

The Vertiport as an Urban Design Problem

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ABSTRACT

This paper explores the urban design problem that the Vertiport poses for integration into the urban fabric and transportation systems. It discusses the complex challenges of site selection, intermodalism, and community acceptance. The paper presents a generic design prototype of a Vertiport for urban harbors as a solution for the land use, site selection, and community acceptance issues.

INTRODUCTION

The Civil Tiltrotor Development Advisory Committee (CTRDAC) Report to Congress (December, 1995) marks a watershed in the development of civil tilt rotor aircraft and the vertiports to support them. For the first time, it lays out a systematic and realistic appraisal of the business, design and organization challenge to develop a viable Civil Tilt Rotor system and infrastructure. The technology to design, manufacture, and fly the Civil Tilt Rotor appears to be fairly well in hand, embodied in the Boeing CTR2000 design for an aircraft that can carry up to 40 passengers on routes up to 600 miles. FIGURE 1 shows an illustration of a generic Civil Tilt Rotor and its distinctive modes of operation.

The principal market for the generic Vertiport would develop in the heavily populated "megapolitan" belts of settlement such as Milwaukee-Chicago-

Detroit-Cleveland or along the "eastern corridor" of Washington DC-Philadelphia-New York-Boston. The west coast offers a potential market of San Diego-Los Angeles-San Francisco-Sacramento. Although each city and route have some unique characteristics, a tiltrotor interurban service would develop certain common features for support.

Alfred J. Grazer of the Port Authority of New York and New Jersey estimated the magnitude of the potential demand to relieve congestion at major airports:

"It is significant to note that at the three Port Authority Airports, 45% of the departures deliver 20% of the passengers to destinations or first stops within 300 nautical miles, a distance well within the maximum effective range of a fully loaded V-22 Osprey. Displacing even a small fraction of the short haul traffic from runways to Port Authority operated vertiports could dramatically reduce delays at our capacity constrained airports." (Grazer, 1995)

The advent of the tiltrotor aircraft in particular for civil aviation will place new demands on the nation's support infrastructure. However, unlike the innovations in aviation that created the demand for vast airfields at considerable distances from the city center, the tiltrotor will have minimal impact on existing jetports. Instead, its greatest

impact will occur near the downtown areas of major cities.

VERTIPOINT SITE CRITICALITY

Indeed, the success of the tiltrotor as a commercial vehicle will depend largely upon its ability to fly new routes from city center to city center between major metropolitan areas. CTRDAC (1995, p. 85) equates the risk and uncertainty of obtaining appropriate vertipoint sites to the other key risks such as CTR aircraft R&D exceeding current time and cost estimates, CTR acquisition, operation, and maintenance costs exceeding current estimates, and unpredicted changes in airline price structure. CTRDAC goes so far as to state that

"Failure to obtain satisfactory demand-center locations for vertipoints for environmental or other reasons would compromise the commercial success of CTR services."

This downtown to downtown link will save the business traveler the time consuming and often stressful trip from the central business district to the airport and upon arrival at the destination, from the airport to the central business district. Because the tiltrotor can fly 350 knots, it can make the trip from say, Cleveland to Detroit in the same time or less than a jet that may fly 600 knots maximum air speed. The jet must spend considerably more time taxiing, waiting to take off, climbing to altitude and to its route, and maneuvering for position to land. By eliminating the shlep to and from major airports, and the attendant delays, the city center Vertipoint promises substantial improvements for air travelers on these routes.

INTERMODALISM

The CTRDAC report places an emphasis upon the value of intermodalism in the passenger transportation system. Intermodalism is most visible in containerized freight systems, in which a Lift On/Lift Off container ship docks in a harbor with direct crane loading access to both a railroad spur and a tractor truck staging area. At this intermodal point, it becomes possible to transfer freight between any of the three vehicles. Intermodalism in passenger transportation should work essentially in the same manner; that when a passenger reaches the intermodal terminal, it is possible to transfer with minimum effort to another means of transportation. From the Civil Tilt Rotor, passengers may transfer intermodally to automobiles, buses, rail, subway, ferry or to a jet aircraft. These synergies intermodal synergies are important for ensuring passenger options to continue on their route and to find successful connecting service.

VERTIPOINT AREA

The estimated area required for a Vertipoint increases substantially over the older paradigm of a heliport. This increase in required area corresponds directly to the increase in capability, both in terms of payload and range that the tiltrotor offers over the helicopter. FIGURE 2 illustrates the envelope of performance capabilities to show the comparative advantage of the short take-off to a vertical takeoff for the V-22 Osprey predecessor to the Civil Tiltrotor.

TABLE 1. Areas of a Large Public-Use Vertiport

AREA	No.	Size in ft	Area in sq ft	Total in sq ft
TLOF*	1	150 x 400	60,000	60,000
FATO*	1	300 x 550	165,000	165,000
Approach	2	(300 x 350) +	117,250	234,500
Gate Positons	8	150 x 180	27,000	216,000
Taxiway	1	1380 x 70	96,600	96,600
Terminal, Parking, Arrival / Departure	1	1500 x 400	600,000	600,000
TOTAL in sq ft				1,312,100
TOTAL in acres				29.8

*FATO includes TLOF within it.

Under the heliport approach, the touchdown and lift-off (TLOF) area required for a tilt-rotor fell within the range of a 100 to 150 foot square of paving (total of 10,000 to 22,500 sq ft). However, Peisen and Ferguson (1996) argue that this "postage stamp" size TLOF is far from adequate because of the great advantage that a short take off roll gives the tiltrotor. Peisen and Ferguson advocate instead the 150 ft X 400 ft TLOF (60,000 sq. ft.) baselined in the CTRDAC report (p. D-16). In addition to the actual paved area are additional operational zones and noise contours that require consideration. FIGURE 3 illustrates these operational

zones around a Vertiport. The flight approach and take off (FATO) zone requires a buffer around the TLOF of 300 ft X 550 ft, with approximately three times greater area of 165,000 sq ft. The Vertiport requires trapezoidal approach zones of 350 ft x 300 ft at each end of the FATO, adding another 231,000 sq ft of clear area. Parallel to the FATO and TLOF, the Vertiport must provide two or more gate positions, with each gate position approximately on the order of the heliport "postage stamp."

Scaling directly from the CTRDAC diagram (p. D-16), these gate positions appear to measure 150 ft X 180 ft. TABLE 1 offers a summation of areas necessary for the "Large Public-Use Vertiport." TABLE 2 gives the summation for a "Small Public-Use Vertiport." A quick comparison shows that the aircraft flight zones account for most of the land area in the case of the "Small Vertiport", but for the "Large Vertiport," the Taxiway, Gate Positions, Terminal, and Arrival / Departure areas play a greater role. Note that these findings indicate substantially larger land areas than the nominal 10 or 20 acre that CTRDAC baselined.

LAND USE & LAND COST

The major urban planning limitation to implementing a city center Vertiport system is the availability of open land with an appropriate land-use designation and the safety clearances around it. In many city cores, the price of land is the highest in that metropolitan area, with the density of buildings correspondingly high to make the best use of the real estate. Therefore, it is unlikely to find existing land to build Vertiports on the most optimal sites. CTRDAC (1995, p. 49) estimated the cost of a "CTR Generic Vertiport" for a city center

application of "elevated vertiport" design on 10 acres in the range of 10 to 40 million dollars. This estimate may prove quite optimistic, because the land alone in a central business district such as New York, Washington or San Francisco could easily come to 10 to 40 million per acre, without the cost of new construction.

TABLE 2. Areas of a Small Public-Use Vertiport

AREA	No	Size in ft	Area in sq ft	Total in sq ft
TLOF*	1	150 x 400	60,000	60,000
FATO*	1	300 x 550	165,000	165,000
Approach	2	(300 x 350) +	117,250	234,500
Gate Positons	2	150 x 180	27,000	54,000
Taxiway	1	400 x 70	28,000	28,000
Terminal, Parking, Arrival / Departure	1	300 x 400	120,000	120,000
TOTAL in sq ft				601,500
TOTAL in acres				13.7

*FATO includes TLOF within it.

According to the coments from the Metropolitan Washington Airports Authority (Wilding, 1995, October 23), the cost of land alone is not the only obstacle:

"Developing even a ten acre site anywhere near the Mall, business

center or the Capitol is very unlikely. By definition, the P-56 Restricted Airspace would prohibit development in this area. Even without the security concerns, the ability to carve out a ten acre site in one of the Nation's most highly visible and regulated land-use areas is problematic. When the extent of the noise impacted area (±120 acres) is considered, the prospects of a truly 'downtown' vertiport seems improbable."

The Metropolitan Washington Airports Authority comments go on to state that in the entire DC metropolitan area, there appear to be only two suburban sites with existing zoning that is appropriate for a vertiport, Tysons Corner, VA and Shady Grove MD.

"Of the two, suburban sites, only officials from Montgomery County (Shady Grove) have expressed an interest in such a development. Unfortunately, the Shady Grove site is the most distant from the demand centers and has the weakest market potential."

The situation appears similar in many other densely populated major cities. The combined factors of land cost, land-use planning, zoning, local political support and local community acceptance militate against converting existing built-up areas to Vertiport use.

NOISE AND COMMUNITY ACCEPTANCE

The CTRDAC report places great emphasis upon the importance of Community Acceptance of Vertiports and the Tiltrotor flight operations for which they exist. The CTRDAC report presents predicted noise contour data

that may prove to hold great importance to the future of Vertiports and tiltrotors. Please refer to FIGURE 4 for a diagram that illustrates the noise contour data for 65, 70 and 75 dB sound pressure levels. The significance of this FIGURE 4 is that it suggests a minimum sideline noise separation of about 500 ft to protect neighbors against exposure to unacceptably high noise levels. Peisen and Ferguson (1996, p. 6) offer an explanation for the challenge of achieving community acceptance:

As the issues evolve, community groups are becoming more concerned about: safety, toxic drainage from fuel and other chemicals, emissions, light pollution, invasion of privacy, and simply the nuisance factor. ***However, the primary reason people do not want a vertiport in their community is still noise [emphasis added].***

Vertiport planners must anticipate that community members will ask very much the same questions they themselves would ask about noise, congestion, traffic, density, security, and safety if someone proposed to build such a facility next to their back yard. Nonetheless, the author agrees with Peisen & Ferguson's statement that noise is the most crucial issue.

Having observed the Supersonic Transport (SST) community hearings in New York at Columbia University in 1971, the subjective, multi-faceted nature of noise perception and noise data impresses its importance upon any discussion of community acceptance. At the SST hearings, the aeronautical and acoustical engineers presented mountains of viewgraphs with encyclopedias of data about predicted

noise levels from different portions of the flight regime compared to other commercial jet aircraft.

However, despite all their preparation, they were unable to answer simple questions from residents such as: "Will there be more noise or less?" Also, the formulation and presentation of the data was crucial to whether the lay community members believed it and were willing to trust it. The SST engineers presented data in formats very much like the average annualized noise contours in the CTRDAC report. However, the engineers were hopeless at explaining that these contours did not necessarily mean, for example, that out of 50 flights per day, there might be five aircraft per day flying close over the neighbor's homes. Because that data was hidden within abstractions such as annualized averages, the residents soon came to distrust everything the SST planners presented from the data.

For the Civil Tilt Rotor and Vertiports to succeed, it is essential that vertiport planners present realistic, understandable and trustworthy data to community members before presenting abstract analytical formulations of questionable merit. For example, a daily flight frequency contour diagram such as appears in FIGURE 5 may prove more useful and meaningful to many citizens than a statistical decibel diagram because they can relate it directly to their own experience. It is not enough for information to the community to be technically accurate; it must also be accessible and make sense of the community members will not trust it. Ultimately however, for vertiports to succeed, the architects and urban planners must find ways to separate them from the neighborhoods that tilt rotor noise might affect. The

only certain way to make this separation is physical distance. This physical distance is rarely if ever available in existing high density urban areas.

HARBOR SITES

However, there is another way to approach the Vertiport development dilemma. Fortunately, most of the United State's great cities stand beside major harbors or other bodies of water. Their founders built them there to take advantage water transport. Although passenger and freight transport by boat diminished considerably in the 20th century, the proximity to an open area of water offers advantages for a Vertiport. CTRDAC (1995, p. 49) estimated the cost of a Vertiport on a "new pier" at 90 to 125 million dollars, which is probably a fairly realistic cost.

Building the Vertiport over water imposes certain constraints such as requiring approval from the Army Corps of Engineers, federal, state and local environmental protection and wildlife agencies, and local port authorities. However, such a site offers a degree of freedom from the contextual constraints that abound in the urban fabric. It allows the opportunity to design a facility specifically adapted to support the tiltrotor and other v/stol aircraft.

DRILLING RIG TECHNOLOGY

This paper proposes the technical innovation of adapting oil drilling platform technology to support an "off-shore" Vertiport. The advantages of the drilling platform paradigm are technical, economic, and environmental. Fabricating the platforms in modular units in a shipyard offers the technical advantages of better quality control, easier customization, and speed of

production compared to traditional poured concrete caissons and piers. The drilling rig structural technology is quite mature, and performs well in harsher environments than most city harbors. The economic advantages are lower cost, much less construction time on site per unit of flight deck area, and potentially significant economies of scale, particularly if one shipyard can produce modules for several Vertiports. A modular unit for Vertiport construction appears in FIGURE 6. It consists of a top deck for aviation operations, two parking decks below, and robust column and beam structures.

This modular design makes possible a "go as you pay" approach to construction. It may be possible to begin flight operations with as little as one third of the total Vertiport area installed, thus beginning an economic payback much sooner than if traditional construction techniques. The environmental advantage is that it involves lesser environmental impact as it requires little or no fill in the river, thus infringing much less upon the aquatic habitat than a traditional coffer dam, retaining wall and soil fill system. In combination, these advantages make a strong case for this architectural design approach to the new generation of Vertiports.

VERTIPORT ARCHITECTURE

This modular vertiport for urban harbors would incorporate several architectural features specific to its special characteristics. These features add to the difference between the Modular vertiport and the typical heliport where the passenger amenities are minimal to nonexistent and the helicopters often must fly elsewhere for fueling or servicing. The Modular Vertiport offers

“full service, one-stop shopping” for both passengers and flight crews. These services include a passenger terminal with sheltered boarding canopy, maintenance facilities, and an aviation fuel pit for refueling the aircraft. Each of these facilities would stand on a portion of modular platform.

In addition to these amenities, the vertiport responds to the demands of urban transportation to and from the passenger terminal. It would be friendly to all accessible forms of urban transport, (although it is unlikely stand close to subway or elevated train lines). Passengers who drive may park in a substantial parking garage on one or more levels beneath the flight deck. Passengers will arrive at the vertiport and depart from it in a covered area formed by customized platform modules, thus minimizing the demand for vehicular traffic areas on existing land. The structural bays of the modular platforms will coordinate with the dimensions and proportions for the parking garage area below.

Thus, the Modular Vertiport begins from the recognition that to succeed it must act as an integral part of the urban fabric, in the manner of Grand Central Terminal in New York and other great urban transportation complexes. One way the plan form of the modular vertiport addresses the relationship to the urban fabric is to place the landing target at least 600 feet from the closest approach to existing urban development. This separation arises from the arrangement of at least four modules 150 feet deep between the landing zone center and the proximal edge of the vertiport complex.

CONCLUSION

The planning, design and construction of Vertiports will comprise one of the great challenges of urban infrastructure development in the 21st Century. It combines the leading edge of both aviation technology and participatory design process. It will be vital to develop accurate facility programming and efficient plan design for every part of the vertiport complex. With careful planning and advocacy and sensitivity to community concerns, the Urban Vertiport can emerge as a new building type on the American landscape.

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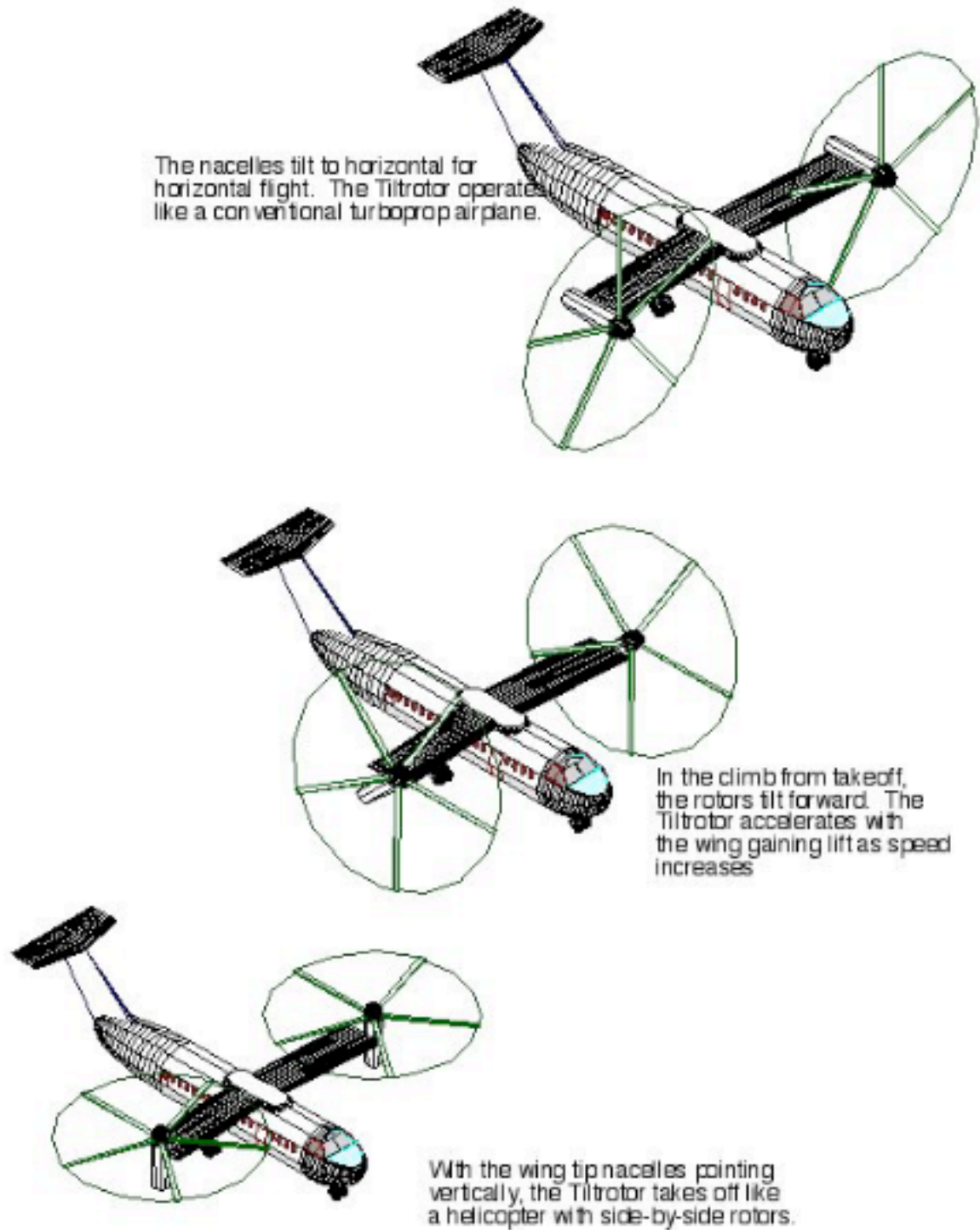


FIGURE 1. Generic Civil Tiltrotor, showing its distinctive modes of flight.

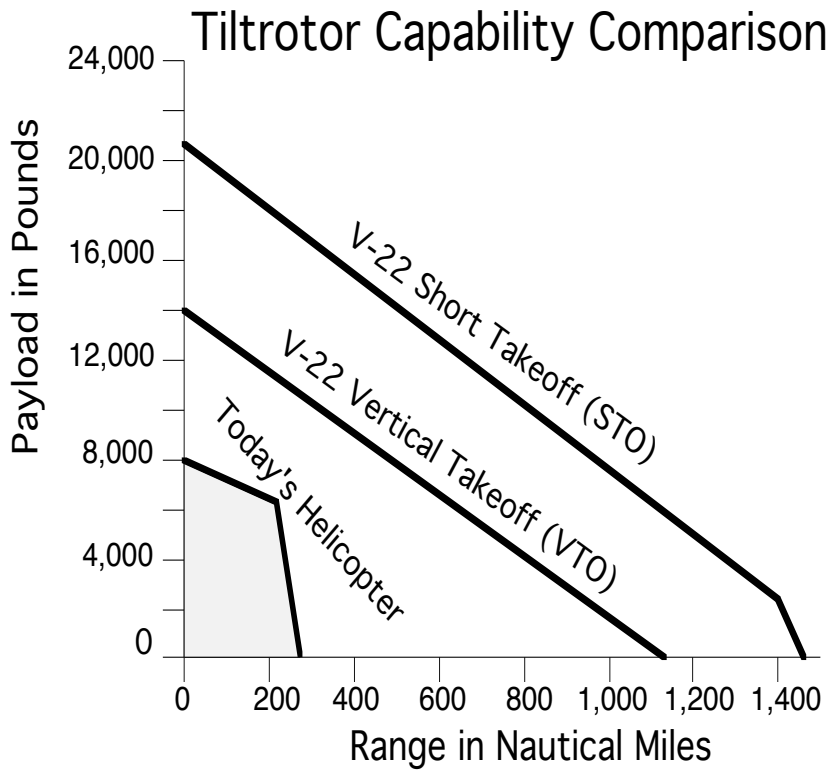


FIGURE 2. Comparison of capabilities for Tiltrotor short (rolling) takeoff, Tiltrotor vertical takeoff, and conventional helicopter (Courtesy of Boeing Helicopter Division, www.boeing.com).

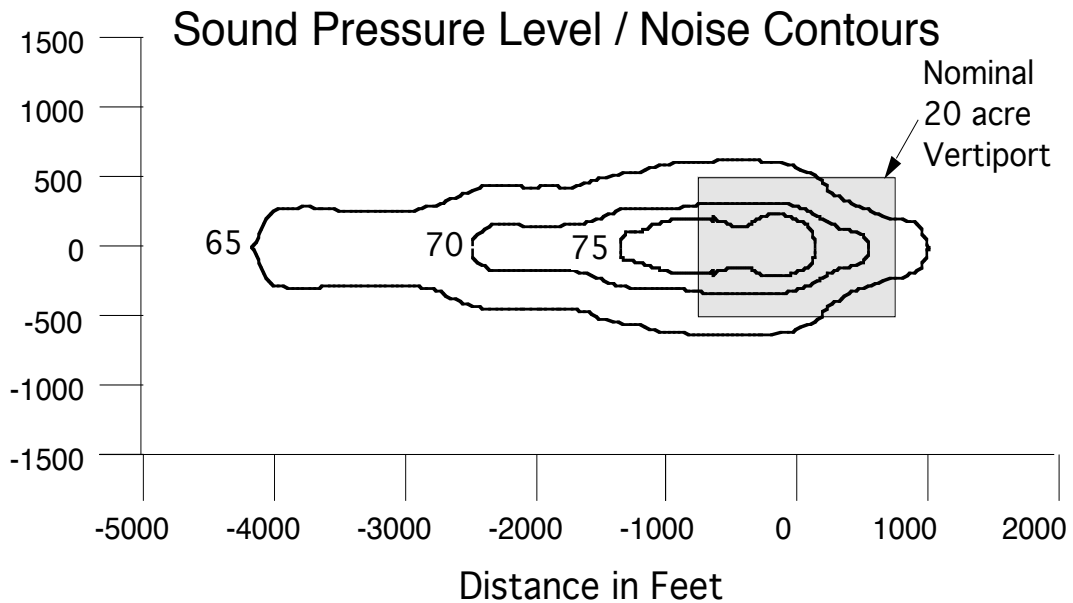


FIGURE 4. Example Noise data in dB, derived from CTR Aircraft Predicted Noise Contours. Based upon 9° approaches, 50 daytime approaches and 50 daytime departures, 5 rotor blades with 740 foot per second tips speed.

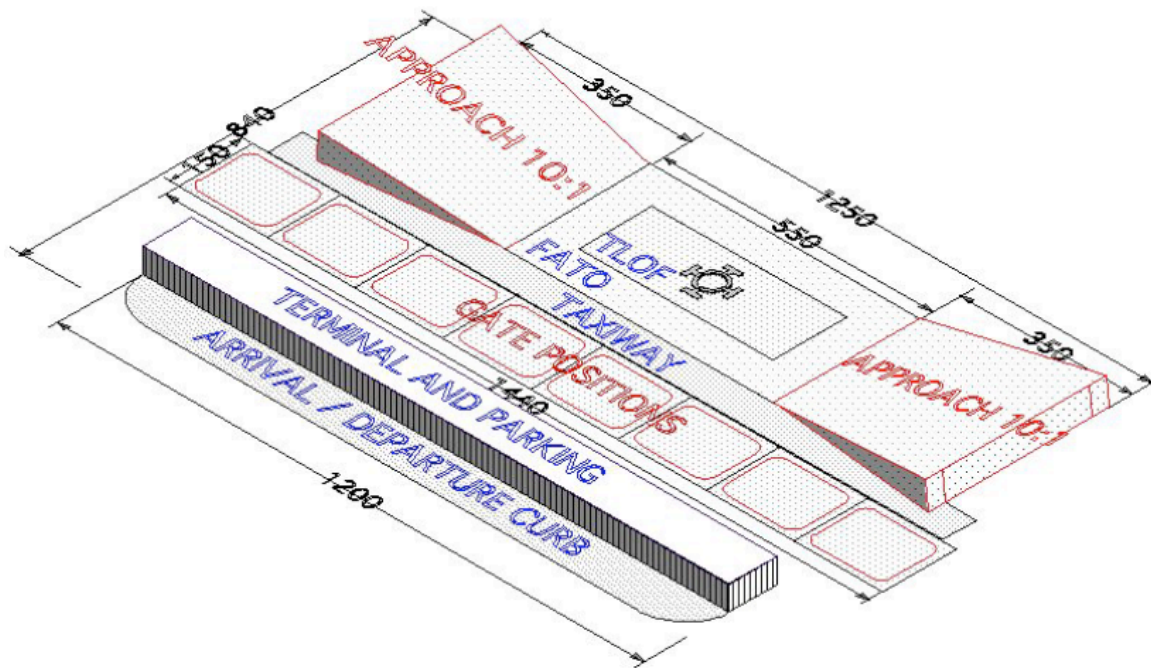


FIGURE 3. Basic Geometry of CTRDAC recommendations for a "Large Public-Use Vertiport," dimensions in feet.

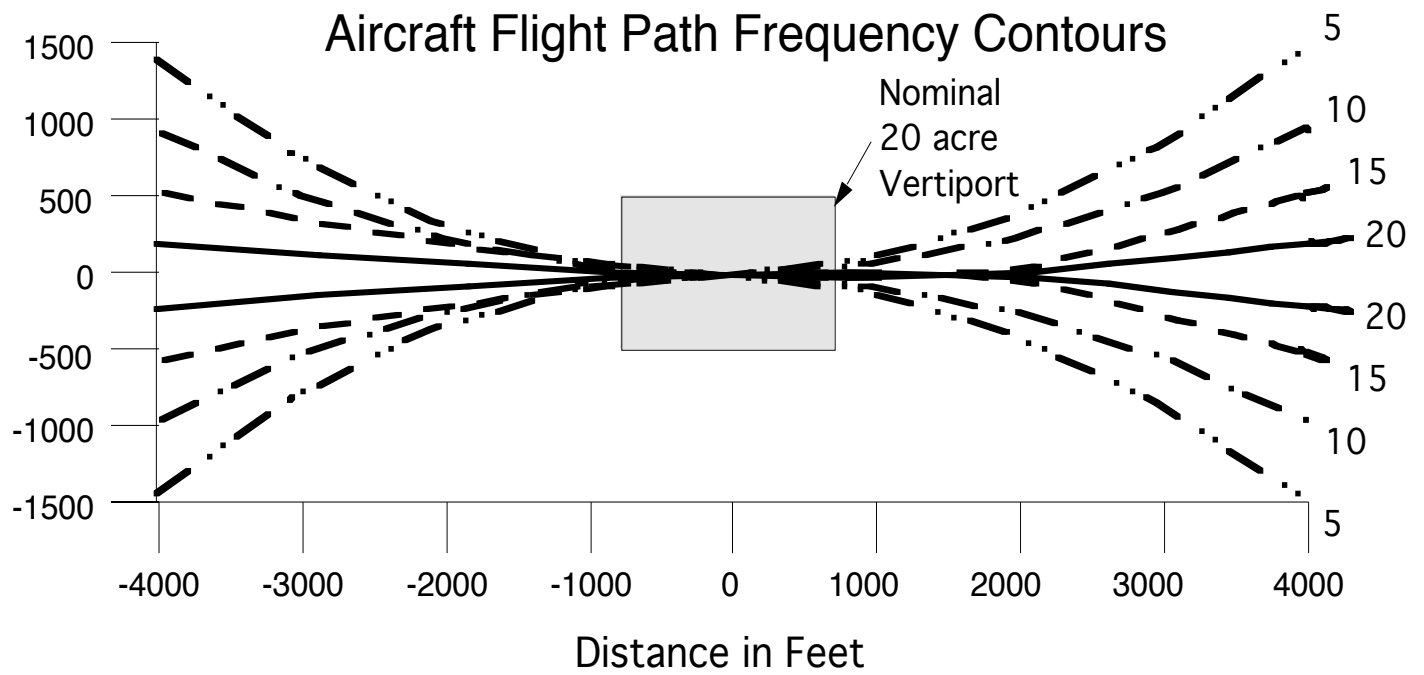


FIGURE 5. Proposed generic diagram of Aircraft Flight Path Frequency Contours as a way to express information of concern to the community about Tiltrotor operations.

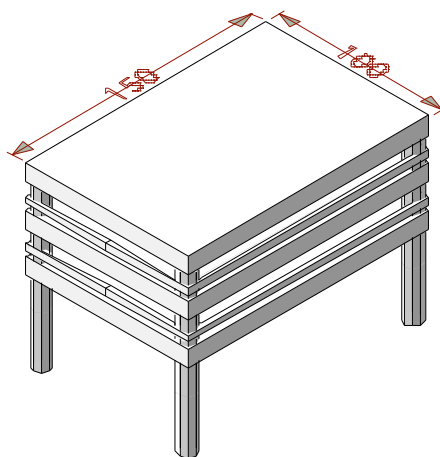


FIGURE 6. Detail of a Vertiport modular unit for construction over an urban harbor. Dimensions in Feet.

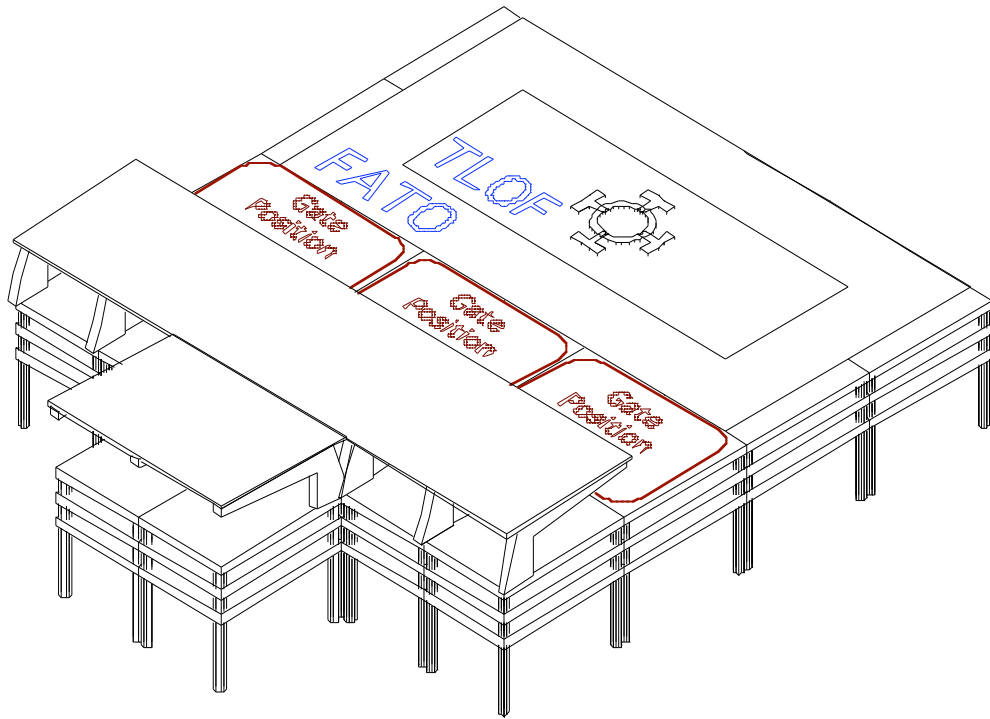


FIGURE 7. Modular Vertiport for an urban harbor with 3 gate positions, passenger terminal, and two levels of parking. It connects to the approach road via the extension to the left. The strip of deck at each end of the FATO provides space for service and emergency vehicle parking and aviation fuel pits for refueling aircraft.