738
Telephone—Paris 01 567-5578
Telex 202746

Chrm. Of The Council-Sweden— J. Stiernstedt (Sweden)

Dir. Gen.-Denmark— Erik Quistgaard

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France
Federal Republic of Germany
Italy
The Netherlands
Spain
Sweden
Switzerland
United Kingdom

Observer States:
Austria
Canada
Ireland
Norway

Dir.-Admin.-Belgium— George Van Reeth
Dir.-Scientific Programs-Germany— Dr. Ernst Trendelenburg
Dir.-Applications Programs-Germany— Walter Luksch
Dir.-Spacelab Program-France— Michel Bignier

European Space Research & Technology Centre (ESTEC):

Tech. Dir.-Italy— Prof. Massimo Trella

European Space Operations Centre (ESOC):

GERMANY, DARMSTADT:

Dir.— Reinhold Steiner

Information Retrieval Service:

ITALY, ROME 00044: Frascati (Tel. 6 942-2401, Telex: 61637)

Service Head— Dr. Tim Howell

ESA Earth Observation Program Office (EOPO):

FRANCE, TOULOUSE CEDEX 31055: Centre Spatial de Toulouse, 18, Ave. E Berlin (2240)

Head-EOPO— Dr. D. Lennertz

U.S. Office:

WASHINGTON, DC 20024: 955 L'Enfant Plaza (Tel. 202 488-4158; Telex: 64412)

Office Head— Wilfred Mellors

EXPERIMENTAL AIRCRAFT ASSOCIATION INC.

EAA
T-518
Box 229
Hales Corners, WI 53130
Telephone—414 425-4860

Pres.— Paul H. Poberezny
Exec. V. P.— Thomas P. Poberezny

Official Publications:
Sport Aviation
Sport Aerobatics
The Vintage Airplane
Warbirds Magazine & Newsletter

EAA Ultralight Assn.:
Pres.— John Ballantyne

Official Publication:
Ultralight

FLIGHT SAFETY FOUNDATION, INC.

T-535
5510 Columbia Pike
Arlington, VA 22204
Telephone—703 820-2777

Pres.— John H. Enders
V. P.-Admin. & Treas.— Dagmar Witherspoon
Official Publications:
Aviation Mechanics Bulletin
Flight Safety Facts & Reports
Accident Prevention Bulletin
Helicopter Safety Bulletin
Human Factors Bulletin
Cabin Crew Safety Bulletin
Air Taxi/Commuter Safety Bulletin
Pilots Safety Exchange
Aviation Security Bulletin
Airport Operations Safety Bulletin

GENERAL AVIATION MANUFACTURERS ASSOCIATION

GAMA
T-569
Suite 517
1025 Connecticut Ave., N.W.
Washington, DC 20036
Telephone—202 296-6540
Pres.— Edward W. Stimpson
V. P.-Govt. Rel.— James D. Gormley

HELICOPTER ASSOCIATION INTERNATIONAL

* HAI
T-572
Suite 430
1110 Vermont Ave. N.W.
Washington, DC 20005
Telephone—202 466-2420
Telex: 89-615

Exec. Dir.— Robert A. Richardson, C.A.E.
Pres.— Carl Dougherty, Petroleum Helicopters Inc., Box T, Lafayette, LA 70502

Official Publications:
Rotornews
International Directory of HAA Members
The Helicopter; Its Importance to Commerce & to the Public
Positive Planning for Heliport Approval

INSTITUTE FOR DEFENSE ANALYSES

IDA
T-578
400 Army-Navy Dr.
Arlington, VA 22202
Telephone—703 558-1000
Pres.— Dr Alexander H. Flax
V. P.-Gen. Mgr.— Richard F. Ottman.

THE INSTITUTE OF NAVIGATION

O-2480
Suite 832
815 15th St., N.W.
Washington, DC 20005
Telephone—202 783-4121
Frank Brady, Ex. Dir.

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Treas.— Alexander B. Winiek, 8304 Westmont Terrace, Bethesda, MD 20034
Exec. Dir.— Frank B. Brady, (Ret.), Suite 832, 815 15th St., N.W., Washington, DC 20005

Official Publication:
Navigation

INTERNATIONAL AIR TRANSPORT ASSOCIATION

IATA
T-628
Head Office:
2000 Peel St.
1000 Sherbrooke St. W.
Montreal, PQ
Canada H3A 2R4
Telephone—514 844-6311
Telex: 05-267627
Cable: IATA MONTREAL
Geneva Office:
26, chemin de Joinville
Box 160
1216 Cointrin/Geneva
Switzerland
Telephone—022 98 33 66
Telex: 23391
Cable: IATA GENEVA
Pres.— Pierre Giraudet, Air France, 1 Square Max Hymans, Paris Cedex 15, France 75741 (Tel. 01 273.41.41)
Dir. Gen.— Knut Hammarskjold

INTERNATIONAL CIVIL AVIATION ORGANIZATION

ICAO
T-664
Intl. Aviation Square, Box 400
1000 Sherbrooke St. W.
Montreal, PQ
Canada H3A 2R2
Telephone—514 285-8219
Telex: 05-24513
Cable: ICAO
Council Pres.— Dr. Assad Kotaite
1st V. P.— R. W. Gross, Australia

Official Publication:
ICAO Bulletin

INTERNATIONAL FEDERATION OF AIR LINE PILOTS ASSOCIATION

IFALPA
T-689
Interpilot House
116 High St.
Egham, Surrey
England TW20 9HQ
Telephone—Egham 0784 37361
Telex: 895-1918
Cable: INTERPILOT
Pres.— Capt. R. F. Tweedy, Entwood, 23 Brook Ct., Monkstown, Co. Dublin, Ireland
Principal V. P.-Membership & Reg. Affairs— Capt. F. Garcia V., Polanco # 65, Col. Polanco, Mexico 5, D.F., Mexico 5, D
(Founded in 1948 to dev. a safe & orderly system of air transp. worldwide & protect the professional interests of air line pilots. IFALPA has 64 member associations rep. over 58,000 pilots. The policies of the Federation are determined by an Annual Conference, & the day-to-day control is exercised by six principal officers & nineteen reg. v.p.'s covering all areas of the world)

INTERNATIONAL FEDERATION OF AIR TRAFFIC CONTROLLERS ASSOCIATIONS

IFATCA
T-692
6 Longlands Park
Ayrshire
Scotland KA7 4RJ
Telephone—0292-42114
Pres.— H. H. Henschler, 1998 Glenmore Ave., Alta., Canada T8A 0X8 (Tel. 403 955-8397)
V. P.-Admin.— P. J. O'Doherty, 26 Carrickhill Close, Ireland

INTERNATIONAL TELECOMMUNICATIONS SATELLITE ORGANIZATION

INTELSAT
T-900
490 L'Enfant Plaza, S.W.
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APPENDIX D

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APPENDIX E

GLOSSARY

ABA	American Bus Association
ABC	Advancing Blade Concept (Contra-Rotating Coaxial Rotorblade Helicopter)
AC or A/C	Advisory Circular
ADAP	Airport Development Aid Program
ADO	Airport District Office
AHS	American Helicopter Society
APA	American Planning Association
ASR	Air-Sea Rescue
ATC	Advanced Technology Concepts; Air Traffic Control
BART	Bay Area Rapid Transit
CBD	Central Business District
CNR	Composite Noise Rating
dB(A)	A-weighted Decibel Level
DEC	Digital Equipment Corporation
DOT	Department of Transportation
ENG	Electronic News Gathering
EPNdB	Effective Perceived Noise (measured in decibels)
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FLIR	Forward Looking Infra Red
GADO	General Aviation District Office
HAI	Helicopter Association International
HIGE	Hovering in Ground Effect
HLH	Heavy Life Helicopter
HOGE	Hovering Outside of Ground Effect
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
Ldn	Noise Level Corrected for Day/Night Events
LRT	Light Rail Transit
MGM	Metro Goldwyn Mayer
NASA	National Aeronautics and Space Administration

NBAA	National Business Aircraft Association
NFPA	National Fire Protection Association
NEF	Noise Exposure Forecast
OSHA	Occupational Safety and Health Administration
PHI	Petroleum Helicopters Incorporated
PNdB	Perceived Noise Level (Measured in Decibels)
STOL	Steep Takeoff and Landing
UMTA	Urban Mass Transit Administration
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

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1. Report No. NASA CR-166266	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle COMMUNITY ROTORCRAFT AIR TRANSPORTATION BENEFITS AND OPPORTUNITIES		5. Report Date December 1981 6. Performing Organization Code
7. Author(s) Glen A. Gilbert, Darrel J. Freund, Robert M. Winick, Nicholas J. Cafarelli, Richard F. Hodgkins, Tirey K. Vickers		8. Performing Organization Report No.
9. Performing Organization Name and Address Helicopter Association International 1110 Vermont Ave., N.W. Washington, D.C. 20005		10. Work Unit No. 11. Contract or Grant No. NAS2-10798
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		13. Type of Report and Period Covered Contractor Report 14. Sponsoring Agency Code

15. Supplementary Notes

Ames Research Center Technical Monitor, Final Report: Dr. John Zuk assisted by William J. Snyder

16. Abstract This study was conducted to provide information about rotorcraft that will assist community planners in assessing and planning for the use of rotorcraft transportation in their communities. However, it was also intended to provide information useful to helicopter researchers, manufacturers, and operators concerning helicopter opportunities and benefits. The three primary topics of the study are:

- o To present the current status and future projections of rotorcraft technology, and the comparison of that technology with other transportation vehicles;
- o To describe community benefits of promising rotorcraft transportation opportunities; and
- o To discuss integration and interfacing considerations between rotorcraft and other transportation vehicles.

The following helicopter applications were examined:

- o Public Service
- o Public Transportation
- o Corporate Executive
- o Energy Exploration
- o Construction
- o Cargo
- o Agriculture/Forestry
- o Other Commercial Businesses

in the following settings:

- o Central Business District
- o Suburban
- o Small Community
- o Remote Area
- o Airport
- o Ocean Area

17. Key Words (Suggested by Author(s)) Rotorcraft Commuter airlines Helicopter urban transportation	18. Distribution Statement Unlimited STAR Category 85

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	180	

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