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Analysis of Vertiport Studies Funded by the Airport Improvement Program (AIP)

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May 1994

Final Report

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U.S. Department of Transportation

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NOTICE

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**Federal Aviation
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MAY 19 1994

Dear Colleague:

Enclosed is a copy of the report **FAA/RD-93/37, Analysis of Vertiport Studies Funded by the Airport Improvement Program (AIP).**

Several years ago, the Federal Aviation Administration (FAA) funded 16 vertiport studies to assess local and regional markets for civil tiltrotor (CTR) aircraft and the resulting need for landing facilities. Transport Canada funded a similar study. The vast majority of these studies are now complete and a summary/assessment is contained in this report.

These studies define benefits of CTR aircraft. The primary benefits are the reduction of airport and ground transportation congestion, however, other benefits are addressed. The studies also provide a view of the need for CTR services in a variety of locations. In total, the analysis of the various studies allows speculation as to the likely locations of the initial CTR operations.

This effort is one of a variety being conducted to enable the FAA and other organizations to plan for the infrastructure needs of CTR aircraft.

for Paul [signature]
Richard A. Weiss
Manager, Vertical Flight Program Office

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16. Abstract

It is expected that advanced vertical flight (AVF) aircraft such as the civil tiltrotor (CTR) will become viable, important vehicles for the relief of both ground and airport congestion. Furthermore, it is expected this will lead to expanded use of rotorcraft for scheduled passenger service. To prepare for this eventuality, the FAA in 1988 funded a program of vertiport feasibility studies. Thirteen locations, encompassing a range of cities, states, and regions, applied for and received funds. Canada conducted their own study. The purpose of these studies was to facilitate the use of AVF aircraft by identifying areas in the United States where the potential for missions using these aircraft is greatest so that infrastructure requirements could be identified and implemented in a timely manner.

This report evaluates the fourteen studies to portray an overview of the status of potential scheduled passenger service and required vertiport development within the United States, Puerto Rico, and Canada. The report also evaluates the methodologies and assumptions used in these studies to reach conclusions regarding the feasibility of AVF aircraft service in these areas. Most studies concluded that the primary mission would be short-haul passenger service between city centers and major urban areas. Some studies, particularly in the lesser developed areas (Puerto Rico and Alaska), concluded that small package delivery and cargo missions were also feasible. Final conclusions and recommendations include suggestions for planning guidelines specifically for vertiports/large heliports developed primarily for passenger operations.

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EXECUTIVE SUMMARY

INTRODUCTION

In the late 1980's the Federal Aviation Administration (FAA) sponsored 16 *vertiport studies* to assess local markets for civil tiltrotor (CTR) aircraft and the resulting need for vertiports in the localities studied. Thirteen of these studies were completed and Transport Canada sponsored their own study. This information will enable the FAA to plan for infrastructure needs of CTR aircraft. This report Analysis of Vertiport Studies Funded by the Airport Improvement Program (AIP) is an analysis of the data provided by the 14 currently completed vertiport studies. The report analyzes where CTR operations are likely to take place during the first 5 years of operation, and it evaluates the studies' assumptions and methodologies. Vertiport studies were completed for the following locations: Manhattan; New York City Airports; Washington D.C.; Orlando, FL; Puerto Rico; Illinois; California; Southern California; Alaska; Southwest Region (Dallas, TX); Boston, MA; St. Louis, MO; San Francisco, CA; and Canada.

There are many similarities among the studies due to their objective. The analyses are based on the Bell/Boeing CTR-22C as the design aircraft. The CTR-22C aircraft design was outlined in the report Civil Tiltrotor Missions and Applications: A Research Study published in 1987. The principal mission investigated is short-haul passenger transportation with emphasis placed on service from city-center to city-center. The expected passenger is the business traveller. Two studies are different in that they considered the use of the CTR for other purposes: Alaska to reduce runway maintenance cost for remote area transportation; and Puerto Rico to provide cargo service due to limitations on ground and sea transportation.

COMPREHENSIVE ASSESSMENT

These vertiport studies recognize that vertical flight transportation competes mostly with ground transportation and that vertical flight planners must consider the needs and desires of the communities where they plan to build facilities. However, specific roles of community planning agencies and facility implementation requirements are not discussed in most of the studies.

These studies define benefits of CTR aircraft. The primary benefit examined is reduction of airport and ground transportation congestion. But it is clear that careful thought went into ascertaining other benefits. These include estimates of jobs created by the vertiport, its operation and construction; enhancement of business access including the increased use of conferences and convention centers; and economic benefits from related sources such as real estate, fuel and occupancy taxes, fees for water/sewer, fire protection, and lease payments for land and hangars.

Better understanding of vertical flight requirements are demonstrated by recognition of the *system concept* in evaluating feasibility and understanding that all-weather operation is essential for schedule reliability for a successful passenger and cargo transportation system.

DEMAND ANALYSIS

Most studies focus on broad scope demand rather than on specific site location elements. In fact, a significant portion of many of the vertiport studies cover estimates of potential passenger demand associated with CTR service. Demand analysis methodologies indicate a good understanding of urban and transportation planning requirements. A range of methodologies are used that vary in degree of "analytic sophistication." The more "sophisticated" use more analytical steps and variables in more interdependent ways. The report discusses the methodologies and prioritizes them by levels of sophistication.

All of the methods are dependent upon various secondary data and/or information sources. The methods appear to have been selected in part based on the availability of data and on the amount of funding allocated to study passenger demand. The most basic of the methodologies are activity growth factors. The most advanced model simulated intercity passenger demand applying structures from basic demographic characteristics of the general population and travel behavior factors from surveys and other sources.

FEASIBILITY

The vertiport studies recognize the need to address the current public perception of helicopters that could negatively affect future CTR aircraft systems. This was clearly stated by the New York City Airports study that to be successful *"...The standard of comparison for manufacturers, travelers, and potential operators must be the fixed-wing service..."* Noise remains the issue that concerns communities and individuals the most. Yet, with an increasing requirement to address public concern for a range of environmental issues, almost half the studies do not discuss any environmental issue besides noise.

A major weakness in the studies, and a flaw in the systems approach, is the general misunderstanding of the complexity of airspace issues. There is a mistaken perception by some that aircraft like the CTR would operate outside current airspace structures. This perception may have reduced the realization of the importance of this element of a system. Even those studies that do address airspace do not completely comprehend how the CTR would fit into the existing airspace structure.

It was anticipated that these studies discuss the intermodal potential of vertiports. A few do provide limited discussions on incorporating vertiports into multi-modal facilities. However, there is a surprising lack of reference to intermodal activity. In many, intermodal potential is not discussed at all, some discussions compare CTR systems to high speed rail, while others saw alternative modes as competition, rather than an enhancement to all modes.

Very little space or detail is given to vertiport funding. Most studies address funding by acknowledging the availability the FAA AIP grants. Those studies geared more toward traditional heliports discuss the potential for private funding. But, little detail is provided beyond what projects an AIP grant covers and the percentages. Only the California study provides a detailed description of state funding processes.

These studies are a good beginning, presenting a variety of elements to be addressed in system planning. Particularly beneficial is the use of locally relevant data. But a complete understanding of the *entire* complex system within which CTR aircraft would operate is lacking. Planning guidelines and demand analysis need to be more specific and standardized to facilitate comparability and consistency among efforts.

CONCLUSIONS

The analysis shows that the greatest demand for CTR aircraft service centers around the Northeast Corridor encompassing Boston, New York City, and Washington, D.C. However, initial implementation of vertiport development and CTR applications may be more feasible in large regions with a single political entity to provide direction and support for system development such as Texas or California, whereas a system in the Northeast Corridor may experience multi-jurisdictional conflicts that may complicate or inhibit development. In addition, studies for lesser developed areas such as Puerto Rico and Alaska show a realistic potential for applications of CTR aircraft in other than congested urban areas.

The consensus of the studies is that potent .' positive economic impacts are great, but the risk of developing and implementing an unknown, untried technology is also great. A major concern recognized by most studies is that basing feasibility analysis on a theoretical aircraft limited the results regarding accuracy and realism. A corollary to the limitation of using the CTR-22C as the design aircraft is that in using only one size, there is no balanced future economic application of other sizes of CTR aircraft. However, most studies feel that the costs of development of a CTR system would ultimately be offset by capacity enhancements. A summary of the studies' conclusions is shown below:

CONCLUSIONS OF STUDIES

STUDY	PREPARER	CONCLUSIONS
Manhattan	Consultant	Demand for vertiports has been established.
New York City Airports	Consultant	Construction to support CTRs not recommended at this time.
Boston	Self	Sufficient demand for CTR service.
Washington, D.C.	Self	No vertiport until demand established in other area, specifically New York and Boston.
Orlando	Consultant	Demand for heliport, but should be built by private entities.
Caribbean Basin	Consultant	Strong support.
Illinois	Consultant	Inconclusive on construction.
California	Consultant	Not a strong market for CTR service.
Southern California	Self	CTR service feasible.
Alaska	Consultant	Inconclusive.
Southwest Region	Consultant	"Powered-Lift" service feasible between Dallas, Austin, San Antonio, and Houston. Dallas is the only place where vertiport is being constructed (but not as result of study).
St. Louis	Consultant	An intermodal heliport is to be constructed.
San Francisco	Consultant	No need for vertical flight of any kind in city.
Canada	Consultant	Conducting further study.

1.0 BACKGROUND

Many transportation planners anticipate that advanced vertical flight (AVF) aircraft such as the civil tiltrotor (CTR) will become viable, important vehicles for the relief of both ground and airport congestion leading to the expanded use of rotorcraft for scheduled passenger service. The increased capability of vertical flight technology was the basis for a 1987 Federal Aviation Administration (FAA) funded tiltrotor feasibility study for New York sponsored by the Port Authority of New York and New Jersey (PANYNJ) (reference 1). In 1988, the FAA funded a more extensive program of vertiport feasibility studies for which sixteen locations, encompassing a range of cities, states, and regions, applied for and received funds. Canada conducted its own study. Not all of these studies were completed. There were 14 completed studies, 13 Airport Improvement Plan (AIP) funded studies and the Canadian study. A list of original sponsors and completed studies is found in tables 1 and 2. The purpose of these studies was to facilitate the use of new vertical flight technology by identifying areas in the United States where the potential for passenger service by large rotorcraft is greatest so that infrastructure requirements could be met in a timely manner.

1.1 INTRODUCTION

In order to support potential implementation of AVF aircraft for scheduled passenger service, it is important for the FAA to anticipate the most likely locations for potential growth. This detailed analysis of the data provided by the 14 completed studies identifies where AVF operations are likely to take place during the first 5 years of operation. This information will enable the FAA to plan for the infrastructure needs of AVF aircraft in order to expedite the implementation of such service. This document portrays a national overview of the status of potential scheduled passenger service and required vertiport development within the United States, Puerto Rico, and Canada. The specific areas where such service is most likely to occur are defined and prioritized. This effort is vital in order to make reasonable allocations of resources to infrastructure development for the use of AVF aircraft.

In addition, an evaluation is made of the methodologies and assumptions used by these studies to reach their conclusions regarding the feasibility of AVF aircraft passenger service in their area. This evaluation provides a foundation for understanding planning requirements for increased use of AVF aircraft for passenger transportation. Final conclusions and recommendations include suggestions for planning guidelines specifically for vertiports/large heliports developed primarily for passenger operations. The FAA issued some basic guidelines for developing these studies, but these guidelines allowed tremendous latitude. Consequently, for the most part, each sponsor determined their own directions for performing the analysis. These studies can therefore be considered as independent evaluations at a local/regional government level of the potential of AVF transportation.

It is interesting to note that some of the study efforts determined from the beginning that they would not have a great demand for AVF aircraft passenger service. These areas, San Francisco, St. Louis, Orlando, and to some extent Washington, D.C., proceeded to perform heliport feasibility studies. The methodologies and reasoning behind this choice also contributes to the overall evaluation, both to the national picture of vertiport demand and to the definition and refinement of urban vertical flight facility planning.

TABLE 1 EVALUATED VERTIPORT STUDIES

COMPLETED AIP STUDIES	SPONSOR
Manhattan	Port Authority of New York and New Jersey (PANYNJ)
New York City Airports	Port Authority of New York and New Jersey
Washington, D.C.	Washington, D.C. Council of Governments
Orlando, Florida	Florida Department of Transportation Orlando Urban Area Metropolitan Planning Organization
Puerto Rico	Commonwealth of Puerto Rico Economic Development Administration of Puerto Rico
Illinois	Illinois Department of Transportation, Division of Aeronautics
California	California Department of Transportation, Division of Aeronautics
Southern California	Southern California Association of Governments (SCAG)
Alaska	Alaska Department of Transportation and Public Facilities
Southwest Region (Dallas, Texas)	Texas Department of Aviation
Boston, Massachusetts	Boston Metropolitan Area Planning Council
St. Louis, Missouri	City of St. Louis Community Development Agency
San Francisco, California*	Port of San Francisco
ADDITIONAL STUDY	
Canada	Transportation Development Centre Transport Canada

* The San Francisco study was terminated after a Phase I effort due to community pressure, but the study was evaluated in this report to help identify issues regarding community attitudes.

TABLE 2 AIP-FUNDED STUDIES NOT EVALUATED

LOCATION	STATUS
Washington State	Delayed Start, Not Yet Available
South Dakota	Funds Not Issued
Dade County (Miami) Florida	Cancelled

1.1.1 Goals and Objectives

There are two major goals of this study. The first is to establish priorities of potential locational demand for AVF passenger transportation. The second goal is to evaluate the studies in terms of the issues defined and the methodologies used, and to determine if these issues were adequately addressed in terms of realistic planning criteria. The overall objective of this effort is to furnish the FAA with credible data regarding the current national demand for potential vertiport development priorities.

1.1.2 Definitions

It is critical to define the basic terms used in this study to promote a broad understanding of the terminology. Since the types of rotorcraft to be used in the vertiport passenger systems are significant advances in technology from previous helicopters, it is important to understand the kind of aircraft that is under consideration and what types of facilities will be required.

1.1.2.1 Advanced Vertical Flight (AVF) Aircraft

The term advanced vertical flight (AVF) aircraft includes in general:

- advanced helicopters like the European Helicopters' EH 101 and the proposed Sikorsky S-92;
- tiltrotors like the Bell/Boeing V-22, its civilian derivatives, and Eurofar; and
- tiltwings like the TW-68 (program currently on hold).

Because the FAA released the NASA data package, most studies use the CTR-22C as their design aircraft. Throughout this report, the term CTR will mean the CTR-22C.

It must be recognized that the CTR-22C is not an actual aircraft but a compilation of what the first civil tiltrotor is expected to be. The CTR-22C is a pressurized aircraft, 11 feet high, 69 feet long, with 46,230 pounds maximum takeoff weight, has an 85-foot tip-to-tip span, and carries 39 passengers.

1.1.2.2 Vertiports/Vertistops

The official definition of a vertiport can be found in FAA Advisory Circular (AC) 150-5390-3, "Vertiport Design." It states that a vertiport is *an identifiable ground or elevated area, including any buildings or facility thereon, used for the takeoff and landing of tiltrotor aircraft and rotorcraft.* It is expected that these facilities will be used primarily for scheduled passenger service. Furthermore, it is envisioned that these facilities, which will be larger than a typical heliport, will accommodate all types of helicopters operating support missions.

The Vertiport Design AC defines a vertistop as *a vertiport intended solely for takeoff and landing of tiltrotor aircraft and rotorcraft to drop off and or pick up passengers or cargo.* The term is employed in this document to indicate facilities that are smaller than a vertiport and have minimal amenities for passenger and aircraft handling, but are capable of supporting tiltrotor aircraft and rotorcraft operations.

1.1.2.3 Large Heliports

In contrast, a large heliport is defined in a manner similar to the transport heliport described in Draft AC 150-5390-2A, (6/6/93) "Heliport Design," which states *A transport heliport is available for use by the general public without a requirement for prior approval of the owner or operator and is intended to accommodate air carrier operators providing scheduled service with large helicopters.*

Obviously, the critical element that both of these definitions have in common is that both facilities are intended for extensive passenger transportation which may include scheduled service.

1.1.3 Vertiport Study Types

The FAA put no specific requirement on the type of sponsor who could apply for a grant to perform a vertiport study. In other words, the grants were not limited to only states or cities, but other potential or quasi-political entities could also apply. In addition, Transport Canada, their equivalent to the U.S. FAA and DOT, decided to fund a national vertiport study. This resulted in studies that investigated the potential of vertical flight for six cities, three states, two associations of government, one port authority jurisdiction, a territory of the United States, and one country. There are two distinctions among these studies: 1) whether they investigate a regional or local area, and 2) whether they are a vertiport study or a traditional heliport study.

A local study only investigates potential facility sites within a limited area, such as a city. Only three are considered local studies: Manhattan, St. Louis, and San Francisco. The other studies evaluate potential CTR facility impact for a much larger area and are considered regional studies (see table 3).

TABLE 3 TYPES OF STUDIES

REGIONAL VERTIPORT	REGIONAL HELIPORT	LOCAL VERTIPORT	LOCAL HELIPORT
New York City Airports	Orlando	Manhattan	San Francisco
Washington, D.C.*	Washington, D.C.*		St. Louis
Puerto Rico			
Illinois			
California			
Southern California			
Alaska			
Southwest Region			
Boston			
Canada			

* The Washington, D.C. study includes elements of both heliport and vertiport studies.

Although labeled as vertiport studies, three studies, St. Louis, Orlando, and San Francisco, are primarily heliport, not vertiport, studies. Some of these studies do mention the impact of CTRs and their reasons for performing heliport studies (see table 3). The Washington, D.C. effort is a combination of both types of study. It provides an inventory of current helicopter activity, then a mathematical demand evaluation of potential CTR service to New York City from specific locations in the Washington, D.C. metropolitan area. The St. Louis effort explains why a vertiport study is not needed and then proceeds with a site selection for a heliport in the city. The Orlando study contained analysis of helicopter activity within the Orlando area, but did not discuss CTR activity. Facilities that would be required for a vertiport were discussed, but all other analysis focused on helicopter activity. San Francisco, an area noted for generally opposing heliport development, used this opportunity to evaluate the need for any helicopter activity within the city. Although the study consultant concluded there is a need for heliports, the sponsor disagreed and cancelled further work on the study.

The studies that focused on heliports are useful to this evaluation. The reasoning behind the decision not to consider CTRs, and the methodologies used, add insight to the national overview and are relevant to vertiport planning.

1.1.4 Role of Sponsor

The role of the sponsors in these studies was to evaluate the potential demand and impact of AVF aircraft and necessary facilities for their specific area. Some performed the work themselves, like Southern California, while other sponsors directed the work of hired consultants who performed the study.

2.0 DETAILED ANALYSIS

Evaluation of the data provided by the 14 completed studies will identify where civil tiltrotor operations are likely to take place during the first 5 years of CTR operation. This effort will focus on demand analysis, feasibility analysis, and evaluation of other issues significant to the development of an infrastructure for AVF aircraft passenger service.

2.1 DEMAND ANALYSIS

A critical step in describing the national overview and evaluation planning methods is to understand factors that create demand for scheduled AVF services. Successful large heliports/vertiports are built where demand exists, not where demand is desired by any individual, organization, or agency. The study locations cannot be considered in isolation. Feeders and intermodal links will identify, as much as possible, a systematic infrastructure, often linking facilities with each other. The relative reasonableness of these locations must be evaluated by comparing methodologies used to reach the conclusions in each study.

2.1.1 Geographic and Planning Areas

The location of each study sponsor is shown in a map in figure 1. The predominant characteristic of all but two of the study areas (Alaska and Puerto Rico) is that it is located in, or encompasses, an urban area that has a large population relative to its setting. Further, aviation ground congestion are imminent threats to the area's economic well-being. It was expected that there would be differences traced to region, e.g., the East Coast findings would be similar to each other but different from West Coast results. This did not turn out to be the case. There appears to be a common problem in all study areas: urban and airport congestion. The exceptions are the remote or special use evaluations found in Alaska, Puerto Rico, and to a limited extent, Canada. In these areas, transportation problems are almost the exact opposite of urban areas. They are remote areas with few roads and small or no airports. In these areas, the appeal of the CTR is the ability to operate as both airplane and helicopter. The CTR has a range and speed more like an airplane, yet requires minimal landing facilities, which means less construction and maintenance costs than airports.

The basic planning area is considered to be the political jurisdiction of the vertiport study's sponsor. This is usually a city, multiple county region such as an association or council of governments, or state, or a special purpose authority such as an airport or port authority. Although informative, neither the simple geographic location nor planning area tells the whole story. A more detailed scope of study is needed to determine the expected extent and range of potential CTR operations (see section 2.1.2). The following paragraphs provide a brief description of each area and its basic character.

2.1.1.1 Manhattan (PANYNJ)

As a section of the largest city in the United States, Manhattan is a high density urban area. This area already has four active public-use heliports including one of the successful FAA

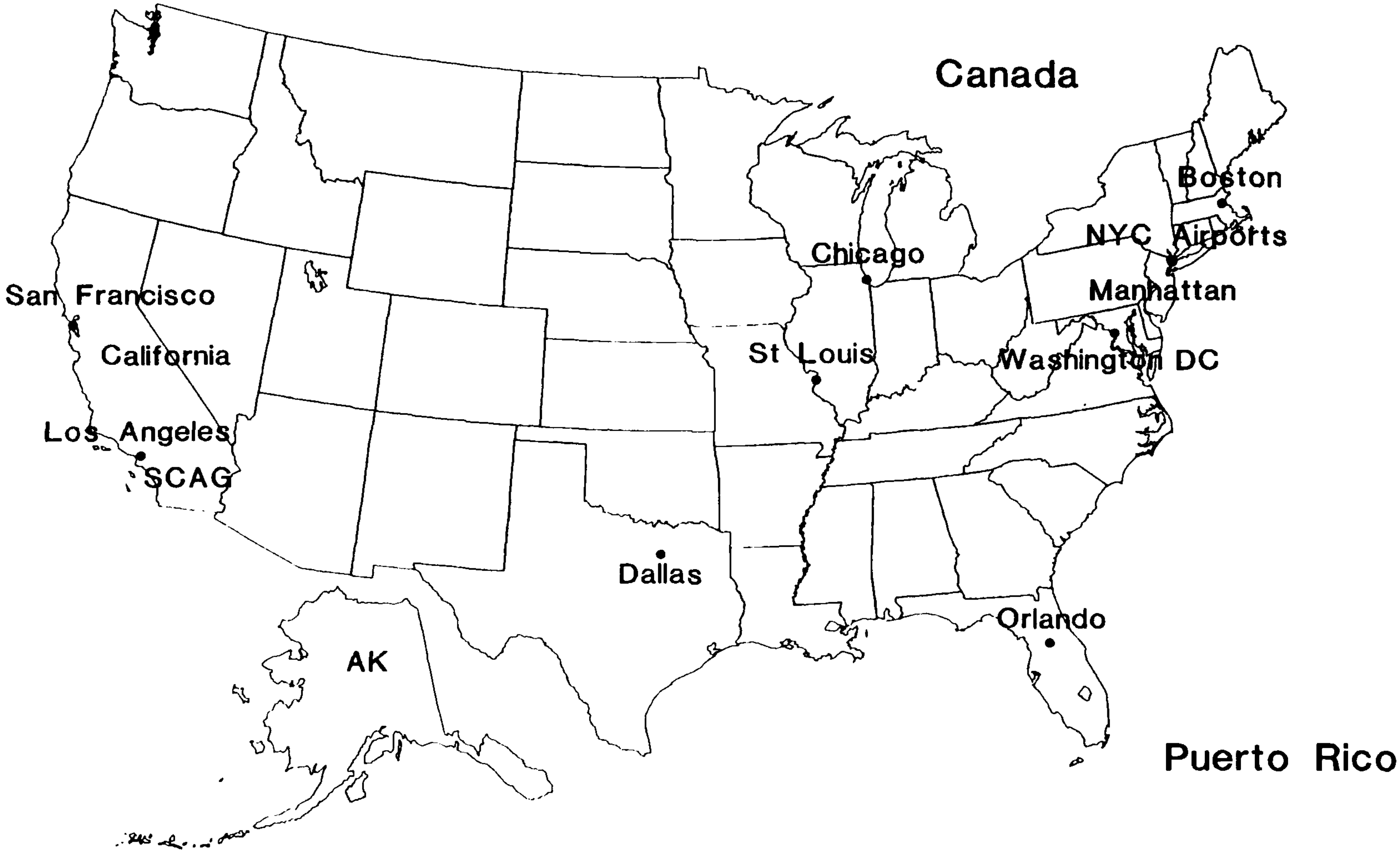


FIGURE 1 MAP OF ALL THE STUDY LOCATIONS

Demonstration Prototype Heliports, the Downtown Manhattan Heliport. The PANYNJ has been involved in heliports since the mid-1950's and sponsored the first tiltrotor study (reference 1). It experiences both ground and airport congestion and is looking for a solution to these problems. This study investigates only potential vertiport sites on Manhattan Island, although it considers various destinations to which passengers would travel from the site.

2.1.1.2 New York City Airports

The New York City Airports study (LaGuardia (LGA), Kennedy (JFK), and Newark (EWR)) is culturally, at least, an extension of New York City, since it encompasses a highly congested metropolitan area. The study focuses on easing airport congestion and evaluates the effects of vertiport and CTR service within the region serving the three major New York City airports.

2.1.1.3 Boston

Boston is located at the northern end of the Northeast Corridor. There is already a higher usage of corporate/executive helicopter service between Boston and New York City than between other cities. There is high population density and heavy urban development in the Northeast Corridor. Both ground and airport congestion are believed to be reaching a critical level. A future goal is to ultimately connect the Boston metropolitan area multi-modal vertiports with vertiports in New York City, and Washington, D.C.

2.1.1.4 Washington, D.C. Council of Governments (COG)

The Washington metropolitan area includes four counties and three cities in Virginia, three counties in Maryland, as well as the city of Washington, D.C. The metropolitan area experiences highly congested ground and air traffic. There are three major airports, National (DCA), Dulles (IAD), and Baltimore-Washington (BWI), to which road access is becoming an increasing concern. One of the major destinations of air passengers departing the Washington, D.C. area is New York City.

2.1.1.5 Illinois

The Illinois study focuses on passenger transportation in the Chicago metropolitan area, a heavily populated urban region. It was estimated that, in 1990, there were 30 million local passengers that traveled to or from Chicago on scheduled commercial airlines. This indicates that the area's two major airports may be soon reaching their capacity limits.

2.1.1.6 Southwest Region (Dallas, Texas)

There is much intrastate travel in Texas due to the size of the state and the needs of its citizens. Some areas of Texas are very urban and much is very rural. However, the study concentrates on the potential for a high density passenger market and not rural or remote area transportation. It evaluates the potential of city-center to city-center transportation among a triangle formed by Dallas/Fort Worth, Houston, and Austin/San Antonio.

2.1.1.7 California

California is a large and populous state. However, in a sense, the state is somewhat isolated. The heaviest population is found along the west coast. It is protected from the level of interstate interaction found on the east coast due to geographic, climatic, and demographic features. However, because of its large population and economic relevance to the United States as a whole, there is significant intrastate and interstate transportation. For these reasons, some of California's airports are counted among the busiest in the world. This study explores the potential use of CTRs to relieve the mounting congestion of both ground and airport transportation.

2.1.1.8 Southern California Association of Governments (SCAG)

The southern portion of California is the most heavily populated section of the state (see section 2.1.1.7). Southern California is famous for its ground transportation system--the freeway, which was, when it was constructed in the 1950s and 1960s, considered the most advanced, modern form of transportation. The constant increase in population of both people and cars has threatened the freeway system with potential gridlock. The ramifications of Los Angeles being the second most populous city in the United States has also meant congestion at the major airports. The study explores the potential use of the CTR to relieve this congestion.

2.1.1.9 Puerto Rico (Caribbean Basin)

The impetus for this study came from Puerto Rico. However, the study evaluates CTR service to 20 island nations and countries bordering on the Caribbean Sea such as Mexico, as well as some countries in South America such as Venezuela and Columbia. This study is unlike the others because its focus is on cargo shipment, not passenger transportation, although passenger service is considered.

2.1.1.10 Alaska

Use of air transportation in Alaska is perhaps more important than in other areas because, due to climate and topography, ground transportation infrastructure is difficult to construct and expensive to maintain. Evaluation of CTRs in the Alaska study had a different premise. It was performed to evaluate the potential of CTRs in remote, not urban, areas to see if building and maintaining vertiports was less expensive than the maintenance of runways. Runway maintenance is extremely costly in the cold climate. The study encompasses a major system of vertiports in the more populated southeastern part of Alaska and to the remote villages in the western part of the Alaskan mainland.

2.1.1.11 San Francisco

San Francisco is a city surrounded on three sides by water. Until about 30 years ago, it was the only true urban area in a rural region. However, with the urbanization of farmland, the area developed severe ground congestion problems for suburban commuters. Although there is a metropolitan area around San Francisco Bay and south of the city, this study considers the need for heliports only within San Francisco itself.

2.1.1.12 St. Louis

The St. Louis study is a heliport siting study. The reason for this adds insight to the national overview of potential vertiport locations. This study determined that St. Louis would not have enough demand to be considered a primary market for CTRs in the early stages of CTR implementation, but would most likely be a secondary market for places like Chicago and Indianapolis. It therefore concluded that, at this time, a heliport would be more germane.

2.1.1.13 Orlando

The Orlando urban area includes eight counties, three of which are Standard Metropolitan Statistical Areas (SMSA) within the central market region of Florida. The Orlando urban area supports the most popular tourist attractions in the state, such as Disney World and Sea World. The economic base of this area primarily consists of service and retail trade and high technology manufacturing.

2.1.1.14 Canada

The Canadian study was sponsored by Transport Canada, Transportation Development Centre. It considers the CTR for passenger service for the more populated southeast and passenger and cargo service for the remote areas in other parts of the country. It also explores links to markets in the northeastern United States.

2.1.2 Market Area

The geographic and planning areas are not sufficient to determine the demand for vertical flight transportation. In order to define and evaluate the true impact of AVF operations on the sponsor's geographic location, the market area must be identified. The market area is defined as all locations from which vertical flight activity will impact the area under study. Once defined, an accurate assessment of current and potential aircraft and operations needs to be determined. Figure 2 and table 4 present market areas for each study.

2.1.2.1 Specification of Market Area Aircraft

The aircraft to be used in the vertiport studies was suggested in the FAA-produced data package (see section 1.1.3.1) that provided information for vertiport planning. The aircraft used most is the CTR-22C, a pressurized 39-passenger tiltrotor aircraft. This aircraft is

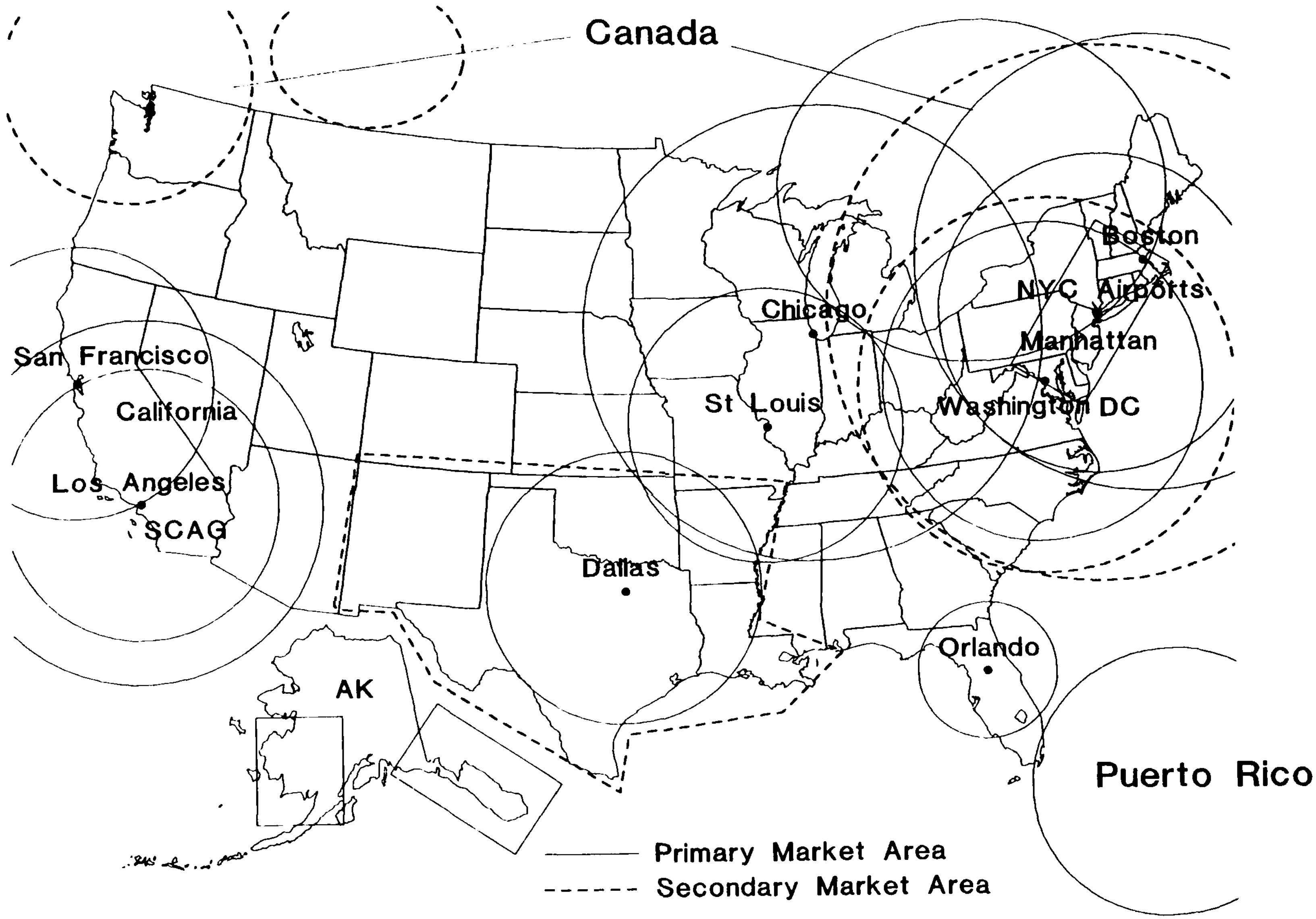


FIGURE 2 MAP OF MARKET AREAS

TABLE 4 MARKET AREAS

STUDY	MARKET AREA
Manhattan	Northeast Corridor (Boston to Washington, D.C.).
New York City Airports	Primary area - all short-haul markets within 350 nautical mile (nm). Secondary area - up to 600 mile radius.
Washington, D.C.	100 to 350 nm radius. City-pairs to 450 nm.
Orlando	150 mile radius (includes Melborne, Daytona Beach, and Tampa).
Puerto Rico	Approximately 300 miles from San Juan: areas that can be reached without refueling.
Illinois	Chicago metropolitan area - 500 mile radius.
California	300 mile radius from San Francisco and 300 mile radius from Los Angeles.
Southern California	Within 400 nm radius.
Alaska	Six towns and villages in southeast Alaska: villages on the western mainland near Bethel.
Southwest Region	Primary area - 300 mile radius . Secondary area - potential five state region centered around Dallas/Ft. Worth, to include Texas, New Mexico, Oklahoma, Arkansas, and Louisiana.
Boston	300 - 500 nm from Boston for CTR. 100 nm for helicopters.
St. Louis	CTR market area 300 miles.
San Francisco	100 mile radius for helicopters. Vertiport market would extend to Los Angeles, San Diego, Orange County, and Las Vegas.
Canada	Primary area - the eastern portion to connect to the eastern U.S. where demand is highest: Secondary area - Vancouver, Seattle, Prince George, Kelowa: Calgary, Edmonton: and remote operations to northern tier.

considered to be an archetype of the first CTR that will be available at the beginning of public transportation service. Since no CTR-22Cs have been produced, operational data are not available. Most studies provided demand estimations and forecasts to determine future aircraft requirements in the appropriate sections.

2.1.2.2 Linked Market Areas

As can be seen in figure 2, in some cases the geographic areas under investigation overlap, or are "nested" within each other. For example, the Canadian, New York City Airport, Manhattan, Washington, D.C, and Boston studies all investigated connections among each other within the Northeast Corridor. The St. Louis study considered potential connections to the Chicago metropolitan area which was evaluated in the Illinois study. In California, two independent studies, San Francisco and Southern California, were "nested" within the area of investigation of the California state study. The market areas of Alaska, Dallas, Orlando, and Puerto Rico are independent of the declared market areas of other studies. These areas can be considered linked into inter-regional/state systems and have similar cultural, economic, and political elements. More specific connections among study areas are determined in section 2.1.3.

2.1.3 Demand Centers

Market areas contain specific locations of demand for vertical flight transportation or "demand centers." A demand center is a geographic area where the potential exists for vertical flight services based on market considerations, not where the sponsor or any other pressure group, would like them to be. A demand center can range from specific cities within a region or state to specific locations within a city, depending on the level of the study (local, state, regional).

Demand centers are determined by understanding where the aircraft come from, where they go, and why. Demand centers can be different for different missions for the same geographic location, e.g., a demand center for passenger transportation may be in a different location in a city than a demand center for cargo. The patterns of demand for vertical flight transportation related missions are more in line with ground transportation patterns than with jet air transport patterns.

In evaluating demand centers and patterns of demands, it is important to determine if smaller private facilities are required as feeders to a large "hub" facility, or if there is enough ridership entering the system at a large urban facility so that only a hub-to-hub structure is required. To ensure a long term structure, changes over time of the system must also be evaluated, planned, and then implemented. Table 5 provides a summary of assumptions and methodologies used to calculate demand in the vertiport studies. Section 2.1.6 provides in-depth evaluations of methodologies for estimating passenger demand.

2.1.4 Mission(s)

The principal mission discussed in most of the vertiport studies was short-haul passenger transportation with sub-groupings of scheduled service, corporate/executive, and air taxi. Particular emphasis was placed on city-center to city-center service because in most locations the rationale for providing CTR service, expected to be more expensive than current modes, is to save time. The travel segment that is the most time consuming, whether from home or office, is considered to be the trip to the airport. Since the primary passenger envisioned supporting this service is the business traveller, the logical location to build vertiports is in downtown areas or in other high activity urban center. However, it is expected [hoped] that once a passenger became accustomed to using AVF transportation, the mode would expand to include personal use.

Two studies, Alaska and Puerto Rico, considered the use of the CTR for other purposes. Alaska evaluated the potential of using the CTR to reduce the cost of runway maintenance for transportation into remote areas. Puerto Rico evaluated the CTR for cargo service into areas where there are limitations on ground or sea transportation. These two studies are more thoroughly discussed in section 2.1.5.

California considered potential CTR use for resource development, public service, remote region access, and small package delivery. The study concluded that short-haul intercity scheduled service was the only feasible mission at this time. However, most studies indicated

TABLE 5 SUMMARY OF ASSUMPTIONS/METHODOLOGIES USED TO CALCULATE DEMAND

Manhattan	Methodologies strongly based on previous studies: The 1985 Airport Access Survey, "VTOL Intercity Feasibility Study," Rand Study, "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market." Use databases of passengers from various sources, developed a "profile" of the Manhattan short-haul business traveler, assigned them to zip codes on the island according to the 1985 PANYNJ Airport Access Survey (reference 2).
New York City Airports	Market Demand Analysis: 1. Identify all air service markets within CTR range of NY airports and determine existing local traffic volumes. 2. Project traffic volumes into 1995 (start date for service), 2000, and 2005 based on FAA terminal forecasts. 3. Review data on intercity travel volumes by modes and estimate the share of market, within CTR range, currently using air travel. 4. Define a mode choice model to predict proportion of travelers using alternative modes in each market (including CTR) as a function of fare/travel time. 5. Develop scenarios covering relative CTR and fixed-wing fares, average air traffic delays for fixed-wing ops, and traveler value of time. 6. Explore potential systems of regional vertiports in NY/NJ, Boston, and DC regions and estimate the share of market accessible to each, on the basis of air passenger ground origins from recent passenger survey data. 7. For each scenario, use the mode choice model to guide estimates of CTR market share and traffic in each air service market, and to project the total CTR market. Assumes passengers from other modes; no latent demand.
Washington, D.C.	Demand Estimation Overview: 1. Determine the number of business air passenger originations in the base year (1990). 2. Forecast the number of business air passenger originations in the forecast year (2000). 3. Determine the fraction of year-2000 business air passengers who would be likely to choose CTR service over conventional air service.
Puerto Rico	CTR competitive cargo markets are: 1. Point-to-point movement of cargo between linked manufacturing plants, and 2. Point-to-market movement of resources where alternative transportation either does not exist or is difficult. Areas that could compete for passengers: 1. areas that do not have current or potential road or air transportation facilities, 2. areas served by single engine or small twin engine aircraft, 3. areas where surface transportation is difficult and time costs are high, 4. areas where the only surface transportation is boat. Also considered emergency medical service (EMS), search and rescue.
Boston	Guiding assumptions: 1. CTR or comparable technology will be available in near future 5-10 years, 2. technological development will allow the aircraft to meet appropriate cost, noise and safety criteria and to provide competitive door-to-door travel times relative to conventional air service, 3. business travelers recognize excessive time and costs of airport commute, and 4. business is willing to pay a premium to take advantage of the service.

Illinois	Used two methodologies: 1. Simat, Helliesen & Eichner Airport Share Model - allocates air traffic demand of a given area to competing airports based on service levels offered at each, adjusted to reflect relative convenience in terms of ground access and relative fares. 2. Value of Time Methodology - time savings with increased fare What both methodologies have in common: - treat CTR as competing for passenger traffic with conventional airline service (at O'Hare and Midway) - used only point-to-point traffic at those airports 1. compared ground access times for airports and specified vertiport 2. compared different fare levels (CTR vs. jet) 3. compared service levels between airports and vertiports - used origin zone for identifying passengers - sensitive to mix of business vs. non-business passengers *in each zone* Differences between methodologies: 1. Airport Share more sensitive to service levels. 2. Value of time - more sensitive to assumed income of passengers. Models used due to lack of real data.
California	CTR Service will only work if: 1. total costs to operate the CTR would not exceed 125% of comparably sized turbo-prop. 2. primary users are those that need origin to destination service and will pay more for it. 3. range does not exceed 600 miles (nm) primary area 100 to 300 miles. 4. highest number of business passengers are for San Jose and Sacramento. 5. capture small number of business passengers that live less than 1 hour from airport that offers equal or better service, lower price, those flying on discount fare. AND, those travelling 3 day+ since time sensitivity varies in proportion to trip length. 6. CTR captures 10-25% all short-haul statewide, and 40% in San jose and Sacramento.Time saving is key to success. Higher ticket prices are assumed. *Business travelers will pay more but only up to a point.*
Southwest Region (Dallas)	Two step process: 1. identify air travel market, and 2. identify demand centers, primary and secondary Generalized Demand Center Characteristics model considers six characteristics (1. population density, 2. income distribution, 3. business activity, 4. vertiport accessibility, 5. vertiport site availability, 6. public acceptance.) First 3 characteristics are evaluated. If an area meets requirements, next 3 evaluated.
Orlando (heliport study)	Demand Centers were identified by origins and destinations of helicopter operators throughout the region and in association with the local definition of Activity Center and verified by survey: 1. A major employment or service center that will represent an ultimate combined employment base of 10,000 or more attendant employees. 2. A major industrial-distribution or office-research center that will represent an ultimate combined employment base of 10,000+ attendant employees. 3. A major tourist destination center or complex that will typically house and service more than 20,000 visitors/day. 4. Any major transportation complex or facility that serves in a multi-modal capacity. 5. A major development core with severe traffic congestion.
Canada	Used iterative approach based on the notion of applying a series of criteria regarding the minimum conditions necessary to create the basis for economical air services from an airline perspective. Methodology Summary: 1. *Identified potential hubs from forecast of domestic and transborder intercity air traffic volumes* for years 2000 and 2010. - Forecasts; determined by Transport Canada, considered both business and non-business passengers. - City pairs selected on basis of 2010 forecast with threshold of at least 725,000 origin and destination (O&D) passengers as precondition for introduction of CTR services in either primary or stand-alone market. - Distance of 185 to 556 km (115 to 345 miles). 2. Other opportunities which might exist due to special circumstances, but would not be supportable as primary market, i.e., a kind of "latent demand" that would only exist due to primary market.

that there is a potential for small package delivery as a support mission for passenger service. This mission is discussed in section 2.1.7.

There were no regional variations in the types of vertiports considered necessary for passenger service. Again, the common thread was that urban areas and potential feeder locations may require different types of vertiports due to differences in service level. The studies indicated that for a big city downtown area, a vertiport would have to be a full service facility that includes such amenities as parking for several aircraft, fuel and maintenance service, navigation aids, hangars, control tower, passenger gates, terminal building with concessions, baggage claim, vehicle parking, and intermodal connections. Vertiports in the suburbs that would act as feeders to the downtown vertiport would be "vertistops" with minimal operational area and passenger facilities. Vertiports located at airports were also thought to require only minimal amenities.

2.1.5 Identification of Any Unique Regional Demand Circumstances

The unique operating characteristics of tiltrotor and tiltwing aircraft provide opportunities to expand the use of vertical flight into new markets by offering services not previously available. This is particularly true in regions that have significant potential for development, yet have few or no roads, and infrequent or no air transportation. These areas include those served by small, fixed-wing aircraft with challenging weather and/or topology, areas where surface transportation is difficult and travel time creates high costs, areas where the only surface transportation is by boat, and where there is too little flat land area to accommodate conventional airport facilities. The unique capabilities of AVF aircraft also provide opportunities for merging missions that have previously been handled by a combination of helicopters and fixed-wing aircraft, thereby reducing the capital outlay involved in providing a particular service. In this section, the unique regional demand circumstances identified in the studies are discussed and summarized. Of particular interest are the Alaska and Puerto Rico studies because each focuses on CTR usage unique to their areas.

2.1.5.1 Mission Identification

In order to define unique regional demand, unique regional missions must be identified. Several studies presented tables listing the broad variety of missions that are singularly applicable for vertical flight aircraft. Table 6 is a consolidation of the missions identified in the studies that fall within the context of unique regional demand for tiltrotor or tiltwing aircraft.

2.1.5.2 Alaska/Canada

The Alaska study focuses on an evaluation of the economic viability of two commuter/cargo service networks that are hypothetical replacements for a "baseline" service network that presently exists in Alaska. This "baseline" network is presently serviced by commuter aircraft, seaplanes, and helicopters.

TABLE 6 UNIQUE REGIONAL CTR MISSIONS

Low Density Passenger/Cargo Service • remote region services	Industrial Cargo/Express Package • high value cargo
Public Service • EMS • search and rescue • disaster relief • fire fighting • maritime/border patrol	Natural Resource Exploration/Development • oil • gas • mining

The first network examined is a 32-route system that provides service between the six service segment airports (Juneau, Gustavus, Sitka, Petersburg, Wrangell, and Ketchikan) in Southeast Alaska and the 32 villages/communities within their "sphere of influence." It has been suggested that in many cases, floating vertiports could replace seaplane operations in this network. The study also indicates that tiltrotor service may be able to offer shorter block times and provide a more reliable service.

The second example network examines commuter/cargo service between Bethel and the 30 villages within its "sphere of influence." The reported advantages in this application are expected to include faster block times, more reliable instrument flight rules (IFR) service, and reduced costs to the state due to lower runway reconstruction and annual maintenance costs. The basic question to be resolved in this study involves the characterization of an economically viable (or least non-viable) system. In the southeast Alaska example, three tiltrotor vehicle configurations are evaluated to accommodate forecast passenger, freight, and mail traffic.

The Canadian study identifies several unique regional demands for the use of CTR technology. These demands are associated with air passenger/cargo service to remote regions, support for resource exploration and development, and public service applications.

Projected CTR passenger services for Canada are viewed from two very different and distinct perspectives. High-density passenger travel is viewed as a short-haul service for urban markets, the same view taken in the majority of the 14 studies. In contrast, low-density services to remote regions are viewed as extensions of air services to places where air transport is currently limited, regulated, or simply nonexistent.

In these much less competitive environments, CTR services is characterized by unique factors. Emphasis is on minimizing the cost of ground facilities (both capital investment and operational/maintenance expenses) and providing minimum-level services to areas that would otherwise be inaccessible by air. Apart from the relatively limited zones of high population concentration in the southern part of Canada, the remainder of the country is sparsely populated with a limited transportation infrastructure. This is especially true in the northern regions. Air transportation is already well established in these regions as the only practical means of year-round transportation. The ability to insure air service under adverse conditions directly affects economic potential and the provision of social services.

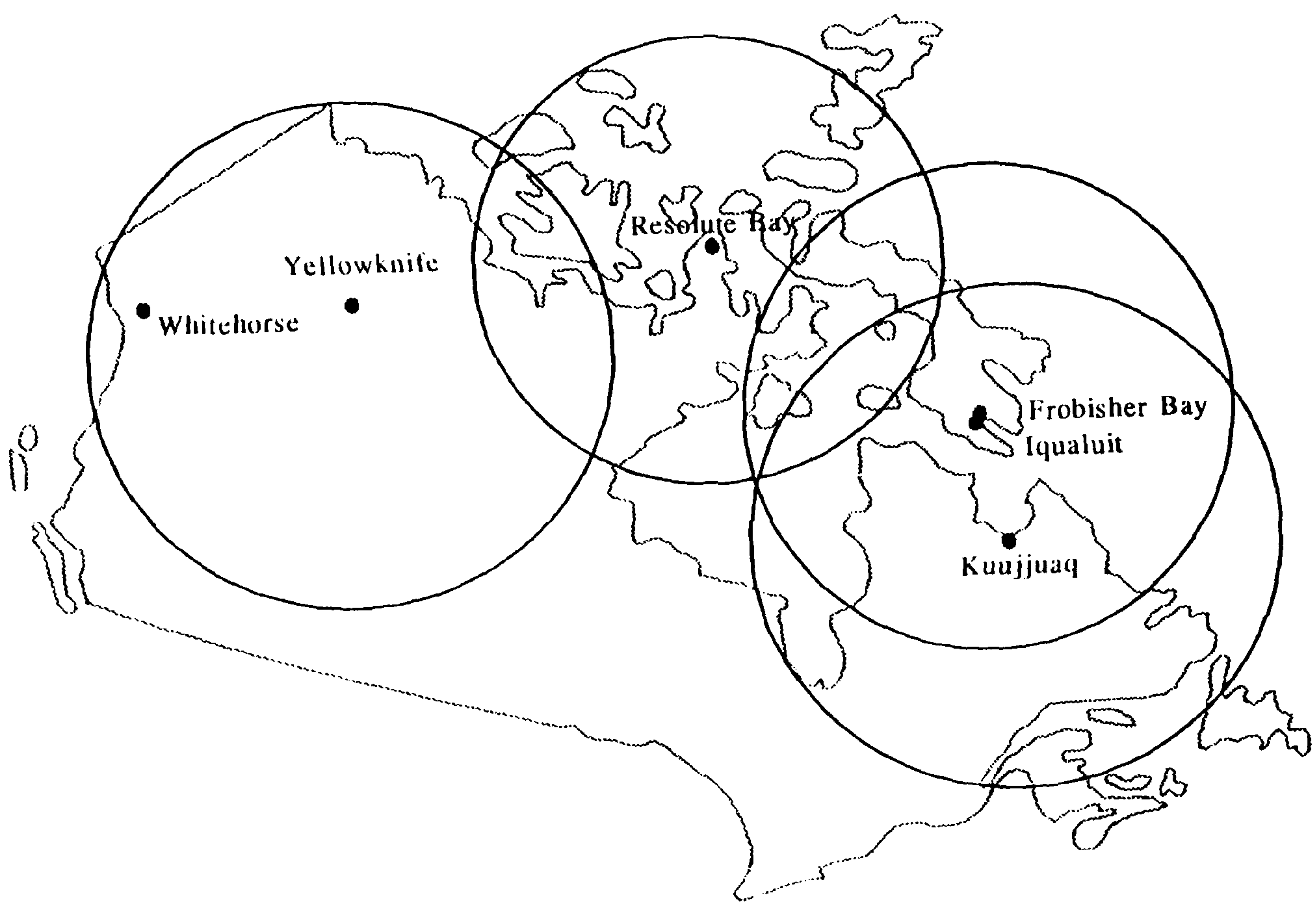
For both northern environments, Canada and Alaska, the unique requirements pose serious operational and economic problems for air transportation, fixed-wing or helicopter. Required services are limited and infrequent by nature because population densities are low. Runway construction and maintenance, as related to service frequencies, is very expensive due to long winters, severe weather, and freeze-thaw cycles. The use of CTR technology could substantially reduce costs at airport facilities if fixed-wing aircraft are replaced. Furthermore, since helicopter range is limited in comparison with CTR vehicles, it is envisioned that the use of CTR vehicles will allow the extension of air service to areas not currently served by helicopters or fixed-wing aircraft.

Figure 3 describes the concept presented by the Canadian study for introducing CTR service through four northern hubs. Regular jet service would off-load passengers and cargo at these hubs for CTR distribution. The approximately 900- mile CTR range of operation would clearly allow for all points in Canada to be fully serviced. While no detailed analysis is presented in the study, it is anticipated that this form of an air transportation system has the potential for lower operations/maintenance and capital costs than either helicopter or fixed-wing options.

Support of resource exploration and development is another mission that was evaluated for potential CTR use. While logging, mining, and general resource development markets exist, the best potential market for immediate introduction is in support of oil and gas exploration and development. Most of the oil and gas reserves are located in western Canada; however, they represent only slightly more than one percent of the country's identified resources.

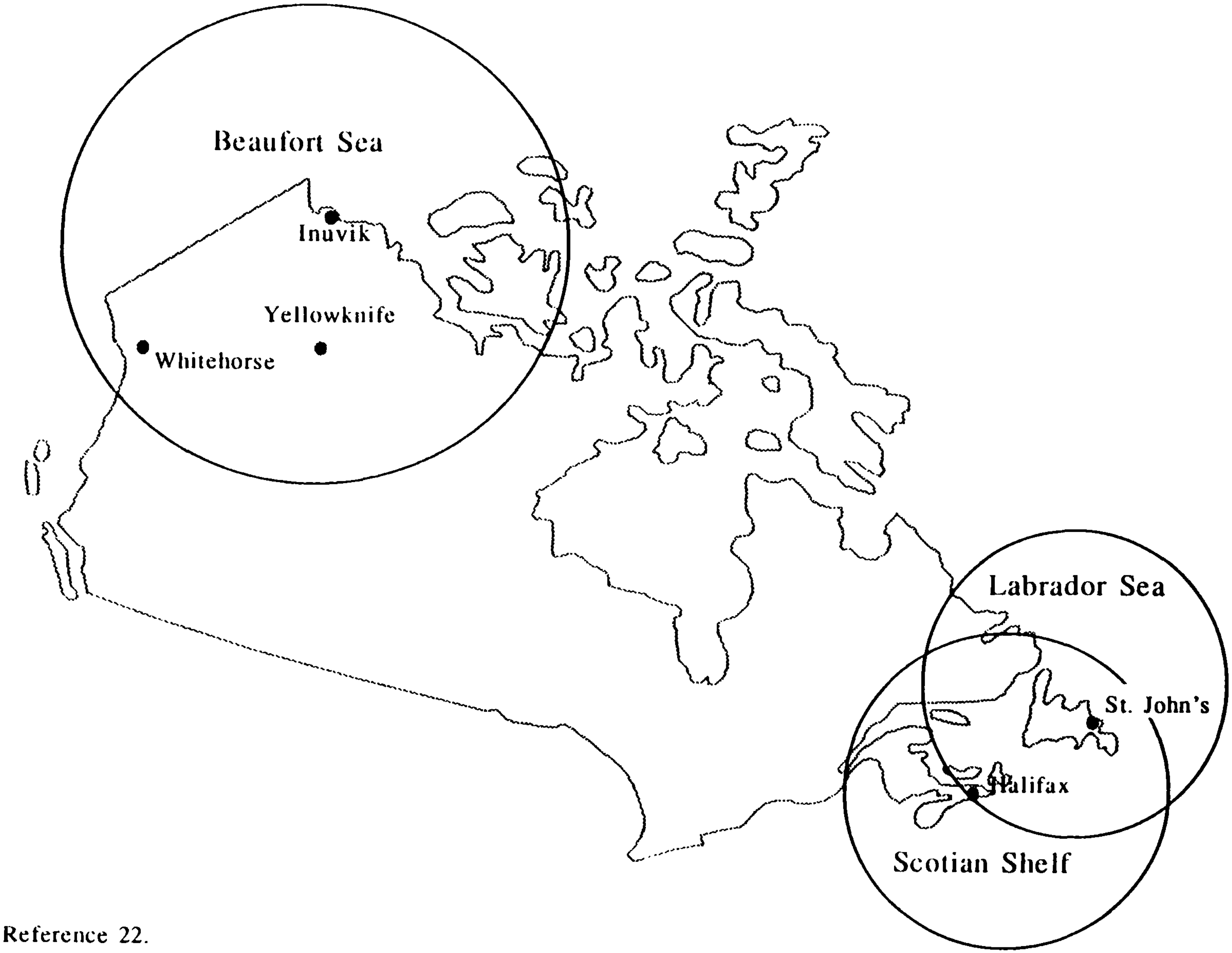
The two major helicopter disadvantages, low cruise speed and short range, are the two major advantages of using CTR technology. Due to these advantages, a smaller fleet of comparable size CTR aircraft should be capable of accomplishing what helicopters are hard-pressed to accomplish at present. A longer range capability would also allow exploration farther out to sea and allow a reduction in the number of supply bases onshore. If biweekly crew transit times and transfer delays due to weather complications to offshore rigs can be significantly reduced, then substantial cost savings would be realized (see figure 4). However, no projections for the numbers of CTR aircraft required for this mission were provided.

Public service missions place the greatest demands on aircraft due to the diversity of assignments they are required to perform. Public service missions are generally provided free of charge to the public by government agencies on a when-and-if-required basis. Costs are typically borne by the government agencies. Public service missions identified by the Canadian study that would benefit directly from the introduction of CTR technology are medical transport, search and rescue, forest fire fighting, disaster relief, and maritime/border patrol. Areas identified for these services are shown in figure 5. In most cases, the CTR-800- or XV-15-size vehicle is identified as the most likely candidate for use. Decisions on use of the vehicle will be made by provincial governments in almost all instances except those involving maritime/border patrol, which is a Federal government responsibility.



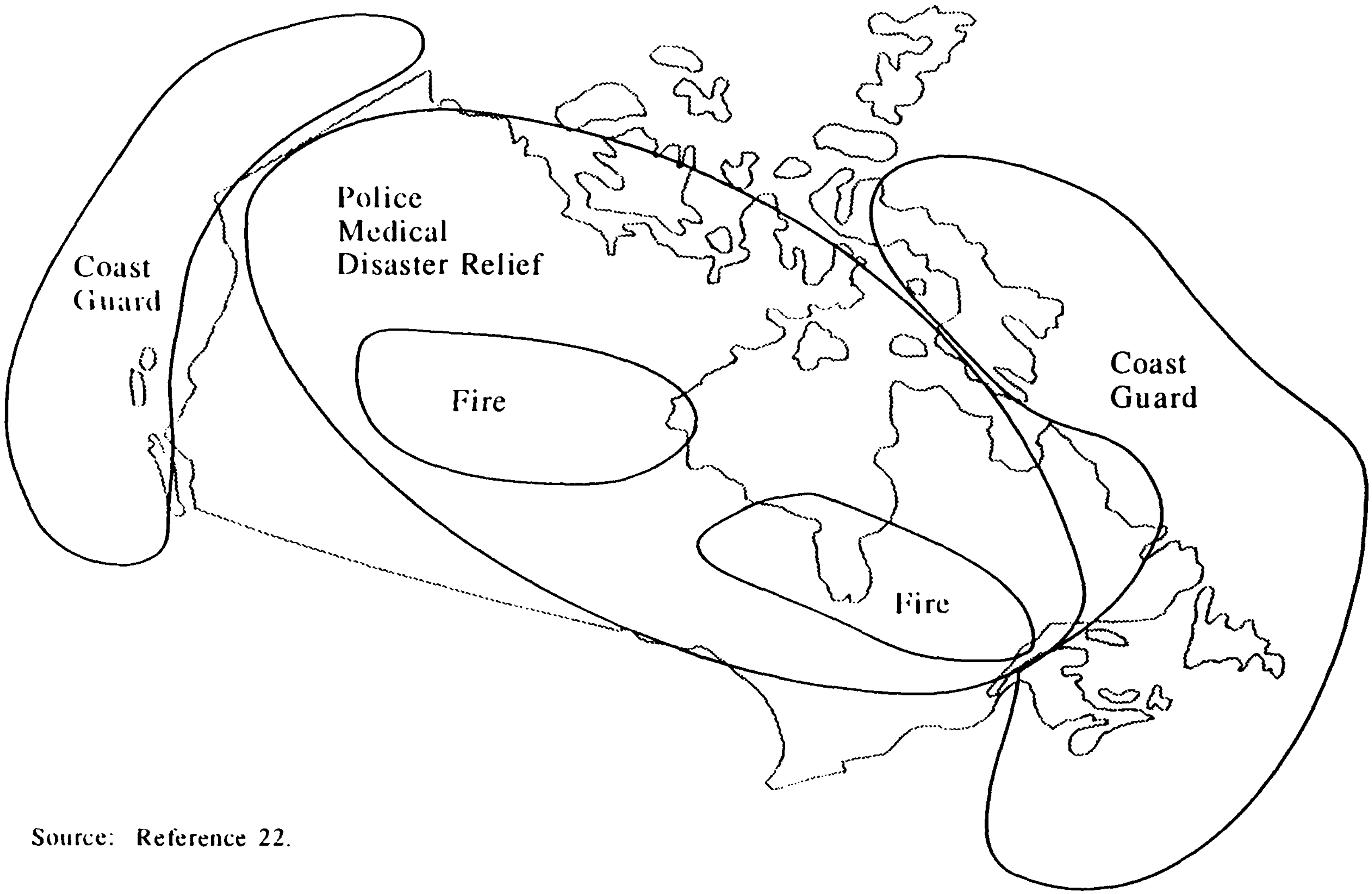
Source: Reference 22.

FIGURE 3 A CONCEPTUAL CTR SYSTEM FOR THE CANADIAN NORTH



Source: Reference 22.

FIGURE 4 A CONCEPTUAL CTR SYSTEM FOR CANADIAN OIL AND GAS EXPLORATION AND DEVELOPMENT



Source: Reference 22.

FIGURE 5 AREAS FOR CTR APPLICATION TO PUBLIC SERVICE MISSIONS

2.1.5.3 Puerto Rico

There are 20 island-nations in the Caribbean with a total population of over 22 million people and a combined gross national product of over $60 billion. Many of these island nations are isolated, often mountainous, and frequently lack adequate transportation infrastructure. The Puerto Rico study evaluated CTR alternatives for use in this region because many of the islands have low activity airports and few funds for infrastructure development.

As a region, the Caribbean nations and their economies have long been of strategic interest to U.S. foreign policy makers. Like most of Latin America, the region was hit hard by the oil crisis in the early 1970s and by the general world decline in international commodity prices. As a result, the United States enacted several laws to improve trade and the standard of living in the region. These and other political actions by both the U.S. and Puerto Rico have promoted manufacturing in the region.

As a result of these changes, in the years from 1984 through 1988, the U.S. trade surplus with the region widened by almost 41 percent to $8.6 billion. The composition of U.S. imports also began to change toward more manufactured goods and nontraditional agricultural crops in contrast to the traditional commodity products imported previously. Air cargo shipments increased at an average annual rate of 8.8 percent and tourism, particularly through the hub at San Juan's airport (SJU), is clearly increasing. By 1991, more than 90 twin-plant industries had also been established where time-critical delivery between Puerto Rico and nearby nations has resulted in significant flows across borders of semi-finished goods.

The "twin-plant" concept allows cargo markets to be effective in point-to-point movement of cargo between linked manufacturing plants and point-to-market movement of resources where alternative transportation either does not exist or is difficult. This system speeds up the manufacturing process and minimizes theft that occurs during the numerous phases of current transportation movements. It is believed that these benefits would contribute to the economic viability of CTR use. The number of CTR-22C vehicles required are determined in the study: one in the year 2000, three in 2010, and five in 2020.

Although this study focused primarily on the cargo mission as the primary advantage to the region, passenger service is considered to be a support mission. The aircraft that carries cargo at night would carry passengers by day. The market for CTR point-to-point passenger service is described as being made up of two components, business travelers and high income tourist travelers. These groups are interested in travel where the CTR would minimize the need for overnight stays (business traveler) and allow quick access to islands with no airport or only single-engine charter operations. In areas with poor infrastructure, the CTR could also transfer people directly from hub airports to hotels and resorts to avoid ground transportation. It was concluded that CTR aircraft should be able to compete effectively with fixed-wing short takeoff and landing (STOL) aircraft in areas that have development potential but have no road or air transportation, areas served by single- or small twin-engine aircraft where surface transportation is difficult and time costs are high, or areas where the only surface transportation is by boat. Figure 6 presents representative Caribbean air routes.

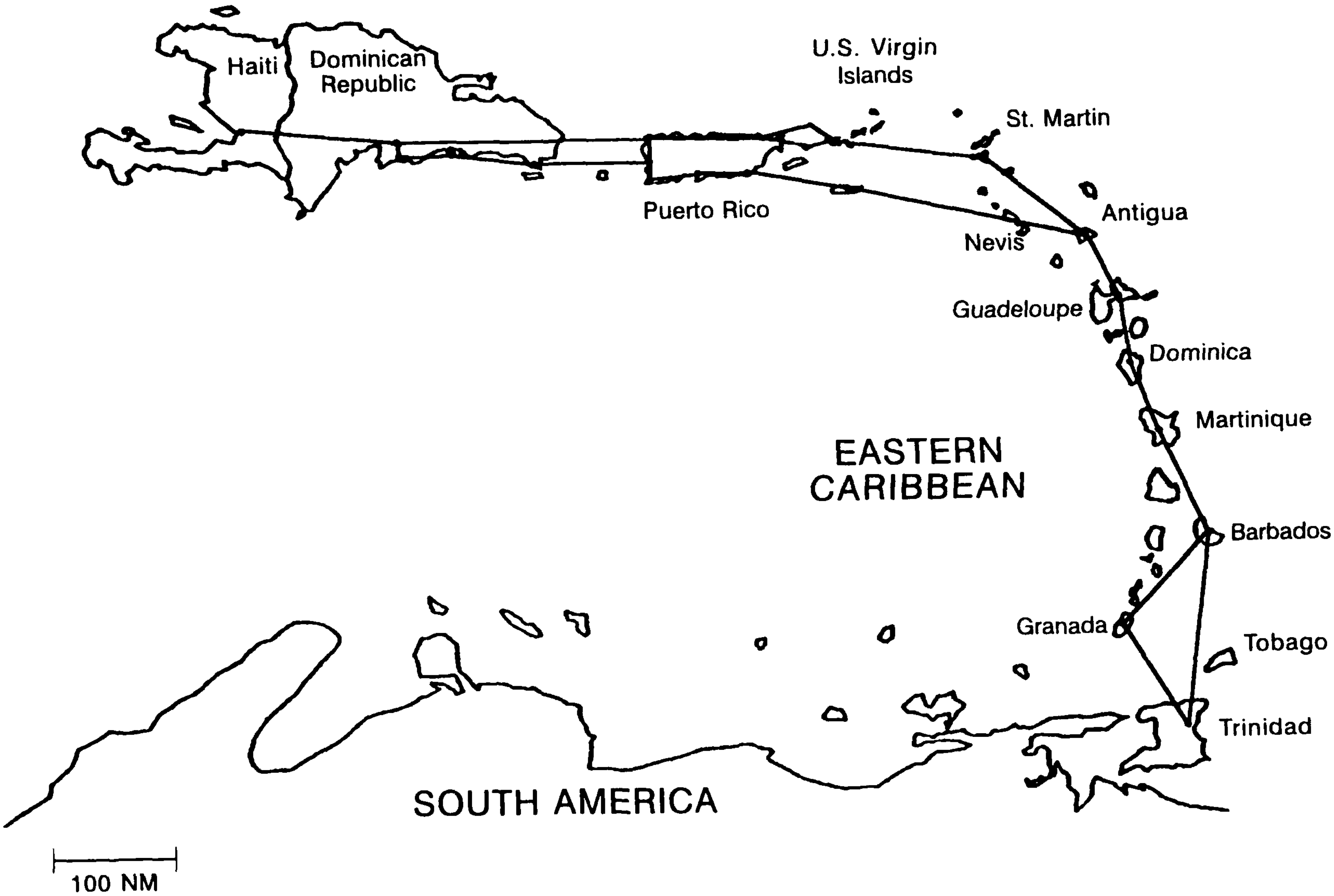


FIGURE 6 REPRESENTATIVE CARIBBEAN AIR ROUTES

The Puerto Rico study also focuses on the unique nature of emergency medical service, search and rescue, and disaster relief. In 1987, a NASA-sponsored study (reference 27) was conducted that indicated that demand existed in the Lesser Antilles to warrant locating two XV-15 size aircraft between Puerto Rico and the most southern island in the chain for EMS purposes only. Disaster relief has been studied and an appendix is provided in the study showing how a CTR vehicle could have been used in the aftermath of Hurricane Hugo. The report concludes that one CTR-22A/B size vehicle could have accomplished in 2 days what was actually accomplished in 7 weeks with Red Cross chartered fixed-wing flights. Mr. Antonio Roosario, administrator for Regional Airports in Puerto Rico is quoted as saying, *A CTR aircraft would be a terrific asset to have in the case of a disaster.*

2.1.5.4 Additional Locations for Unique CTR Use

The other studies evaluated other uses of the CTR to varying degrees. The Southwest Region made a brief mention regarding a need for tiltrotor service in oil and gas exploration/production in the Gulf of Mexico and certain seasonal charter markets (i.e., horse/dog racing, snow skiing, offshore gambling). However, due to limited study resources, these items were expressly mentioned as being deleted from detailed study. Mention is also made with respect to cargo, express package delivery, and corporate/executive markets. However, detailed discussion of these markets is not provided.

The New York City Airport, Manhattan, Illinois, Washington, D.C., and Southern California studies focused on passenger services. However, the PANYNJ recommended that unique/niche missions would be a good application for initial tiltrotor service to develop confidence with the technology prior to use in scheduled passenger service. Unfortunately, no other details are provided with the recommendation.

Of the three California studies, the state-wide study considers CTR potential for six missions or markets, scheduled intercity passenger service (the primary focus), small package/cargo delivery, corporate/executive/air taxi, resource development, public service, and remote region access. The study notes that California's strategic position as the gateway to Pacific Rim nations provides special opportunities for air travel passenger and cargo growth; however, missions other than passenger service were not considered feasible at this time.

2.1.5.5 Unique Regional Demand Summary

Many of the studies identified potential unique missions for tiltrotor aircraft. Unfortunately, due to a lack of resources the majority of these studies were forced to give a secondary priority to these markets following an analysis of scheduled passenger service. No serious attempts by any of the studies were made to detail quantification of the corporate/ executive market for a small tiltrotor, off-shore resource needs, or the general utility markets.

2.1.6 Estimating Potential Passenger Demand

A significant portion of many of the vertiport studies covered the work which was done to estimate the potential passenger demand that would be associated with the operation of CTR service. The following section presents a review of the various methodologies, techniques, and key analytic variables that were used in these different studies. This review found that there was a range of methodologies that varied in their degree of "analytic sophistication." The most basic of the methodologies were activity growth factor methods. The most advanced were models that simulate intercity passenger demand, where the model structures starts from basic demographic characteristics of the general population and travel behavior factors obtained from surveys and other sources. All of the methods were dependent upon various secondary data and/or information sources that have been collected for other purposes. The methods appeared to have been selected in part based on the availability of such data, as well as on limits imposed by the amount of funding made available to study passenger demand.

There was no prescribed analytical method for these studies. The fact that a range of methods was chosen can actually be used as an opportunity to examine the relative strengths and weaknesses of the different methodologies. As a result, it may be possible, when the FAA sponsors similar studies in the future, to prescribe a narrower set of methodologies to be used. However, the innovativeness and different study emphases also reflected, in part, some of the uniqueness of each of the areas in terms of their geographic and economic settings that perhaps indicates that no one methodology would be best in all circumstances.

The remainder of this section discusses the range of methodologies and the basic analytic steps, variables, and their sensitivity to variations in the analytic factors.

2.1.6.1 Range of Passenger Demand Methodologies Used in the Studies

While there was no prescribed methodology specified for the vertiport studies, there was a resulting pattern of similar types of methodologies that were actually used. If one views these methodologies from the perspectives of typical methods used in urban transportation planning and/or intercity transportation passenger demand forecasting, there are some recognizable patterns among the different methodologies.

2.1.6.1.1 Types of Passenger Demand Methodologies

Five different types of methodologies were used that varied according to their relative analytical sophistication with respect to demand forecasting techniques, data needed, mathematical formulations and models, and normative theories of economic responses and of travel behavior. The five types, in order of increasing analytical sophistication, are briefly identified as follows.

1. Activity Growth Factors - currently observed and/or trends in previous operations and enplanements are extrapolated into the future using techniques such as graphs and/or mathematical regression equations that are correlated to trends in various other factors.

This methodology may also use experience and judgement to estimate directly the magnitude of the number of CTR flights in particular travel markets and perhaps the expected load factor of passengers per flight.

2. Simple Diversion from Air Carrier Passengers - estimates likely diversions of air passengers to a proposed CTR service based upon various key analysis factors. This methodology relies on a basic database of air carrier passenger forecasts, from which the diversion of intercity passengers takes place. The basis for diverting a specific amount of passengers can vary from a) keeping constant market shares for a city-to-city pair, to b) diversions based upon the relative magnitude of ground access time.

3. Market Share Models with Diversion Only from Air Carrier Passengers - diverts air passengers with the use of computerized simulation models that are based on factors such as relative overall travel times, access travel times, costs to the user, and relative service levels supplied, such as frequency of flights.

4. Intercity Passenger Demand Models - directly estimates the number of passengers who would use different intercity transportation modes by starting from general characteristics of the population and/or employment, generating an expected amount of intercity travel, distributing the travel to other urban areas, choosing the most appropriate mode of travel, and then summarizing the route selection and facility demands.

5. Intercity/Intraurban Passenger Demand Models - combines the features of the previous type with an ability to simulate directly the travel behavior within an urban area with regard to getting to and from the intercity transportation modes. The overall choice of mode depends upon both a) the intercity portion of the travel, and b) the relative qualities of the intraurban portion of the travel.

2.1.6.1.2 Categorization of Each Area by Methodology Used

Table 7 categorizes the vertiport studies according to which of the five types of passenger demand forecasting methodologies was used. The table shows that four of the five demand methodologies were used. The table also shows that the most prevalent methodology, used in six of the studies, was the simple diversion from air carrier passengers. However, even though these six studies used the same general methodology, there nevertheless are some differences in the particulars used, such as the analysis factors used in making the diversion determination.

As can be seen from table 7, only four of the five methodologies were used in the studies. None of the studies developed the fifth one, a combined intercity/intraurban model, either because of its expected greater complexity, data requirements, and costs, or that it still may be beyond the state of the art for heliport/vertiport planning.

TABLE 7 CATEGORIZATION OF STUDY AREA BY TYPE OF PASSENGER DEMAND FORECASTING METHODOLOGY

TYPE OF PASSENGER DEMAND FORECASTING METHODOLOGY	STUDIES
1. Activity Growth Factors	St. Louis Orlando San Francisco
2. Simple Diversion from Air Carrier Passengers	Puerto Rico Canada Boston California State Southern California Washington, D.C.
3. Market Share Models with Diversion from Air Carrier Passengers	New York City Airports Manhattan Illinois (Chicago)
4. Intercity Passenger Demand Models	Southwest Region (Dallas)
5. Intercity/Intraurban Passenger Demand Models	

2.1.6.1.3 Relationship to Urban and Intercity Travel Forecasting

The theory, methods, and techniques used in making urban travel demand forecasts have been developed and have evolved over many decades. There was some very early work in the 1920s, but the vast majority of it occurred since the 1950s and 60s with the advent and widespread use of computer technology. The models that are used to forecast travel demand are most typically characterized as consisting of four related steps, each of which have their own techniques and multiple variations. In concept, the basic characteristics of the different types of methodologies used in the vertiport studies can also be viewed as being analogous to the four basic steps of urban travel demand models. It appears that the vertiport studies did not explicitly make such a linkage either in the body of the reports or in the appendixes of supporting documentation. Although sometimes different terminology may be used, these four basic steps of travel demand forecasting, and the travel decisions they address are listed below. These are used in the discussion below to help clarify the various factors and variables used in the passenger demand methodologies of the vertiport studies.

- Trip Generation -- How many trips are people making?
- Trip Distribution -- What direction(s) are they going in?

- Mode Choice -- Which means of transportation will they use?
- Route Choice -- What path in particular will be followed?

The state-of-the-art in intercity travel demand forecasting is less developed and more diverse than that used in urban travel demand forecasting. While the urban travel forecasting methods deal with average weekday travel patterns, intercity methods are usually concerned with longer time patterns, often dealing with annual ridership estimates. Most of the recent research reported in the literature have come from work being performed for studies associated with estimating ridership for proposed high speed rail projects in several intercity travel corridors.

While space does not permit much discussion, suffice it to say that intercity travel demand models need to be based upon variables that: a) stratify trips being made by their purpose, such as business, recreation, or personal business; b) segment travel markets by length of the trip; c) account for travel times and costs to the user of both the main mode of transportation, as well as those of any access trips that contribute to the overall door-to-door trip time and cost; d) recognize characteristics of the traveler of particular concern to intercity demand forecasting, particularly those of income of the traveler and the size of the group involved in the travel; and e) include various other characteristics such as length of stay and the planned activities at the other end of the trip. How the vertiport studies generally accounted for variables such as these is discussed next.

2.1.6.2 Basic Analytic Steps and Variables Used in the Methodologies

This part of the review discusses the four basic analytic steps in urban travel demand forecasting by going through the five types of methodologies defined in section 2.1.6.1. The focus here is on the typical variables which have been used by the vertiport studies and the conceptual aspects they bring to simulating the very complex personal and group decision making processes that people appear to use in actually deciding whether, where, how, and when to travel between cities. This discussion is consistent with the definition of the term "sophisticated methodology," in that more analytical steps and more variables are used in more interdependent ways for the more sophisticated methodologies.

2.1.6.2.1 Rotorcraft Activity Growth Factor Methodologies

The St. Louis, San Francisco, and Orlando studies had the fewest analytical steps and used the fewest variables of all of the vertiport studies with regard to the topic of forecasting CTR activity and passenger demands. These three studies focused on the number and activity of the current helicopter fleet and made growth factor projections of the activity into the future. They did not attempt to forecast passenger activity. The variables used as a basis of the growth factors are trends in population growth and economic activity in certain sectors of the economy. The basic approach to this methodology was to first estimate the number of helicopters, next to evaluate the trends in average annual activity, then combine the factors to determine overall future helicopter activity.

The St. Louis study recognized that a detailed estimate of the CTR service would require a separate study well beyond the scope of the funded project. That study examined the variable of travel distance and looked at major destinations and the current number of air carrier flights within 300 miles. The study then reasoned that city-center to city-center service would be the main market. It also made a judgement that service to/from Chicago would occur first and to Kansas City second, and a few other nearby areas third. The St. Louis study then simply assumed a level of CTR activity relative to the current air carrier activity and did not estimate a number of passengers. Several variables were identified as site selection factors for a downtown vertiport including the travel time to existing and potential demand centers, the relative congestion of local streets and arterials, access to transit modes, and parking availability.

The San Francisco study was similar to the St. Louis one but did look at a few additional variables. In particular, trip time comparisons were made for several destinations from San Francisco regarding helicopter flying time, non-peak driving time, and peak period driving time in order to estimate the variable of travel time that could be saved by a helicopter/CTR passenger service. In addition, maps were shown of the locations throughout the region of a) recurrent congestion in 1987 and b) forecasts of future morning congestion on the freeway system. Those variables were only used qualitatively in the analysis. These variables are most related to the trip distribution aspects of passenger demand forecasting.

The Orlando study was also similar to the St. Louis and San Francisco studies in terms that an activity growth factor methodology was used to forecast helicopter activity levels. This study looked somewhat more in depth at the variables that would be associated with trip generation of passenger demand for CTR service, particularly population and employment levels by industry type, economic development activity, and the special tourist attractions associated with Florida. The study used various data and information related to these variables to qualitatively identify what are termed, "Vertiport Demand Centers," within the Orlando area. This study also had some limited discussion about a proposed scheduled helicopter passenger service in the area tying into the Orlando International Airport (MCO). The relative qualitative effects of the variables of relative travel time and costs, fares to the users, and load factors were reviewed. In addition, the importance of developing interlined fares and reservations with major airlines at MCO in order to increase ridership was also discussed.

2.1.6.2.2 Simple Diversion From Air Carrier Passengers

Six of the vertiport studies are characterized as using a methodology of a simple diversion from air carrier passenger forecasts (Puerto Rico, Canada, Boston, California, Los Angeles, and Washington, D.C.). However each applied the general methodology differently by accounting for different combinations of variables. In addition, each of these studies did make explicit forecasts of the CTR activity levels and also the associated passenger demands. In addition, the techniques and key assumptions also varied within this group such that no two of the six were done the same. The following discussion of these key variables and assumptions is organized by the four basic steps of the urban travel forecasting process rather than a separate discussion for each study area.

Trip Generation - How many trips are people making? The main similarity among the six studies is that a major component of the estimation of trip generation, the number of overall potential CTR passengers, stems from the air carrier passenger forecasts which were previously prepared for their own purposes. The main variables used here are: 1) the proportion of the total passengers who are flying for business purposes, 2) the distance of the trip, 3) the overall relative size of the travel market between the origin and destination, and 4) the relative frequency of the CTR service in terms of the scheduled number of flights per unit of time. These studies basically skipped over the determinants of trip generation identified in the previous category of methodologies above. They have relied upon the air carrier passenger forecasts to account for variables such as population and economic growth as factors that affect the amount of trips being generated. The Puerto Rico/Caribbean Basin study did analytically account to some degree for increased economic activity in terms of relating the number of trips to the number of hotel rooms within the study area, the more hotel rooms at a destination the more CTR passengers are forecast. Three of the studies, Boston, Los Angeles, and Washington, D.C., used locally conducted air passenger or general surveys to determine percentages of business versus non-business travel and the dispersion of the origins and destinations of the trips.

Trip Distribution - What direction are they going in? The air passenger forecasts also provided key pieces of data and information regarding current and/or future origin and destination patterns of the intercity air travelers. Those patterns also represent what is referred to as the trip distribution patterns in the terminology of urban travel demand forecasting. The main part of this second step of the methodology is to provide a logical and consistently applied set of techniques as a basis for taking the total number of trips from the first step of trip generation and then estimating the spatial or geographic pattern of the CTR passengers, the trip distribution.

The basic technique used by the six studies was to first make a simple segmentation of the air carrier passenger forecasts into markets which would be likely CTR passengers and then second to divert an appropriate share of those markets depending upon specific variables and their measured, projected, or assumed values. This market segmentation technique generally first separated out business from non-business travelers, as well as segmented them by length of trip between origin and destination pairs. Both the Puerto Rico and California studies did keep the non-business market segments in the estimate of CTR users while the remainder only used business passengers. In some cases a market size threshold of a certain number of annual enplanements was also used in the segmentation of the markets, such as the value of 750,000 annual enplanements in the Canada study. In doing this segmentation into markets, five main conceptual variable categories were used in different degrees, as briefly discussed next.

Speed/Travel Time Variables - These variables can be measured in two basic ways or their combination: 1) by estimating the expected block time, or average line-haul speed, for CTR service between origins and destinations, often expressed in terms of knots, and 2) the overall door-to-door travel time of CTR compared to air carrier or commuter service. Some of this group of studies concentrated only on the first measure of line-haul speeds. However, some also included with the line-haul travel time, the terminal wait times, gate times, or the ground time with the engines on as part of the CTR travel time.

Some of these studies also accounted for, or estimated, the second measure of access and/or egress time from the travelers actual point of origin to their actual point of destination. While this latter measure can be more aptly considered separately as an access variable, accounting for it that way is also appropriate in using speed or travel time in making demand estimates. For the range of line-haul distances under consideration of 200 to 300 miles, the line-haul or block speeds for CTR service is not that appreciably different from that of air carrier and commuter services. The larger part of the differences in overall travel time come from differences in access times and terminal wait times, as shown in some of the diagrams of the Boston and California studies. The Canada study, in particular, had a short discussion that gave a very good summary and conceptual description of several of the basic characteristics of the CTR system. It included vertiport design features and operations, that would contribute to the overall reduction in door-to-door travel time associated with CTR service.

Even though speed and travel time are discussed as important variables by most of the studies, most of these six studies did not explicitly use overall CTR speed or travel time as a variable in developing the estimate of passenger demands. Rather, they tended to recognize in a qualitative way that the characteristic of CTR service that enables faster door-to-door travel times should be an important marketing feature that potential users would find of value. For example, the *California study said*, "Future marketing of tiltrotor service...would need to focus on portal-to-portal costs and the value of time saved, as well as convenient access to vertiports, and de-emphasize the difference between the airline and tiltrotor ticket prices."

Access Time, Distances, and Intermodal Connection Variables - Some of the studies stressed the relative access times to get to and from the CTR service as a main determinant of whether an air passenger is assumed to divert to CTR service. The Washington, D.C. study in particular, used a "gravity model" technique from urban travel demand forecasting to estimate how the air carrier market would be segmented to one of five assumed vertiport locations or whether they would continue to use one of the three air carrier airports. The Boston study used geographic proximity as a surrogate for access travel times as a judgmental variable to say whether air passengers from a given area would use the CTR service.

Costs and Fares Variables - The projected cost of providing the CTR service, and particularly the projected fares to the user are other important variables in these studies. Some, such as the Puerto Rico study, used fare elasticities as an explicit variable in deriving the estimate of CTR passenger demand. The California and Southern California studies, in particular, emphasized the relative cost and fare considerations. They assumed that the primary users of CTR services will be passengers who would be willing to pay a higher ticket price for the value of time saved, primarily the business traveler. The Washington, D.C. study estimated the sensitivity of the potential CTR passengers to higher ticket prices using elasticities obtained from the surveys from the Southwest Region (Dallas) study, discussed below. The Canada study basically gave no consideration to cost or fare variables.

Frequency of Service/Reliability Variables - Three of these studies considered variables that related to service level measured in terms of the hourly frequency of flights. The Canada study assumed that a 30-minute frequency would capture two-thirds of a market pair while a 60-minute frequency would capture a third of a market pair. The Washington, D.C. study estimated the sensitivity of the potential CTR passengers to a fewer number of flights from the service level initially assumed in the analysis. The Puerto Rico study, in addition to considering a 30-minute gate time, also examined seasonal variations in potential demand by month, as well as likely variations in passenger demands by day of the week.

Comfort/Convenience Variables - The Puerto Rico study gave some qualitative consideration to the inconvenience of customs requirements that would be associated with the international application of CTR service in the Caribbean Basin.

Mode Choice - Which means of transportation will they use? The six studies that used the simple diversion from air carrier passengers methodology, basically presented an "either-or" choice with respect to which intercity mode of transportation would be selected, air carrier or a new CTR service. It should be made clear that the adjective, "simple," has been used here to describe this type of methodology only because it uses standard, simple arithmetical proportions to separate out the market shares based upon assumptions derived from the variables. Of these six studies, only Washington, D.C. begins to use more than some basic mathematical calculations. However, since the gravity model technique is usually associated with the trip distribution step of urban travel demand forecasting, Washington, D.C. was included in this methodology. For the six studies associated with this type of methodology, the trip distribution step and the variables associated with it are the main determinants of the CTR passenger demand. The next section discusses how market share mode choice models are used in more mathematically rigorous ways.

The California and Southern California studies had some discussions and qualitative comparisons to high speed rail and magnetic levitation technologies, as well as conventional intercity and commuter rail corridors, which have been under consideration in some of the travel corridors being examined in those vertiport studies. The gist of the conclusion from those qualitative considerations is that *...CTR service will find its niche with very time-sensitive business travelers. Rail on the other hand, will find a niche with pleasure travelers and non-time-sensitive business travelers. ...The bottom line is that CTR can operate independent of other ground-based transit modes without a negative impact on their passenger ranks...* (Southern California study, p.IV-5).

Route Choice - What path in particular will be followed? Several of the studies considered the potential routings of CTR service in estimating their passenger demands. The Puerto Rico study discussed four routes in the Caribbean Basin. The results of the California study were organized by a very dispersed, many-to-many route pattern. The Washington, D.C. study segmented the air passenger market to one of five potential vertiport sites.

2.1.6.2.3 Market Share Models Methodologies Based Upon Diversions From Air Carrier Passengers

Three of the vertiport studies were categorized above as market share model methodologies that are also based upon diverting air carrier passengers (Illinois, New York City Airports, and Manhattan studies). With regard to overall passenger demands, the Manhattan study relied upon the New York City Airports study, although it does consider some access variables in more detail than most of the other studies. Consequently, this part focuses on the first two of these studies, the Illinois and the New York City Airports studies.

The Illinois study based its demand forecasts upon a combined analytic approach that the study termed as 1) the value of time methodology, and 2) the airport share model. Neither of these methodologies use a standardized approach which has parallels in urban travel forecasting.

The first of these two methodologies simulates the likely total number of passengers that would use a vertiport service. From a trip generation perspective, this methodology accounts for both business and non-business air passengers as well as distinguishing between residents and visitors. According to the study, this method *...simulates a passenger's decision process in selecting one airport/vertiport among multiple options. The variables considered in the decision process are total trip times, total trip costs, and the comparative service levels available at the competing airports and vertiport* (Illinois Summary Report, p. 19). The first stage of the model estimates demand based solely on trip time and trip cost comparisons between the tiltrotor and conventional jet service. The second stage of the value of time method projects tiltrotor flight frequency to each candidate destination from the initial demand forecasts. Adjustments are made to account for disadvantageous flight frequencies for the tiltrotor service.

The key parameter of this value of time methodology is the estimated income distribution of airline passengers who begin or end their travel at one of the Chicago airports. Surveys were conducted in the late 1980s that estimated these income distributions for both business and non-business passengers. The key step in the simulation of the percentage of passengers selecting tiltrotor service is to compare the wage rates of the air passengers to the added costs due to the tiltrotor service. If the wage rate, the presumed value of time for the business passengers, is greater than the added costs of using the tiltrotor service then those trips are assumed to make a mode choice of the tiltrotor service. If the wage rate is less than the added costs, then the passenger is assumed as staying with the conventional air passenger service.

The second of the two models used by the Illinois study, termed as the airport share model, *...is a methodology for allocating air traffic demand of a given area to competing airports (or vertiports) based upon the service levels offered at each of the airports, adjusted to reflect the relative convenience of the airport in terms of ground access and the relative fares for the service at each airport...* (Illinois study, page 23). The airport share model is more like a technique for route choice from urban travel demand forecasting. Three main analysis variables are used as the primary factors which determine an airport's or vertiport's share of passengers, 1) ground access time, 2) fare levels, and 3) service levels at each airport. When comparing the airport share model to the first model/technique of the value of time method, it can be seen that the airport share model has greater sensitivity to the assumed service levels at each airport/vertiport and is less sensitive to the specific values of time or income levels of the passengers.

The Illinois study provided rather extensive and detailed documentation in its main report and appendixes. The study also made several sensitivity tests for variation in the values of the key variables. Specific sensitivity tests were done to estimate the effects of: a) increased airport congestion and more time consuming airport access, b) higher values of time, and c) multiple vertiport locations. Another feature used in the passenger demand forecasting was that of feedback, particularly feedback related to CTR flight frequency. Space limitations here prevents providing much more on this review of the Illinois study.

The New York City Airports study uses a mathematical technique to segment the air passenger travel market to provide a mode choice through the application of a "Logit Model." Such logit formulations are often used in market share analyses for urban travel demand forecasting, airline route choice applications, and in forecasting the relative market shares of may different services or products. In particular, the New York study says, "The logit model has been widely used for both mode choice and airline route choice applications, and appears to be applicable to modeling the choice between tiltrotor and fixed-wing service in a given market." Appendix B of the New York study, "Review of Previous Models," discusses issues of a) model calibrations, b) interpretation of the parameter values, and c) quality of service.

Logit models are mathematical techniques that usually look at similar attributes of two or more competitive products or services such as their price, perceived value to the customer, time it might take to use the service, or an indicator of the convenience or comfort of the service to the users. If a person 1) measures the relative shares of the market that each of the competitors have, and 2) correlates that to the different values of the market attributes of the competitive services, then 3) it is possible to calibrate a logit model of that market. That logit model can then be used to simulate what might happen to the market shares of the different competitive services for various assumed changes in the attributes of the services, such as cost or travel time.

The New York City Airports study took such an approach and applied a logit model formulation to a two competitor market to estimate passenger demands for CTR service in comparison to conventional airline service in the same travel markets. Some logit models of intercity travel look at more than two competitive services, such as intercity rail or use of automobiles. However, one limitation of the use of logit models is that they can only estimate the relative shares between two or more competitors in a market. Other estimation and/or modeling techniques are needed to forecast whether the total size of a market will change due to the introduction of a new product or service into that market.

The particular logit model developed for the New York City airports study was based upon four main variables associated with each of the two modes being compared: 1) airfares; 2) schedule delay; 3) flight time, including air traffic delays; and 4) access time to terminals. A good amount of documentation is given in the report. The analysis forecasts CTR demand versus demand for fixed-wing service between destination cities and the three New York City airports treated as a single entity. Data obtained from various surveys and focus groups were used to help understand various aspects of the travel behavior and choices of typical air passengers, as well as to help in the process of calibrating the logit model for the particular application. It was possible to estimate values for several key variables from those surveys, based upon an implied value of time. This study examined the sensitivity of the results with different implied values of time.

The variable of schedule delay accounts for air traffic delays or circuitous routings due to terminal approach and departure procedures, which can become significant at the New York City airports. The study examined various data related to schedule delay for current air carrier and commuter services. Two scenarios that limit travel time advantage were specified to account for these schedule delays in the analysis. The first assumes that the CTR service will have a 15 minute advantage over conventional air service in most travel markets and 30 minutes in the Boston and Washington markets. The second limiting scenario assumes that CTR service will not lead to any significant travel time advantage due to the absence of schedule delay.

The study notes that the linearity of the utility functions in the logit formulation, in terms of access times and costs, permits the analysis to be performed using differences rather than absolute values for these variables. Three baseline scenarios were used: 1) CTR service competes and substitutes for conventional fixed-wing commuter airplanes at the three New York City airports, 2) a new vertiport is developed in midtown Manhattan, and 3) a series of vertiports is established in submarkets within the region served by PANYNJ. A separate site location study was performed related to the second baseline scenario. It should be noted that the Manhattan sites study relied upon the New York City airports study for its basic passenger demand forecasts. However, the Manhattan study did apply some peaking factors to better estimate the demands at different times of the day. That study focused more on the Manhattan originating travelers and their access than it did on the business travelers destined to Manhattan and their access to local destinations. It also made the unsubstantiated assumption that these inbound travelers would essentially have the same travel behaviors as the outbound travelers.

The New York airports study identified access times and costs to the terminals as significant factors in the logit formulation. However, the study only assumed some straightforward differences in those variables among the scenarios rather than trying to establish techniques that would estimate such differences. Some of the other vertiport studies for Illinois, Washington, D.C., and Boston were able to rely upon data from local agencies to have a better understanding of the actual values of these variables, and not just assume relative differences.

2.1.6.2.4 Intercity Passenger Demand Models

The Southwest Region vertiport study is the only study that seems to have developed an intercity passenger demand model that is not tied to the observed or forecast pattern of air carrier passenger travel. This study was centered on CTR service to and from the Dallas, Texas area. The analysis included two primary data collection efforts and the extensive use of secondary data.

The primary analytic technique used to develop the passenger demand estimates for the Southwest Region study was that of conjoint analysis. This analytic technique is often used in market research and has also begun to be used in recent years in urban travel demand forecasting, particularly with respect to forecasting use of urban transit system passengers. Commercial software is available that can be used in the performance of a conjoint analysis. An appendix is given in the Southwest Region study that gives an overview of conjoint analysis:

> *Conjoint Analysis assumes that products are decomposable into separate attributes. In a conjoint study we show respondents hypothetical product concepts that differ systematically in their attributes and ask them for overall reactions to each concept. From their responses, and our knowledge of the attributes composing each concept, we infer or estimate the values they place on the separate attributes. Since the early 1970's conjoint analysis has received considerable academic and industry attention as a major set of techniques for measuring buyers's trade offs among multi-attribute products and services.* (Southwest Region study, appendix C, page C-3).

Perhaps the easiest way to summarize the demand methodology used by the Southwest Region study is to go through it in terms of the four steps of the urban travel demand forecasting methods.

Trip Generation: - How many trips are people making? The Southwest Region study segmented intercity passengers in the five state area of Texas, Arkansas, Louisiana, Oklahoma, and New Mexico, into three basic travel markets: 1) business air travelers, 2) personal/ vacation air travelers, and 3) business car travelers. The personal/vacation air travel market was examined because many business travelers also qualify as personal/vacation travelers and would be inclined to use CTR service if they were satisfied from their business travel experience. Surveys were conducted to gage the basic information on the size and characteristics of the market for air travel.

This resulted in annual and daily trip generation rates per capita for each of these three markets of air travelers. It is this aspect of these trip generation rates that distinguished this study from the other vertiport studies and resulted in this review categorizing the study as an intercity passenger demand model. The analysis methodology was then able to start from estimates of the total adult population 18 years of age or older obtained from

1990 census data. It did not have to start from the more limited population of observed or forecasted air travelers, as the other studies did.

With regards to the particular trip generation rates, the surveys showed that about 28 percent of the adult population in the Dallas/Fort Worth area had taken one or more business trips via air in the past 12 months by all modes, and that the average business traveler made about 7.8 trips annually. Separate trip generation rates were developed for personal/vacation air travelers as well as for business car travelers. The surveys showed that about 27 percent of the area residents made at least one personal/vacation trip in the preceding 12 months, while about 18 percent of the residents made one or more intercity business trips by car in the past 12 months within the five-state region. The surveys also found that the average personal/vacation traveler made about 2.8 trips annually, while the average business car traveler made about 3.5 trips per year.

There were also some sharp contrasts in the annual frequency of intercity travel within the Southwest Region for different individuals. Frequent travelers (five or more trips per year) and medium travelers (three or four trips per year) were about half of the intercity travelers but made about 90 percent of the trips. About 55 percent of the total survey respondents made at least one trip by air in the previous 12 months.

Trip Distribution - In which directions are the trips going? As with most of the other studies, the connections between the origin and destinations, the distribution of the trips, has been assumed to be constrained by the basic definition of the likely service area for CTR service. This study defined a 300 nautical mile radius from Dallas, which covered most of the five-state area referred to above. County population statistics were used to estimate the total number of potential travelers to and from each of these areas and the Dallas area. The study presented a comparison of its results with FAA data for the Dallas/Ft. Worth to Houston city pair, that showed a good correlation with the simulated travel between the areas. The study also noted an important distinction to be made between trips beginning in the Dallas area versus those destined to the area.

> *Studies show that most air travelers depart on trips from their place of residence and not their place of work. Therefore, if access is to be strongly considered in the sitting of vertiports, then vertiports need to be sited close to residential areas when initiating a trip and sited close to CBD districts on the destination end. This means that there should be two types of facilities working in concert with each other as part of a regional transportation network.* (page 4-12)

Mode Choice - Which means of transportation will they use? The conjoint analysis technique, discussed previously, was used in performing what was basically the mode choice part of the analysis. That technique provided the basis of what the study termed as a "realistic" market share estimate. Three key variables were identified as factors in the conjoint analysis: 1) timed saved to and from the airport on the round trip, 2) ticket cost relative to existing air fares, and 3) frequency of flights relative to existing airline schedules. The realistic market share range is based upon a fare up to 50 percent higher than for conventional scheduled airlines, time savings of up to 2 hours for the traveler, and up to 50 percent fewer flights than conventional scheduled airlines. This methodology was applied separately to each of the three travel markets and then added together.

This mode choice portion of the analysis resulted in estimates of these realistic market shares of about 22 percent for the business air travelers, about 20 percent for personal air travelers, and about 25 percent of the business car travelers. Overall, the analysis resulted in about 40 percent of the approximate 40,000 daily passenger demand coming from business air passengers, about 45 percent coming from personal/vacation travelers, and about 15 percent coming from business travelers who now use their cars.

Route Choice - What path in particular will be followed? The Southwest study identified potential demand centers both within the Dallas/Fort Worth area and within the overall Southwest Region. Diagrams were shown which indicated the relative demand between particular city-to-city pairs. No calculations or analytic technique was presented to support the diagrams. A list of 12 regional population centers for which CTR service could be provided on a direct-connection basis was also presented. Again, no specific estimates were given of the potential passenger demand for particular city pairs.

2.1.7 Cargo Services

Cargo was the primary focus for Puerto Rico, more so than any other area, although other locations with remote areas, such as Canada and Alaska, also explored the possibility (section 2.1.5). The California, San Francisco, Orlando, and Manhattan studies emphasized passenger transportation, but also investigated cargo more in terms of small package delivery than industrial cargo, as contemplated by Puerto Rico. Small package delivery is discussed in section 2.3.2. The remaining studies did not consider the cargo mission.

2.1.7.1 Puerto Rico Precepts

Puerto Rico is particularly interested in using the CTR for cargo because many areas are isolated by mountainous terrain and frequently lack adequate ground transportation infrastructure. Presently, cargo in Puerto Rico is moved from point-to-point and point-to-market. In point-to-point, the product is moved between linked manufacturing plants. In point-to-market, the product is shipped directly from the manufacturer to the point of sale. The movement of these resources occurs where alternative transportation is either difficult or non-existent. Cargo shipments between Puerto Rico and the other islands, inbound and outbound, are forecast to be generally equal. In 1987, foreign trade in the Caribbean was $50 billion, with air cargo shipments between Caribbean island nations and the U.S. totalling $775 million.

Operations using the CTR for the movement of cargo within Puerto Rico will be economically marginal because of the deep discounting of posted rates by many regional carriers. However, by operating the CTR in a quick change (QC) mode, a 2 to 3 percent increase in profit could be realized. In the QC mode, the CTR would be used for the movement of passengers during the day and then reconfigured for cargo operations at night.

2.1.7.2 <u>Support Mission</u>

Two methods were suggested for using CTRs for cargo. First, it was felt that operators of tiltrotor passenger flights could provide cargo services with low marginal costs by using the method similar to today's use of belly cargo space on commercial airline flights. It was suggested that helicopter operations, however, will most likely remain the most cost-efficient means of satisfying the demand for short-haul, small package express services.

The second method, described in the study for Puerto Rico, operated the aircraft in a dual role, with passenger service during the day and package express during the night. This would improve the efficiency of the vehicle and increases profits. Dedicated aircraft would likely be introduced once the service is well-established and proven. However, preliminary studies indicate that while it would be desirable to operate the CTR at night in the dual role, noise may restrict the possibility of night operations, depending on the location of the vertiport.

2.1.7.3 <u>Identification of Potential Demand</u>

The Puerto Rico study provided the most detailed identification of potential cargo demand, shown in tables 8 and 9. The Canadian study made seemingly conflicting statements. On one hand, they state express package delivery is the faster growing sector of air transport; on the other, the report says the market appears to be limited with no definitive market potential identified.

TABLE 8
EXPECTED CARGO GROWTH

YEAR	POUNDS
1989	70 million
1995	145 million
2010	439 million
2020	840 million

TABLE 9
CTR REQUIREMENTS

YEAR	NUMBER
2000	1
2010	3
2020	5

Other studies stated that cargo is expected to grow but did not relate this growth to potential CTR use. One factor mentioned was that vertical flight demand is related to road congestion. Orlando has adequate road access before and after rush hours and therefore did not consider cargo as a growth area. California predicted 98 percent of all cargo enplanements will continue to be generated within three major metropolitan areas: Los Angeles, San Francisco, and San Diego. However, small package delivery is expected to increase faster outside of those areas in other parts of the state where CTR use was not considered economical. San Francisco predicted vertical flight aircraft would be applicable to small package and cargo delivery. However, the city still will not allow helicopters to land.

In Manhattan, small package cargo carriers have largely avoided the capacity problem through extensive use of nighttime operations. However, nighttime tiltrotor cargo operations from a Manhattan vertiport would be less acceptable to neighboring residents than daytime passenger flights. Furthermore, the potential introduction of CTR services is driven by capacity constraints at the New York metropolitan airports - constraints which only manifest themselves during the daytime and evening hours. Hence, there is less of an incentive to use the tiltrotor for nighttime operations such as cargo services.

In Manhattan, the cargo market is expected to increase at negligible levels and as a result, will not be a driving factor for introduction of a Manhattan vertiport. For planning purposes, dedicated cargo operations should not be discounted during the marketing phase. However, once a Manhattan vertiport has been established, it is possible that cargo services would be introduced.

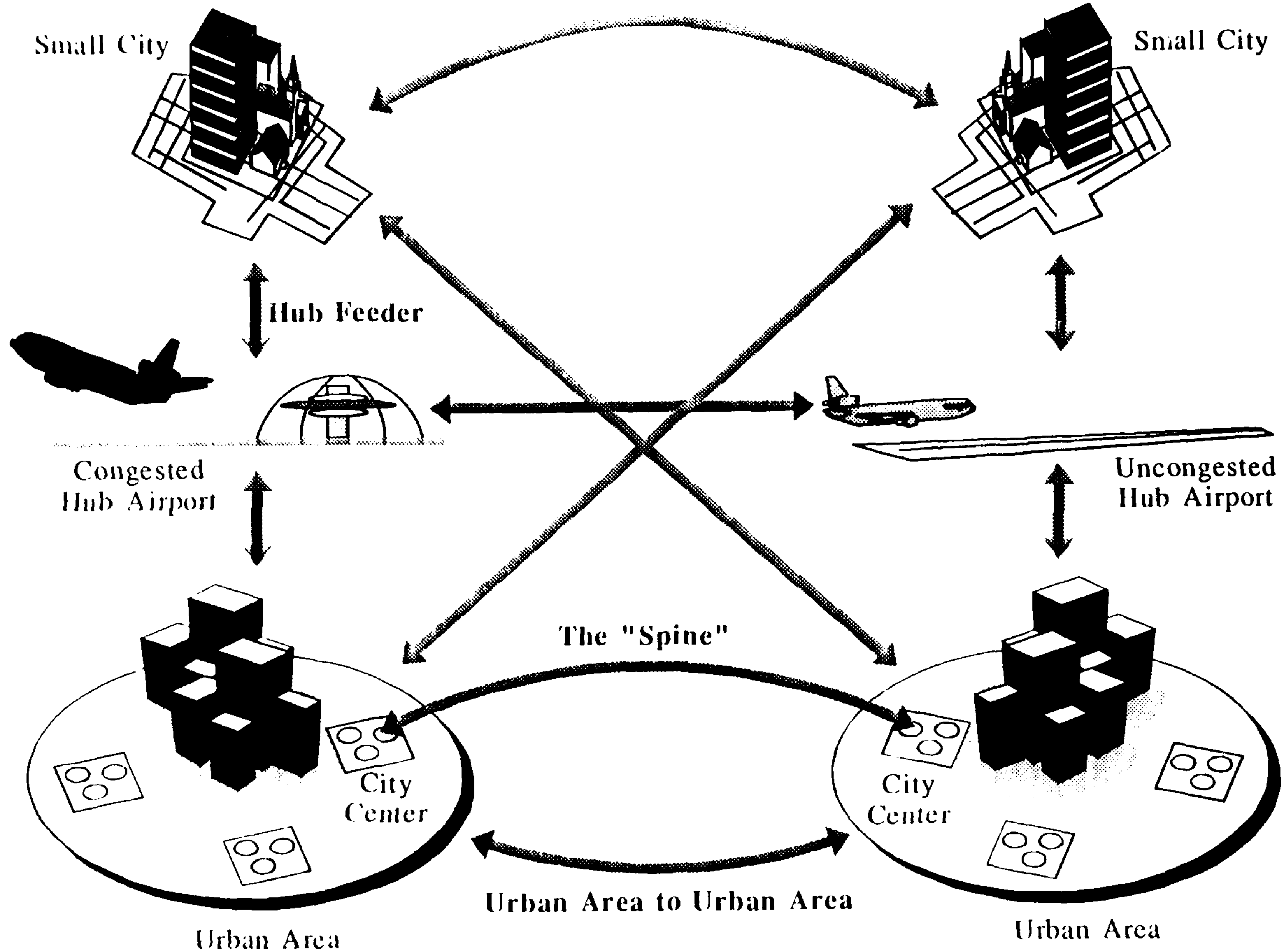
2.1.8 Annual Operations Scenarios

In determining the potential success of AVF passenger service in particular areas, it is critical to see how the service will be operated over time. For example, will scheduled carrier service vary due to seasonal demand factors or be stable year round. An anticipated pattern can be simple pairing of service between the downtowns of two nearby urban areas. Other scenarios might involve the addition of vertiports at other urban activity centers, or to connect other nearby areas. Operational scenarios may include vertiport-to-vertiport hubbing with a route structure to facilitate transfers among all the possible routes.

However, it must be pointed out that operational scenarios were developed based on CTR operating characteristics (range, cruise speed, payload, etc.). These characteristics were defined in "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market," by Bell-Boeing and NASA, and not by any empirical operational data except for preliminary results from the XV-15 and V-22 flight test programs. The scenarios presented in the studies, therefore, are strictly hypothetical until proven by an extensive CTR demonstration program, which was recommended in almost every study.

2.1.8.1 Formulation of Annual Operations Scenarios

The unique operating characteristics of CTR and tiltwing aircraft and the strong competition from fixed-wing air carriers requires that AVF aircraft be operated in new and unique ways. Head-to-head competition with major passenger air carriers between airports will not be profitable unless airport congestion and slot restrictions severely limit fixed-wing air carrier operations. In this hypothetical scenario, commuter CTR operations may selectively replace turboprop commuter fixed-wing operations, thereby opening up runway slots for much larger fixed-wing aircraft. This "hub feeder" operational scenario was initially identified and discussed in "Civil Tiltrotor Missions and Applications: A Research Study" and "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market." All total, nine operational concepts were evaluated (figure 7) and six of these were identified as showing little economic potential. The remaining three operational concepts, hub feeder, city-center to



Source: Reference 28.

FIGURE 7 CTR OPERATIONAL SCENARIOS

city-center (the "spine"), and urban-area to urban-area operations were shown to have excellent potential for CTR development. These findings are confirmed by the 14 analyzed studies. The only deviations to these conclusions involve the studies that present unique regional uses of CTR operations (see section 2.1.5).

2.1.8.2 Mission Identification

The mission that is identified with virtually all the operational scenarios discussed in the studies is that of scheduled passenger operations. The analysis of region-unique operations in Alaska (see section 2.1.5) discussed low density passenger operations in conjunction with cargo/mail delivery. Likewise, a detailed discussion of region-unique cargo operations, particularly at night using convertible passenger/cargo versions of the CTR-22C, is analyzed in the Puerto Rico study (section 2.1.7.1). Since these region-unique missions are discussed in separate sections, the emphasis in this section will be on the analysis of operational scenarios for the scheduled passenger mission. Key features of the operational scenarios, or service patterns, that are discussed in the studies are:

- system/route structure,
- target air traveler type,
- type of vertiport required,
- time-of-day/day-of-week operation,
- CTR vehicle size, and
- flight frequency and load factor.

Each of these specific issues is discussed in more detail in the following paragraphs.

2.1.8.3 System/Route Structure

As stated in section 2.1.8, "Civil Tiltrotor Missions and Applications: A Research Study" and "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market" identified three basic CTR systems or route structures that showed economic promise. Collectively, the studies agreed with these results.

The first structure was identified in the Illinois, New York, Boston, and California studies. These studies indicated a great need in their regions for a hub-feeder network to relieve airport congestion and increase long term airport slot capacity. These hub-feeder route structures identified in outlying service areas, generally 300 to 500 miles maximum, could be replaced, completely or partially, by scheduled CTR routes. Many of these routes presently utilize turboprop commuter aircraft in the CTR-22C size class. The majority of the routes, at least for initial CTR operations, were defined as being economically feasible only if more than 200,000 passengers per year presently (or at a projected date) travel the route.

The Boston study provides an excellent example of the need for this type of network. Logan International Airport presently operates with 75 percent of its flights to/from destinations of 300 miles or less. The vast majority of these passengers are connecting with longer distance flights to other locations and a significant percentage travel on commuter-size, fixed-wing aircraft. Each slot opened at Logan by 39-passenger CTRs allows the potential for replacement by a large jet for long distance service. This ability to replace turboprop flights with CTRs and utilize their runway slots to accommodate long distance jets will become increasingly important as air travel grows over the next several years. Several of the studies, i.e. the Illinois study, even assigned dollar values to the opening of slots specifically for large aircraft. Using the 200,000 annual passenger criteria, four primary (New York, Washington D.C., Philadelphia, and Montreal) and two secondary markets (Toronto and Baltimore) were identified from the Boston area for initial CTR service using multiple vertiport locations. These markets are shown in figure 8. If a vertiport system is set up in the northeast region, estimates show that between 2.4 and 5.2 million passengers per year might be diverted from Logan runways in the year 2000.

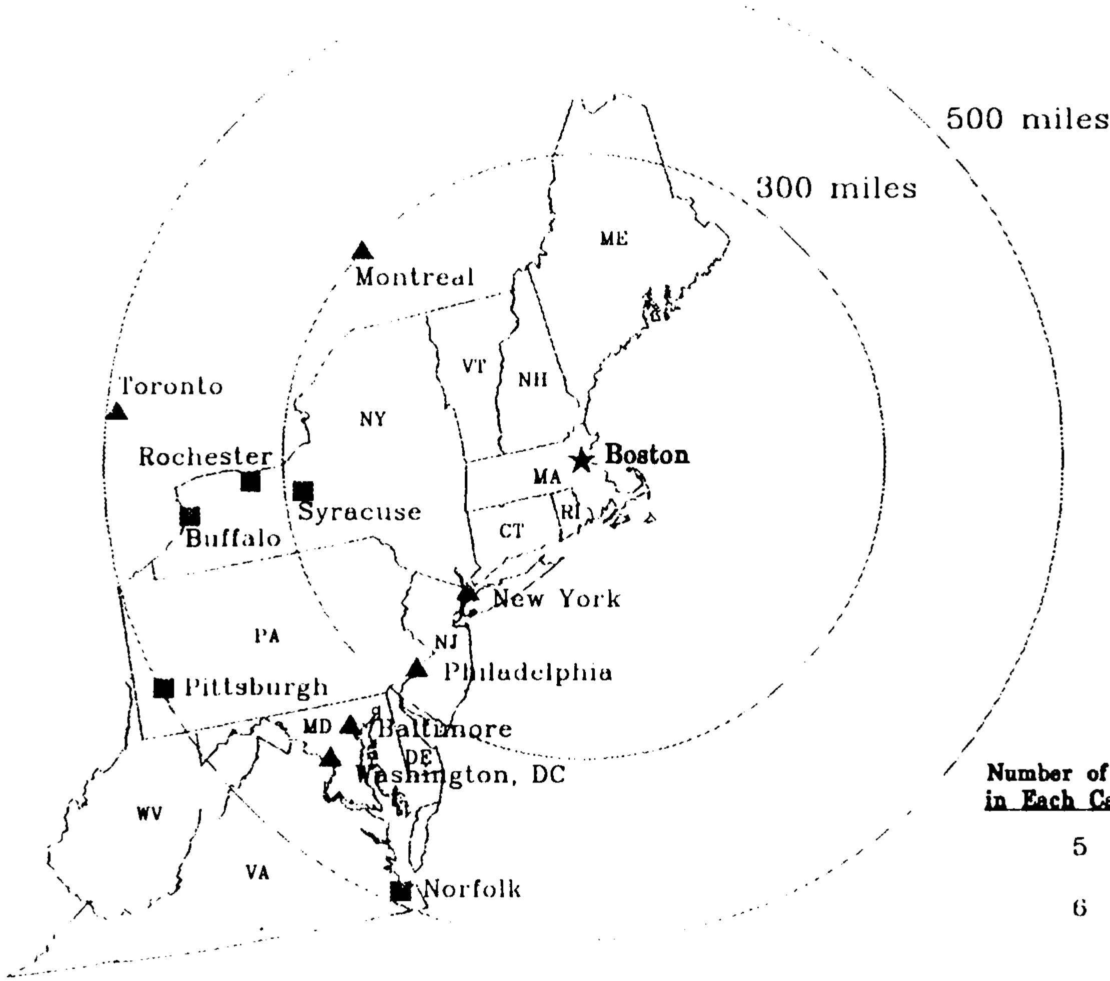
The second operational structure of particular interest to virtually all of the studies was the "spine" or city-center to city-center vertiport system. The intention of this system is to allow passengers to simply bypass congested airports altogether. Operations would be from full-service vertiports for primarily business passengers. While the Boston, Illinois, California, and New York studies saw this option as a relief for local airports, several studies like the Southwest Region study had motivations for development of this structure as mainly a time saving option for travelers. Airport slot creation was a much lower priority benefit. Figure 9 provides a summary of the Phase I system reported for this region.

The third operational structure, urban-area to urban-area, became somewhat harder to identify as a distinct entity in the studies. This is because there was significant mixing in many of the proposed vertiport systems of all three structural types. For example, some systems were composed of several cities with only a city center vertiport connecting to several vertiports in a larger city, some of which may have been at an existing airport.

One additional structure was mentioned in the studies that is worth noting. This structure involves a CTR flying from a large hub out to a group of small service points, all located in the same general geographical area before return. This structure is referred to as a "round-robin" path in the Southwest Region study. It is also used to fly to groups of islands in the Puerto Rico study and isolated communities in the Alaska and Canada studies. This route structure will most likely be profitable in the case where natural obstacles and a lack of landing locations (i.e., water and small islands) are key issues.

2.1.8.4 Target Air Traveler

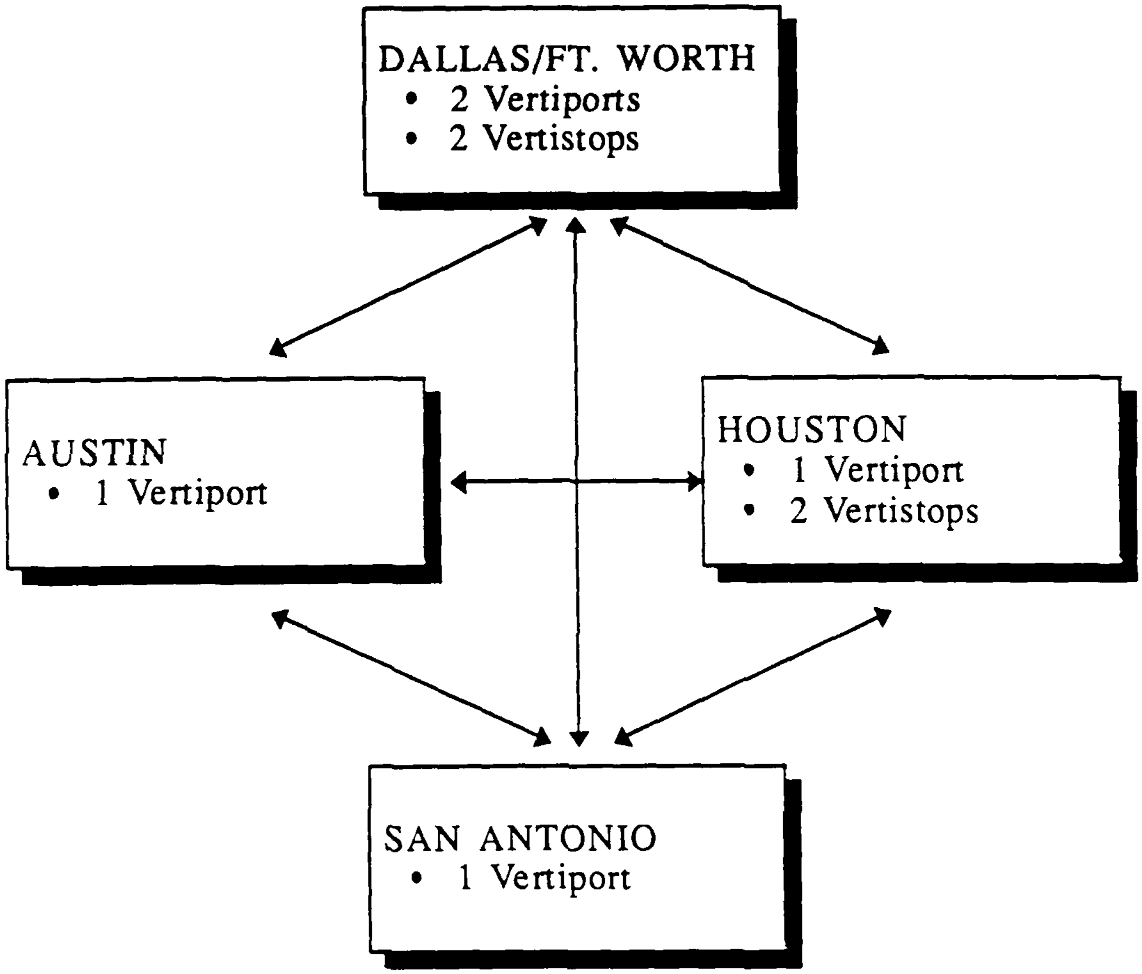
The business air traveler was the primary target air traveler that defined the operational scenarios in all of the studies of scheduled passenger operations. This traveler was assumed to be the most likely to pay a ticket premium for CTR service. Through a large survey, the Southwest Region study also reported the identification of a component of ground-based business travel that might be diverted to CTR service if significant travel time savings could be realized.



Number of Cities in Each Category		Annual Passengers to/from Boston
5	▲	78,000 – 199,999
6	■	200,000 +

Source. Reference 15.

FIGURE 8 MAJOR AIR TRAVEL MARKETS WITHIN CTR RANGE OF BOSTON



SYSTEM CHARACTERISTICS (20% Market Share)
6,300 seats per day 762 flights per day 22 PLVs (39 seats) $83 million construction cost

* PLV = Power lift vehicle.

Source: Reference 14.

FIGURE 9 PHASE I SOUTHWEST REGION VERTIPORT SYSTEM

The Puerto Rico and Southwest Region studies also identified major markets for the combined personal/vacation traveler. The Southwest Region belief that a significant personal/vacation travel market exists is based upon results of a large survey conducted specifically for their study. This survey focused on trip time saved, flight frequency, and ticket price as variables. Unfortunately, it is unknown whether or not this result is generally applicable or only applicable to the Southwest Region.

2.1.8.5 Vertiport Requirements

The vertiports that define the operational scenarios in almost all of the studies are described as multiple pad, "full service" vertiports. They include passenger terminals, associated rental car/parking facilities, CTR fueling and limited maintenance capabilities. In the Boston, Washington, DC, Canadian, and the two New York studies, the term "transportation centers" is sometimes included to point out the requirement for intermodal transportation connections. Almost all of these vertiports are sited at airports or in center city locations for the initial establishment of viable CTR service patterns. The Southwest Region study allows for several, less complex vertiport/vertistops to be included in that system. The Puerto Rico study defines requirements for full service vertiports to be located at major connecting airports but uses vertistops or small airfields for operations at outlying island service locations.

2.1.8.6 Time-of-Day/Day-of-Week Operations

The daily operations of the vertiport systems were generally based around what was perceived as the business traveler's schedule. Specific operating times varied from 6:00 to 8:00 A.M. for start of operations and 8:00 to 10:00 P.M for an ending of operations. The Boston, Manhattan, and Southern California studies mentioned peak hours in the morning and evening for CTR traffic. The studies stated that these operations should be used for sizing the vertiport. This peak traffic scenario generally led to a requirement for two takeoff/landing pads as a minimum. In conjunction with time-of-day discussion, several studies very strongly stated that all-weather operations would be required or business passenger use of the vertiport would be diminished. All-weather capability is interpreted to mean that CTR aircraft must be capable of operating in at least the same or worse weather conditions as fixed-wing aircraft from the same airport or geographical area.

Day-of-week or yearly operations were also mentioned in several of the studies. The Canadian study mentioned weekday to weekend service at a ratio of 3 to 1. The Southern California study stated limited weekend use would be required. The Boston and Southwest Region studies based passenger demand requirements for the system and facility sizing on use of the facility 5 days and 6 days per week, respectively. However, they did not imply that service would not be available the other days of the week. The study stated that 7-day-a-week service would be provided. The Boston and Puerto Rico studies also mentioned that due to significant tourist traffic, passenger enplanements in their regions were seasonal in nature. However, they did not anticipate that this would significantly influence the viability of year-round CTR service.

2.1.8.7 CTR Vehicle Size

The CTR vehicle size used in defining virtually all of the operational scenarios was the 39-passenger CTR-22C with the round, pressurized cabin. The Puerto Rico and Alaska studies also mentioned limited need for the CTR-22B with the aft cargo ramp. Only the New York study mentioned a 31-passenger vehicle for system planning. This is somewhat surprising when one considers that load factors and flight frequency were noted as being critical to a successful system. The Eurofar (30 passenger) and NASA CTR-19 (19 passenger) configurations are mentioned in many of the reports as being candidate vehicles but no mix of sizes is used in defining operational system characteristics. This lack of size mixing appears to be a weakness in the studies, as this issue is critical in fixed-wing scheduled passenger route planning.

2.1.8.8 Flight Frequency Load Factor

CTR service frequency in many of the studies is quantified as flights per day for comparability with fixed-wing service frequency for market share calculations. The majority opinion of these studies is that flight frequency needs to at least equal fixed-wing flight frequency to a specific location. The Boston and Southwest Region studies document detailed attempts to converge the desired frequencies or operations with a corresponding number of vertiport sites and landing pads to insure that system continuity exists. One aspect mentioned in the Southwest Region study that may be accounted for but not fully documented in several of the other studies (i.e., New York, Boston, Illinois) is the market share effect due to a reduction in fixed-wing service frequency as CTR frequency is increased. This factor is shown to have a significant effect on market share results in the Southwest Region study.

The Canadian study anticipates 30-minute departures on major routes at peak hours will be required to initiate successful system operations. The Puerto Rico "round robin" routes anticipate 30-minute stops at hub airports and 15-minute stops at small island locations. The St. Louis study refers most of its CTR analysis of flight frequency to *the results from the yet to be completed Illinois study*. However, since St. Louis anticipates limited CTR demand, the projection is made for a maximum of only eight takeoffs and landings per hour.

Load factors used in the calculation of flight frequency are almost all between 60 and 70 percent for the CTR-22C vehicle. Most calculations are based on 63 or 65 percent. The New York study, with limited use of an upper value of 80 percent, and Puerto Rico study, with a minimum value of 54 percent, are the only deviations from the 60 to 70 percent range for non-unique regional demand scenarios.

2.1.9 Statistical Information Sources

The helicopter industry has a lack of hard statistical data because to date vertical flight has primarily operated from airport and heliport facilities that are outside of the FAA's statistical data collection system. Therefore there is a concern that disparate data sources may skew the outcome of a national analysis with regard to each region's current and future requirements for large heliport/vertiport facilities.

2.1.9.1 Lack of Data

The prime reason why some of the reports do not have good data is because it is not available. Databases from which researchers can draw data to support their efforts regarding vertical flight operations are unavailable. This is a major hinderance and results in the necessity to make numerous assumptions. It also explains the significant number of surveys that were conducted in the studies, particularly in the areas of passenger demand and forecasts.

One promising sign in these studies is the use of urban and transportation planning data sources. These were almost totally lacking in the earlier heliport system studies of the 1980s. The use of these broader data sources illustrates that: 1) vertical flight transportation competes most with ground transportation, and 2) vertical flight planners must consider the needs and desires of the communities in which they wish to build their facilities.

2.1.9.2 Comparison of Sources

The vast majority of the reports referenced the same sources for their data, which is not unusual considering the small number of statistically oriented reference material available. All of the studies used information that is presently available, although limited, from the FAA, NASA Ames, and Bell/Boeing, manufacturers of the V-22. It is rather difficult to compare the sources. Several of the studies had many previous studies to which they could reference, while others depended on Helicopter Association International (HAI) and other association statistics. Again, the vast majority of the "hard" data originated from surveys. Some studies completed one survey; others completed several. It is from this source that the greatest amount of usable information came. The other positive note is that surveys from the 14 studies have provided the beginning of a fairly comprehensive database, particularly for passenger demand.

2.1.10 Forecasting Demand for CTR Services

The main goal of the forecasting methodologies and models in all the studies was to determine market share that the CTR is expected to capture for each area over time. Starting with this premise, the methods and data used to determine market share then varied among the studies with regard to the types of information considered significant to that locale. Since there are no CTRs in operation today, the numbers used as the foundation for forecasting were most often gathered from previously completed local and national studies and forecasts (see section 2.1.9). Many studies used their own survey data to establish and/or verify forecast results. This can be considered a significant improvement over earlier heliport studies, because it means that an effort is being made to connect with the reality of the community. The numbers were then manipulated using the best judgement of those performing the forecast. The intent was to combine quantitative methods with local judgement to produce forecasts that were mathematically reasonable and intuitively sound. Both numbers of passengers and operations were forecast, and cargo was considered in some studies. Potential passenger demand is discussed in section 2.1.6.

The basic forecasting technique was to identify a segment of the population with the most potential for using CTR technology, delineate a certain percentage of specific passengers who would use CTRs at any given time, and from these numbers, determine the numbers of CTR operations per day, week, or year. The segment of the population expected to use the CTR in the future was most often considered to be persons who now fly the routes identified as the most likely market for CTR use. Then this segment would be refined by various factors such as determination of the number of business travelers. Table 10 from the Manhattan study presents excellent examples of the basic process of forecasting.

Each study then uses various additional data as constraints, caveats, and boundaries to refine results appropriate to the area. These include such data as numbers of potential passengers from alternate modes, extent of airport/ground congestion, which city pairs to use, which not to use, etc. Not all studies used all criteria since they may not apply to a particular area. However, in some cases, perhaps additional criteria should have been considered. For instance, only the Illinois study considered the impact of ATC capability, which is likely to have significant impact in other areas as well.

The potential fare was considered critical in determining the number of people who would consider CTR transportation. Because the true cost of operating a CTR is unknown, most studies felt unsure of the final results. New York City Airports and Illinois considered load factors.

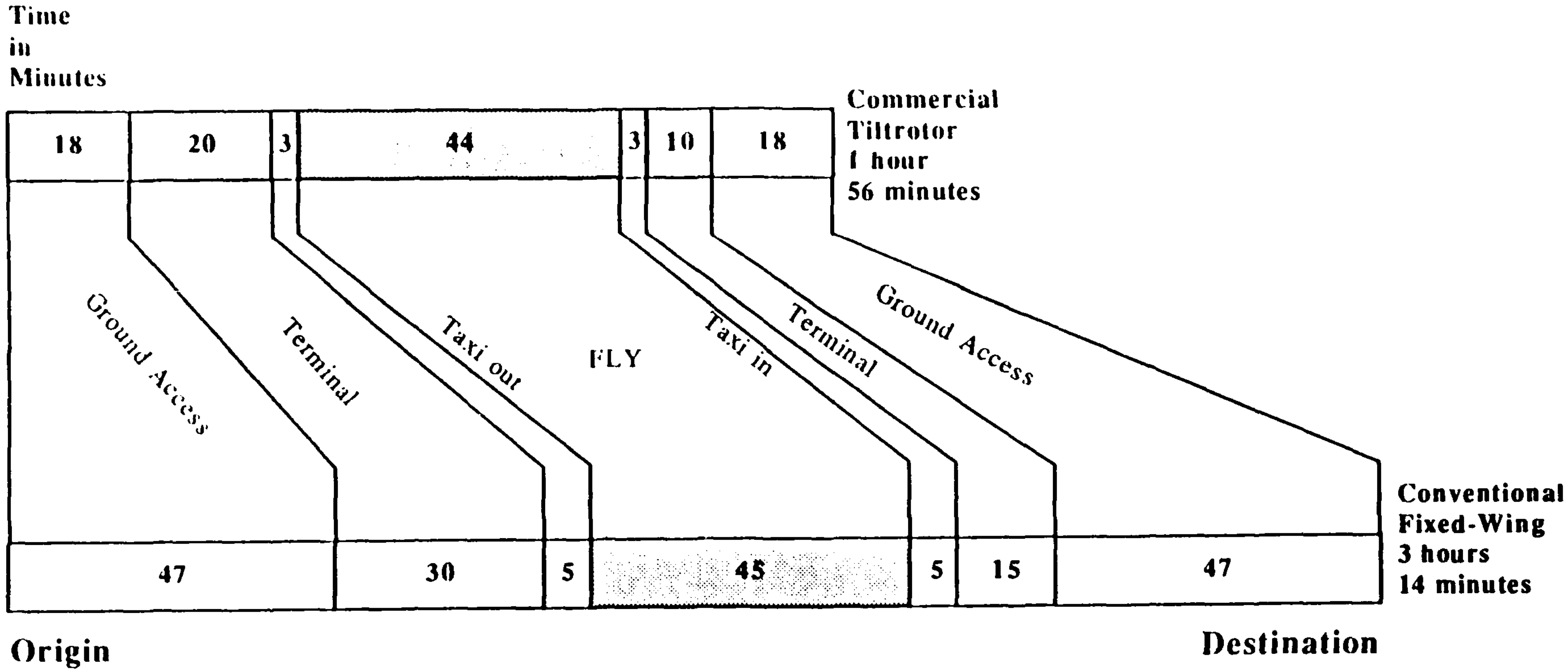
Manhattan determined peak hour demand for facility planning. Manhattan, New York City Airports, Boston, Puerto Rico, and Washington, D.C. developed low, medium, and high forecasts. Ground access time was another common criterion because many of the studies based the public's desire for CTR transportation on the time savings during the trip to the airport, as shown in figure 10 based on a compilation of various combinations of Northeast Corridor city pairs (Boston, New York City, Philadelphia, and Washington, D.C.) (reference 28).

Some additional criteria used is applicable only to specific local situations. For example, Illinois applied the fact that O'Hare's terminal and groundside facilities have been expanded and therefore are not a constraint to CTR service development. Furthermore, enhancement of Chicago's image as a leader in development of the nation's future air transportation system was a consideration.

Other local factors may be appropriate for areas to consider. These items include noise pollution, aircraft safety, local heliport ordinances, refueling, and vertiport siting or socio-economic elements such as level of income, employment, population densities, assessments of increased employment, time savings for short haul air travelers, etc.

TABLE 10 EXAMPLE OF BASIC FORECASTING PROCESSES

MANHATTAN
Given [certain] assumptions, a forecasting methodology was adopted that involved a 10 step process: 1. The Civil Aeronautics Board (CAB) reported New York-Northeast local passenger traffic for the year ending June 30, 1985 was used as a basis. Six northeast markets were chosen based on their 1985 metro area populations exceeding 1.5 million: New York, Washington, D.C., Boston, Hartford, Philadelphia, and Baltimore. 2. Passengers traveling to foreign destinations were removed. 3. Passenger statistics were assigned to the origin in each origin-destination (O&D) market. This was done since some city pairs did not display an equal distribution of passengers originating at each of the two cities. 4. Passenger origins were assigned to specific ground origin zones. 5. Passenger destinations were assigned to the ground zones identified in step #4. 6. Forecasts for 1995 and 2000 traffic were developed for each pair of zones, based on a forecast developed by the FAA and presented by the Department of Transportation in the Texas Air-Eastern Acquisition Case, Docket 43825 Exhibit AEP-D-306. 7. The share of passengers traveling as business passengers were determined. Essentially, two scenarios were examined: one with a 40% share, and one with a 75% share. 8. The NY market was further divided into sub-zones, based on traffic distributions and buying power index. 9. The share of N.Y. passengers that would not be diverted from existing metro airports was estimated. 10. Price sensitivity to CTR ticket costs was investigated. This analysis was based on 1985 air shuttle ticket prices and a tiltrotor ticket price of $112 (as predicted by Boeing).



Source: Reference 28.

FIGURE 10 NORTHEAST CORRIDOR TILTROTOR TIME SAVINGS

The years and period of time during which the forecasts were performed for each study varied. Some started with 1995, some 2000, but the latest year for which forecasting was completed for any study was 2020. A summary of the results of the forecasts by year and number of operations is presented in table 11.

Most of the forecasting was performed in a methodical and logical manner. Each technique seemingly made sense for its study area. Until CTR passenger transportation service becomes common place and there are real numbers on which to base forecasts, there can be no hard and fast judgement over which method is correct. Although generally more quantitative and thought out than the forecasts of the 1980s heliport studies, there is still a need for standardization of data elements and processes for comparability purposes. However, it is critical that all these methods been examined by both aviation and city planning forecasting experts to determine which elements, both for aviation and urban planning, are critical in developing forecasts.

2.2 FEASIBILITY ANALYSIS

2.2.1 Environmental Analysis

Addressing the basic public concern for environmental issues is essential. Noise remains the issue that most concerns communities and individuals. Noise alone can negatively affect any attempts to establish vertiports. In the future, these issues will become more consequential for two reasons: 1) legitimate concerns as people feel more empowered over their own lifestyles, and 2) outright attempts by those opposed to vertical flight facilities to block construction. Almost half of the studies did not address any environmental issues besides noise.

2.2.1.1 Noise

The significance of noise in siting vertiports in terms of community opposition/support will depend a great deal on proposed methods of noise mitigation in proximity to these facilities. Opposition is usually stronger where there are citizen groups already mobilized from earlier attempts to block the siting of new facilities or coalitions opposed to existing airport operations impacting on a particular area. This will be even more true in the future than it is today, since the trend is for community noise standards to become more restrictive over time. In addition, an essential element to public acceptance is safety. This new transportation mode must actually be safe, and equally important, the public must perceive it as safe.

2.2.1.2 Tiltrotor Noise Compared to That of Other Noise Sources

The XV-15 tiltrotor is a test aircraft developed by the U.S. Army, U.S. Navy, and Bell Helicopter in 1972. This aircraft has undergone extensive full-scale wind tunnel testing and has amassed over 750 flight hours during experimental and developmental testing. If modified for use as a civil tiltrotor, the XV-15 design could carry eight passengers or 1,200 pounds of cargo.

TABLE 11 NUMBER OF PROJECTED ANNUAL OPERATIONS FOR CTR SERVICE

STUDY	NUMBER OF ANNUAL OPERATIONS/TYPES OF MISSIONS *
Manhattan	Approximately 97 daily operations in 1995 increasing to 337 by 2015. Demand requiring 4 daily operations required to commence service. Demand requiring $\geq$ 8 daily operations required to sustain service. Small package cargo service was investigated but thought to be negligible.
New York City Airports	Three scenarios: a) CTR is a substitute for fixed-wing commuter aircraft which would land and depart at New York City Airports; for year 1995, approximately. 100-320 operations per day. b) A vertiport site in Downtown Manhattan. For year 1995, approximately 104-189 operations per day. c) A system of vertiports in the evaluated area served by the Port Authority. For year 1995, approximately 318-578 operations per day.
Washington, D.C.	By year 2000, approximately 24 to 54 daily operations (depending on the site selected).
Puerto Rico	Scheduled Service - Average daily operations at San Juan (SJU); 46 in year 2000 and 66 in year 2015. Cargo Service - Routes from San Juan to Dominican Republic and Haiti; average daily cargo at SJU (5 days/week & 52 weeks/year) = 96,300 pounds in year 2000 and 251,500 pounds in 2015. Average daily CTR cargo activity to/from SJU would be approximately 8 operations in year 2000 and 29 operations in 2015.
Illinois	CTR service at O'Hare (ORD); 200 to 442 daily operations by 2010. Downtown Chicago; for year 2000 approximately 70 to 348 daily operations. No role for CTR at Midway Airport.
California	Average daily operations by 2005 would be approximately 732 to 1,704.
Southern California	No estimated operations.
Southwest Region (Dallas)	Phase I system serving only primary demand centers, 9 landing sites, total of 762 flights per day. Ultimate projected average CTR activity in total CTR system; 2,090 daily operations.
Boston	For year 2000 projected number of average operations for <u>each</u> vertiport of a three vertiport system: low 146; medium to low 358; medium 440; high 532 per weekday.
Canada	Forecasts were developed for year 2000 and year 2010. Six vertiports were shown to be required to support scheduled CTR service. By year 2010 average daily operations (annual movements/365) would be as follows: Downtown Toronto = 254 operations; outside downtown Toronto = 209 operations; downtown Montreal = 223 operations; outside downtown Montreal = 96 operations; Ottawa = 182 operations; Quebec City = 34 operations.

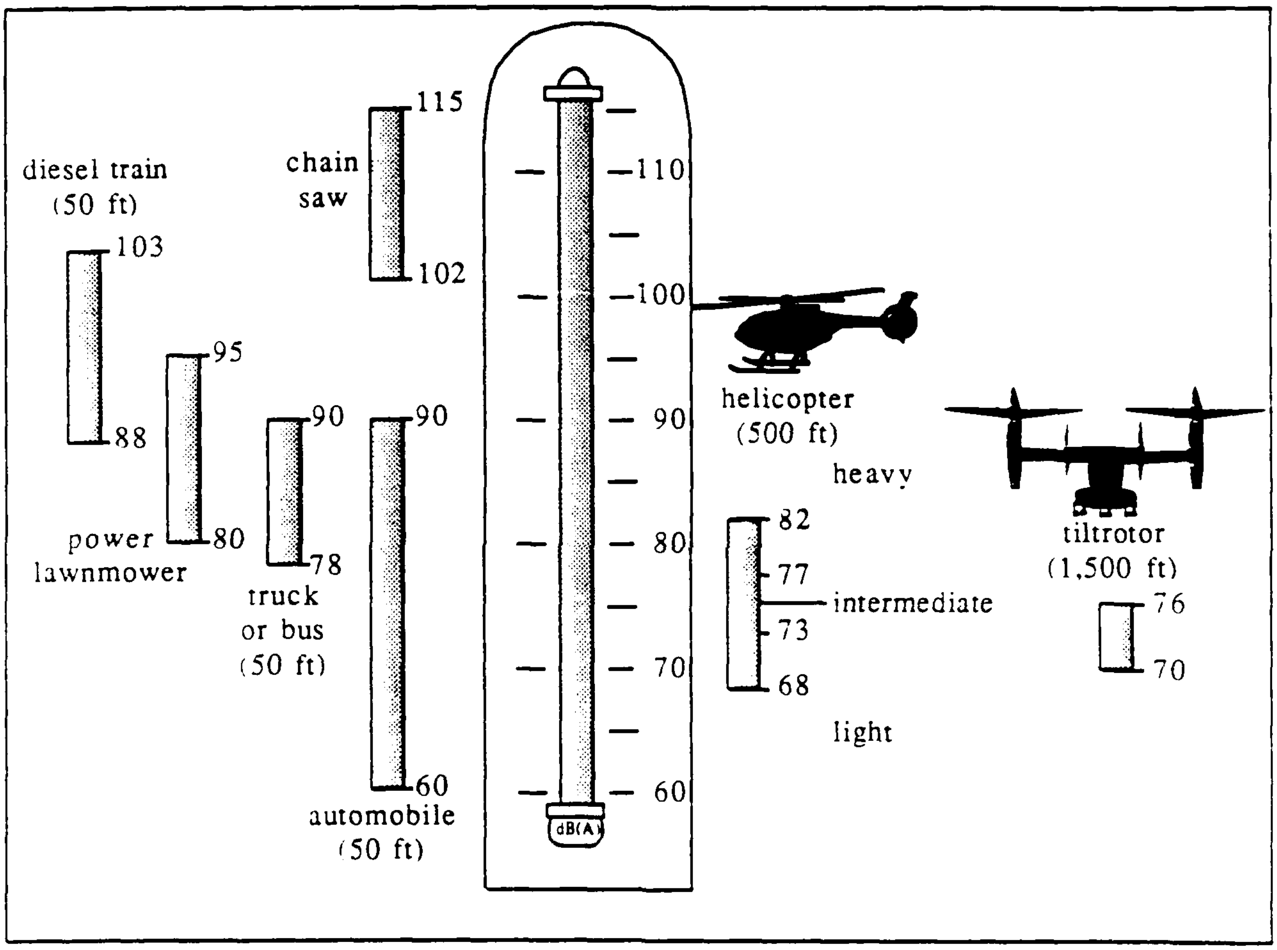
* All numbers approximate based on data available.

NASA-Ames and Bell Helicopter have considerable data on XV-15 noise for takeoff, approach, and level flight. That aircraft has been shown to have noise levels similar to a helicopter when in the helicopter mode, but a decrease of 10 to 14 decibels (dB) is seen when the tiltrotor converts to airplane mode. In addition, the tiltrotor design has a high potential for noise abatement using its unique operational envelope (variations in airspeed, altitude, nacelle tilt).

Currently, no significant noise flight test data exists for a V-22 sized tiltrotor. At this time, assessment of noise for a transport-sized tiltrotor (45,000 pounds) must rely on extrapolation from XV-15 (13,000 pounds) data. In light of the future uncertainty in being able to obtain the V-22 for noise tests, developing noise prediction models and simulation tools becomes extremely important. Bell is currently developing a civil tiltrotor noise impact prediction methodology to predict noise contours and the effects of various CTR operating modes on approach noise. Existing XV-15 and V-22 noise data are being used in this methodology in conjunction with the FAA's Heliport Noise Model. This methodology is currently in the initial stages of development.

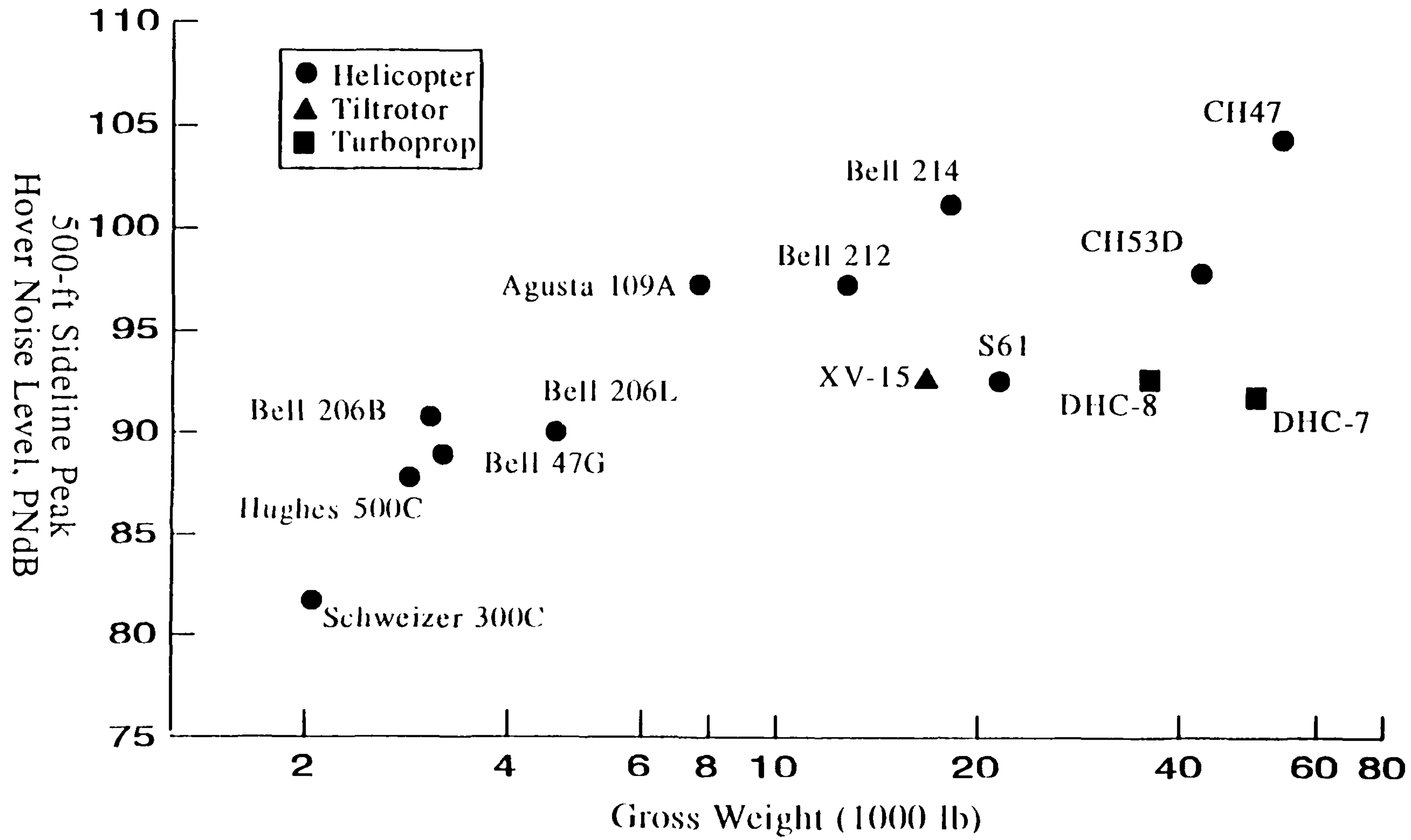
Studies to date indicate that the extent and levels of noise generated by CTR aircraft will meet standards for community acceptance established by civil aviation authorities and will have less overall impact than either turboprops or helicopters. For example, the NASA CTR Missions and Applications Study published in 1987 showed that the community noise levels (of a CTR-22C), expressed in terms of effective perceived noise decibels (EPNdB), are significantly lower than those stipulated in the relevant FAA regulations for both fixed-wing (Title 14 Code of Federal Regulations (14 CFR) Part 36, Appendix H) and rotary-wing (Notice of Proposed Rule Making (NPRM) 14 CFR), which has now been incorporated into Federal Aviation Regulation (FAR) Part 36, Appendix H aircraft. Table 12 provides a graphic comparison of estimated CTR community noise levels with those of typical current turboprops and helicopters, as well as with relevant FAA noise certification rules. These estimates were obtained using noise prediction code and extrapolation from XV-15 noise data.

Figure 11 depicts a comparison of helicopter noise with other common types of noise encountered in daily life. The tiltrotor has been located on figure 11 based on the available noise data while in the helicopter mode. As mentioned in the preceding paragraph, the CTR is expected to have less noise impact on the community than either helicopters or turboprops. Figure 12 shows a comparison of sideline/hover noise data obtained by Bell/Boeing comparing several types of helicopters, turboprops, the XV-15, and estimated values for a V-22. It can be concluded that since the tiltrotor compares favorably with existing helicopters and turboprops that it also would compare favorably with other sources of noise such as those depicted in figure 12. Bell summarized the potential noise impact of the tiltrotor in the following manner: *The tiltrotor's inherently low noise characteristics and operational flexibility gives this type of aircraft an acoustic advantage over conventional helicopters and fixed-wing airplanes of similar size. With careful attention to future designs, further development of noise abatement procedures, and proper land use planning, tiltrotor operations at future vertiports should be compatible with the dual public needs for an improved transportation system and an acceptable acoustic environment* (reference 30).



Estimated tiltrotor added to HAI Fly Neighborly Guide, February 1991.

FIGURE 11 COMPARISON OF ROTORCRAFT NOISE WITH FAMILIAR SOURCES OF NOISE



Source: Bell-Boeing Helicopters.

FIGURE 12 SIDELINE/HOVER NOISE COMPARISON OF HELICOPTERS, TURBOPROPS AND TILTROTORS

TABLE 12 COMMUNITY NOISE LEVELS

	Location	Rule	CTR Estimate	BV-234 Actual	DHC-8-102 Actual
14CFR 36 Stage 3 (EPNdB) (Fixed-Wing)	Takeoff Sideline Approach	89 94 98	60 74 77	-- -- --	80.8 86.3 94.8
NPRM 14 CFR (EPNdB) (Rotary-Wing)	Takeoff Sideline Approach	101.6 102.6 103.6	78 84 77	96.2 97.2 102.1	-- -- --

Source: Boeing Commercial Airline Co., Bell Textron, Boeing Vertol, and NASA ARC, "Civil Tiltrotor Missions and Applications: A Research Study," NASA CR 177452, July 1987.

2.2.1.3 Other Environmental Concerns

Only two studies (Southwest Region and St. Louis) recognized that the following elements may be considered if an environmental assessment (EA) is required for vertiport construction:

- water quality,
- endangered species (flora and fauna),
- wetlands,
- floodplains,
- natural resources,
- construction impacts,
- biotic communities,
- coastal zone management and coastal barriers,
- wild and scenic rivers system,
- prime and unique farmland,
- energy supply and natural resources,
- light emissions,
- solid waste, and,
- construction impacts.

Several other studies addressed air pollution, water, and wetland issues. The consensus was that it is not expected that a vertiport would create a substantial air quality problem because engine emission levels are expected to be acceptable and not contribute significantly to general levels of air pollution. An air quality impact analysis may be required if a formal environmental review process is required. However, air quality impact analysis requirements not only can change, but are different in different areas. For example, in the Boston study it stated that the new Clean Air Act requires that any proposed transportation project be included in the region's Transportation Plan and Air Quality Plan, which must assure a net reduction in air pollution emissions. Additional concerns with CTR air pollution are with respect to dust raised by rotor downwash and ground turbulence during liftoff and touchdown. However the study concluded, neither the volume generated nor the area affected is expected to be significant.

Environmental impacts resulting from construction are similar for all public works projects and are temporary. Water resource and quality impact all sites located along the waterfronts. These impacts can be minimized through careful drainage design.

Canada also recognized energy consumption as a concern. The direct consumption of energy for propulsion will be higher for tiltrotors than for other aircraft, although many of the indirect components of energy consumption, such as vehicle production, vehicle maintenance, infrastructure construction, and infrastructure maintenance, will be lower. The net difference will depend on the particular characteristics of the service in question.

2.2.1.4 Site Location Criteria/Feasibility

2.2.1.4.1 Noise Criteria

The only studies that specifically discussed why they chose specific vertiport site(s), with regard to noise, were Manhattan, Illinois, and Boston. Many of the studies provided a general discussion of tiltrotor noise studies done to date, what the results show, how tiltrotors compare to other aircraft, and details of the noise compatibility planning process, including developing noise contours for evaluating different land uses around vertiports. Studies quoted were usually "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market" and other noise studies done by Bell on the XV-15. Several studies emphasized the need for transport-size CTR noise data, since that is the size that would be similar to the first civil tiltrotor At this time, extrapolations must be made from XV-15 data, which is not totally desirable since the XV-15 weighs approximately 32,000 pounds less than would a CTR-22C sized aircraft.

Studies selected sites based on noise mitigating capability such as being adjacent to roadways, rivers, and railroad tracks. When used to delineate flight tracks, these land use features mask most rotorcraft-generated noise. In addition, vertiports located at waterfront sites may not generate undue annoyance, since these sites are often occupied by industry, factories, or shipping warehouses.

2.2.1.4.2 Siting Criteria

For the most part, the 14 studies focused on broad scope demand rather than on specific elements that are important in locating appropriate sites for vertiport facilities in the community. In other words, the element of community planning was not discussed. St. Louis, a heliport study, and the vertiport section of the Washington, D.C. study defined siting criteria for their area. A third study, Manhattan, developed methodology to locate a site based on potential passenger use.

St. Louis performed site selection in two phases: first, a general site screening process, then a site-specific evaluation. The site screening first eliminated all the unsatisfactory locations rather than trying to select the best sites on the first attempt. This process uses overlays or transparencies, each depicting features that apply to site selection (i.e., zoning, noise sensitive areas, etc.) in shades of grey. After all are applied, the lightest areas are the best. This process is used to define the study region, define parameters and a rating system, apply parameters to a geographical area through overlays, and select sites with highest potential. The four basic issues considered in designing the overlays are, operations and safety, environmental/land use compatibility, user convenience, and development potential.

The next step employed in the St. Louis study was the site selection process where actual sites within the areas indicated by the screening process are chosen. The factors considered important in both site screening and final selection are shown in table 13.

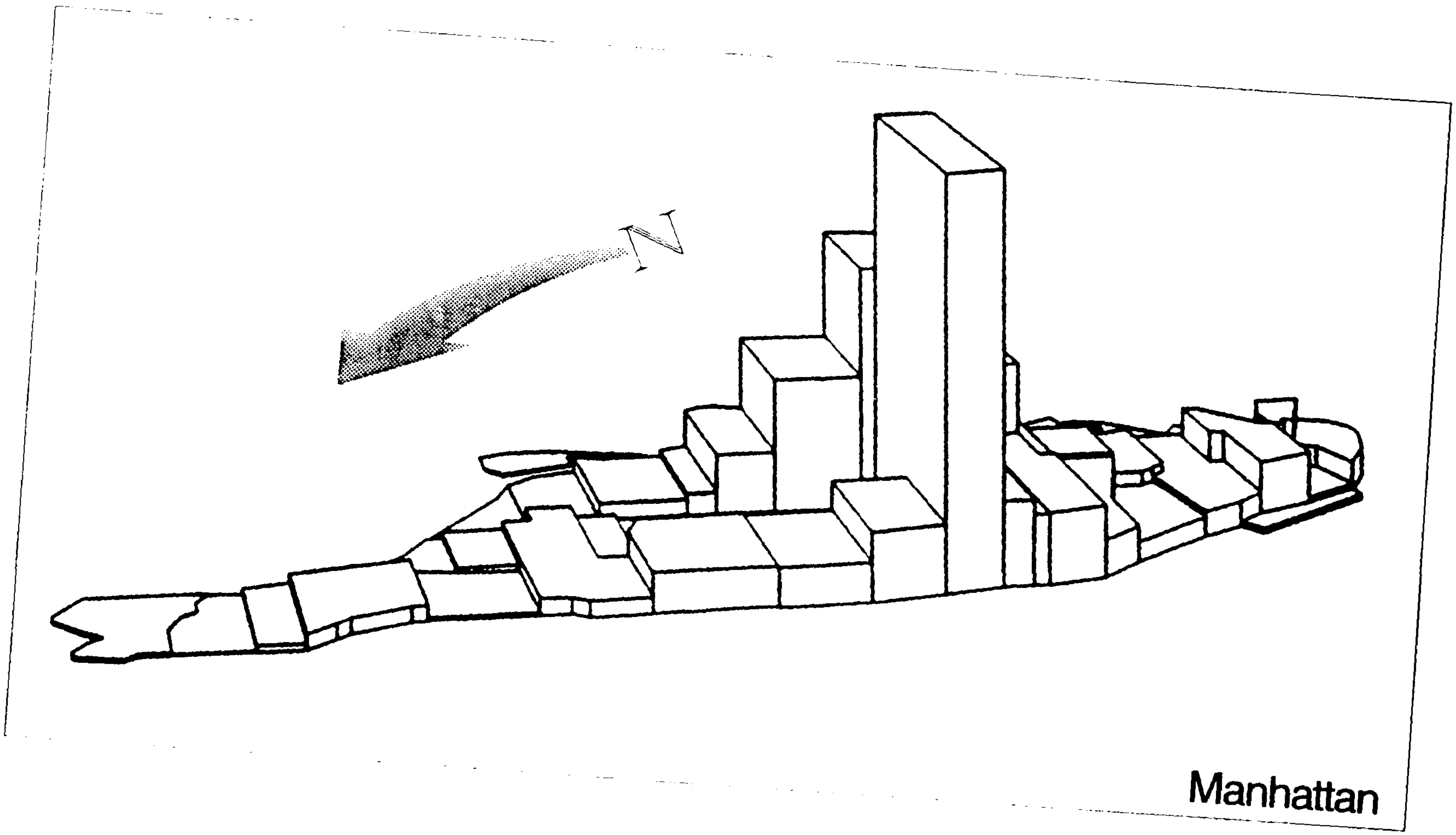
TABLE 13 ST. LOUIS SITE SCREENING AND SELECTION CRITERIA

Basic Issues	Site Screening Criteria	Site Selection Process
1. Operations and safety 2. Environmental/land use compatibility 3. User convenience 4. Developmental potential	1. proximity to tall structures 2. proximity to residential areas 3. proximity to noise-sensitive areas 4. airspace environment 5. access to alternate transportation 6. proximity to proposed development as one market possibility.	1. decide upon the number of heliports/vertiports required in the system 2. develop conceptual facilities 3. identify specific sites 4. airspace, distance to residential area, ground transportation accessibility, land use compatibility, access to transit modes, construction costs, parking availability, site size, travel time to demand centers, environmental impacts, response time of emergency services, site ownership 5. evaluate sites quantitatively and ranked then qualitatively 6. recommend system

Washington, D.C., delineated criteria important in the site selection process for both heliports and vertiports. These were location of demand, community and local government acceptance, land use compatibility with existing and planned uses, available ground transportation, airspace considerations, environmental impact, and financial concerns. For this study, the selection criteria specified that the site must:

- be located near a major demand center,
- have local interest in developing the site (government/developer or both),
- lie outside of prohibited airspace,
- show "reasonable promise" to accommodate 14 CFR Part 77 (airspace), and
- contain land zoned to allow heliport/vertiport development.

The Manhattan study performed site selection by determining zip codes from which the most potential passengers can be expected to originate (see table 5 in section 2.1.3). The results of this research are shown in figure 13.



Source: Reference 1.

FIGURE 13 SITE SELECTION PRESENTED BY ZIP CODE IN MANHATTAN

2.2.2 Institutional Feasibility

The potential for successful development must realistically detail which agency(ies) are amenable to vertical flight transportation, which are not, and their reasons. The measure of local government support can be an indicator of the prioritization of development for a national system of vertiports. This would necessarily include jurisdiction of the sponsoring agency with regard to airport/aviation activities, as well as other agencies in the planning area with authority for vertiport development.

2.2.2.1 Attitudes of Sponsors and Other Local Officials

The 14 studies were completed by either the sponsors themselves or a consultant hired by the sponsor who gave varying levels of input to the consultant. However, in most of the studies, sponsor attitude was not always clearly stated. If the studies were prepared by the sponsor, it is assumed that the findings and conclusions of the study reflect the attitude of the sponsor. The reflection of a sponsor's attitude in the findings and conclusions of studies that were not prepared by the sponsor, can only be inferred.

The most enthusiastic sponsors in terms of positive findings for potential implementing CTR service or vertiport (or heliport) construction, appear to be Puerto Rico, Manhattan, Southern California, Southern Region, and St. Louis (heliport). The least enthusiastic appear to be New York City Airports and California, in terms of negative findings with regard to the economics of CTR passenger service implementation construction. In San Francisco, a heliport study, negativism was public acceptance, not economics.

2.2.3 Airspace Compatibility

Vertiports are visualized as a way to increase air transportation system capacity, particularly at congested airports. This can be accomplished through a reduction of delays for fixed-wing aircraft, by a redistribution of air carrier operations, by door-to-door passenger transport between vertiports located in downtowns or urban activity centers, and by locating vertiports on airports, but away from fixed-wing functions. The magnitude of interest in this hypothesis is reflected in observing some of the locations that sponsored the vertiport studies. These include: New York City, Chicago, Los Angeles, Washington, D.C., Boston, and Dallas, places that already experience substantial ground and air transportation congestion.

All but three of the studies (Boston, San Francisco, and Washington, D.C.) considered the impacts of initiating CTR service into their air transportation system (airspace) at some level. The resulting evaluation produced requirements ranging from: no new equipment or systems needed, to revamping the entire infrastructure. The consensus of these evaluations of airspace requirements is divided into terminal areas, route structures, and regulatory issues.

2.2.3.1 Terminal Areas

Since most vertiport operations are expected to occur in metropolitan areas, some level of understanding of the terminal airspace structure and flight regulations governing its operations is required.

It was recognized that the new transportation system needs to be integrated into the existing system. In other words, AVF aircraft will not operate exclusively in their own infrastructure with no contact with the current one. However, there is a need for specific procedures for CTRs to perform certain operations. Specifically designated approach and departure routes, using both visual flight rules (VFR) and IFR procedures within terminal areas will be required. The performance capabilities of the aircraft can be maximized for congestion reduction if at least four refinements to current procedures are made: steeper approach angles, low airspeed approaches, decelerating approaches, and fully coupled (autopilot) approaches to a hover with a vertical let-down.

All-weather operations are considered a must. This will require using advanced navigation and landing systems to support full instrument flight capabilities. Innovative IFR procedures using newer technologies like microwave landing system (MLS) or global positioning system (GPS) will be required to integrate and accommodate the unique operating capabilities of AVF aircraft. Current FAA policy trends favor early implementation and evolution of GPS as the primary means of air navigation.

The Canadian study proposed true vertical lift operations. These would be the most desirable from the point of view of minimizing required airspace around vertiports. If engine power and aircraft performance are sufficient to permit vertical takeoffs and landings from points well above surrounding structures, problems related to steep-angle climb and descent maneuvers are less of an issue. However, such procedures will likely limit payload. Due to operational considerations, therefore, vertical landings and takeoff, if feasible, would be executed only at sites where no other alternatives are possible.

2.2.3.2 New Route/Approach Systems in Existing Route Configurations

Airspace is one of the most complex issues impacting the feasibility of CTR service, specifically route configurations within designated airspace. At a minimum, an examination of the complex network of arrival and departure routes, airspace sectors, controller workload, traffic flow patterns, and advanced navigational and guidance systems must be accomplished to ensure adequate integration into the present route configuration. One of the most important elements in implementing a new aviation system into the current airspace structure is development of a successful system-wide plan.

2.2.3.3 Regulatory Nature of Controlled Airspace

The establishment of intracity and intercity flight tracks has implications for safety, noise, and obstacle avoidance. New technology, such as satellite navigation and revised electronic navigation aids criteria, may also permit instrument approaches where existing FAA criteria do not.

Airspace regulatory issues need to be reviewed and updated. Performance standards, such as decreased approach speeds and steep angle approaches, would allow smaller instrument approach surfaces, making various approaches to urban vertiports feasible. IFR separation standards must be updated to recognize the flight capabilities of tiltrotors. Regulations that address CTR capabilities from both an air traffic management and flight standards (obstacle avoidance) should be reviewed.

As traffic levels increase around vertiports and extensive passenger operations become the norm, vertiports may require an operational control tower. Finally, as in any area of technology, as improvements evolve, appropriate updates must be accomplished. The support system of the current communication, navigation, and surveillance (CNS) must evolve to meet future requirements.

2.2.4 Political and Social Acceptability

Political acceptability follows social acceptability. In other words, locally elected officials most often reflect the attitude of their community. If local governments and agencies believe that their constituency does not sufficiently support vertiports, they will not provide support. Even the willingness to study or entertain the question of having vertiports can run afoul of concerns of political or social acceptability. The primary basis of social, and consequently, political, acceptance is considered by most studies to be safety issues, noise, and other environmental concerns. Visual pollution, where even the sight of vertical flight aircraft is unacceptable, received limited recognition. Additional issues, known to affect public opinion to varying degrees, including invasion of privacy or personal space and the unpredictability of vertical flight aircraft movement were not addressed.

It was felt that to develop the public's confidence that the CTR is safe, a definite record of safety had to be established. The California study stated that the CTR would *...need [an] above average safety record as well as have the public perceive that they are safe and reliable.*

The studies illustrate that social attitudes vary among locations. Some areas like New York City, Boston, and St. Louis tend to support vertical flight activity. Other areas, like San Francisco, are strongly opposed. In still others, like California, Southern California, and the Washington, D.C. metropolitan area, there are a mix of attitudes. The Puerto Rico study based their social acceptance heavily on estimates of reduced noise with the CTR. Orlando and Alaska did not address this issue.

2.2.4.1 Role

It was indicated in "Four Urban Heliport Case Studies" (reference 7) that one of the most important factors in developing and maintaining a heliport is positive support or at least a lack of opposition from the local government. However, the direct role of the 14 sponsors with regard to actual vertiport/large heliport development ranges from making recommendations and assisting in state-wide infrastructure planning (such as regional government organization) to making an actual decision on construction (as in the case of a port authority or local government). However, at this point in vertiport development, no one agency can make a unilateral decision. The responsibility for fostering CTR vertiport development still falls on a wide range of agencies (see section 2.3.8).

2.2.4.2 Impact

It is most often stated that community and neighborhood anti-heliport/vertiport organizations are the reason that rotorcraft facility development is defeated. However, these groups alone cannot be blamed for that failure. The reasons behind the groups' feelings may be the real problem. The rotorcraft industry itself has played a role in producing negative feelings, particularly during the early years.

A good example of creating negative public attitudes occurred in San Francisco. At one time, rotorcraft activity along the San Francisco waterfront was fairly active. However, some aerial tour operators failed to consider the impact their aircraft had on the residents of the city. By not flying "neighborly," the actions of the operators angered the residents to the point where their voice against current and future rotorcraft activity became overwhelmingly loud and clear. Similar anecdotes are told in Texas and Maryland. Allegedly helicopter pilots have deliberately hovered over houses or blown laundry off clothes lines of someone who expressed concern over heliport development. An industry effort to "fly neighborly" has curbed much of this type of activity, but the damage done is slow to heal.

In San Francisco, the fury expressed by anti-rotorcraft groups could not be ignored. With this anger vented in a controlled and focused manner, politicians in San Francisco had virtually no other recourse other than to stop any further advancement in promoting CTR service in the city.

The Washington, D.C. study provides seven reasons why no progress has been made on the development of a heliport within the District of Columbia. Except for the last two local concerns, the following list provides a good example of typical community attitudes:

1. total lack of broad-based community and local government support,
2. community opposition,
3. lack of awareness of possible benefits to the community,
4. cost,
5. much of the lower portion of the city is not accessible by aircraft because of prohibited airspace, and
6. the close proximity of Washington National Airport to downtown Washington.

As long as vertiports are seen as benefiting a privileged few who can afford expensive rotorcraft service, it will be very difficult to obtain and sustain necessary political support. It is anticipated that the consideration of scheduled passenger service from vertiports, where a much larger number of users can benefit, will be a catalyst for facilitating widespread political approval and social acceptance of vertiports. Yet, a survey completed by the New York City Airports study of passengers selected as potential users indicated that many did not feel that the possible time saved using CTR service, the key to CTR desirability expressed in many studies, was worth the extra cost.

The New York City Airports study clearly stated, *Tiltrotor developers must establish a frame of reference for the civil sector that is not helicopter-derived. The standard of comparison for manufacturers, travelers, and potential operators must be the fixed-wing service that will be operating after the turn of the century.*

2.3 OTHER ISSUES

2.3.1 Potential Ridership

In determining what creates passenger demand for vertical flight transportation, there were two main assumptions that dominate calculations in most the vertiport studies. These were: 1) the primary passenger will be the business traveller, and 2) the appeal of the CTR will be the time saved in ground travel between origin and aircraft takeoff facility, and aircraft landing facility and final destination. Additional assumptions were employed in applying methodologies and calculations but were expansions of these two basic themes. Evaluation of the need for CTRs for relieving airport congestion focused more on enhancing service levels rather than time saving.

The basis for determining the potential number of CTR passengers was the current number of fixed-wing passengers. Some studies considered the possibility of capturing passengers from alternate modes. Most delineated specific origins and destinations for their calculations. The level of demand determined in most studies was city pairs. Puerto Rico determined specific routes for both passengers and cargo. The heliport studies, St. Louis and Orlando provided actual sites within their city. San Francisco determined no need and did not continue their study to site selection. The heliport studies that were completed, St. Louis and Orlando, performed site selection methodologies to determine exact sites at which to build heliports. The site selection methodologies stipulated greater level of detail. Specific details of methodologies are presented in section 2.1.6. Table 11 in section 2.1.10 presents the projected number of annual operations for CTR service.

2.3.2 Small Package/Freight Delivery

A large heliport/vertiport, although capable of accommodating AVF aircraft for scheduled commuter operations, will accommodate various smaller helicopters used in other missions. These other missions can be expected to contribute revenue for the facility. One mission with outstanding revenue potential is small package/freight delivery. The studies that explored small package delivery were California, San Francisco, Orlando, and Manhattan. The others did not consider the cargo mission.

Three factors drive express package delivery: time saving, reliability, and competitive pricing. The cost of express delivery operations is important because of the high level of competition in the industry. Companies such as Federal Express have examined CTRs for use in their operations and have said that the CTR's primary operating advantage over airplanes, such as the Cessna Caravan, is its VTOL capability. They have concluded the CTR needs to be equally as reliable as the present fixed-wing aircraft fleet and have comparable operating costs. CTR aircraft do not provide sufficiently unique operating advantages to justify higher costs or losing money on their operation, particularly when competing against fixed-wing aircraft.

Federal Express has expressed a willingness to participate in a demonstration program of the CTR, but would not commit to purchasing or operating the CTR until the aircraft's reliability and costs have been proven. For Federal Express, the CTR would have to be profitable in terms of their national route structure, but not necessarily profitable on each individual route. Commercial passenger airlines also carry packages. The California study noted, *Throughout the forecast period, passenger-carrying aircraft are expected to transport most of California's air cargo (80 percent in 2005).* Further, the major airlines operate similar hub-oriented networks as overnight express carriers even though their primary business is carrying passengers.

Small package delivery was envisioned as a support mission to the primary mission of passenger transportation. Some areas, like Manhattan, already have a sizeable small package/cargo system supported by helicopters (reference 29), of which an appropriate share of this could be handled by the CTR. Overall, the sponsors did not think the numbers significant. Others felt that if this service were available it would grow substantially. The mechanics and potential markets for cargo and small package delivery are discussed in section 2.1.7.

2.3.3 Benefits Estimation

The benefits attributed to rotorcraft have been listed over the years and are quite numerous. However, these benefits have not yet been sufficient incentive to induce the widespread development of vertical flight facilities. The benefits are usually tied to public service and do not touch enough people's lives often enough to counteract negative or, at best, neutral perceptions. An example of this is the appreciation San Francisco demonstrated for the assistance helicopters provided in rescue and disaster relief operations after the 1989 earthquake. This help was not powerful enough to sway public opinion to allow rotorcraft into the city during normal times. AVF type aircraft, such as the CTR, are expected to provide more substantial benefits to a larger segment of the population through airport and ground transportation congestion relief.

2.3.3.1 Reduced Airport Congestion

The CTR is expected to relieve airport congestion because it would operate from off-airport locations, downtown-to-downtown, or activity center-to-activity center, thereby diverting a certain percentage of passengers and reducing the requirement for traditional aircraft at airports. It is envisioned that this type of service would replace short-haul jet and commuter aircraft that take up gate space at airports. This way, more passengers would be able to use the air transportation system while at the same time reducing airport operations.

The consensus of the studies was that there is potential for the CTR to provide the following advantages:

- reduction in door-to-door intercity travel time,
- avoidance of airport and road congestion,
- potentially increased airport capacity,
- air transportation provided to cities where it is not now available,
- intracity transportation, and
- easier, faster access from downtown or suburbs to airports.

As the Manhattan study contends:

> *...By transferring these operations from major airports to vertiports, additional capacity would become available for long and medium range operations employing larger aircraft. The net result would be a greater throughput of passengers - in other words, a more efficient use of airspace and airport resources.*

However, the studies were cautious about accepting the effectiveness of an untried new technology, as expressed by four basic questions in the Southern California study:

1. Will people ride it (based on assumed time savings)?
2. Can the airlines operate it (profitably)?
3. Can it ameliorate congestion (both air and ground)?
4. Are its impacts acceptable?

Many studies concluded that a working demonstration was necessary before they would back the CTR unequivocally.

2.3.3.2 Economic Impact

2.3.3.2.1 Construction and Operation

The consensus was that potential positive economic impacts are great, but the risk of developing and implementing an unknown, untried technology is also great. Most studies felt that the costs of development would ultimately be offset by capacity enhancements.

The California study stated that *...the cost of CTR service must be evaluated to determine if it can be provided at a competitive price within a deregulated, open marketplace.* The New York City Airport study suggested that although the CTR: *...offers a novel approach for increasing the capacity of the airport system--an approach that if further refined and perfected, could save billions of dollars of investments in other means for achieving airport capacity expansion,* it must be considered that:

...the financial and technical risks in developing this technology are high, and it is unlikely that a commercial version of the vehicle will be funded by the private sector without significant subsidy. The CTR offers the potential of long-term benefits to the aviation system, but poses high risks to the aircraft developer. The federal government should view the CTR as a technique for improving airport capacity (much as it views improved air traffic control systems), rather than as a vehicle required to pass a pure market test.

Ultimately, the *...cost of the CTR may be less than other alternatives for increasing airport capacity.* Additional arguments for continued CTR development were that it would have a positive effect on the U.S. balance of trade and on continued respect for our technological achievements.

2.3.3.2.2 Benefits to the Community

The public still does not accept rotorcraft for everyday transportation. People often see helicopters as "toys of the rich," as tools of war, an annoyance in their neighborhoods, or, at best, a rescuer in emergency situations (see section 2.3.3). Four studies, Illinois, St. Louis, Southwest Region, and Boston, attempted to assess direct economic benefits of rotorcraft for their community.

Benefits were primarily viewed as providing new aviation and non-aviation employment. The Illinois study stated that the number of Chicago area jobs created by development of a CTR system and the accompanying annual payroll for employment was estimated using relationships of jobs to aviation activity that are commonly used in airport economic impact analyses. With a fleet size of 25 aircraft, it was projected that approximately 622 persons would be hired, of which 75 percent would be based in Chicago. A total of 2,439 jobs were projected to be generated by the CTR activity, with a payroll of over $70 million. These estimates of economic impacts take into consideration increased growth in travel demand and related business activity as a result of CTR service.

The Southwest Region study estimated that construction of a system of vertiports in Dallas County, Texas would create 494 jobs for an expenditure of $21.61 million. With two of the major vertical flight vehicle manufacturers located in Tarrant County, Texas, the economic impact, given a moderate production rate, would result in over $2 billion in output with nearly $700 million in annual earnings and the creation of over 25,000 new jobs. However, once construction of the system is concluded, this impact will dissipate rapidly.

St. Louis estimated that initial construction of a heliport in the downtown area would produce a one time economic benefit of approximately $17.4 million. This figure accounts for the helipad, office, storage, fuel storage, and the sharing of common multi-modal facilities such as parking, lobby, and access/traffic improvements.

The Boston study stated that vertiports will provide a range of benefits to the city and neighboring communities where the facilities are located. Facilities such as vertiports can be expected to create jobs and enhance business opportunities. Access to business would be improved by providing valuable transportation links and the purchase of goods and services would help support those businesses. The economic impact from a vertiport was computed in the same manner as the St. Louis study. Total economic benefit, again including direct, indirect and induced impacts, ranges between $86 to 150 million, depending on whether the low or high ridership scenario occurs.

Employment opportunities for the Boston community, based on existing and projected airport job-generation rates, are forecast to range between 548 to 1,455 positions and 1,280 to 3,400 positions. The openings would again be dependent on whether there is low or high ridership. Jobs include both on-site, vertiport-related jobs and off-site jobs like hotel and restaurant employment. The vertiport also would enhance the community's ability to retain existing businesses and attract new ones as well. As brought out in the other studies, a downtown vertiport increases the city's competitiveness in marketing itself as a conference or convention center. Convention and conference centers generate considerable amounts of money for the local economy on an annual basis.

Communities would also receive economic benefits from vertiport facilities from sources such as real estate, fuel and occupancy taxes, fees for water and sewer, fire protection, and lease payments for land and hangars. Those communities that own the land or participate in a partnership to develop a facility are likely to realize even greater benefits.

2.3.3.3 Public Service

In some areas, a CTR system would benefit the community by providing improved service in areas of forest fire fighting, disaster relief, and search and rescue (see section 2.1.5). These improvements would be attributed to the aircraft's ability to cover a wide area of territory, remain airborne for long periods of time, fly at turboprop speeds, hover, and perform precise vertical landings and takeoffs.

For EMS missions in remote areas, the CTR would improve response and transport time. CTRs would eliminate the necessity to use both a helicopter and an airplane. Both are used when only a helicopter can make the initial patient pick-up, but where transfer to an airplane is necessary because of trip length. The CTR would save time because it could be used for the entire mission. Valuable time is not lost transferring the patient from the helicopter to the airplane at the departure airport, and again at the destination airport from the airplane to an ambulance for transport to the medical facility. The airplane's need to taxi, take off, climb to cruise, descend, and taxi again also uses time that is critical to patient survival.

2.3.4 Landing Area Number, Type, and Cost

The two basic types of facilities discussed in the studies were the vertistop and the vertiport. These terms are used primarily to denote the size, amenities, and level of service of the facility.

The vertistop implies a small facility, usually just approach/ .eparture airspace, a landing area, and a wind sock that would be located in a suburban area for the pickup and drop-off of passengers and act as a feeder to a larger vertiport. The use of the term vertiport indicates a large facility in a downtown or busy activity center. The vertiport usually has at least several parking places for CTRs, multiple landing pads, multiple approach/departure paths, a terminal building with various services, intermodal capabilities, and fuel and maintenance where appropriate.

Based on the numbers of operations forecast for each study in section 2.1.10, seven vertiport studies determined the numbers of landing areas with generalized or specific locations. An eighth study, California, only stated that vertiports would be built at locations other than airports. Three of these studies, Manhattan, New York City Airports, and Puerto Rico, developed facility requirements at particular locations. The others delineated only general requirements. These are shown in table 14. It is interesting to note the similarities and differences in what elements are considered necessary. The need for a rollway is indicated in three studies (Puerto Rico, California, and Canada). With the emphasis on scheduled passenger service, a precision approach is only mentioned in one study (Manhattan). Aside from the need for the true basics such as a touchdown pad, the most common elements are a terminal building and automobile parking.

The costs associated with development were estimated by four studies, Manhattan, Puerto Rico, Southern California, and Southwest Region. The only studies to include land acquisition costs are shown in table 15. Depending on the location and level of amenities, cost estimates ranged from $1,000 in the Caribbean to $87,300,000 on Manhattan Island. Table 16 presents an example from the Southwest Region study of how generic vertiport costs were determined.

2.3.5 Generalized Vertiport/Large Heliport Design Examples

There were no distinctive designs or design requirements for vertiports peculiar to one region (section 2.1.4). The primary mission anticipated for vertiports is scheduled passenger service, except where indicated (see sections 2.1.4 and 2.1.5). Facilities were also deemed to be the same for interstate and intrastate passenger service. The only differences are in the number of amenities (e.g., number of parking spaces, size of terminal, and number of landing pads).

The only requirement that was different was not really regional but based on the international political necessity for customs and immigration service. This would add to the requirements for the terminal building and terminal area. This necessity was described by the Puerto Rico study. It was not discussed in the Canadian study, although it would likely be necessary.

Another distinctive requirement mentioned by the Puerto Rico study was specific to cargo requirements and type of system to be used. For cargo operations, the empty parking lots at factories would be used as vertiports at night when the basic function of the factory is closed. Requirements specific to such vertiports include pavement standards in addition to those required in a typical parking lot to allow for the exhaust heat from the CTR. Of necessity, these vertiports would be closed to the public.

TABLE 14 VERTIPORT STUDIES - LANDING AREA NUMBER, TYPE

STUDY	VPTS	LOCATION	FACILITIES REQUIRED
Manhattan	1	Pier 76 facing the Jacob Javitz Convention Center	One touchdown and liftoff surface, 8 gates, precision approach, ground control, airport rescue and firefighting, fuel, 66,600 square feet terminal and 400 [automobile] parking spaces
New York City Airports	4+	a) each of the three PANYNJ airports b) downtown/midtown Manhattan c) number in sub-markets served by PANYNJ	a) LGA - successful operation of a vertiport is highly questionable due to lack of space. JFK - two landing pads, four to seven gates at existing terminals. EWR - six landing pads, four to seven gates at existing terminals. b) two landing pads, five gates, a terminal, and 595 auto parking spaces. c) not stated.
Puerto Rico	system	a) SJU (international airport) low activity airports b) factory parking lots/industrial parks c) resorts inland resources d) marine resource industry/St. John in U.S. Virgin Islands	a) most at existing airports; a rollway is recommended [heavy loads/hot climate] b) minimal c) terminal building, vertiport should have a paved or packed dirt touchdown/takeoff surface, daytime use only requiring markings, a wind cone and a navaid d) on barges with the same facilities as for serving inland resources
California	---	located at other than airports, no specific locations	General requirements: small ground level - small landing area, taxiway, parking for two CTRs and a terminal large ground level - a rollway, taxiway parking five CTRs and a terminal rooftop - a small landing area, taxiway and parking for one CTR
Southern California	12	Los Angeles Central Business District, Century City-Westwood, LAX-El Segundo, Torrence-South Bay, southern Long Beach, Burbank-Glendale-Pasadena, Anaheim-Fullerton, Orange-Santa Ana, Costa Mesa-Newport Beach, Irvine, and San Bernardino	General requirements: two landing areas, parking for approximately five CTRs, a terminal, and auto parking.
Southwest Region (Dallas)	4+	(Phase I) Dallas/Ft. Worth, Austin, Houston and San Antonio, one or two in Dallas/Ft. Worth and Houston metro areas	Types considered: rooftop and ground level vertiports and vertistops, no requirements given
Boston	3-4	Downtown Boston/Cambridge area (one or two), Route 128 corridor north/northwest of Boston, Route 128 corridor west of Boston	Types considered: ground level, interchange or over a highway, rooftop, and waterfront or floating General requirements: one to three landing pads, fueling and maintenance services, CTR parking, terminal and auto parking where needed
Canada	6	Downtown Toronto, outside of downtown Toronto, downtown Montreal, outside of downtown Montreal, Ottawa, Quebec City	Types considered: ground-level and rooftop at: airports, waterfront, over highway, and offshore as appropriate. Generic facilities: one landing area, rollway, ground taxi and hover taxiways, auto parking, full terminal services, cargo handling, aircraft maintenance, fuel, crash and rescue, and commercial businesses

TABLE 15 VERTIPORT STUDIES - COSTS

STUDY	TYPE	COST
Manhattan	development	$ 87,300,000
Puerto Rico	barges or resorts individual site marine resource industry industrial site	1,000 - 2,500 5,000 - 7,000 7,500 - 25,000 10,000 - 15,000
Southern California	per site	11,000,000
Southwest Region (Dallas) (including land acquisition)	rooftop vertiport ground level vertistop rooftop vertistop ground level vertiport at existing airport	13,205,000 10,435,000 4,015,000 4,345,000 minimal

TABLE 16 GENERIC VERTIPORT DEVELOPMENT COSTS
Source: Southwest Region Study

COST ELEMENT/ VERTIPORT TYPE	Vertiport Rooftop	Vertiport Ground	Vertistop Rooftop	Vertistop Ground
Land Acquisition	0	375,000	0	225,000
Air Rights acquisition	4,000,000	5,000,000	2,000,000	3,000,000
Sitework/Utilities	125,000	150,000	50,000	40,000
Paving-Vehicle/Pedestrian	110,000	110,000	40,000	40,000
Rollway and Apron Paving	5,200,000	3,000,000	1,500,000	1,000,000
Rollway and Apron Structure	650,000	0	225,000	0
Lighting	100,000	100,000	25,000	25,000
Fueling Systems	400,000	300,000	0	0
Terminal Facilities	380,000	380,000	60,000	5,000
Acoustical Mitigation	2,000,000	500,000	0	0
Communications	10,000	10,000	5,000	5,000
ILS*	0	500,000	0	0
Vertical Transportation	200,000	0	100,000	0
Fire Protection	30,000	10,000	10,000	5,000
TOTALS	13,205,000	10,435,000	4,015,000	4,345,000

Assumptions used in preparing the costs include:

1. CBD land estimated at $75,000/acre.
2. air rights acquisition costs which depend on siting (estimated costs represent an amount to cover the lost opportunities of a high rise),
3. order of magnitude estimates to delineate estimated costs of vertistops, and
4. rooftop facilities assume no participation in the purchase of land.

* Applied as generic IFR landing system cost.

2.3.6 Intermodal Relationships

The term intermodal connections needs to be defined as it pertains to CTR service. The current focus on intermodal movement is rail development. While rail could be an important connection for CTRs, especially intracity rail (subway and light rail), it is clear that auto and taxi connections are required as well. A curbside or parking lot connection is an intermodal connection in the pure sense of the term and should be considered as such. The integration of park-and-ride concepts with vertiports, for example, is compatible with the intermodal goal of automobile trip reduction.

It is clear that CTRs diverge from helicopters when it comes to the applicability of intermodalism. Helicopters are a more direct origin and destination (O&D) form of transport than a future CTR will be. Consequently, the need for additional transport at the end of a helicopter trip may be no more than an elevator or, at most, a short car ride. CTRs will have a larger demand service area making transportation connection options such as subways and light rail transit desirable in addition to connections via cars and taxis.

Any surface transportation component of a CTR intermodal system will have to be attractive to the expected CTR user, the business traveller. For such a traveller, attractive equates primarily to reliability, cleanliness, and safety, with price being secondary.

2.3.6.1 Study Results

It was anticipated that these studies would provide discussion on: level of activity, type of region (urban, suburban, rural), expected ridership, etc. However, there was a surprising lack of reference to intermodal activity for vertiports. Six studies (Puerto Rico, Illinois, New York City Airports, Washington, D.C., Alaska, and Manhattan) did not discuss intermodal potential at all. Others, like California, provided a brief discussion about alternative modes of transportation, i.e., high speed rail, yet did not address intermodal facilities. In many cases, Southern California, Orlando, and San Francisco in particular, the subject was broached, but alternative modes of transportation were regarded as competition for the CTR. Southwest Region, Canada, St. Louis, and Boston did provide limited discussions of incorporating vertiports into multimodal facilities.

The Southwest Region study did not pay particular attention to intermodal relationships until near the end. High speed rail (HSR), conventional rail, buses, and automobiles were viewed strictly as alternative means of transportation. A vertiport located in the Dallas CBD was determined to be good because, it *...is close to private and public transportation modes (i.e., automobile, bus and light rail).*

A comment on the current site where a vertiport is being build stated, *It is expected that a terminal for HSR and conventional rail will be located on the lower floor of the vertiport. Additionally, the vertiport is located at the junction of three major interstate highways...* And, *The Dallas heliport/vertiport is currently under construction. Provisions have been made to* *accommodate a HSR terminal on the lower floor of the vertiport. This will allow passengers a choice of travel...*

In Boston, the Metropolitan Area Planning Council (MAPC) formulated a regional development plan called Metroplan 2000. This plan, which was used as a guide for the vertiport study, encourages concentrated growth in areas that already have or will have the infrastructure. Further, *...it is hoped (the growth) will be anchored by a transportation center housing commuter rail, parking, carpool drops, taxi stands, and helicopter/tiltrotor berths.*

Canada provided one of the strongest statements regarding vertiport intermodal integration. It was identified as a necessary criterion for CTR service to be commercially successful and to ensure the unique competitive advantages of that technology.

The study went on to say that all forms of local transportation must have convenient and easy access to the local vertiport in order to maximize market exposure. It is assumed in the study that all vertiports under consideration would be adequately integrated.

The St. Louis study was a heliport study, but it stressed the importance of multimodal service since the location for development of a proposed heliport is also the site of a proposed multimodal transportation center. It was determined that the proposed heliport would be an integral part of the transportation center and that facilities should be designed to allow easy transfer between modes. Although it is believed that few, if any, helicopter users were expected to transfer to bus or rail modes, it is also thought that incorporating the heliport into a multimodal transportation center is important.

2.3.6.2 Intermodal Significance

The lack of intermodal material in the studies may perhaps be attributed to limited funding for this facet of investigation, coupled with the fact that at the present time, intermodal project funding is as tentative as vertiports. However, it may also be symptomatic of one of the major factors inhibiting public agency interest in the CTR. Civil application of CTR technology will not occur unless the CTR is seen as part of a transportation system. To date, as evidenced in the studies, CTR service has been analyzed as a stand-alone system servicing a particular niche of the travelling public. The focus of transportation planners and of transportation dollars today is on intermodalism, more specifically, the reduction of travel by automobile. The Clean Air Act mandates it, and the Intermodal System Transportation Efficiency Act (ISTEA) begins to fund its implementation.

A CTR system is likely to make more sense economically, operationally, and politically (which may be most important) if it is part of an intermodal network.

> *The multimodal transportation center is viewed as a single facility for all the different transportation modes. This center would allow the efficient use of scarce urban land that would consolidate all auto parking needs and provide for efficient service from local taxis and limos.*

This concept seems to provide a way to reduce environmental concerns, transportation infrastructure costs, and improve efficiency in general by focusing transportation at one geographic site. As such, one location could be a solution for minimizing forces that organize against noise, visual pollution (being able to see helicopters), invasion of privacy, etc. People will be likely to accept at least one location for transportation purposes or the community will cease to function effectively.

2.3.7 Development of Vertiport/Large Heliport Plans

Many types of plans are used by both local, state, and Federal transportation planners and aviation agencies. These include master plans for individual aviation facilities (airports, heliports, or vertiports) master plans for local ground transportation or urban development planning, and system plans for different levels of regional transportation planning where vertical flight facilities will be developed. Each has its own specific purpose and value, and would necessarily connect to planning for vertiports and vertiport systems if they were to be developed in a community. Unfortunately, most studies did not evaluate how their plan would fit into local community plans. None of the studies discussed the interrelationship of the vertiport/heliport plan with other local, state, or national plans beyond the requirements of the individual sponsor and environmental concerns (see section 2.2.2). In other words, the plans of other agencies in the same area as the sponsor were not considered.

2.3.8 Implementation

An important issue is the implementation requirements for AVF passenger transportation systems once they are defined. Implementation requires a systematic approach to deal with the processes or role of each agency, funding, economic viability, and legality. City and county agencies are primarily responsible for zoning, permitting, and administrative procedures to provide the framework for private vertiport development. The role of state and local governments in supporting vertiport development is focused primarily on: adopting policies, land use planning, property acquisition, revising existing regulations and ordinances where necessary, and instituting education programs. The roles defined for state, regional, and local agencies are dependent on other parties, particularly the FAA and private companies. Lack of participation or support by the FAA and/or private companies would jeopardize successful implementation of vertiport development.

Canada, Washington, D.C., Southern California, New York City Airports, and Alaska did not discuss the interconnecting roles and processes of implementation that other national, state, or local agencies may play. Areas of funding and environment were briefly discussed in the San Francisco study. Orlando, Southwest Region, Puerto Rico, Boston, and St. Louis provided high level outlines of some requirements. California and Manhattan provided an extensive review of implementation needs.

2.3.8.1 Approaches to Implementation

Varying approaches to implementation are described in the studies. The extent which implementation is addressed is primarily based on the type of sponsor (i.e., city, region, state) and the type of study (i.e., local heliport or state-wide vertiport system plan). For instance, Orlando, a heliport study, attempts to provide a framework within which local governments and private investors can build heliports. California, on the other hand, has provided a complete list of the agencies involved in developing a vertiport and their responsibilities for implementation. (see table 17).

The Manhattan study provided an extensive list of the agencies and regulations involved in developing a vertiport in Manhattan, including the Federal government, New York City, and New York State. These regulations dealt with zoning and environmental concerns regarding the use of rivers, liability, etc.

The Southwest Region study presented five elements for assessing technical feasibility.

1. Physical - includes the capability of existing site configuration, topography, utilities, and structures to accommodate developmental needs of the vertiport within acceptable cost and environmental parameters.

2. Functional - includes the capability for a vertiport layout and location to accommodate efficiently the functional relationships necessary for facility needs, capacity, access requirements, and functional expansion.

3. Operational - includes the factors necessary to accommodate power lift vehicle (PLV) operations at an airport such as airspace, operational surfaces and clearances, rollway lengths, touchdown pads, and appropriate navigational aids.

4. Economic - considers the capital expenditures necessary to achieve operational and development scenarios. Examines the operating and maintenance costs of developmental scenarios along with a projection of potential revenue generation capability.
   The value of economic impact on a local area in terms of construction and operations also may play into the equation of vertiport feasibility.

5. Environmental - includes an analysis of environmental consequences as set forth in the National Environmental Policy Act (NEPA) and FAA guidance, to include noise and land use compatibility. This part of the analysis is based upon requirements of the project as defined by the four preceding elements.

These five were to be evaluated individually and in relationship to each other. A sixth element, political feasibility, was also considered pivotal to final vertiport development.

TABLE 17 AGENCY RESPONSIBILITY FOR AVF PASSENGER TRANSPORTATION SYSTEM DEVELOPMENT

FAA	
1. Certify the aircraft 2. Analyze noise data for possible revision 3. Update computerized heliport noise model (HNM) to include CTR data 4. Educate and train airport personnel on vertiport development and operations requirements 5. Approve and assist a civil demo program 6. Adopt final standards and guidelines on vertiport design 7. Incorporate vertiports into National Plan of Integrated Airport Systems (NPIAS) and Capital Improvement Plan (CIP) 8. Award AIP grants for site specific vertiport planning and construction	9. Revise ACs to reference CTR/Vertiport Design Guide 10. Develop procedures for conducting airspace analysis for vertiports 11. Develop and adopt CTR IFR approach criteria to vertiports 12. Develop/adopt ATC procedures for CTR ops 13. Amend FARs for CTR 14. Install and operate National Airspace System (NAS) Plan Facilities/ Equipment 15. Establish training and licensing requirements CTR flight crews 16. Revise FAA Form 7480-1, to include vertiports
NASA	
1. Continue R&D of CTR technology 2. Provide information and educate policy makers on value of CTR	3. Act as liaison between FAA, CTR manufacturers, Department of Defense (DOD), and state and regional agencies 4. Support CTR demo
DoD	
1. Complete flight and ground testing of V-22 2. Fund full scale V-22 development and production 3. Conduct environmental tests, particularly noise monitoring of V-22	4. Disseminate V-22 flight test/ops data to FAA/NASA 5. Provide V-22 test aircraft for a civil demo program 6. Obtain operational experience with V-22 by the U.S. Navy and Marines Corps
US CONGRESS	
1. Continue to fund V-22 development and encourage full military deployment 2. Continue support CTR program	3. Provide funds for a CTR demo program 4. Require FAA to provide necessary administrative and infrastructure support
STATE (CALIFORNIA)	
1. Establish policy on statewide vertiport development 2. Incorporate vertiport development into California Aviation System Plan (CASP) 3. Revise priority rating program to include vertiports as part of CASP within mid and long-range planning horizons 4. Revise state regulations to include vertiport permitting and adding CTR-specific definitions	5. Support statewide CTR demo programs 6. Coordinate with Airport Land Use Commission (ALUC) to circulate rules and regulations for CTR operations 7. Revise Airport Land Use Planning Handbook to include CTR terms of reference
REGIONAL & LOCAL	
1. Adopt policy supporting CTR/vertiports 2. Conduct workshops for public officials on benefits of alternate modes of air transportation 3. Actively support CTR demo programs 4. Develop model zoning ordinance to include vertiports	5. Revise Airport Land Use Plans to include CTR/vertiport terms 6. Sponsor vertiport feasibility and site selection studies 7. Sponsor vertiport master plan studies and environmental assessments 8. Undertake property acquisition, vertiport design, and construction
BELL/BOEING	
1. Continue the certification and development of CTR 2. Sponsor and/or support a CTR demo program	3. Finalize CTR configuration, performance and costs, and commit to production
AIRLINES	
1. Define specific data/performance needs to reach CTR purchase decision 2. Participate in CTR demo programs 3. Buy or lease CTRs for scheduled passenger and cargo service starting with high-density markets	4. Integrate CTRs into local/regional systems and hub ops and actively promote CTR as part of regional/national networks

Source: "Civil Tiltrotor Aircraft Feasibility Study for the: California Department of Transportation - Technical Report." Hoyle, Tanner & Associates, Inc. for The California Department of Transportation, June 1991.

2.3.8.2 Funding

Most studies address funding by acknowledging the funds available from FAA AIP and private investors. The California study provides a lengthy description of FAA and state processes. Otherwise, little detail was provided beyond what projects an FAA grant would cover and at what percentage. Very little space or detail was given to this topic.

2.3.8.2.1 Federal Funding

The FAA AIP grants can be used for planning, development, or noise compatibility projects. The AIP was recently revised to include privately owned airports and vertiports that are open to the public. However, the FAA requires that private owners sign the same grant assurances as public agencies, which has decreased the attractiveness of Federal participation for private owners. The Federal share of costs associated with planning and development is based on the service level of the facility, typically, the Federal share is 90 percent.

2.3.8.2.2 State/Local Funding

California provided a description of its state funding possibilities. The aviation element of the California Transportation Commission is similar to the FAA's National Plan of Integrated Airport Systems (NPIAS). Like NPIAS, a project must be an approved facility in the plan. A sponsor for a new airport, or in this case a vertiport, would have to submit a request for inclusion and approval by the commission. The project goes through a prioritization to determine how important the facility and project are to the overall state aviation system. The rating an improvement project receives determines if and when funding will be made available. Unlike the FAA, CALTRANS does not fund privately owned, public-use reliever facilities, which represents a major segment of public-use facilities.

Neither the FAA nor the state provides grant money for terminal buildings for general aviation or reliever facilities. California departs from the Federal government, however, with an innovative program that will loan the airport money for terminals as well as other improvement projects, including hangars, fuel storage, lighting, fencing, and drainage.

Although technically classified as "airports," vertiports will qualify for Federal funding if they fall into one of the FAA's required categories. The vertiport could be considered a supplemental commercial service reliever vertiport, the primary purpose of which would be to offload short haul traffic from the congested hub airport. In terms of funding, supplemental commercial service reliever vertiports would fall into a high priority category based on their dual role.

The schedule of vertiport development will depend heavily on who acts as sponsor of the facility, as well as the financing strategies of the sponsor. Under present legislation, the FAA could pay for 90 percent of the vertiport construction costs, while the sponsor is obligated for providing the remaining 10 percent.

Subsequent to the vertiport becoming operational, the allocation of funds diverges. As a publicly owned commercial service vertiport, the facility would receive not only Federal entitlement from the FAA for the passengers enplaned at the facility, but also discretionary funds for high priority projects. As a privately owned, commercial service vertiport, it would not qualify for entitlement money, thereby reducing its Federal funding opportunities to discretionary allocations only.

If a vertiport were to qualify either as a reliever or other eligible facility in California, the vertiport could receive an annual grant of $5,000 for facility development, operations, or maintenance projects upon sponsor application for the funds. On Federally funded projects, CALTRANS might loan the local entity matching funds, up to 10 percent of the cost of the overall project.

For non-federal capital improvement projects, the California Transportation Element might incorporate the vertiport into the overall improvement program and pay for up to 90 percent of the project cost (not to exceed $500,000). The amount must then be matched by the local sponsor as an expression of commitment towards development of the facility.

Alternative, and somewhat creative methods available to California sponsors for infrastructure development include tax incentives, revenue bonds, special facility bonds, leases, service contracts, and privatization.

In the Orlando study, which discussed only heliports, private funding was emphasized as the primary funding avenue. It stated that, in the ...*Central Florida region being generated by businesses in activity centers, which are privately developed and owned, the vertiports to accommodate demand from those centers should also be privately owned and operated as well.*

The Southwest Region study discussed potential sources of revenue generation from the vertiport itself after it was in operation, including:

- jet fuel sales,
- landing fees,
- rental - overnight parking,
- lease of space for aircraft basing,
- terminal concessions,
- automobile parking fees,
- cab access fees, and
- licensing fees.

Further benefits to the community are presented in section 2.3.3.

3.0 SUMMARY

This section presents a summary of the analysis of the 13 FAA AIP-funded and Canadian vertiport studies.

3.1 EXPECTED OPERATIONS WITHIN THE FIRST 5 YEARS OF OPERATION

A brief summary of the final conclusions of all the studies is presented in table 18. Strictly based on these conclusions, as a function of the demand, the region that shows the most promise for successful vertiport development is the Northeast Corridor. This area spawned the most studies, Manhattan, New York City Airports, Boston, Washington, D.C., and Canada. What gives this area even greater significance is that these studies are unintentionally "nested." In other words, without previous planning, each of the Northeast Corridor studies defined its market area including the other, e.g., Boston shows New York and Washington, D.C. as destinations, Washington shows New York and Boston, etc.

TABLE 18 CONCLUSION OF STUDIES

STUDY	PREPARER	CONCLUSIONS
Manhattan	Consultant	Demand for vertiports has been established.
New York City Airports	Consultant	Construction to support CTRs not recommended at this time.
Boston	Self	Sufficient demand for CTR service.
Washington, D.C.	Self	No vertiport until demand established in other area, specifically New York and Boston.
Orlando	Consultant	Demand for heliport, but should be built by private entities.
Caribbean Basin	Consultant	Strong support.
Illinois	Consultant	Inconclusive on construction.
California	Consultant	Not a strong market for CTR service.
Southern California	Self	CTR service feasible.
Alaska	Consultant	Inconclusive.
Southwest Region	Consultant	"Powered-Lift" service feasible between Dallas, Austin, San Antonio, and Houston. Dallas is the only place where vertiport is being constructed (but not as result of study).
St. Louis	Consultant	An intermodal heliport is to be constructed.
San Francisco	Consultant	No need for vertical flight of any kind in city.
Canada	Consultant	Conducting further study.

Currently, however, the only study location that built a vertiport is Dallas, Texas, the focus of the Southwest Region study. (It is interesting to note that the decision to build that vertiport was made independently of the vertiport study--which may be significant in itself.) It is quite likely that, as with heliports, the interest and support of the local government will be the impetus to vertiport construction rather than statistically defined need imposed on unwilling local governments. Furthermore, it is likely that vertiport systems will be more developed more easily in locations where construction and implementation are least complicated. Places where entire vertiport systems can be implemented under one political structure, such as in states like Texas or California, may be the least difficult to coordinate and therefore more amenable to development. These systems would have the support of one principal sponsor--the state, which would then be able to focus transportation policy to encourage local governments to support the project.

In contrast, the Northeast Corridor has both the biggest demand and the biggest stumbling blocks. Vertiport development is likely to encounter more difficulties there because it would take the coordination and cooperation of several states and perhaps two countries to implement a system. Since there is currently no national level transportation policy to encourage vertiport development, there is no primary sponsor. Presently, the primary national financial support comes from the FAA AIP grants, which provides funds for construction after the decision to build is made but does not act directly as a policy stimulus.

These studies also showed that even though the marketing emphasis for AVF aircraft has been geared toward the relief of airport and urban congestion, underdeveloped areas may have a greater potential as a market for AVF application than some urban areas. In addition, enthusiasm of the sponsor is also an important consideration in potential system development whether urban or underdeveloped. This can be seen in the fact that Dallas built its vertiport independent of the study. In other words, this relates to the local government being the most important factor in heliport development; if an area wants a vertiport, it will build it. It is hoped that the decision of a local or state government is based on adequate demand so that the project is successful. If not, it may prove a poor example to other areas and consequently deter development.

Based on the above considerations, the most likely areas to develop a vertiport system would be Texas for passenger operations and Puerto Rico for cargo operations. Puerto Rico and the Caribbean Basin are very encouraging from an economic development viewpoint. However, development could be stymied by international aviation considerations. If these prove to be economically and systematically successful, the next areas to develop would most likely be California for passenger operations and Alaska for combined passenger/cargo operations. The development of the Northeast Corridor would likely follow successful implementation of a statewide system like Texas or California.

3.2 STUDY LIMITATION

One basic limitation of these studies is that the results are based on a theoretical aircraft. Consequently, there are restrictions to accuracy and realism, a limit that most studies recognized. The California study best summed up the requirements for more authentic data for future needs with the following questions:

- Will the military operate the V-22 Osprey and provide data to NASA & the FAA?
- When will FAA certification and civil production occur?
- What will be the actual purchase and operating costs?

- What will be the configuration and size of the CTR?
- What are the actual performance and noise data?
- Who will fund or sponsor a CTR demonstration program?
- Who will buy and operate the CTR?
- What is the schedule for funding development of the infrastructure?

3.3 SPONSORS ATTITUDES

A survey of the 14 study sponsors was performed to find out if they were satisfied with the results of their area's study and what the possible follow-on would be.

Overall, most considered their individual studies to be very informative and helped them to focus and become more specific on their needs. It was felt that the next step in the process should be a demonstration program. These demonstration programs would be readily accepted in Puerto Rico and Texas. The sponsors from Puerto Rico and the Southwest Region are by far the most active and energetic supporters of the CTR program at this time. Puerto Rico is more focused on the movement of cargo among its 600 manufacturing plants that are dispersed throughout the islands. Texas is interested in testing the movement of passengers in a triangular shaped service area from Dallas to Houston to San Antonio.

California sponsors indicated they would consider working with and funding the University of California at Berkeley to conduct a follow-up study. The study would research the feasibility of having a demonstration model to determine where exactly the CTR would fit, i.e., small package, commercial passenger service, or corporate. Reception to date from the business community has been lukewarm. Presently, the sponsors feel the prime focus is small package transport from major hubs. CTR service between Los Angeles, Orange County and Ontario airports would be very advantageous.

California sponsors believe that many years ago there was great excitement about the potential of the CTR. Since then, numerous feasibility studies have been completed by local and state governments. Now, however, no one is sure the CTR is ever going to happen. They feel no clear cut direction or goals have been provided by the Federal government. It is believed that the FAA needs to take a stronger lead in the process.

San Francisco sponsors, on the other hand, felt that NASA/AMES was very much in favor of establishing a vertiport in San Francisco, as was CALTRANS. They saw the Los Angeles - San Francisco corridor as having the most potential for the CTR. However, both NASA and CALTRANS failed to recognize the problem of lack of community acceptance of vertical flight transportation with which San Francisco had been dealing. More attention should have been given to alleviating these specific problems before proceeding to a higher level of aircraft activity.

Other sponsor comments included those related to the current vertiport design AC (150-5390-3); they felt it is not a workable document because it is based on a theoretical aircraft. More focus is needed on terminal procedures for new technology aircraft. Also, real noise signatures and other associated data needs to be obtained on the CTR. Many of the respondents felt that the available data in this area was weak and insufficient.

Many of the sponsors were unhappy that their studies were not being implemented to any degree. They felt their studies would just "sit on the shelf." Respondents felt that the FAA got everyone excited about the CTR program, funded studies and then they lost interest. Many feel that even with all their effort, the CTR will not be developed. Several have decided that vertiport development is not their responsibility so they will not take the initiative at this time. They want to "wait and see what the federal government is going to do."

Regardless of these issues, some sponsors like the Puerto Rico and the Southwest Region have enough momentum that they could become a catalyst for others. Puerto Rico is also interested in conducting further studies, in conjunction with the states of Washington (study recently begun) and Alaska due to their common interest in non-urban CTR transportation.

The PANYNJ continues to have keen interest in the development of the civil tiltrotor or comparable aircraft. They are determined to relieve air traffic congestion while increasing regional capacity through growth and development in air transport within the region. However, in PANYNJ's Phase II and III studies, they stated that they have no intention of expending funds towards the development of any site or associated facility for either the CTR or any other new technology vehicle until such time there is an aircraft available.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the conclusions and recommendations resulting from the analysis of the 13 AIP-funded and Canadian vertiport studies.

4.1 CONCLUSIONS

The following paragraphs contain the major conclusions drawn from the analysis.

- For the most part, these vertiport feasibility studies are better than the previously completed heliport studies (reference 33). They are more sophisticated in their analysis and more realistic in their appraisal of feasibility. It is apparent that the study sponsors and consultants have a greater awareness of the community setting in which the vertiports would be located considering the realities of both aviation and community requirements.

- The majority of the studies made special mention of the system concept as being the most important operational issue. If a system of vertiports is not developed in a coordinated manner in several major regional markets, the system will probably fail

- Special emphasis was also made in a majority of the studies to state the requirement for all-weather operations. All-weather operations are essential to achieving the schedule reliability needed for a successful passenger transportation system.

- Several of the studies did not try to link the characteristics of the vertiports (i.e. number of gates, takeoff/landing pads) with the market share projections even though flight frequency was considered a key issue. This deficiency could lead to inaccurate results regarding the size of the vertiport needed and therefore skew system projections and requirements.

- The studies performed in lesser developed areas such as Puerto Rico and Alaska show a realistic potential for applications of AVF aircraft in locations in addition to those anticipated in highly urban areas.

- One weak area in all the studies was the investigation into airspace and ATC systems. There was little understanding of how AVF aircraft would fit into the current and future systems. There is a mistaken perception by some that aircraft like the CTR would operate outside current airspace structures. This perception may have reduced the realization of the importance of this element of a system. These issues are among the most complex in initiating CTR service. At a minimum, an examination of the complex network of arrival and departure routes, airspace sectors, controller workload, traffic flow patterns, and advanced navigation and guidance systems must be accomplished to ensure adequate integration into the present route configuration.

- Weaknesses exist in many of the analyses in that only one size of aircraft (CTR-22C) was used in most calculations where frequency and load factor were considered critical. This limits evaluation of balanced future economic application of AVF aircraft. The economic flexibility of AVF aircraft and vertiports would be greater if employed in the same manner as today's airports. In other words different sizes for different applications.

- Locations that can institute a singular policy of vertiport development and AVF applications in a large regional area (such as a state like Texas or California) may develop systems more easily than areas with more apparent demand such as the Northeast Corridor. In the Northeast Corridor multi-jurisdictional conflicts may inhibit AVF system development. These systems are likely to need the backing of a strong national policy to ensure development.

- Among the studies, there was a significant variation in the particular techniques used in determining passenger demand and forecasting methodologies (see section 2.1.6.). This should not be construed to imply that some of the studies were either done inappropriately or were faulty. Rather, it appears that the scopes of the different studies emphasized different concerns and the analysts may have put more resources into other aspects of the overall question of feasibility. This range of methodologies and techniques actually provides an interesting opportunity to consider the relative strengths and weaknesses of the different approaches to passenger demand forecasting.

- For the first time a few of the studies attempted to quantify real benefits to the community of heliports and vertiports. These benefit elements go well beyond previously identified benefits of public service and jobs provided by the owners of rotorcraft. Benefits to the community are more carefully thought out and more comprehensive in these studies.

4.2 RECOMMENDATIONS

Operations geared to scheduled passenger service differ, in some respects, from the missions that rotorcraft currently fly. Thus, there is a need to develop new, and refine existing, planning guidelines to address these differences. Specialized operational requirements and vertiport dimensions need to be established, while certain other design elements need to be enhanced or modified. Vertiports/large heliports can be effectively integrated into both aviation and ground intermodal transportation systems when all the processes of development, from construction to community issues, are understood.

4.2.1 Recommended Planning Guidelines

There can be no question that planning guidelines need to be more specific and standardized. The completion of these studies is a good beginning. They present a variety of elements that need to be addressed in system planning. Taken individually they are, however, incomplete. Incomplete because not all of the good ideas and carefully developed elements were found in every study. This deficiency indicated that few study areas understood the *entire* system within which AVF aircraft will operate. These system requirements are identified in table 19. For most effective planning, these system elements need to be integrated into a standard set of planning requirements.

TABLE 19 INCLUSIVE VERTIPORT SYSTEM

AVIATION	COMMUNITY	OPERATIONAL/PLANNING
AIRSIDE vertiport design operational area AIRSIDE PROCEDURES ATC CTR transition aircraft approach/departure TERPs terminal routes SIDs STARs AIRSPACE en route (class E) terminal (class B/C) vertiport (class D) INFRASTRUCTURE communication navigation surveillance weather controller workstations GROUNDSIDE physical requirements amenities services mission critical aircraft lighting marking	LAND USE compatibility applicability existing transportation ENVIRONMENT noise air quality water quality PUBLIC NEED social benefits economic benefits PUBLIC ACCEPTANCE political factors intermodal connections multi-use advantages	OPERATION COSTS aircraft amenities FORECASTS/DEMAND passengers cargo PLANNING TOOLS DATABASES record use operations SAFETY emergency record FUNDING STRATEGY local state regional Federal private partnerships IMPLEMENTATION government policy procurement STANDARDIZATION methodologies PRIORITIZATION

In evaluating the planning techniques and guidelines there are some areas that need specific attention. These areas are discussed in the following paragraphs.

- Benefits to the Community. It is recommended that the good start these studies provided on benefits to the community be more thoroughly examined and expanded. This is an element that has been discussed for years within the industry but not clearly defined. Examples are: jobs for construction of the facility as well as for employment after it is completed; jobs to build the required aircraft; the multiplier effect of goods and services for those employed, and; additional economic benefits to the community from sources such as real estate, fuel, and occupancy taxes, fees for water and sewer, fire protection, and lease payments for land and hangars. This beginning needs refinement and framework of methodologies for future planning efforts.

- Planning Database. There is still a need for a database that provides useful information for future planning assessments. Perhaps data elements can be defined and initiated with the Dallas Vertiport in order to keep a record of activity from the beginning.

- Vertiport Funding. A further help to potential vertiport developers would be to outline credible funding sources on a national level as clearly detailed as that in the California study (see section 2.3.8.2). This would provide additional public alternatives to raising capital for vertiport implementation besides the operating budget of local government and AIP funds. This outline would also provide an opportunity to seek private funds in a partnership arrangement.

- Planning Coordination. More exact ways of identifying and applying other planning documents significant to the vertiport project within each community needs to be specified. Planners need to make better connections with other planning agencies and documents. Not only would this involve more planners and government agencies but may therefore be an excellent platform from which to educate other government and planning agencies regarding the applications of AVF aircraft, and, may provide a broader base of support.

- Implementation. A generic detailed system study of what is really required to implement a small prototype system would be a valuable tool for presenting necessary planning elements. It could use a real area that is amenable to system development to portray the plan dynamics. An example can be the Southwest Region which has shown inclination towards system development. The plan should define the system including an operations analysis of the route aspects of a hypothetical system to define schedules, resources required by FAA to control the airways, computer resources, radar or GPS, ATC, etc. Such a plan would be the best way to identify the definitive planning requirements for feasibility studies.

- Community Needs. Improvements in these studies can be seen in the increased involvement with the passenger and the increased understanding of community needs. It is also evident by expanded application of surveys (see appendix B). Surveys allow the study sponsor to evaluate what the end user of the systems expects and would tolerate in a transportation system. Here again, however, the goal and expected results and evaluation methodologies need to be standardized.

- Demand and Forecasting. The lack of standardized formulas for determining demand and forecasting continues to be a limiting factor because it reduces or impedes accuracy of results and comparability among studies. Although, as discussed, since methodologies are still at the beginning stages these studies can be used as an opportunity to present alternatives from which a standard can be more easily produced.

- New Technology Tools. Rapidly advancing technology makes possible the use of personal computers to aid in heliport/vertiport planning. Specifically, technologies such as geographic information system (GIS), multi-media sound and graphics presentation, and virtual reality, to name a few, should be investigated for application to heliport/vertiport planning and communications. In particular, these tools could be used to simulate operations at a proposed heliport/vertiport site and demonstrate, to the public, how these operations would affect their communities.

4.2.2 Future Planning

The sophistication of the 14 vertiport studies can be seen in the overall theories, approaches, and methodologies applied. The more discerning quality of these efforts is considered to be a significant improvement over the previously completed heliport studies. The heliport studies of the 1980s, due to the newness of the field and lack of experience of those who performed them, focused more on aviation aspects than on the interface between aviation and community that is required with a passenger vehicle operating in urban areas. When the first heliport system plans were being developed, helicopters were being introduced into urban environments. However, the concept of formally integrating helicopters into the overall transportation system was very new. Perhaps the improved understanding demonstrated in these studies is due to increased experience in rotorcraft planning or because these efforts are more focused on a specific use of rotorcraft--the application of AVF aircraft for large-scale passenger transportation, or both.

The increased similarities in structure and methodology among studies attests to this improved understanding and application, particularly since minimal structure and oversight was exercised by the FAA in the completion of these projects. However, there is still a need to broaden understanding of the complex elements of the aviation system and of community planning. Both aviation and community planning issues can be used to improve system concepts and to create standardized methodologies. This will produce more comparable results that allows prioritization of infrastructure development. To summarize, future planning efforts need to strive for open and direct communications among all parties, the aviation interests and the various community interests.

LIST OF ACRONYMS

AC	Advisory Circular
AHS	American Helicopter Society
AIP	Airport Improvement Program
ALUC	Airport Land Use Commissions
ARFF	Airport Rescue & Firefighting
ATC	Air Traffic Control
AVF	Advanced Vertical Flight
BWI	Identifier for Baltimore-Washington International Airport
CAB	Civil Aeronautics Board
CALTRANS	California Department of Transportation
CASP	California Aviation System Plan
CBD	Central Business District
CFR	Code of Federal Regulations
CIP	Capital Improvement Plan
CNS	Communication, Navigation, and Surveillance
COG	Council of Governments
CTR	Civil Tiltrotor
dB	Decibels
DC	District of Columbia
DCA	Identifier for Washington National Airport, Washington, D.C.
DOD	Department of Defense
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMS	Emergency Medical Service
EPNdB	Effective Perceived Noise Decibels
EWR	Identifier for Newark International Airport in New Jersey
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FBO	Fixed Base Operator
GIS	Geographic Information System
GPS	Global Positioning System
HAI	Helicopter Association International
HNM	Heliport Noise Model
HSR	High Speed Rail
IAD	Identifier for Dulles International Airport
IFR	Instrument Flight Rules
ILS	Instrument Landing System
ISTEA	Intermodal System Transportation Efficiency Act
JFK	Identifier for John F. Kennedy International Airport in New York
LGA	Identifier for LaGuardia International Airport in New York
MAPC	Metropolitan Area Planning Council (Boston)
MCO	Identifier for Orlando International Airport
MLS	Microwave Landing System

MTOW	Mission Takeoff Weight
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
nm	Nautical Miles
NPIAS	National Plan of Integrated Airport Systems
NPRM	Notice of Proposed Rule Making
O&D	Origin and Destination
OEI	One Engine Inoperative
ORD	Identifier for O'Hare International Airport, Chicago, Illinois
PANYNJ	Port Authority of New York and New Jersey
PLV	Power Lift Vehicle
QC	Quick Change mode (used in Puerto Rico study's CTR cargo)
R&D	Research and Development
SAR	Search and Rescue
SCAG	Southern California Association of Governments
SJU	Identifier for Luis Munoz Marin International Airport, San Juan, Puerto Rico
SMSA	Standard Metropolitan Statistical Areas
STOL	Short Takeoff and Landing
TERPS	Terminal Instrument Procedures
V-22	A Military Tiltrotor
VFR	Visual Flight Rules
XV-15	An Experimental Tiltrotor

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APPENDIX A
STATISTICAL SOURCES USED BY THE 14 STUDIES

NOTE: This data is not meant to be a bibliography; it is used to present the types of data sources used by the 14 studies. Format of the entries is that found in the studies. ( ) = number of times listed.

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APPENDIX B
NUMBER AND TYPES OF SURVEYS USED BY THE 14 STUDIES

WASHINGTON, D.C.: The Washington, D.C. study conducted two surveys. In the first, managers of all of the major airports in the area (DCA, IAD, BWI) which are the primary helicopter landing facilities, were contacted. This survey attempted to identify the estimated number of helicopter operations there during a given period of time.

The second survey contacted local helicopter operators to verify their name, address, telephone number, the services they provide and the number of aircraft in their fleet.

To better define ticket price sensitivities for the vertiport portion, the Washington, D.C. study referred to the conjoint analysis survey that was conducted by the University of Texas for the Southwest study.

CALIFORNIA: Two mail-out surveys were conducted. One survey was sent to public travel agencies and the other went to corporations and businesses.

These surveys were performed to:

- validate the assumptions used in the study,
- identify issues that were not originally addressed in the market analysis,
- identify passengers modal choice and travel characteristics and air travel preferences including price sensitivity

The surveys identified additional factors that may be unique to the California market.

MANHATTAN: To avoid duplication of efforts, the Manhattan study used those results obtained from the 1985 Airport Access Survey in the Rand study.

SAN FRANCISCO: Three surveys were conducted for the San Francisco study. Two were mail-outs and one was conducted by telephone.

The first mail survey went to businesses and industries. This survey was designed to measure the demand for, and potential use of, a public use vertiport in the city.

Helicopter operators received the second mail survey which asked questions relating to:

- number and type of based aircraft
- type of missions flown
- services provided
- origin and destination

The telephone survey was conducted to gather information about military operations in the San Francisco Bay area. In addition to confirming the unit's location, the survey asked for:

- number and type of based aircraft
- type of missions flown
- routes normally flown
- altitudes
- destinations
- their opinion regarding vertiports in the city

ALASKA: None.

SOUTHWEST: Two surveys were conducted for this study. The data for both surveys were collected by means of central location telephone interviews using a computer assisted approach.

The first survey was designed to quantify the size of the overall market for air travel and obtain demographic and psychographic data.

In the second survey, which was conducted using the same methodology, participants identified as frequent travelers were again contacted. This survey was designed to obtain a specific profile on regular air travelers particularly for travel in Texas, Louisiana, Arkansas, Oklahoma, and New Mexico. All questions related to business automobile travel was included in this survey.

ILLINOIS: None.

CANADA: None.

CALIFORNIA: One mail survey was conducted for the California study. This survey was administered by a consultant and contained a small questionnaire aimed at gauging the target group's attitude toward the use of the CTR. The survey documented:

- travel market preference
- frequency of travel
- fare sensitivity

The results were then used to refine Southern California's estimate of the pool potential of CTR passengers.

Because of a poor response to the initial mailing, a follow-up mailing was conducted. However, this also had a low response. A third survey was then conducted and additional zip codes were added.

Out of a total of 9,941 surveys mailed, only 548 were returned, an approximately 6% response.

Although the relatively low return eliminated the opportunity to allow fine analyses, the sample was large enough to produce valid regional and sub-regional results.

BOSTON: None.

NEW YORK AIRPORTS: The New York Airports study conducted four "passenger focus groups." These interview sessions were designed to help the administrators of the study to better understand how the traveling public values point-to-point travel time savings, and therefore, the potential benefits of the CTR.

Those selected for interview traveled on business more than two times per month for the previous 12 months to cities within 500 miles of NYC.

Two of the four group travelers typically flew the shuttle between NYC and Boston, or Washington, D.C. The other two groups of travelers flew to smaller cities that are serviced by commuter aircraft from the three major NYC area airports.

All of the groups were comprised primarily of mid-level executives or managers who were employed by large firms or institutions. Each participant was paid $75 for a two-hour session. Two sessions were conducted during lunch with the other two occurring after the work day.

All of the interviews were conducted in NYC and all of the participants lived in the NYC area.

CARIBBEAN: Although the Caribbean study stated that their data was gleaned from many different sources, including surveys and questionnaires, no specifics were provided.

Interviews were limited to air traffic and airport officials. Separate questionnaires and surveys were distributed to airport and aircraft operators. A blank copy of these two questionnaires were included in the study.

ORLANDO: One survey was completed for the Orlando, Florida study. These questionnaires were sent to helicopter operators and asked the following questions:

- Where are their aircraft based
- How many
- Type
- Primary mission(s)
- Destinations
- Average length of mission
- Flight altitude
- Percentage of total flight time at night
- Percentage of total flight time IFR
- Opinions on public heliports