DRAFT

Federal Aviation Administration

Memorandum

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To: All Airports Regional Division Managers

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Prepared by:

Subject: Engineering Brief No. 105, Vertiport Design

This Engineering Brief provides interim guidance to airport owner operators and their support staff for the design of vertiports for vertical takeoff and landing (VTOL) operations. Note that this interim guidance will be subject to updates as data, analysis, and VTOL aircraft and operations develop in the future.

Attachment

FAA
Airports

ENGINEERING BRIEF NO. #105

Vertiport Design

I Purpose.

This Engineering Brief (EB) specifies design guidance for vertiports and vertistops, including modification of existing helicopter and airplane landing facilities and establishment of new sites. Although the design guidance contained herein refers to vertiport design, the design guidance applies to both vertiports and vertistops where apposite. This EB is written for vertical takeoff and landing (VTOL) powered with electric motors and utilizing distributed electric propulsion in contrast to propulsion systems built solely around an internal combustion engine. This EB serves as the FAA's initial interim guidance and will be updated over time to address new aircraft and technology.

II Background.

The Federal Aviation Administration (FAA) has identified a need for guidance for vertiports to be utilized by VTOL aircraft.

The FAA's previous Advisory Circular (AC) on Vertiport Design, published on May 31, 1991, provided guidance for vertiport design and was based on civil tiltrotors modeled after military tiltrotor technology. However, the intended aircraft were never used commercially, and the AC was cancelled on July 28, 2010. Currently the closest type of aviation infrastructure, being used by many for comparison purposes, is heliports and helistops. AC 150/5390-2, *Heliport Design*, is based on helicopters with single, tandem (front and rear) or dual (side by side) rotors. The emerging VTOL aircraft and industry advanced air mobility (AAM) concepts of operation are yet to be proven to perform like either of these designs or operational templates. Additionally, because VTOL aircraft and the AAM industry are rapidly evolving, there is limited demonstrated performance data on how these aircraft operate.

Research efforts are underway to better understand the performance capabilities and design characteristics of emerging VTOL aircraft. The FAA will develop a performance-based AC on vertiport design in the future that will detail categories of vertiport facilities requiring different design criteria depending on the characteristics of the aircraft they plan to support and activity levels at the facility. The future guidance will address more advanced operations including autonomy, different propulsion methods, and high tempo facilities. The AC on vertiport design will also address VTOL aircraft using alternative fuel sources such as hydrogen and hybrid.

However, interim guidance is needed to support initial infrastructure development for VTOL operations. This EB provides that interim guidance. Future updates to this EB will be published to provide reconsidered guidance as additional performance data is gleaned about these emerging VTOL aircraft. The EB revisions will also include aircraft that do not currently conform to the composite aircraft included in this EB; for example, aircraft with MTOW over 7,000 pounds, and address instrument flight rules (IFR) capability.

This EB provides guidance for existing safety-critical vertiport elements. Additional research is required to develop a comprehensive vertiport design AC. EB guidance is correlated to the composite VTOL aircraft described in paragraph 1.5. The composite aircraft was developed based on interactions with original equipment manufacturers (OEMs) and multiple FAA lines of business (LOBs), and encompasses the performance characteristics of nine VTOL aircraft in development.

To support the development of a comprehensive vertiport design AC, additional research is required to garner VTOL aircraft performance data on downwash/outwash, failure conditions or degradation of performance, landing precision, climb/descend gradients and all azimuth weather capabilities. The data will be collected and used by the FAA research team to fill in aircraft information gaps. The FAA will base the future Vertiports AC on aircraft performance, size and design groupings, linking these characteristics to vertiport dimensional criteria and approach/departure surfaces. This will require coordination within the FAA across the various LOBs, as well as external collaboration with manufacturers and other stakeholders.

III Application.

This EB is intended as interim guidance for vertiport design until a more comprehensive, performance-based vertiport design AC is developed. These guidelines are mandatory for vertiport projects receiving federal grant-in-aid assistance and for federally obligated airports. However, the FAA recommends using the guidelines contained in this EB in the design of new civil vertiports, and for modifications of existing helicopter and airplane landing facilities to accommodate VTOL operations.

The vertiport design criteria in this EB is intended for VTOL aircraft that meet the performance criteria and design characteristics of the composite aircraft described in paragraph 1.5, flying in visual meteorological conditions (VMC) with the pilot on board. These design recommendations are for a single aircraft using the touchdown and lift off (TLOF), final approach and takeoff (FATO), and Safety Area at one time. Vertiport operators referencing this EB are responsible for confirming the ingress and egress capabilities of the design VTOL aircraft based on site selection and environmental factors.

For vertiport facilities that will also accommodate helicopter operations, the proponent should follow the recommendations in this EB and mark the facility as a vertiport unless the facility is to be built to the transport heliport design standard, as described in paragraph 3.0.

Vertiport facilities that are intended to serve aircraft that do not meet the performance criteria and design characteristics of the composite aircraft included in this EB should begin coordination with the FAA Office of Airports early in the planning and design process for the landing area.

V Questions.

Contact the FAA for any questions about this EB.

VI Effective Date.

This EB becomes effective as of the date the associated memorandum is signed by the Manager, FAA Airport Engineering Division, AAS-100.

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1.0 Introduction

1.1. Engineering Brief (EB) Guideline Justification

Information collected through a literature review and original equipment manufacturer (OEM) coordination indicates that emerging VTOL aircraft will demonstrate similar performance characteristics compared to helicopters. However, limited data is available on VTOL aircraft operational characteristics, performance, maneuverability, downwash/outwash impacts, and vertiport obstacle information needs. Consequently, this EB is limited to pilot-on-board, visual flight rule (VFR) operations, and VTOL aircraft that have the characteristics and performance of the composite aircraft described in paragraph 1.5.

Heliports provide the most analogous present-day model for VTOL vertiports. However, despite the similarities between the two types of aircraft, there are design differences between traditional helicopters and VTOL aircraft. VTOL aircraft come in varied configurations and propulsion systems, with and without wings, and with varied landing configurations. As a result, the conversion ratio in AC 150/5390-2, of 0.83 × the overall length being used to calculate the main rotor diameter of the design helicopter, is inconsistent with the various VTOL aircraft being developed. In addition, there persists a lack of validated data on the performance capabilities of VTOL aircraft.

The limited tangible data available to validate OEM performance, especially in failure conditions, calls for a wider touchdown and liftoff area (TLOF) and load bearing final approach and takeoff area (FATO) than currently required for a general aviation heliport in AC 150/5390-2. The larger physical dimensions would accommodate a potentially wider landing scatter and decreased climb performance in different scenarios.

The anticipated advanced air mobility (AAM) operational tempo is expected to be high and will include 14 CFR Part 135, *Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons On Board Such Aircraft*, certificated operations which require certain safety levels and infrastructure requirements.

There is a predetermined level of safety for §135.229, air carrier, transport operations at heliports set in the Transport Category heliport design guidelines in AC 150/5390-2. Preliminary data garnered from the VTOL aircraft manufacturers to support the development of this EB claims no need by the aircraft for effective transitional lift (ETL) to fly and an ability to hover out of ground effect (HOGE). Therefore, the minimum sizing standards that accommodate the need for ETL per the transport category heliport criteria (e.g., 100 feet (30.5 m) by 200 feet (61 m) FATO) is not specified in this EB. As such, this EB is intended for aircraft that have HOGE capability. If the vertiport design aircraft is proven not to perform HOGE, this EB is not applicable and the sponsor must work directly with the FAA to determine alternative vertiport sizing for that design aircraft.

1.2. Explanation of Terms.

Terms used in this EB:

1. *Approach/Departure Path*: The approach/departure path is the flight track that VTOL aircraft follow when landing at or departing from a vertiport.
2. *Composite Aircraft:* The composite aircraft represents an VTOL aircraft that integrates the performance and design characteristics of nine VTOL aircraft currently in development. This composite aircraft is used to specify the performance and design characteristics for the purposes of vertiport design in this EB.
3. *Controlling dimension (CD)*: The CD is the longest distance between the two outermost opposite points on the design VTOL aircraft (e.g., wingtip-to-wingtip, rotor tip-to-rotor tip, rotor tip-to-wingtip, fuselage-to-rotor tip), measured on a level horizontal plane that includes all adjustable components extended to their maximum outboard deflection.
4. *Design VTOL aircraft:* The design VTOL aircraft is the largest electric, hydrogen, or hybrid VTOL aircraft that is expected to operate at a vertiport. This design aircraft is used to size the TLOF, FATO and safety area. Note that the design VTOL aircraft is different from the composite aircraft used to define the performance and design criteria in this EB.
5. *Downwash/Outwash*: The downward and outward movement of air caused by the action of rotating rotor blade, propeller, or ducted fan. When this air strikes the ground or some other surface, it causes a turbulent outflow of air from the aircraft.
6. *Elevated vertiport*: A vertiport is considered elevated if it is located on a rooftop or other elevated structure where the TLOF and FATO are at least 30 inches (0.8 m) above the surrounding surface.
7. *Failure condition (FC)*: FC is generally defined as an occurrence of any likely event, caused, or contributed to by one or more failures, which affects the aircraft's ability to generate lift or thrust and results in a consequential state that has an impact for a given flight phase.
8. *Final approach and takeoff area (FATO)*: The FATO is a defined, load-bearing area over which the aircraft completes the final phase of the approach, to a hover or a landing, and from which the aircraft initiates takeoff.
9. *Imaginary surface*: The imaginary planes defined in 14 CFR Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace*, centered about the FATO and the approach/departure paths, which are used to identify the objects where notice to and evaluation by the FAA is required.
10. *Obstruction to air navigation*: Any fixed or mobile object, including a parked aircraft, of greater height than any of the heights or surfaces presented in subpart C of 14 CFR Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace*.
11. *Operational tempo:* Representation of the density, frequency, and complexity of operations. Tempo evolves from a small number of low complexity operations to a high density and high rate of complex operations.

12. *Safety Area*: The Safety Area is a defined area surrounding the FATO intended to reduce the risk of damage to aircraft accidentally diverging from the FATO.

13. *Touchdown and liftoff area (TLOF)*: The TLOF is a load bearing, generally paved area centered in the FATO, on which the aircraft performs a touchdown or liftoff.

14. *Vertiport*: An area of land or a structure, used or intended to be used, for electric, hydrogen, and hybrid VTOL landings and takeoffs and includes associated buildings and facilities.

15. *Vertistop*: An area similar to a vertiport, except that no charging, fueling, defueling, maintenance, repairs, or storage of aircraft are permitted. The design standards and recommendations in this EB apply to all vertiports and vertistops.

1.3. State/Local Role

Many state departments of transportation, aeronautics commissions, or similar authorities require prior approval and, in some instances, a license to establish and operate landing facilities. Several states and municipalities administer a financial assistance program like the federal program and are staffed to provide technical advice. Those seeking to establish a vertiport should first contact their respective state or local transportation or aeronautics departments or commissions for specifics on applicable licensing and assistance programs. Contact information for state aviation agencies is available at https://www.faa.gov/airports/resources/state_aviation/.

In addition to state requirements, many local communities have enacted zoning ordinances, building and fire codes, and conditional use permitting requirements that can affect the establishment and operation of landing facilities. Some communities have developed codes or ordinances regulating environmental issues such as noise and air pollution. Therefore, communities or sponsors seeking to establish a vertiport should make early contact with local officials or agencies representing the local zoning board; the fire, police, or sheriff's department; and stakeholders who represent the area where the vertiport is to be located.

State regulators, departments of transportation, and local communities can also use the guidance and best practices outlined in this EB when reviewing a proposed vertiport facility or developing independent standards.

In addition to state and local coordination, vertiport proponents are encouraged to coordinate potential sites with any nearby airports or aviation stakeholders.

1.4. Airspace Approval Process and Coordination

For development on non-federally obligated airports or heliports or for non-federally funded stand-alone vertiport sites, and in compliance with 14 CFR Part 157, *Applications for Certificates of Public Convenience and Necessity and for Orders Permitting and Approving Abandonment under Section 7 of the Natural Gas Act, as Amended, Concerning Any Operation, Sales, Service, Construction, Extension, Acquisition or Abandonment*, the proponent must submit FAA Form 7480-1, *Notice for Construction, Alteration and Deactivation of Airports*, at least 90 days in advance of the day that construction work is to begin on the landing area. **Note:** Airspace determination is not tied to this 90-day advance notice. The FAA highly encourages that engagement with the appropriate FAA regional or district office begin before the submission of the Form 7480-1, but an FAA evaluation is predicated on the submitted Form 7480-1.

For vertiport development on federally obligated airports, the infrastructure or equipment must be depicted on the Airport Layout Plan (ALP) and a Form 7460-1 submitted for an airspace determination prior to development. The FAA's review of the ALP and airspace determination must be completed prior to the start of operations.

Approved heliport facilities that are being converted to a vertiport, if non-federally funded, will need to submit a new Form 7480-1 to re-designate the facility as a vertiport before VTOL operations can commence at the site. The 7480-1 can be submitted electronically as a Landing Area Proposal (LAP) on OEAAA.faa.gov. The FAA's Flight Standards Service Office will determine when to do an onsite evaluation using risk-based analysis .

1.5. Composite Aircraft

The composite aircraft represents a VTOL aircraft that integrates the performance and design features of nine VTOL aircraft currently in development. This composite aircraft is used to specify the performance and design characteristics for the purposes of vertiport design in this EB.

Emerging VTOL aircraft models are evolving rapidly with OEMs approaching aircraft certification from a wide range of different designs. While aircraft classifications are useful in takeoff and landing area design and airspace analysis, new VTOL concepts vary significantly in terms of design, aircraft dimensions, performance, and operational characteristics. Furthermore, these new VTOL aircraft do not have an established safety record and have not yet received FAA airworthiness certification. This makes it impractical to categorize VTOL aircraft as the FAA has traditionally done with FAA certificated fixed wing and rotor aircraft. However, OEM engagement has revealed some common characteristics among VTOL aircraft prototypes including multiple propulsion systems, HOGE capability, and helicopter performance similarities.

The vertiport design guidance in this EB relies on design characteristics, expected performance capabilities, and preliminary assumptions regarding landing area design, until there is adequate research on these emerging aircraft to develop a performance-based vertiport design AC. Accordingly, the aircraft features and performance capabilities listed in Table 1-1 create a composite aircraft type to inform this EB. The design characteristics, performance, and operating conditions that make up this composite VTOL aircraft will be reviewed in the future as the FAA continues to engage with emerging VTOL aircraft manufacturers.

Table 1-1: Composite Aircraft

Design Characteristics	Criteria
Propulsion	Electric battery driven utilizing distributed electric propulsion
Propulsive units	2 or more
Battery packs	2 or more
Maximum takeoff weight (MTOW)	7,000 pounds (3,175 kg) or less
Aircraft length	50 feet (15.2 m) or less
Aircraft width	50 feet (15.2 m) or less

Operating Conditions	Criteria
Operation location	Land-based (ground or elevated) – no amphibian or float operations
Pilot	On board
Flight conditions	VFR

Performance	Criteria
Hover	HOGE in normal operations
Takeoff	Vertical
Landing	Vertical
Downwash/Outwash	Must be considered in TLOF/FATO sizing and ingress/egress areas to ensure no endangerment to people/property in the vicinity, and no impact to safety critical navigational aids and surfaces, supporting equipment, nearby aircraft, and no impact to overall safety

2.0 Vertiport Design and Geometry (Safety-Critical Design Elements)

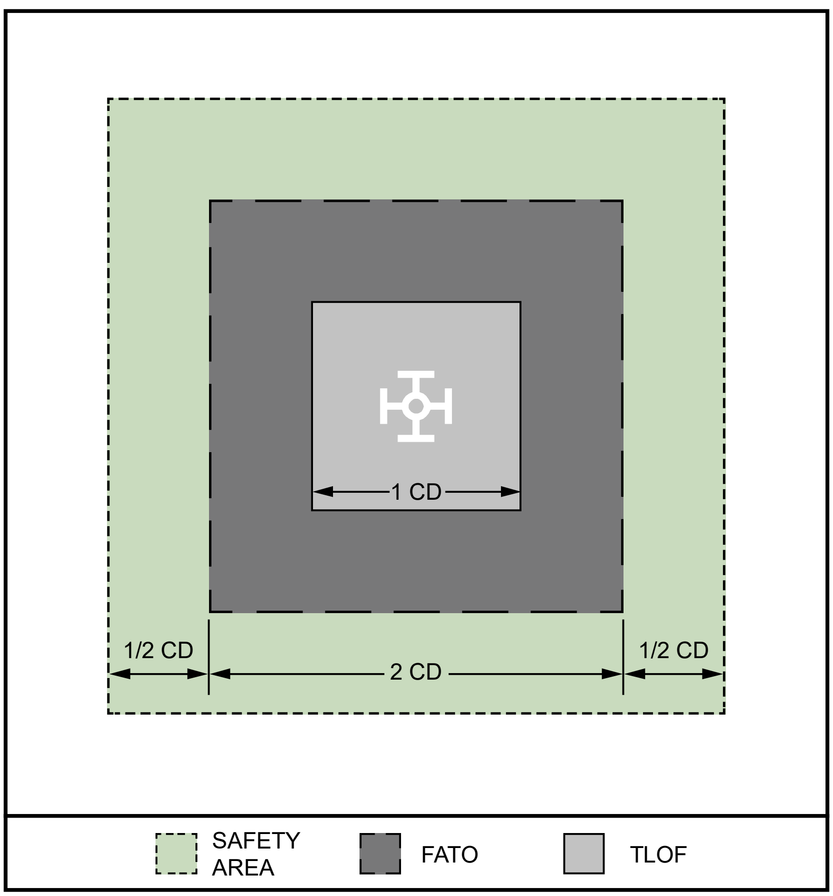
2.1. Overview

The landing area design and geometry contained in this EB includes the TLOF, the FATO, and the Safety Area. The dimensions for these areas are presented in Table 2-1 and are based on the controlling dimension (CD) of the design VTOL aircraft as defined for each vertiport facility. The CD is the longest distance between the two outermost opposite points on the aircraft (e.g., wingtip-to-wingtip, rotor tip-to-rotor tip, rotor tip-to-wingtip, or fuselage-to-rotor tip), measured on a level horizontal plane that includes all adjustable components extended to their maximum outboard deflection. 1CD is equal to the longest distance described above. The following sections provide specific details about these areas. See Figure 2-1 for the relationship among the TLOF, FATO, and Safety Area.

Table 2-1: Landing Area Dimensions

Element	Dimension
TLOF	1CD
FATO	2CD
Safety Area	3CD (½ CD added to edge of FATO)

Figure 2-1: Relationship and Dimensions of TLOF, FATO, and Safety Area



2.2. TLOF Guidance

The TLOF is a load bearing, generally paved area centered in the FATO, on which the VTOL aircraft performs a touchdown or liftoff. The following guidelines apply to the TLOF:

1. Located at ground level, on elevated structures[‡], or at rooftop level.
2. On level terrain or a level structure.
3. Clear of penetrations and obstructions to the approach/departure and transitional surfaces.
4. Load bearing (static and dynamic for design aircraft).
    a. Supports the weight of the design VTOL aircraft and/or any ground support vehicles, whichever is more demanding for pavement design. The static loads are equal to the aircraft's maximum takeoff weight applied through the total contact area of the landing gear. For this EB, the maximum takeoff weight is 7,000 pounds (3,175 kg).
    b. Supports the dynamic loads based on 150 percent of the maximum takeoff weight of the design VTOL aircraft.
    c. Accounts for rotor downwash load in load-bearing capacity.
5. Centered within its own FATO.
6. Minimum width is 1CD[§],
7. Minimum length is 1CD[4].
8. Circular, square, or rectangular in shape[**]. The TLOF should have the same shape as the FATO and Safety Area.
9. Design the distance between the TLOF, FATO and safety area perimeters to be equidistant regardless of the shape of the TLOF.
10. Meets general surface characteristics and pavement guidelines including the following:
    a. Has a paved or aggregate-turf surface (see AC 150/5370-10*, Standards for Specifying Construction of Airports*, items P-217, Aggregate-Turf Pavement and P-501, Portland Cement Concrete (PCC) Pavement).

[‡]A vertiport is considered elevated if it is located on a rooftop or other elevated structure where the TLOF and FATO are at least 30 inches (0.8 m) above the surrounding surface.

[§] The controlling dimension (CD) of an aircraft is the longest distance between the two outermost opposite points on the aircraft (e.g., wingtip to wingtip, rotor tip to rotor tip, rotor tip to wingtip, fuselage to rotor tip) measured on a level horizontal plane that includes all adjustable components extended to their maximum outboard deflection. 1CD is equal to the longest distance described above. 2CD is equal to twice the long distance describe above.

[**] In 2011, the National EMS Pilots Association conducted a survey of 1,314 EMS Pilots and found that the square was the preferred visual cue for judging aircraft closure rate, altitude, attitude, and angle of approach. It was rated higher than a circle, triangle, or octagon.

b. Uses PCC when feasible. An asphalt surface is discouraged as it is susceptible to heat stress and may rut under the weight of a parked VTOL aircraft, creating loose debris and potential catch points for landing gear.

c. Has a roughened pavement finish (e.g., brushed, or broomed concrete) to provide a skid-resistant surface for VTOL aircraft and a non-slippery footing for people.

d. Elevations between any paved and unpaved portions of the TLOF and FATO are equal.

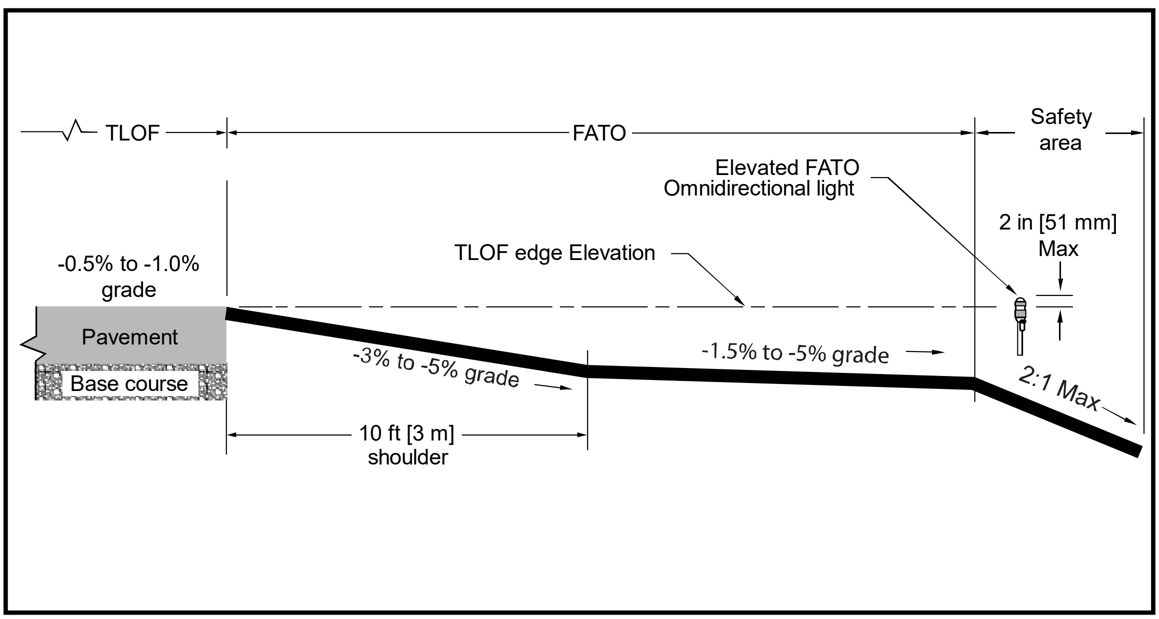
e. Surface is stabilized to prevent erosion or damage from rotor downwash or outwash from VTOL aircraft operations. (Find guidance on pavement design and soil stabilization in AC 150/5320-6*, Airport Pavement Design and Evaluation*, and AC 150/5370-10).

f. Preferred surface of elevated TLOFs is concrete. If the surface is metal, insulate to the extent feasible to eliminate the threat of conducting electricity in cases of a short circuit or lighting strike.

g. Elevated TLOFs comply with 29 CFR Part 1926.34, *Means of Egress*, and 29 CFR Part 1910.24, *Fixed Industrial Stairs*, as applicable.

11. Gradient provides positive drainage (between -0.5 and -1.0 percent) off of and away from the pavement as shown in Figure 2-2.

Figure 2-2: Vertiport Gradients and Rapid Runoff Shoulder



12. For rooftop or other elevated TLOFs, ensure that:

a. The FATO and TLOF are at or above the elevation of the adjacent Safety Area.

b. Elevator penthouses, cooling towers, exhaust vents, fresh-air vents, and other elevated features or structures do not affect VTOL aircraft operations or penetrate the TLOF, FATO, Safety Area, Approach Surface, or Transition Surface.

c. Fresh air vents for any attached building are not impacted by landing facility operations.

2.3. FATO Guidance

The FATO is a defined area over which the VTOL aircraft completes the final phase of the approach to a hover or a landing and from which the aircraft initiates takeoff. The following guidelines apply to the FATO:

1. Located at ground level, on elevated structures, or at rooftop level.
2. Clear with no penetrations or obstructions except for navigational aids that are fixed-by-function[††], which must be on frangible mounts.
3. Load bearing (static and dynamic for design aircraft), including the following features:
    a. Supports the weight of the design VTOL aircraft and any ground support vehicles. The static loads are to be equal to the aircraft's maximum takeoff weight applied through the total contact area of the landing gear.
    b. Assume dynamic loads at 150 percent of the maximum takeoff weight of the design VTOL aircraft.
    c. Rotor downwash load is accounted for in load-bearing capacity.
4. Centered within its own Safety Area.
5. Minimum width is 2CD.
6. Minimum length is 2CD.
7. The same geometric shape as the TLOF[‡‡] and safety area.
8. Design the distance between the TLOF, FATO and safety area perimeters to be equidistant regardless of the shape of the TLOF.
9. Meets general surface characteristics and pavement guidelines including the following:
    a. Paved or aggregate-turf surface (see AC 150/5370-10, items P-217, Aggregate-Turf Pavement and P-501, Portland Cement Concrete (PCC) Pavement).
    b. Uses PCC when feasible. An asphalt surface is less desirable as it may rut under the weight of a parked VTOL aircraft.
    c. Has a roughened pavement finish (e.g., brushed, or broomed concrete) to provide a skid-resistant surface for VTOL aircraft and a non-slippery footing for people.
    d. Elevations between any paved and unpaved portions of the FATO are equal.

[††] An air navigation aid that must be positioned in a particular location to provide an essential benefit for aviation is fixed-by-function.
[‡‡] In 2011, the National EMS Pilots Association conducted a survey of 1,314 EMS Pilots and found that the square was the preferred visual cue for judging aircraft closure rate, altitude, attitude, and angle of approach. It was rated as excellent while the circle was rated as acceptable.

   e. Surface is stabilized to prevent erosion of damage from rotor downwash or outwash from VTOL aircraft operations. (Find guidance on pavement design and soil stabilization in AC 150/5320-6 and AC 150/5370-10).

   f. Preferred surface of elevated FATO is concrete. If the surface is metal, it must be insulated/grounded to the extent feasible to eliminate the threat of conducting electricity in the case of a short circuit or lighting strike.

   g. Elevated FATOs should be metal or concrete and comply with Part 1926.34 and Part 1910.24, as applicable.

10. FATO surface prevents loose stones and any other flying debris caused by rotor downwash or outwash.

11. Gradient provides positive drainage (between 1.5 and 5.0 percent) off of and away from the pavement, with a 10-foot wide (3 m wide) rapid runoff shoulder sloped between 3.0 and 5.0 percent, as shown in Figure 2-2.

12. The edge of the FATO abutting the TLOF is the same elevation as the TLOF.

13. If the FATO is located on a rooftop or other elevated structures:

   a. FATO and TLOF elevations are at or above the elevation of the adjacent Safety Areas.

   b. The FATO is above the level of any obstacle in the Safety Area that cannot be removed.

   c. Title 29 CFR Part 1910.23, *Guarding Floor and Wall Openings and Holes*, is followed for all platforms elevated 30 inches (0.8 m) or more.

   d. Does not use permanent railings or fences that would be safety hazards during aircraft operations.

   e. Optionally, can use safety nets that meet state and local regulations, are at least 5 feet (1.5 m) wide, and meet the following criteria:

      i. The insides and outside edges of the nets are fastened to a solid structure.

      ii. The net is constructed of materials that are resistant to environmental effects and inspected annually for integrity.

      iii. The net has a load carrying capability of 50 pounds per square foot (244 kg/sq m).

      iv. The net is located at or below the edge elevation of the FATO.

      v. The net is attached to the outer perimeter frame of the FATO.

2.4. Safety Area Guidance

The Safety Area is a defined area surrounding the FATO intended to reduce the risk of damage to VTOL aircraft unintentionally diverging from the FATO. The following guidelines apply to the Safety Area:

1. Located at ground level, on elevated structures, at rooftop level, and can extend over water or in clear airspace.

2. Clear with no penetrations or obstructions except for navigational aids that are fixed-by-function[§§], which must be on frangible mounts.
3. For elevated TLOFs, no fixed objects within the Safety Area project above the FATO except those fixed-by-function which must be on frangible mounts.
4. Minimum width is ½ CD from the edge of the FATO.
5. Minimum length is ½ CD from the edge of the FATO.
6. The same geometric shape as the TLOF and FATO.
7. Design the distance between the TLOF, FATO and safety area perimeters to be equidistant regardless of the shape of the TLOF.
8. If at ground level, the surface prevents loose stones and any other flying debris caused by downwash or outwash.
9. Gradient provides positive drainage away from the FATO no steeper than 2:1, horizontal units and vertical units respectively. See Figure 2-2.
10. On rooftop or other elevated FATOs, meets requirements contained in Part 1910.23.

2.5. VFR Approach/Departure Guidance

2.5.1. VFR Approach/Departure and Transitional Surfaces

The imaginary surfaces defined in 14 CFR Part 77, *Safe, Efficient Use, and Preservation of the Navigable Airspace*, for heliports are applicable to vertiports and include the primary surface, approach, and transitional surfaces. Part 77 establishes standards and notification requirements for objects affecting navigable airspace. This notification provides the basis for: evaluating the effect of construction or alteration on aeronautical operating procedures; determining the potential hazardous effect of proposed construction on air navigation; identifying mitigating measures to enhance safe air navigation; and aeronautical charting for new objects. The following applies to these imaginary surfaces:

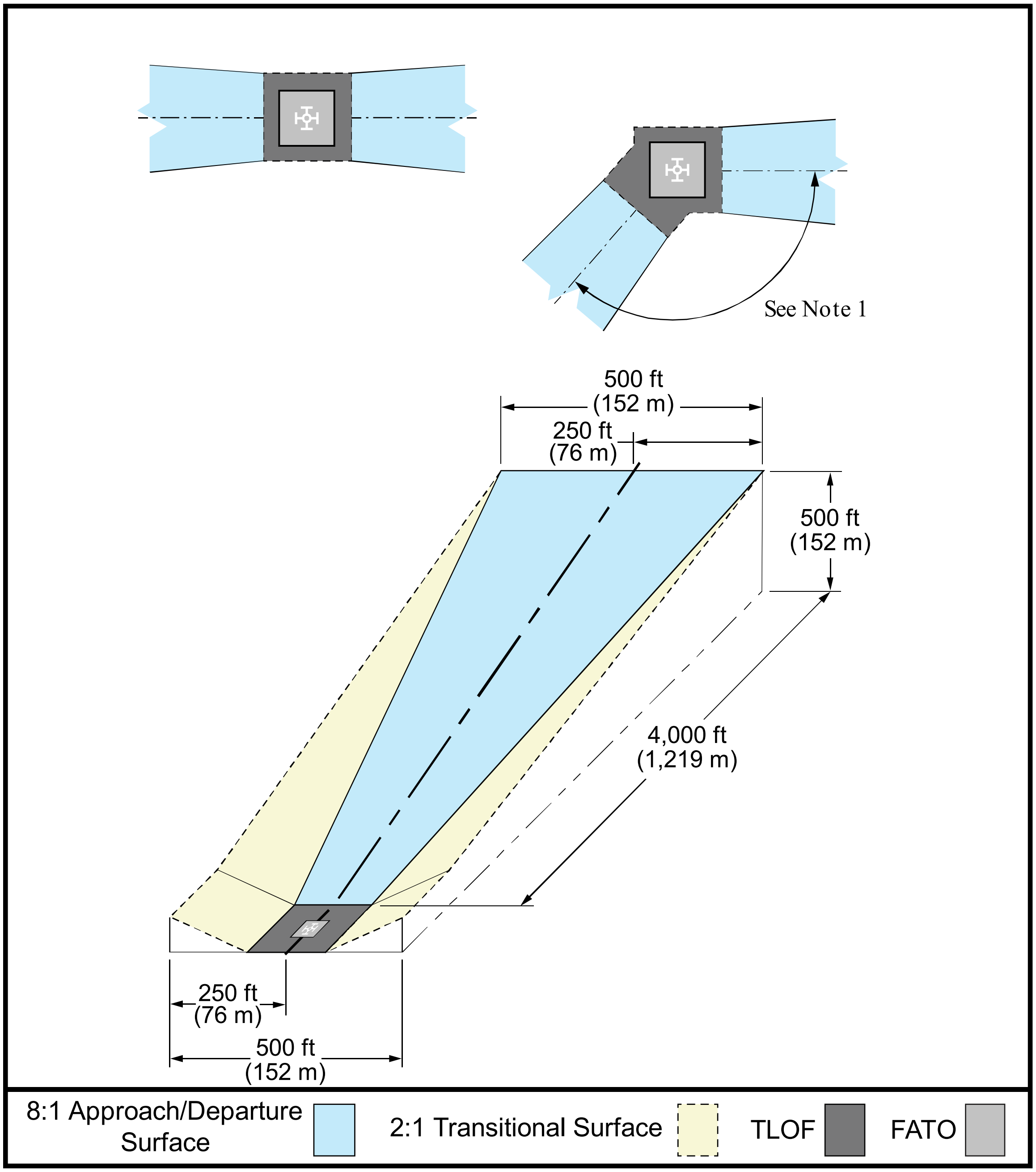
1. The primary surface coincides in size and shape with the FATO. This surface is a horizontal plane at the elevation of the established vertiport elevation.
2. The approach surface (and, by reciprocal, the departure surface) begins at each end of the vertiport primary surface with the same width as the primary surface and extends outward and upward for a horizontal distance of 4,000 feet (1,219 m) where its width is 500 feet (152 m). The slope of the approach surface is 8:1, horizontal units and vertical units, respectively.
3. The transitional surfaces extend outward and upward from the lateral boundaries of the primary surface and from the approach surfaces at a slope of 2:1, horizontal units and vertical units, respectively, for 250 feet (76 m) measured horizontally from the centerline of the primary and approach surfaces.

[§§] An air navigation aid that must be positioned in a particular location to provide an essential benefit for aviation is fixed-by-function.

4. The approach and transitional surfaces are clear of penetrations unless an FAA aeronautical study determines penetrations to any of these surfaces not to be hazards.

See Figure 2-3 for visual depiction of this guidance.

Figure 2-3: VFR Vertiport Approach/Departure Surfaces



Note 1: The preferred approach/departure surface is based on the predominant wind direction. Where a reciprocal approach/departure surface is not possible in the opposite direction, use a minimum 135-degree angle between the two surfaces.

2.5.2. VFR Approach/Departure Path

The approach/departure path is the flight track that VTOL aircraft follow when landing at or departing from a vertiport. The following guidelines apply to the approach/departure path(s):

1. Preferred approach/departure paths are aligned with the predominant wind direction as much as possible, to avoid downwind operations and keep crosswind operations to a minimum.
2. More than one approach/departure path is provided as close to reciprocal in magnetic heading as possible (e.g., 180° and 360°).
3. Additional approach/departure paths are based on an assessment of the prevailing winds or separated from the preferred flight path by at least but not limited to 135 degrees.
4. All approach and departure surfaces are free of obstructions.
5. The approach/departure paths must assure 8:1 horizontal units and vertical units.

See Figure 2-3 for a visual depiction of this guidance.

3.0 Marking, Lighting, and Visual Aids

This section provides guidelines on marking, lighting, and visual aids that identify the facility as a vertiport. These guidelines apply to new vertiports or to altered heliports that are converted to vertiports.

3.1. General

The following general guidelines apply to markings:

1. Paint or preformed materials define the TLOF and FATO within the limits of those areas. See AC 150/5370-10, Item P-620, for specifications.
2. Reflective paint and retroreflective markers are optional and should be used with caution, as overuse of reflective material can be blinding to a pilot when using landing lights.
3. Outlining markings and lines with a 2-6-inch (55-152 mm)-wide line of a contrasting color is an option to enhance conspicuousness.
4. TLOF perimeter marking is a 12-inch-wide (305 mm wide) white line.
5. TLOF size and weight limitation box is included on a TLOF with a hard surface (described in paragraph 3.3) and as an option on a TLOF with a turf surface.
6. FATO perimeter is marked by 12-inch-wide (305 mm wide) dashed white lines that are 5 feet (1.5 m) in length with end-to-end spacing of 5 to 6 feet (1.5 to 1.8 m) apart.

See Figure 3-1 for a visual depiction of standard vertiport markings.

Figure 3-1: Standard Vertiport Marking

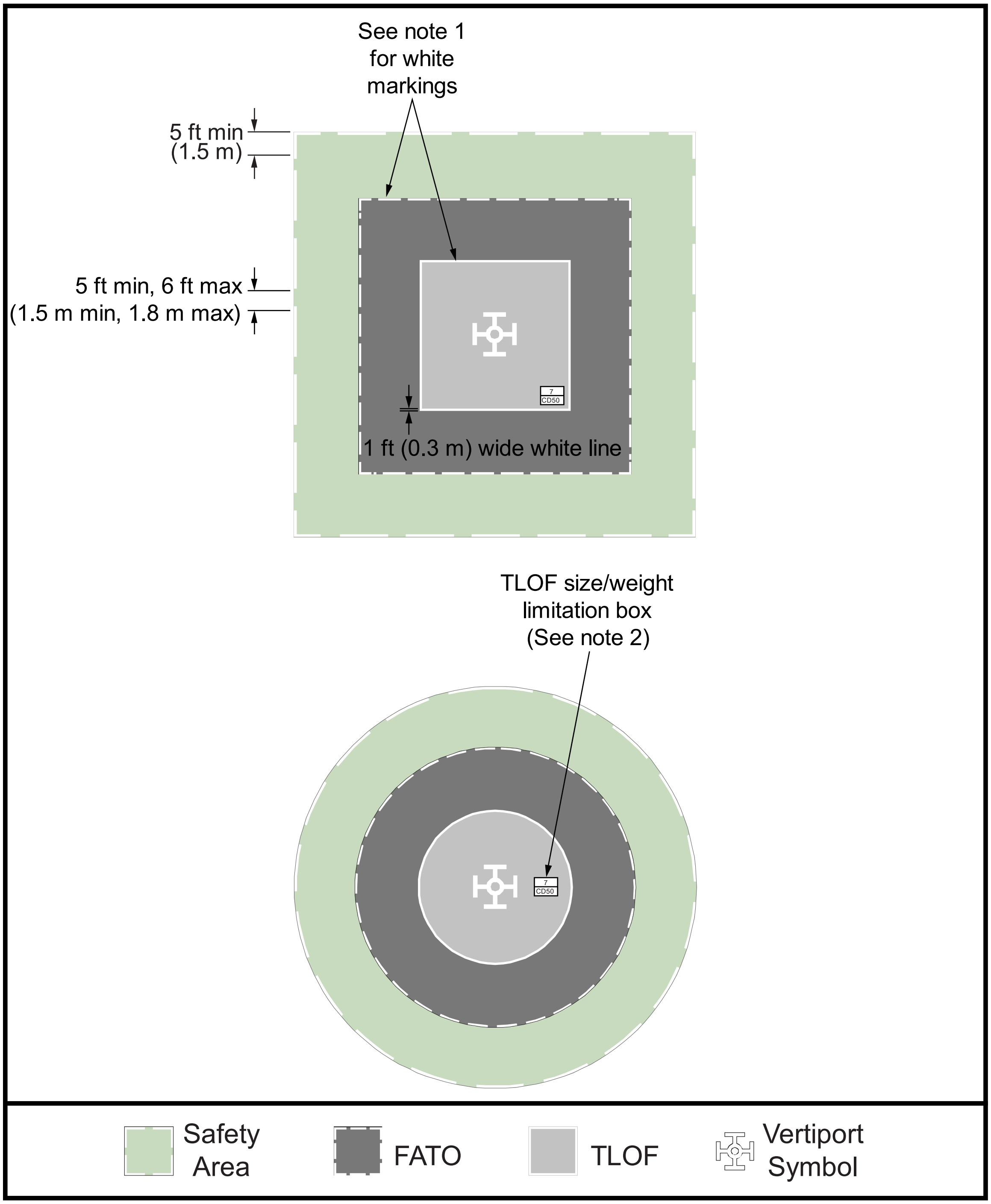


Figure scaled for 50-foot (15.2 m) TLOF.

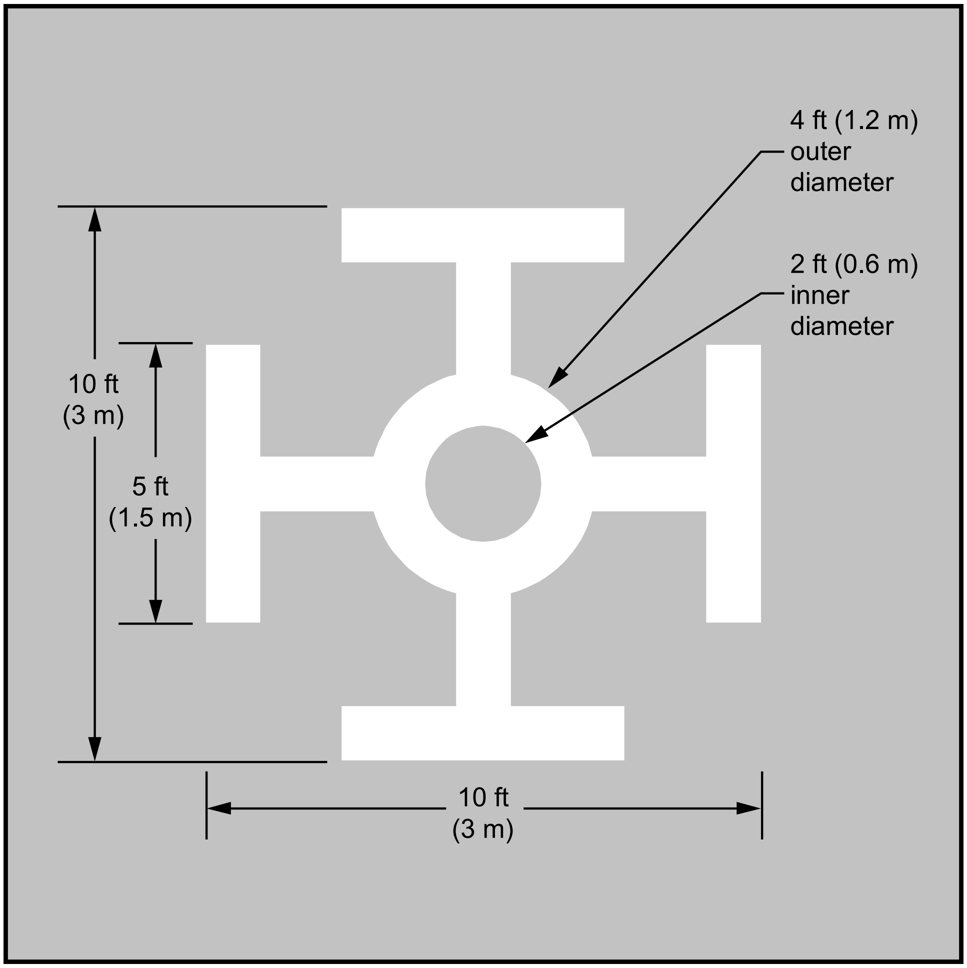
Note 1: Solid and dashed white lines are 1 foot in width. Dashed lines are 5-foot (1.5 m) in length with 5-6-foot (1.5-1.8 m) spaces.

Note 2: See Figure 3-3 for details on the TLOF Size/weight limitation box.

3.2. Identification Symbol

The vertiport identification marking or symbol identifies the location as a vertiport, marks the TLOF, and provides visual cues to the pilot. Vertiport facilities should use the broken wheel symbol shown in Figure 3-2.*** The symbol is in the center of the TLOF.

Figure 3-2: Vertiport Identification Symbol



*** The broken wheel symbol placed second in a research test conducted in 1967 for most visible and informative symbol for heliports. The most visible and informative was a Maltese Cross, which the FAA adopted for heliports and then repealed. The broken wheel symbol performs the following functions: identifies the vertiport from a minimum distance and angle; offers a means of directional control on approach; serves as a field of reference in maintaining attitude on approach; assists the pilot in controlling the rate of closure on approach; acts as a point of convergence to a desired location; and assists the pilot when the aircraft is directly over the vertiport. It was adopted by the now cancelled Vertiport Design AC. (Smith, Safe Heliports Through Design and Planning, 1994, p. 41).

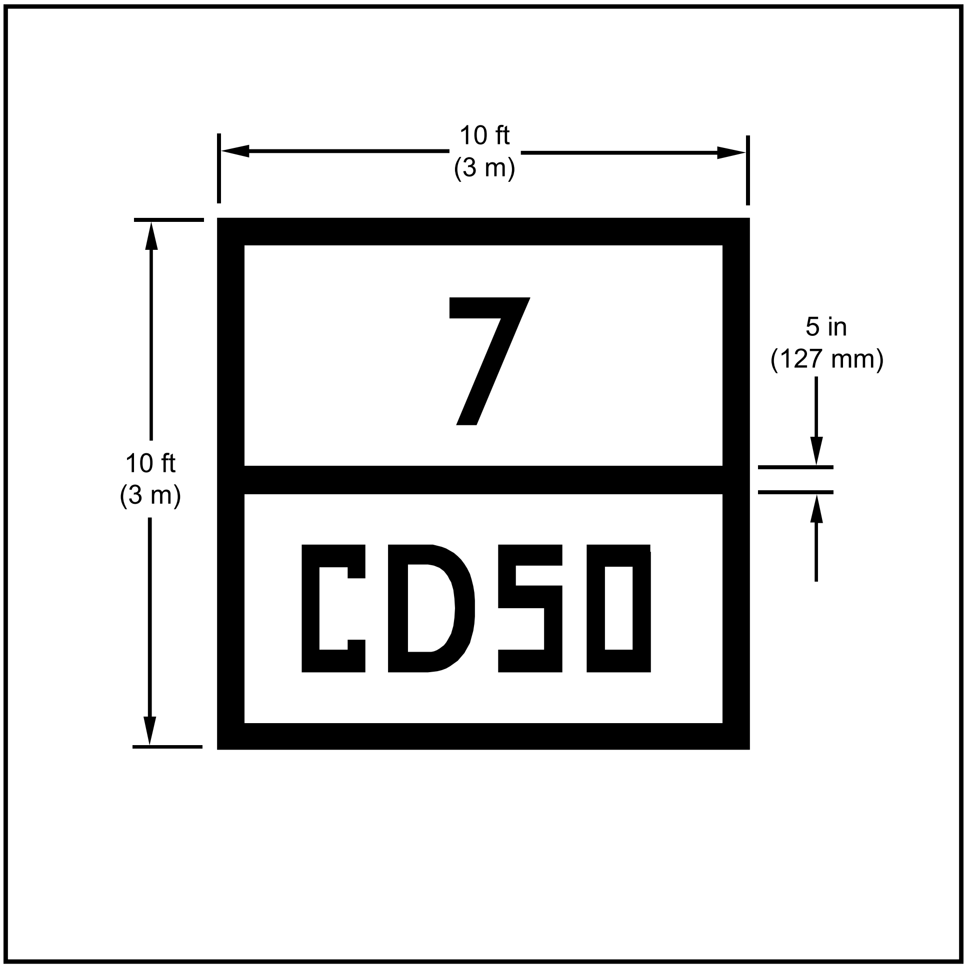
3.3. TLOF Size/Weight Limitation Box

The TLOF size/weight limitation box indicates the controlling dimension (maximum length or width) and the maximum takeoff weight of the design VTOL aircraft that can use the vertiport. Weight limitation boxes should meet the following guidance:

1. The letters "CD" and the weight, in imperial units, of the design VTOL aircraft that the vertiport is designed to accommodate are in a box in the lower right-hand corner of a rectangular TLOF, or on the right-hand side of the symbol of a circular TLOF, when viewed from the preferred approach direction.
2. The numbers are black on a white background.
3. The top number is the maximum takeoff weight of the design VTOL aircraft in thousands of pounds and is not to exceed 7,000 pounds (3,175 kg). It is centered in the top half of the box.
4. The bottom number is the controlling dimension of the design VTOL aircraft, is centered in the bottom half of the box, and is preceded by the letters "CD."
5. An existing TLOF without a weight limit is marked with a diagonal line extending from the lower left-hand corner to the upper right-hand corner in the upper section of the TLOF size/weight limitation box. All new vertiport designs under this EB will have a weight limitation of 7,000 pounds (3,175 kg).

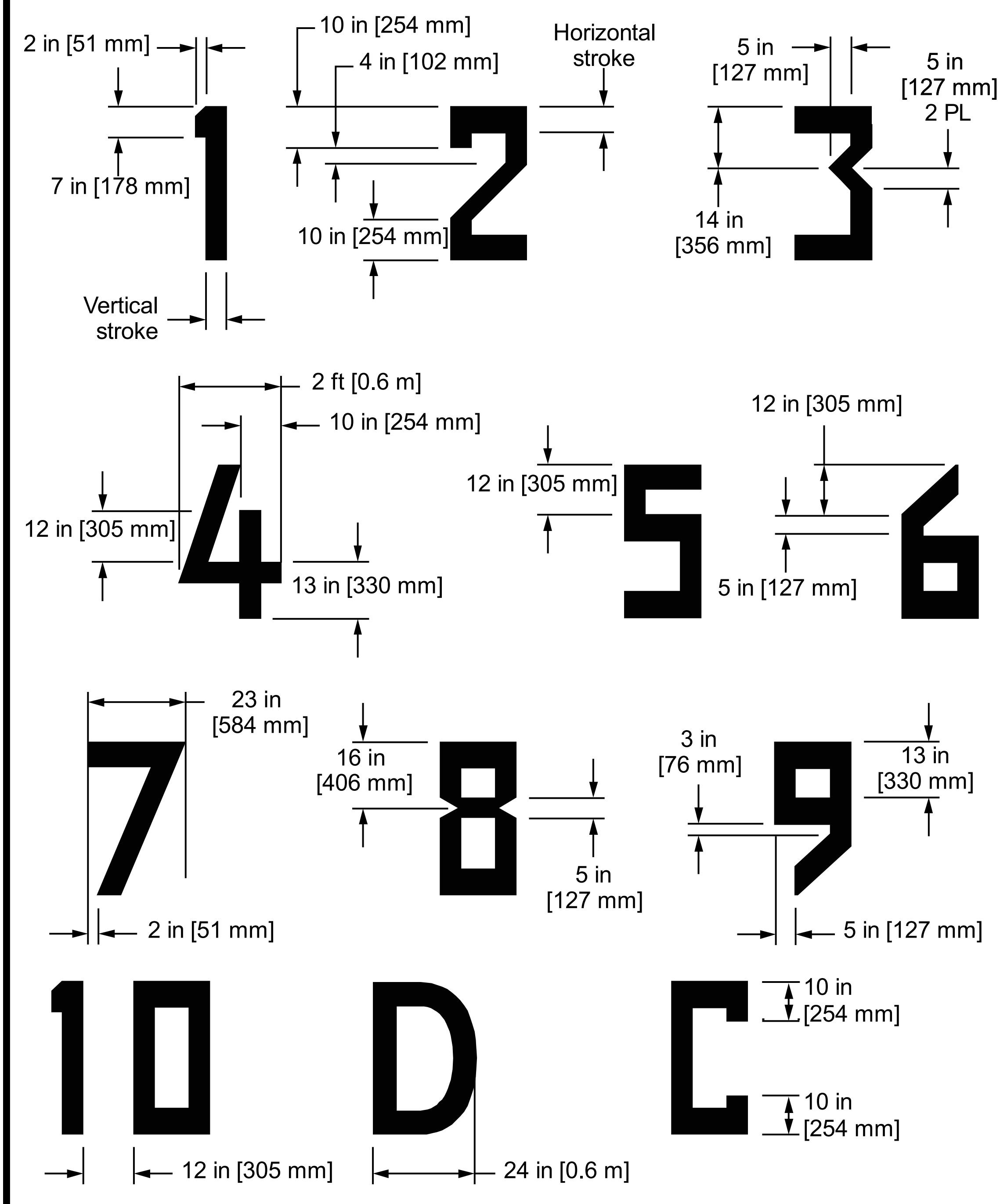
See Figure 3-3 for details on the TLOF size/weight limitation box, and Figure 3-4 and Figure 3-5 for details on the form and proportions of the numbers and letters specified for these markings.

Figure 3-3: TLOF Size/Weight Limitation Box



Note: 10 ft (3 m) square is encouraged where possible for improved visibility.

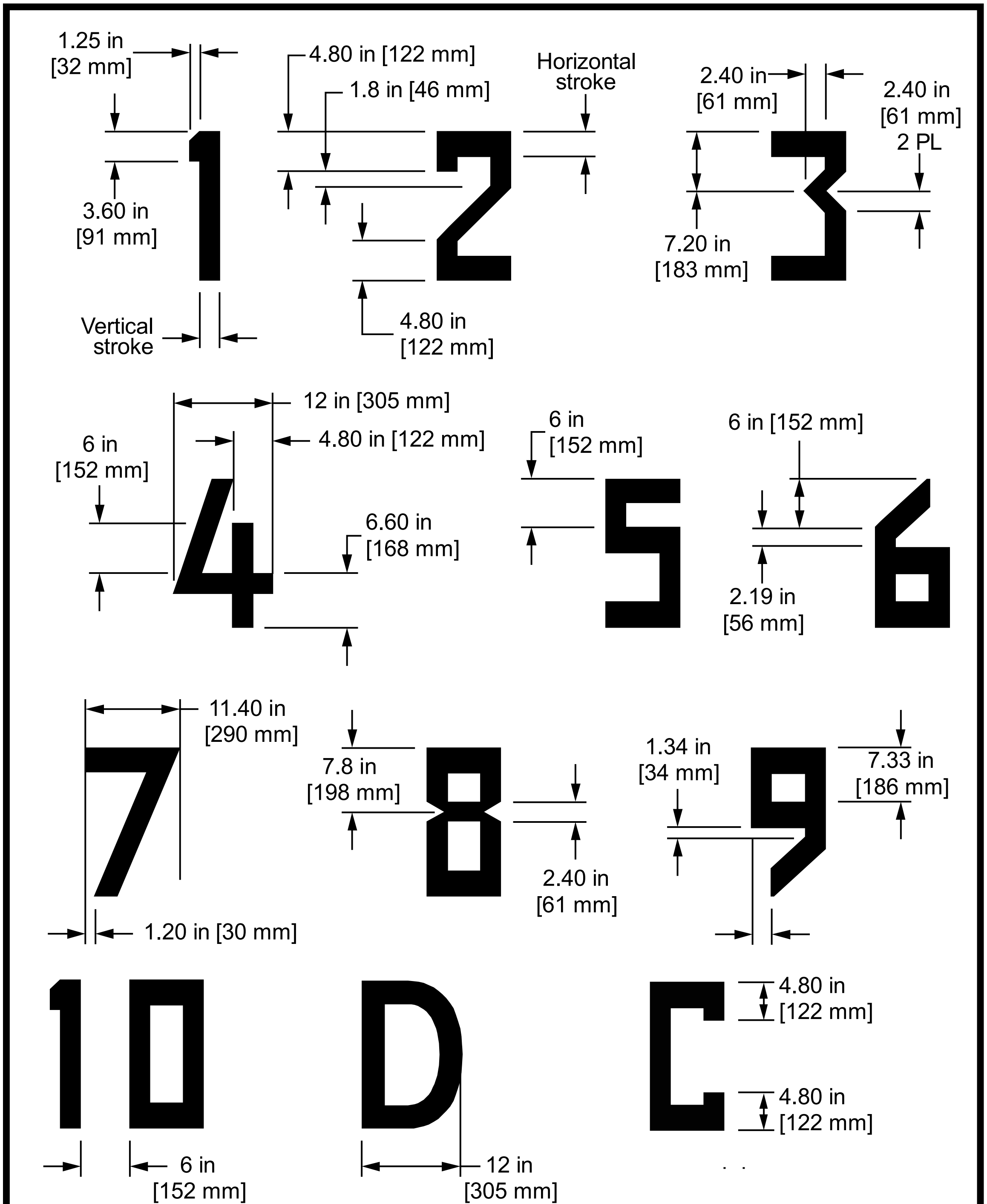
Figure 3-4: Form and Proportions of 36-inch (0.9 m) Numbers for Marking Size and Weight Limitations



All characters have the following characteristics (Unless otherwise specified):

3 ft [0.9 m] high	Vertical stroke of 5 in [127 mm]
1.5 ft [0.5 m] wide	Horizontal stroke of 6 in [152 mm]

Figure 3-5: Form and Proportions of 18-inch (0.5 m) Numbers for Marking Size and Weight Limitations



All characters have the following characteristics (Unless otherwise specified):

1.5 ft [0.5 m] high	Vertical stroke of 2.5 in [64 mm]
9 in [229 mm] wide	Horizontal stroke of 6 in [152 mm]

3.4. Flight Path Alignment Optional Marking and Lighting

Flight path alignment guidance is optional and includes markings and/or lights when it is desirable and practicable to indicate available approach and/or departure flight path direction(s). Guidance for optional flight path alignment marking and lighting includes:

1. The shaft of each arrow is 18 inches (0.5 m) wide and at least 10 feet (3 m) long.
2. The arrow heads are 5 feet (1.5 m) wide and 5 feet (1.5 m) tall.
3. The color of the arrow must provide good contrast against the background color of the surface. Provide a contrasting border around the arrows if needed to increase visibility for the pilot.
4. An arrow pointing toward the center of the TLOF depicts an approach direction.
5. An arrow pointing away from the center of the TLOF depicts a departure direction.
6. In-pavement flight path alignment lighting is recommended.
7. For a vertiport with a flight path limited to a single approach direction or a single departure path, the arrow marking is unidirectional (e.g., one arrowhead only). For a vertiport with only a bidirectional approach/takeoff flight path available, the arrow marking is bidirectional (e.g., two arrowheads).

See Figure 3-6 for additional guidance.

Figure 3-6: Flight Path Alignment Marking and Lighting

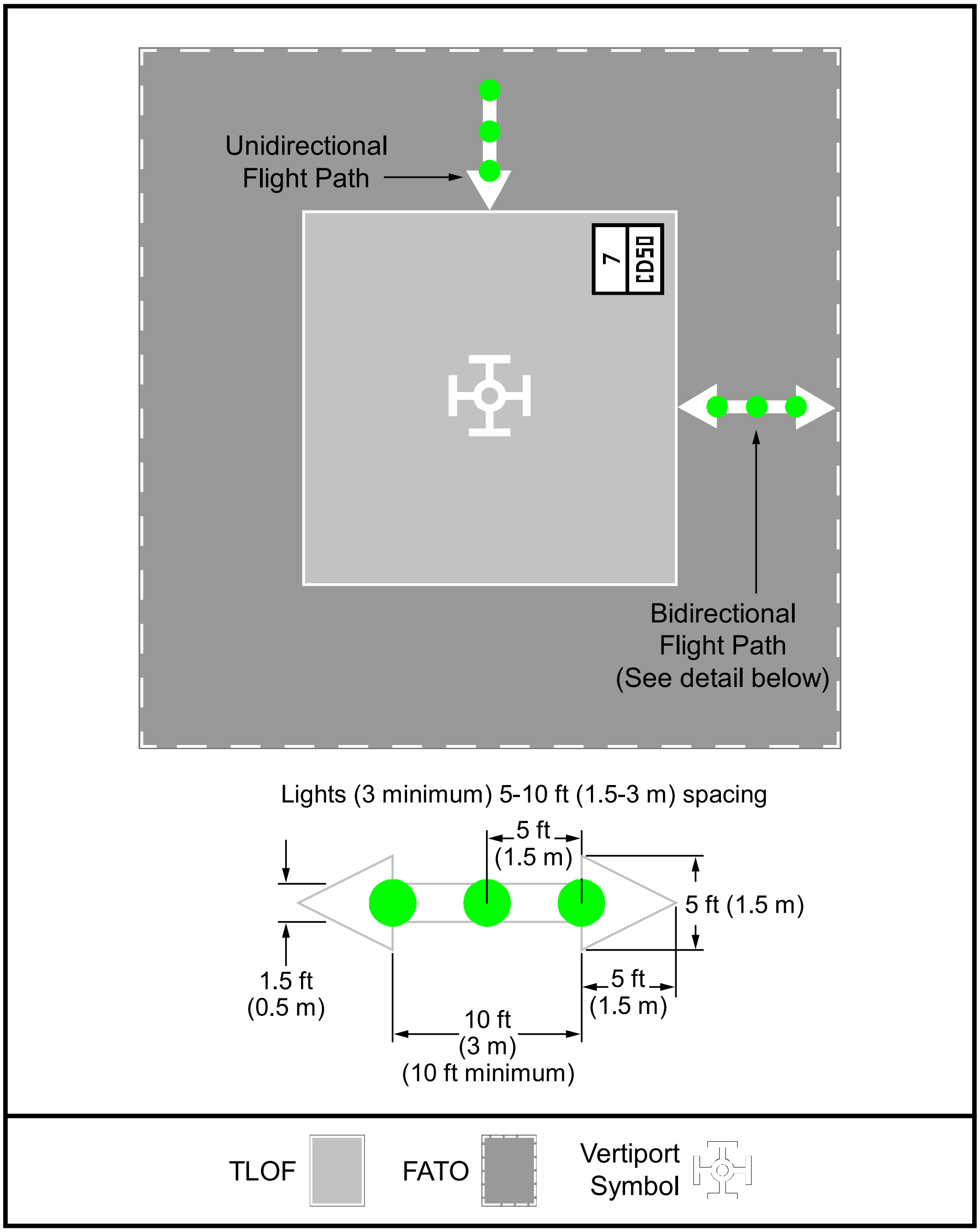


Figure scaled for 50-foot (15.2 m) TLOF

Note 1: Arrowheads have constant dimensions.
Note 2: If necessary, adjust stroke length to match length available. Minimum length = 10 ft (3 m).
Note 3: Light type: omnidirectional green lights, Type L-860H or L-852H.
Note 4: If necessary, locate the lights outside of the arrow.
Note 5: In-pavement flight path alignment lighting is recommended.
Note 6: See paragraph 3.4 for guidance on flight path alignment markings.

3.5. Lighting

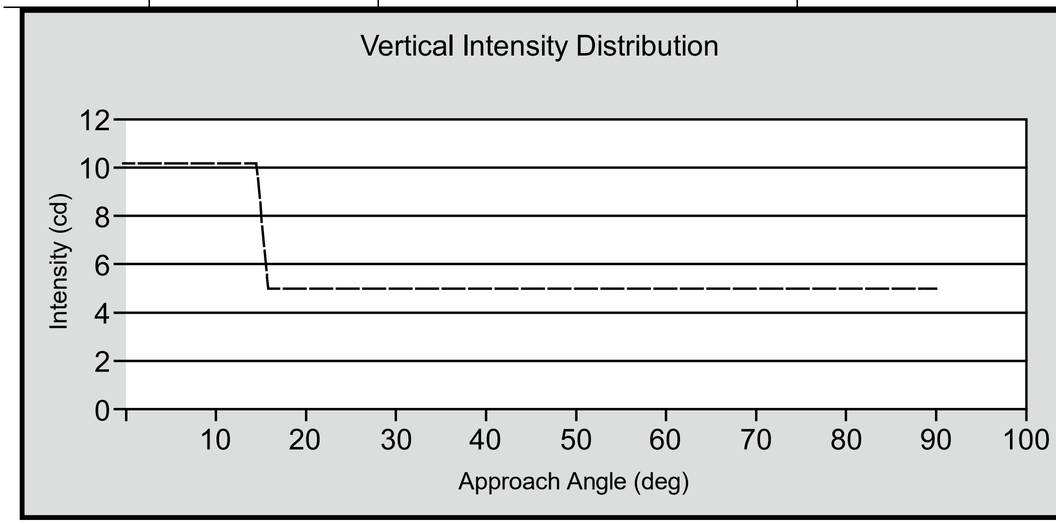
Lighting is required for vertiports that support night operations. The lighting should enable the pilot to both establish the location of the vertiport and identify the perimeter of the operational area. In-pavement lighting is preferred to elevated lighting. The following guidelines apply to lighting:

3.5.1. General

1. The FAA type L-860H omnidirectional perimeter light fixture supports all possible directions of approach. AC 150/5345-46, *Specifications for Runway and Taxiway Light Fixtures*, provides the standards for the FAA type L-860H light fixture.
2. The light fixtures are listed in AC 150/5345-46 as FAA type L-860H, elevated heliport perimeter light, and Type L-852H, in-pavement heliport perimeter light.
3. With light fixture FAA type L-860H as the base, elevated (FAA type L-860H) and in-pavement (FAA type L-852H) fixtures will be established in the next update of AC 150/5345-46. Use FAA type L-860H for TLOF and FATO perimeter applications and for Flight Path Alignment Lights and Landing Direction Lights. See EB 87, *Heliport Perimeter Light for Visual Meteorological Conditions (VMC)*, and AC 150/5345-46 for additional information.
4. The elevated light emitting diode (LED) vertiport fixture and LED in-pavement fixtures are identified as L-860 (L) and L-852H (L), respectively.
5. Perimeter light fixtures must meet chromaticity requirements for "aviation green" per SAE AS 25050, *Colors, Aeronautical Lights and Lighting Equipment, General Requirements*, when using incandescent lights. For light fixtures that use LEDs, see the standards in EB67, *Light Sources Other Than Incandescent and Xenon For Airport and Obstruction Lighting Fixtures*.
6. Photometric standards for perimeter light fixtures are included in Table 3-1. See AC 150/5345-46, paragraph 3.3, Photometric Requirements, for detailed measurement methods and standards.

Table 3-1: Perimeter Lighting Intensity and Distribution

	0 to 15 degrees		16 to 90 degrees
Color	**Minimum**	**Minimum average intensity**	**Minimum**
Green	10	15	5



7. Elevated perimeter light fixtures will be installed in a load-bearing light base (L-868, Size B) or non-load-bearing light base (L-867, Size B) per AC 150/5345-42, *Specification for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories*. Shallow base type light bases will not be used.
8. Installation of vertiport lighting is to be in accordance with AC 150/5340-30, *Design and Installation Details for Airport Visual Aids*.

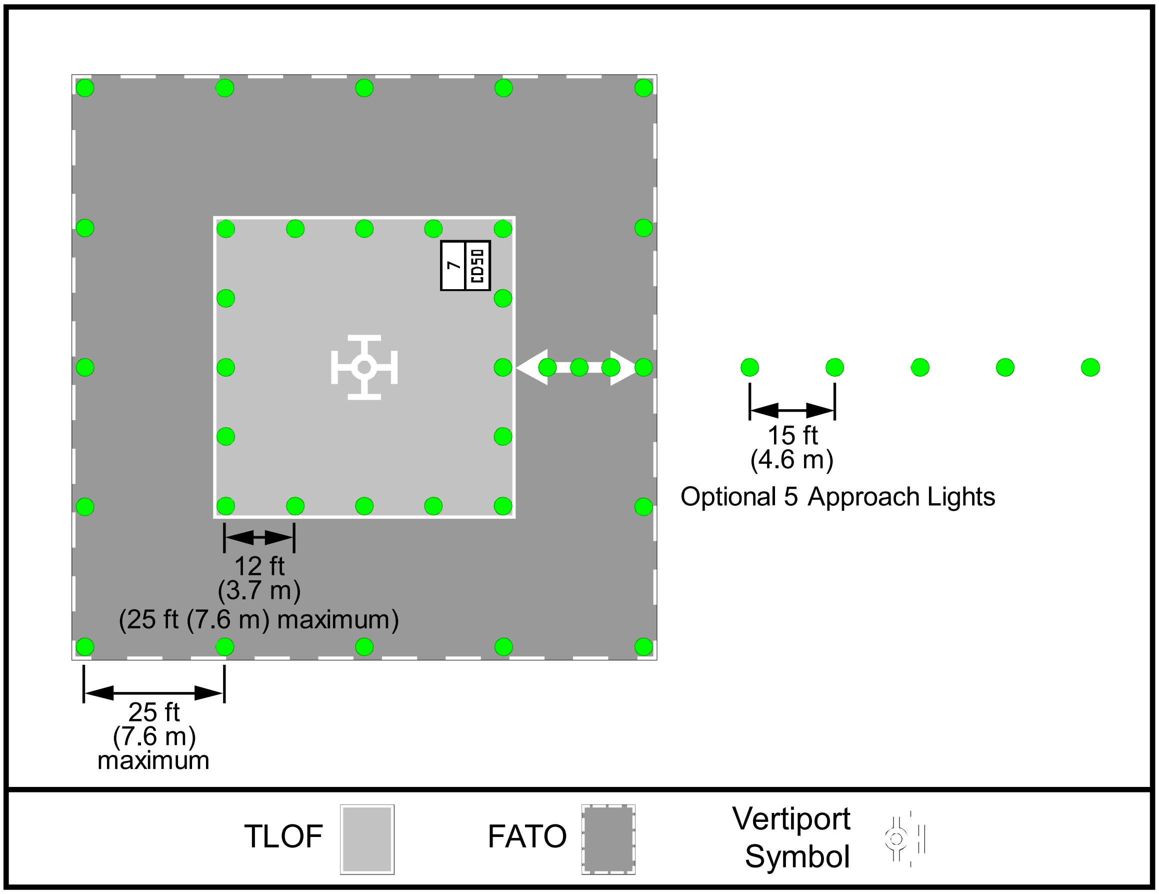
3.5.2. In-Pavement Perimeter Lights on TLOF and FATO

1. TLOF perimeter lights are green and FAA type L-860H (AC 150/5345-46) or FAA type L-852H. LED versions of FAA type L-860H and L-852H are per AC 150/5345-46 and EB 87.
2. A square TLOF has:
   a. One light in each corner.
   b. Lights uniformly spaced between the corners with no less than five lights on each side.
   c. Lights spaced no more than 25 feet (7.6 m) apart.
   d. A light along the centerline of the approach.
3. A circular TLOF has an even number of lights, with a minimum of eight, uniformly spaced.
4. TLOF lights are within 1 foot (0.3 m) inside or outside of the perimeter line.
5. TLOF lights are installed in accordance with AC 150/5340-30.

6. Flight path alignment arrow lighting is recommended for night operations and includes a minimum of three lights spaced 5-10 feet (1.5 to 3 m) apart. These lights may extend across the TLOF, FATO, Safety Area, or any suitable surface in the immediate vicinity of the FATO or Safety Area, if necessary.
7. FATO perimeter lights are optional.
8. If installed, FATO perimeter lights are green and FAA type L-860H (AC 150/5345-46) or FAA type L-852H. LED versions of FAA type L-860H and L-852H are per AC 150/5345-46 and EB 87.
9. A square FATO has:
    a. One light in each corner.
    b. Lights uniformly spaced between the corners with no less than five lights on each side.
    c. Lights spaced no more than 25 feet (7.6 m) apart.
    d. A light along the centerline of the approach.
10. FATO lights are within 1 foot (0.3 m) of the inside or outside of the perimeter line.
11. Approach lights are optional. When installed they include a line of five green, omnidirectional lights located on the centerline of the preferred approach/departure path. The first light is 30 to 60 feet (9.1 to 18.3 m) from the TLOF. Remaining lights are spaced at 15-foot (4.6 m) intervals aligned on the centerline of the approach path.

See Figure 3-7 for additional guidance on perimeter lighting for surface level vertiports. See Figure 3-8 and Figure 3-9 for guidance for lighting for elevated vertiports.

Figure 3-7: TLOF/FATO Perimeter Lighting

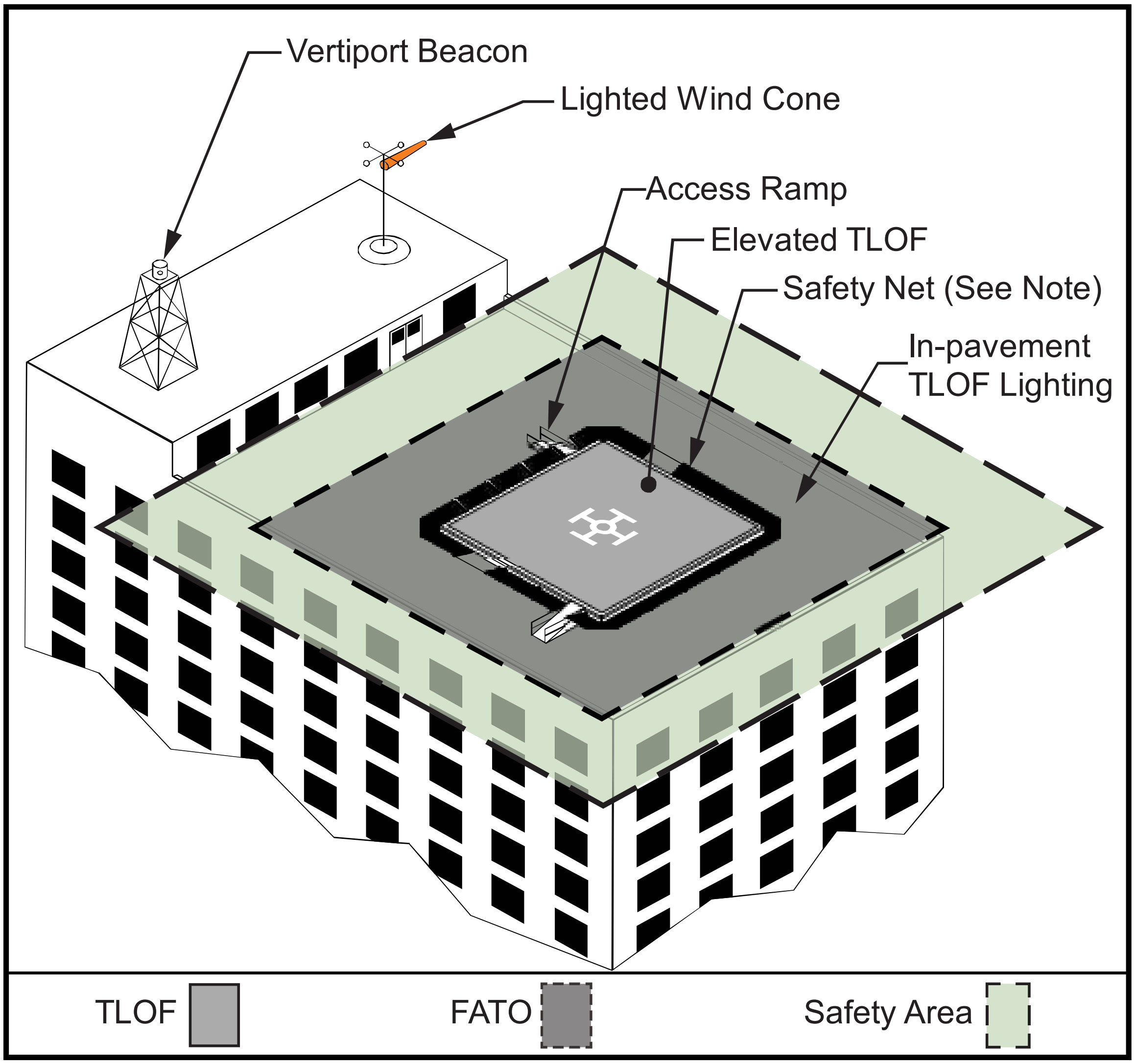


Note 1: In-pavement lights are within 1 foot (0.3 m) of the inside or outside of the TLOF and FATO respective perimeters.

Note 2: Elevated lights are outside and within 10 feet (3 m) of TLOF and FATO respective perimeters.

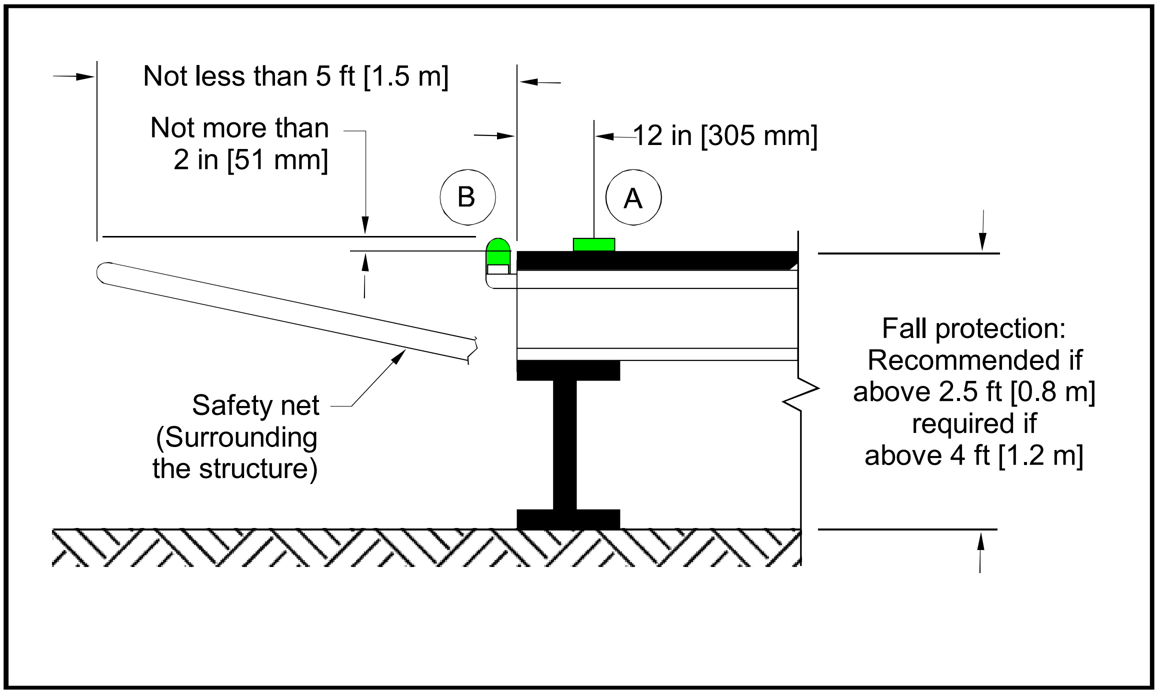
Note 3: Exhibit scaled for 50-foot (15.2 m) TLOF.

Figure 3-8: Elevated Vertiport Configuration



Note: See Figure 3-9 for safety net and lighting details.

Figure 3-9: Elevated Vertiport Perimeter Lighting



Note 1: Install either "A" Type L-852H, or "B" Type L-860H.
Note 2: In-pavement edge light fixture Ⓐ (Type L-852H).
Note 3: Omnidirectional light Ⓑ, mounted off the structure edge (Type L-860H).
Note 4: Ensure elevated lights do not penetrate a horizontal plane at the TLOF elevation by more than 2 inches (51 mm).
Note 5: For TLOF and FATO lighting standards, see EB 87.
Note 6: A safety net's supporting structure should be located below the safety net.

3.5.3. Elevated Perimeter Lights on TLOF and FATO

The same standards for in-pavement lights apply to raised lights except for the following:

1. Lights are omnidirectional.
2. Lights are on the outside edge of the TLOF and FATO.
3. Lights are on frangible elevated light fixtures, no more than 8 inches (203 mm) high, and no more than 10 feet (3 m) out from the TLOF and FATO respective perimeters.
4. Lights do not penetrate a horizontal plane at the TLOF edge elevation by more than 2 inches (51 mm), as shown in Figure 2-2.

See Figure 3-7 for additional information.

3.6. Identification Beacon

An identification beacon is required for night operations. The identification beacon is flashing either white, yellow, or green with a rate of 30 to 45 flashes per minute. Install beacons per the guidance below:

1. AC 150/5345-12, *Specification for Airport and Heliport Beacon*, provides specifications for a beacon.
2. AC 150/5340-30 provides guidelines for installing a beacon.

3.7. Wind Cone

Wind cones provide the direction and magnitude of the wind. The following guidelines apply to wind cones:

1. Minimum of one wind cone conforming to AC 150/5345-27, *Specification for Wind Cone Assemblies*.
2. Orange, yellow, or white in color to provide the best possible contrast to its location's background.
3. Locate to provide valid wind direction and speed information near the vertiport under all wind conditions.
4. Visible to pilots on the approach path when the aircraft is 500 feet (152 m) from the TLOF.
5. Visible to pilots from the TLOF.
6. Located within 500 feet (152 m) of the TLOF.
7. If one location does not provide for all the above, multiple locations may be necessary to provide pilots with all the wind information needed for safe operations.
8. See AC 150/5345-27 and AC 150/5340-30 for primary and secondary wind cones for multiple wind cone requirements.
9. Located outside the Safety Area and does not penetrate the approach/departure or transitional surfaces.
10. Follows installation details specified in AC 150/5340-30.
11. Lighted internally or externally for night operations.

4.0 Charging and Electric Infrastructure

Most early concepts of operation for AAM activity indicate the use of electric propulsion by VTOL aircraft. The electrical needs for these aircraft vary based on design and manufacturer. This EB addresses battery driven technologies. Future guidance will be provided on other emerging energy concepts (e.g., hydrogen).

Electrification of aviation propulsion systems is an evolving area with few industry-specific standards. In addition to relevant national, state, and local building codes, the following sections provide a partial list of relevant standards that may assist when specifying charging systems and facility layout for this emerging industry. Current charging standards for light duty vehicle charging (up to 350kw) align with multiple light electric aircraft currently applying for certification. However, higher capacity batteries and novel systems for meeting operational characteristics may require alternate charging methods including mobile charging systems, fixed battery storage, cable and/or on-board battery cooling, or other concepts.

At the time of this publication, consensus has not been identified nor specified regarding classes of charging or connection standards and could vary based on the aircraft duty cycle, charging speed, battery chemistry, charging system, and battery cooling system, etc. Charging infrastructure design for vertiports should consider adapting to multiple aircraft specific systems. Additional guidance is currently being developed as this industry continues to evolve.

Battery charging must be done in a safe and secure manner. Any batteries stored on site should be stored safely away from safety critical areas. As additional research is developed, further recommendations will be released.

4.1. Standards

National Fire Protection Association (NFPA) Considerations

- NFPA 70, NEC Article 625 - *Electric Vehicle Charging System*: Covers the electrical conductors and equipment external to an electric vehicle that connect an electric vehicle to a supply of electricity by conductive or inductive means, and the installation of equipment and devices related to electric vehicle charging. It also addresses scenarios that would allow the use of load balancing functions on electrical supply systems.

- NFPA 400, *Hazardous Materials Code*: Covers the minimum NFPA standards for the storage and handling of hazardous materials such as lithium batteries.

- NFPA 418, *Standard for Heliports*: This standard establishes fire safety standards for operations of heliports and rooftop hangars for the protection of people, aircraft, and other property. Future editions of this standard will include electric mobility asset considerations.

- NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*: Covers the minimum NFPA standards established for design, installation, and maintenance of a stationary energy storage system including battery storage systems.

4.1.1. Occupational Safety and Health Administration Considerations

- 29 CFR 1910.176, *Handling Materials – General*: This standard provides the minimum requirements for the storage and handling of hazardous materials such as lithium batteries.

4.1.2. Underwriter's Laboratories (UL) Certifications Considerations

The following standards focuses on certifying the components and safety of the systems.

- UL 2202, *Standard for Safety of Electric Vehicle (EV) Charging System Equipment*: Covers conducting charging system equipment (600 volts or less) for recharging batteries in surface electric vehicles.

- UL 2580, *Batteries for Use in Electric Vehicles*: Covers electric equipment storage assemblies in electric powered vehicles.

4.1.3. Power quality Considerations

- IEEE 519-2014, *IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems*: The grid impact of high wattage charging stations needs to be considered when designing and adopting charging stations. This standard provides guidance in the design and compliance of power systems with nonlinear loads.

4.1.4. Vehicle to Infrastructure Considerations

- SAE J1772, *SAE Electric Vehicle Conductive Charge Coupler*: This standard was developed to define the fit and function of a conductive coupler for use in charging electric vehicles. It was later expanded to include direct current (DC) charging through combined alternating current/direct current (AC/DC) physical connector referred to as the Combined Charging Standard (CCS).

- SAE AS6968, *Connection Set of Conductive Charging for Light Electric Aircraft* (under development): An SAE working group has been creating this standard to inform the design and requirements of connectors for use in conductive charging of electrically powered aircraft, with a particular focus on lightweight vehicles and provides up to 250kW charge rates.

- SAE AIR7357, *MegaWatt and Extreme Fast Charging for Aircraft* (under development): This standard is a work in progress under SAE leadership and intended to provide a charging interface for battery packs from 150kWh-1MWh within aircraft.

- Megawatt Charging System (MCS): The MCS is intended to extend the capabilities of the CCS to accommodate the charge rate demands of larger vehicles and thus serve the trucking and aviation sectors. Ratings should exceed 1MW (Max 1,250 volt and

3,000 ampere (DC)) while also addressing communication and controls using ISO/IEC 15118 and meeting UL 2251 touch safe standards.

- ISO/IEC 15118, *Road Vehicles*: Vehicle to grid communication interface: This standard defines the digital communications protocol to be used for the charging of high voltage electric vehicle batteries from a charging station. Beyond the basic handshakes and charge control between a vehicle and a charging station, this standard also includes convenience and security layers that support the "plug and charge" experience. Additionally, it offers the potential to schedule and coordinate the charging demands with the grid conditions.

5.0 On-Airport Vertiports

To support AAM operations, certain OEMs and operators are interested in developing vertiports on airports and modifying existing on-airport helicopter landing facilities. All federally obligated airport sponsors are required to ensure the safety, efficiency, and utility of the airport and to provide reasonable and not unjustly discriminatory access to all aeronautical users.

This chapter addresses design considerations for separate vertiport facilities on airports. VTOLs can operate on airports without interfering with airplane traffic and operations. Operations can occur on existing airport infrastructure (e.g., on airport taxiways) or on dedicated vertiport facilities.

Separate vertiport facilities and approach/departure procedures may be needed when the volume of airplane and/or VTOL traffic affects operations. Airports with interconnecting passenger traffic between VTOLs and fixed wing aircraft should generally provide access between the respective terminals for boarding with applicable security measures in place.

Any new vertiport infrastructure or fixed equipment must be depicted on the ALP and submitted for FAA review prior to development and operation. For projects subject to FAA approval, an appropriate level of environmental review under the National Environmental Policy Act (NEPA) is required. These on-airport vertiport facilities should follow all guidance detailed in this EB. Aircraft that use existing infrastructure may do so if they comply with all rules and obligations of the airport sponsor.

For facilities being built on non-federally obligated airports, in compliance with Part 157, the sponsor or proponent must submit FAA Form 7480-1 at least 90 days in advance of the day that construction work is to begin on the vertiport landing area.

5.1. On-Airport Location of TLOF

Locate the TLOF to provide ready access to the airport terminal with applicable security measures in place or to the VTOL user's origin or destination. Locate the TLOF away from aircraft movement areas (e.g., runways, taxiways, and aircraft parking aprons).

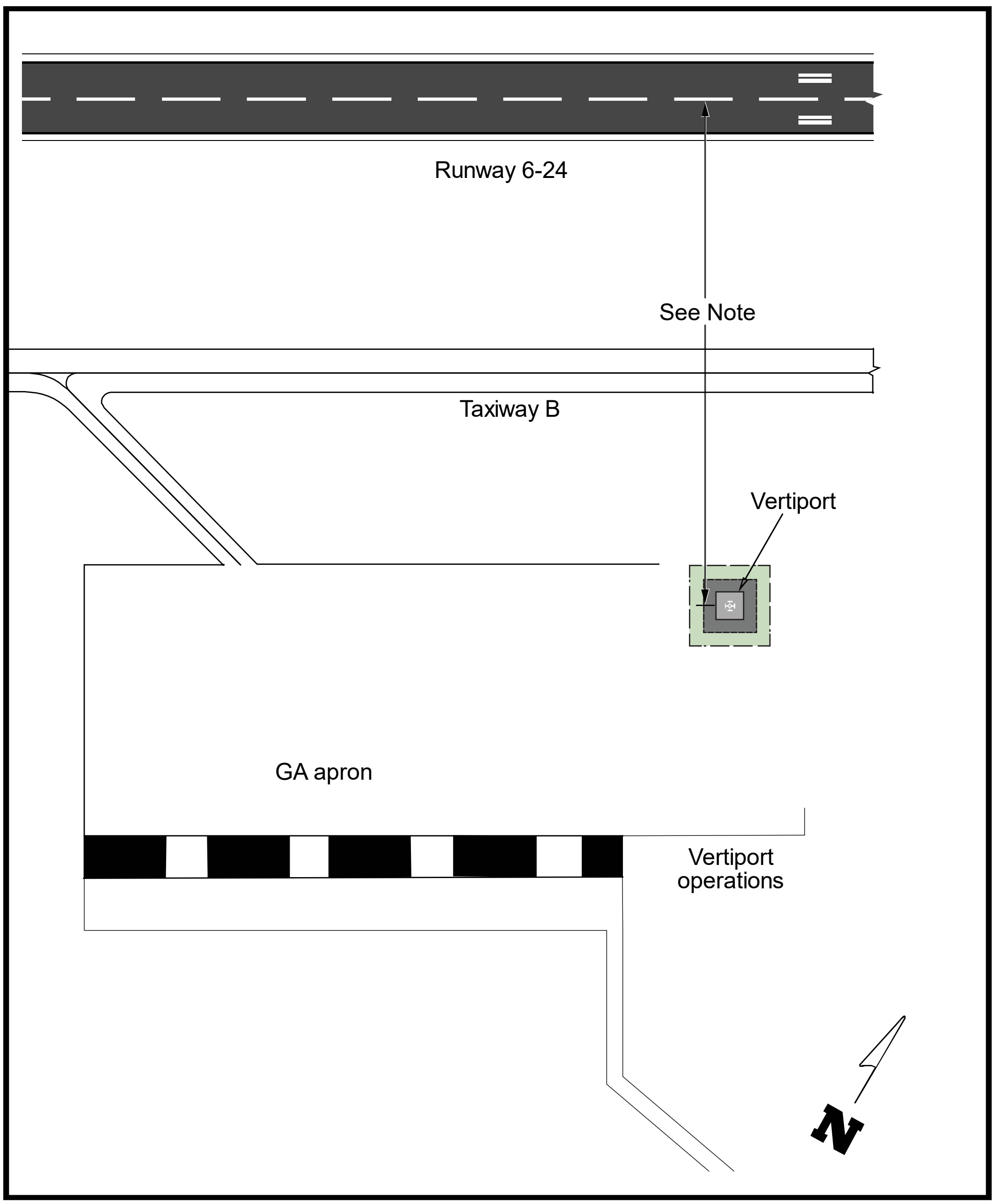
5.2. On-Airport Location of FATO

See Table 5-1 for standards of the distance between the centerline of an approach to a runway and the centerline of an approach to a vertiport's FATO for simultaneous, same-direction VFR operations. Figure 5-1 depicts an example of an on-airport Vertiport location.

Table 5-1: Recommended Distance between Vertiport FATO Center to Runway Centerline for VFR Operations

Airplane Size	Distance from Vertiport approach to Runway approach
Small Airplane (12,500 pounds (5,670 kg) or less)	300 feet (91 m)
Large Airplane (12,500-300,000 pounds (5,670-136,079 kg))	500 feet (152 m)
Heavy Airplane (Over 300,000 pounds (136,079 kg))	700 feet (213 m)

Figure 5-1: Example of an On-airport Vertiport



Note: See Table 5-1.

5.3. VFR Approach/Departure Paths

To the extent practicable, design vertiport approach/departure paths to be independent of approaches to, and departures from, active runways if separate vertiport landing areas are needed.

6.0 Site Safety Elements

6.1. Fire Fighting Considerations

The procedures to put out a battery system fire on an aircraft may differ from one VTOL to another. Previous FAA research with small lithium battery cells found that water and other aqueous-based fire extinguishing agents were more effective for suppressing lithium battery fires and preventing thermal runaway than gas or dry powder extinguishing agents during experiments within a 4-foot (1.2 m) by 4-foot (1.2 m) by 4-foot (1.2 m) test chamber[†††]. The cooling effect of the extinguishing agent was the key factor in preventing the fire from spreading. Although this method was found to be effective for small battery packs, it is yet to be determined if similar results would be achieved with large battery packs.

The firefighting techniques for VTOL aircraft are still unknown and may differ from model to model. Providing adequate fire protection for VTOL aircraft on vertiports will require a full understanding of the hazards related to the specific aircraft that will be using the vertiport. This also applies to the utility infrastructure needed to charge the VTOL aircraft.

Vertiports will also need to comply with applicable local fire, environmental, and zoning regulations. Vertiport operators will need the means to control and extinguish VTOL aircraft fires. Firefighting personnel, including local first responders, should be trained and equipped to manage the specific needs associated with electric aircraft such as lithium battery fires, electrical fires, toxic gas emissions, and high voltage electrical arcing.

Firefighting equipment should be adjacent to, but outside, the TLOF and FATO area. Fire safety equipment should be clearly marked for conspicuousness from anywhere within or outside the FATO. For elevated sites, fire equipment may be located below the level of the FATO but must be fully accessible under all circumstances and clearly marked to anyone on the TLOF and FATO.

The current NFPA 418, *Standard for Heliports* (2021), is based on conventional liquid fuel and its dangers and risks. This standard is currently under revision to account for electrical hazards and fire safety standards for vertiports, which is expected to be published on or before January 2024.

6.2. Security

For vertiports located in secured airport environments, unless screening was carried out at the VTOLs passengers' departure location, Transportation Security Administration regulations may require that a screening area and/or screening be provided before passengers enter the airport's secured areas. If necessary, airports should establish multiple VTOL parking positions and/or locations in the terminal area to service VTOL

[†††] Maloney, Thomas. DOT/FAA/TC-13/53, *Extinguishment of Lithium-Ion and Lithium-Metal Battery Fires*. Federal Aviation Administration, 2014.

passenger screening and/or cargo needs. General information about passenger screening is available on the Transportation Security Administration website, www.tsa.gov/public/.

Controlling vertiport access and keeping operational areas clear of people, animals, equipment, debris, and vehicles is important for safety and security. The following guidelines apply to safety barriers and access control measures:

1. For ground-level vertiports, erect a safety barrier around the VTOL aircraft operational areas in the form of a fence or a wall outside of the Safety Area and below the 8:1 elevation of the approach/departure surface.
2. If necessary, near the approach/departure paths, install the barrier well outside the outer perimeter of the Safety Area and below the elevation of the approach/departure and transitional surfaces described in paragraph 2.5.
3. Safety barriers must be high enough to present a positive deterrent to persons inadvertently or maliciously entering an operational area, but at a low enough elevation to be non-hazardous to all aircraft operations.
4. Provide control access to airport airside areas with adequate security measures as required or recommended by the Transportation Security Administration.
5. Display a vertiport caution sign like that shown in Figure 6-1 at all vertiport access points.

For on-airport vertiports, proponents should work with their local Transportation Security Administration security representative.

Figure 6-1: Vertiport Caution Sign

6.3. Downwash

The downwash and outwash impacts of VTOL are still being researched. However, the impacts of the ground geometry, surrounding infrastructure, and the re-circulatory flow impact on rotor aerodynamics performance and vehicle flight dynamics should still be considered in vertiport siting.

If downwash and outwash of the VTOL will create safety issues for people or property, or if the VTOL aircraft aerodynamic performance will be impacted by how the downwash and outwash interacts with the surrounding ground or infrastructure, then the TLOF, FATO, and Safety Areas should be adjusted appropriately, or alternative mitigations should be taken.

6.4. Turbulence

Air (e.g., wind) flowing around and over buildings, stands of trees, terrain irregularities, and elsewhere can create turbulence on ground-level and rooftop vertiports that may affect VTOL operations. The following guidelines apply to turbulence:

1. When possible, locate the TLOF away from buildings, trees, and terrain to minimize air turbulence near the FATO and the approach/departure paths.
2. Assess the turbulence and airflow characteristics near and across the surface of the FATO to determine if a turbulence mitigating design measures are necessary (e.g., air gap between the roof, roof parapet, or supporting structure).
3. A minimum six-foot (1.8 m) unobstructed air gap on all sides above the level of the top of a structure (e.g., roof) and the elevated vertiport will reduce the turbulent effect of air flowing over it.
4. Where an air gap or other turbulence-mitigating design measures are not taken on elevated structures, operational limitations may be necessary under certain wind conditions.

6.5. Weather Information.

An automated weather observing system (AWOS) measures and automatically broadcasts current weather conditions at the vertiport site. When installing an AWOS, locate it at least 100 feet (30.5 m) and not more than 700 feet (213 m) from the TLOF and such that its instruments will not be affected by rotor wash from VTOL operations. Find guidance on AWOS systems in AC 150/5220-16, *Automated Weather Observing Systems (AWOS) for Non-Federal Applications*, and FAA Order 6560.20, *Siting Criteria for Automated Weather Observing Systems (AWOS)*. Other weather observing systems will have different siting criteria.

6.6. Winter Operations.

Swirling snow dispersed by an VTOL's rotor wash can cause the pilot to lose sight of the intended landing point and/or obscure objects that need to be avoided.

1. Design the vertiport to accommodate the methods and equipment to be used for snow removal.
2. Design the vertiport to allow the snow to be removed sufficiently so it will not present an obstruction hazard.
3. For vertiports in winter weather, an optional dark TLOF surface can be used to absorb more heat from the sun and melt residual ice and snow.
4. Find guidance on winter operations in AC 150/5200-30, *Airport Field Condition Assessments and Winter Operations Safety*.

Acronym List

AAM	advanced air mobility
AC	Advisory Circular
AC	alternating current
AGL	above ground level
ALP	Airport Layout Plan
AWOS	automated weather observing system
CCS	combined charging standard
CFR	Code of Federal Regulations
CD	controlling dimension
DC	direct current
EB	Engineering Brief
ETL	effective transitional lift
EV	electric vehicle
eVTOL	electric vertical takeoff and landing
FAA	Federal Aviation Administration
FATO	final approach and takeoff area
FC	failure condition
HOGE	hover out of ground effect
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFR	instrument flight rules
ISO	International Organization for Standardization
LDR	landing distance required
LED	light emitting diode

LOB	line of business
MCS	megawatt charging system
MTOW	maximum takeoff weight
NEC	National Electric Code
NEPA	National Environmental Policy Act
NEMSPA	National EMS Pilots Association
NFPA	National Fire Protection Association
OEM	original equipment manufacturer
PCC	Portland cement concrete
RTODR	rejected takeoff distance required
SAE	SAE International
TDP	takeoff decision point
TLOF	touchdown and liftoff area
TODR	takeoff distance required
TSA	Transportation Security Administration
UL	Underwriters Laboratories
VFR	visual flight rule
VMC	visual meteorological conditions
VTOL	vertical takeoff and landing