



Federal Aviation Administration

Memorandum

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To: All Airports Regional Division Managers

From: Michael A.P. Meyers, P.E.
Manager, Airport Engineering Division, AAS-100

A handwritten signature in black ink, appearing to read "M. Meyers", written over a faint, light-colored watermark or background.

Prepared by: Robert Bassey, P.E., AAS-110

Subject: Engineering Brief No. 105, Vertiport Design

This Engineering Brief provides interim guidance for the design of vertiports for aircraft with vertical takeoff and landing (VTOL) capabilities. Note that this interim guidance will be subject to update as data, analysis, and VTOL aircraft and operations develop in the future.

Attachment



**FAA
Airports**

ENGINEERING BRIEF #105

Vertiport Design

I Purpose.

This Engineering Brief (EB) specifies design guidance for public and private vertiports and vertistops, including modification of existing helicopter and airplane landing facilities, and establishment of new sites. While the design guidance contained herein refers to vertiport design, the design guidance applies to both vertiports and vertistops where appropriate. This EB is written for vertical takeoff and landing (VTOL) aircraft powered with electric motors and utilizing distributed electric propulsion in contrast to propulsion systems built solely around an internal combustion engine.

At this time, the Federal Aviation Administration (FAA) does not have enough validated VTOL aircraft performance data and necessarily is taking a prescriptive and conservative approach with the recommendations in this EB. Vertiport guidance is expected to evolve into a performance-based design standard, potentially with aircraft grouped by their performance characteristics. This EB is written for aircraft with a maximum takeoff weight (MTOW) of 12,500 lbs (5,670 kg) or less.

This EB is a living document that serves as the FAA's initial interim guidance and will be updated over time to adapt and address new aircraft and technology as performance data is received. Figures in this document are general representations and are not to scale.

II Background.

The 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 are not proven to perform like conventional helicopters or very large tiltrotor aircraft.

This EB provides the interim guidance needed to support initial infrastructure development for VTOL operations. This EB provides guidance for existing vertiport design and geometry elements. This guidance is correlated to the reference VTOL

aircraft described in paragraph 1.5 below. The Reference Aircraft represents a VTOL aircraft that integrates certain performance and design characteristics of nine emerging aircraft currently in development and is used to specify certain performance and design characteristics that informed the guidance in this EB. The Reference Aircraft was developed based on interactions with original equipment manufacturers (OEMs) and multiple FAA lines of business (LOBs).

There is currently limited demonstrated performance data on how VTOL 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, as additional performance data is gleaned about these emerging VTOL aircraft. The AC will detail categories of vertiport facilities requiring different design criteria depending on the characteristics of the aircraft they plan to support as well as the activity levels at the facility.

The future guidance will address more advanced operations including autonomy, different propulsion methods, density, frequency, and complexity of operations facilities. The AC on vertiport design will also address VTOL aircraft using alternative fuel sources such as hydrogen and hybrid. Future guidance will also include aircraft that do not currently conform to the Reference Aircraft included in this EB (for example, aircraft with an MTOW over 12,500 pounds (5,670 kg)) and address instrument flight rules (IFR) capability and the use of multiple final approach and takeoff areas (FATOs).

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. This will require coordination within the FAA across the various LOBs, as well as external collaboration with manufacturers and other stakeholders. A proponent interested in sharing data must work with FAA Office of Airport Safety and Standards to provide validated empirical data that addresses these performance data gaps.

III Application.

This EB is intended as interim guidance for vertiport design until a more comprehensive performance-based vertiport design AC is developed. The guidance herein is not legally binding in its own right and will not be relied upon by the FAA as a separate basis for affirmative enforcement action or other administrative penalty. Conformity with this guidance, as distinct from existing statutes, regulations, and grant assurances, is voluntary only, and nonconformity will not affect existing rights and obligations. The standards and guidance contained in this EB are practices the FAA recommends to establish an acceptable level of safety, performance and operation in the design of new civil vertiports, and for modifications of existing helicopter and airplane landing facilities to accommodate operations of VTOL aircraft.

The vertiport design criteria in this EB is intended for VTOL aircraft that meet the performance criteria and design characteristics of the Reference Aircraft described in

paragraph 1.5 and Table 1-1, 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) area, FATO area, and Safety Area at one time. Vertiport operators working with the proponent referencing this EB are responsible for confirming the ingress and egress path is clear. See paragraph 2.5.

Table 1-1: Reference Aircraft

Design Characteristics	Criteria
Propulsion	Electric battery driven, utilizing distributed electric propulsion
Propulsive units	2 or more
Battery systems	2 or more
Maximum takeoff weight (MTOW)	12,500 pounds (5,670 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	Hover out of ground effect (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 overall safety

Further research is needed to understand VTOL taxiing and parking needs. In future guidance, parking and taxiway guidance will be included. If necessary in the interim, vertiports designed for ground taxiing can follow AC 150/5300-13, Airport Design, taxiway guidelines for Group 1 aircraft. For hover taxi, vertiport design should follow taxiway guidance in AC 150/5390-2, Heliport Design, for the Transport Category. For parking, vertiport design should follow guidance in AC 150/5390-2 for the Transport Category.

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 built to the Transport Category heliport design standard, as described in paragraph 3.0.

This EB provides guidance on marking, lighting, and visual aids that identify the facility as a vertiport. This guidance applies to new vertiports or to heliports that are altered to vertiports.

Vertiport facilities that are intended to serve aircraft that do not meet the performance criteria and design characteristics of the Reference Aircraft included in this EB should begin coordination with the applicable FAA Regional or Airports District Office early in the planning and design process for the takeoff and landing area and will be subject to review on a case-by-case basis.

V Questions.

Contact the FAA Airport Engineering Division, AAS-100, 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.

Table of Contents

1.0	Introduction.....	8
1.1.	Engineering Brief (EB) Guideline Justification.....	8
1.2.	Explanation of Terms.....	9
1.3.	Airspace Approval Process and Coordination.	11
1.4.	State/Local Role.....	12
1.5.	Reference Aircraft.....	12
2.0	Vertiport Design and Geometry.	14
2.1.	Overview.....	14
2.2.	TLOF Guidance.	15
2.3.	FATO Guidance.....	17
2.4.	Safety Area Guidance.	19
2.5.	VFR Approach/Departure Guidance.....	20
3.0	Marking, Lighting, and Visual Aids.....	24
3.1.	General.....	24
3.2.	Identification Symbol.....	26
3.3.	TLOF Size/Weight Limitation Box.	27
3.4.	Flight Path Alignment Optional Marking and Lighting.	31
3.5.	Lighting.....	33
3.6.	Identification Beacon.	40
3.7.	Wind Cone.	40
4.0	Charging and Electric Infrastructure.....	41
4.1.	Standards.....	41
5.0	On-Airport Vertiports.....	44
5.1.	On-Airport Location of TLOF.....	44
5.2.	On-Airport Location of FATO.....	44
6.0	Site Safety Elements.....	46
6.1.	Fire Fighting Considerations.....	46
6.2.	Security and Safety.	46
6.3.	Downwash/Outwash.	48
6.4.	Turbulence.	48
6.5.	Weather Information.....	49
6.6.	Winter Operations.....	49

6.7. Access to Vertiports by Individuals with Disabilities.....	49
Acronym List.....	50

Figures

Figure 2-1: Relationship and Dimensions of TLOF, FATO, and Safety Area.....	14
Figure 2-2: Vertiport Gradients and Rapid Runoff Shoulder	17
Figure 2-3: VFR Vertiport Approach/Departure Surfaces.....	22
Figure 3-1: Standard Vertiport Marking.....	25
Figure 3-2: Vertiport Identification Symbol	26
Figure 3-3: TLOF Size/Weight Limitation Box	28
Figure 3-4: Form and Proportions of 36-inch (914 mm) Numbers for Marking Size and Weight Limitations	29
Figure 3-5: Form and Proportions of 18-inch (457 mm) Numbers for Marking Size and Weight Limitations	30
Figure 3-6: Flight Path Alignment Marking and Lighting.....	32
Figure 3-7: TLOF/FATO Perimeter Lighting.....	36
Figure 3-8: Elevated Vertiport Configuration Example	37
Figure 3-9: Elevated FATO Perimeter Lighting.....	38
Figure 5-1: Example of an On-airport Vertiport.....	45
Figure 6-1: Vertiport Caution Sign.....	48

Tables

Table 1-1: Reference Aircraft	4
Table 2-1: Takeoff and Landing Area Dimensions	14
Table 3-1: Perimeter Lighting Intensity and Distribution.....	34
Table 5-1: Recommended Minimum Distance between Vertiport FATO Center to Runway Centerline for VFR Operations.....	45

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 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 Reference Aircraft described in paragraph 1.5.

Heliports provide the most analogous present-day model for vertiports. However, despite the similarities between the two types of aircraft, there are design differences between traditional helicopters and VTOL aircraft. VTOL aircraft have 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 $0.83 \times$ the overall length being used to calculate the main rotor diameter of the design helicopter is not representative of the diverse characteristics associated 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, recommends 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. Due to these performance data gaps, including downwash, the larger physical dimensions would accommodate a potentially wider landing scatter and decreased climb performance in different scenarios

The anticipated Advanced Air Mobility (AAM) density, frequency, and complexity of operations is expected to be high in some cases. These operations are also anticipated to include commercial and air carrier operators, and will require certain safety levels and infrastructure requirements most analogous to the predetermined level of safety set in the Transport Category heliport design guidelines in AC 150/5390-2.

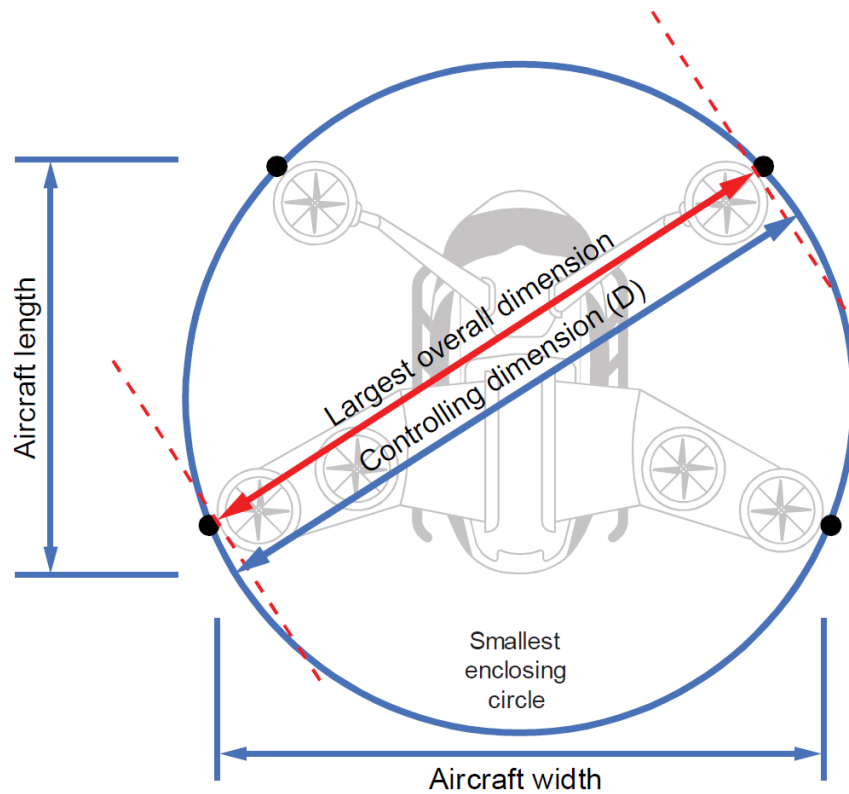
Preliminary data garnered from the VTOL aircraft manufacturers to support the development of this EB claims no need by the aircraft for effective transitional lift (ETL) to fly and an ability to hover out of ground effect (HOGE). Therefore, the minimum sizing standards that accommodate the need for ETL 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 VTOL 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 VTOL 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 taking off from a vertiport.
2. *Battery*: One or more electrically connected cells, assembled in a single container having positive and negative terminals. A battery may include inter-cell connectors and other devices.
3. *Battery pack*: Two or more battery systems.
4. *Battery system*: Comprised of the battery, the battery charger and any protective, monitoring, and alerting circuitry or hardware inside or outside of the battery. It also includes vents (where necessary) and packaging.
5. *Controlling dimension (D)*: The diameter of the smallest circle enclosing the VTOL aircraft projection on a horizontal plane, while the aircraft is in the takeoff or landing configuration, with rotors/propellers turning, if applicable. See [Figure 1-1](#).
6. *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 VTOL aircraft is used to size the TLOF, FATO and Safety Area. Note that the design VTOL aircraft is different from the Reference Aircraft used to define the performance and design criteria in this EB.
7. *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.
8. *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 (a ground level vertiport with the TLOF on a mound is not an elevated vertiport).
9. *Effective transitional lift (ETL)*: The pronounced increase in translational lift during transition to forward flight due to the rotor/propeller experiencing a significantly decreased induced airflow.
10. *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.

Figure 1-1: Controlling Dimension



11. *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.
12. *Ground Effect*: A condition of usually improved performance encountered when the aircraft is operating very close to the ground or a surface. It results from a reduction in upwash, downwash, and/or blade tip vortices, which provide a corresponding decrease in induced drag.
13. *Hover*: The word “hover” applies to an aircraft that is airborne and remaining in one place at a given altitude over a fixed geographical point regardless of wind. Pure hover is accomplished only in still air. For the purpose of this EB, the word “hover” will mean pure hover.
14. *Hover out of ground effect (HOGE)*: The ability to achieve hover without the benefit of the ground or a surface.
15. *Imaginary surface(s)*: The imaginary planes defined in Title 14 Code of Federal Regulations (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.

16. *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*.
17. *Reference Aircraft:* The Reference Aircraft represents a VTOL aircraft that integrates certain performance and design characteristics of nine emerging aircraft currently in development. This Reference Aircraft is used to specify certain performance and design characteristics that informed the vertiport design guidance in this EB.
18. *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.
19. *Translational Lift:* Translational lift is the improved rotor/propeller efficiency resulting from directional flight.
20. *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.
21. *Vertiport:* An area of land, or a structure, used or intended to be used, for electric, hydrogen, and hybrid VTOL aircraft landings and takeoffs and includes associated buildings and facilities.
22. *Vertiport elevation:* The highest elevation of all usable TLOFs within the vertiport expressed in feet above mean sea level (MSL).
23. *Vertistop:* A vertistop is a term generally used to describe a minimally developed vertiport for boarding and discharging passengers and cargo (i.e., no fueling, defueling, maintenance, repairs, or storage of aircraft, etc.). The design standards and recommendations in this EB apply to all vertiports, which includes vertistops.

1.3. Airspace Approval Process and Coordination.

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.

For development on non-federally obligated airports or heliports or for non-federally funded standalone vertiport sites, and in compliance with 14 CFR Part 157, *Notice of Construction, Alteration, Activation, and Deactivation of Airports*, 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 takeoff and landing area. **Note:** Airspace determination is not tied to this 90-day advance notice. Given the nascence of the AAM industry, 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.

Heliport facilities that are being altered in geometry in accordance with the design criteria in this EB, if non-federally funded, the sponsor will need to submit a new Form 7480-1 to re-designate the facility as a vertiport before VTOL operations should commence at the

site. The [Form 7480-1](#) can be submitted electronically as a Landing Area Proposal (LAP) at OEAAA.faa.gov. The FAA's Flight Standards Service Office will determine when to do an onsite evaluation using risk-based analysis.

1.4. State/Local Role.

Many state departments of transportation, aeronautics commissions, or similar authorities require prior approval and, in some instances, a license or permit to establish and operate landing facilities. 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 or permitting. Several states and municipalities also administer a financial assistance program like the federal program and are staffed to provide technical advice. 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, proponents, or sponsors seeking to establish a public- or private-use 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. Lack of early coordination can cause airspace, operational, safety, capacity, and financial impacts. While the FAA will review all new vertiport proposals for the safe and efficient utilization of navigable airspace by aircraft and the safety of persons and property on the ground, early coordination with these entities may offer early insights into airspace and capacity conflicts before investments are made.

1.5. Reference Aircraft.

The Reference Aircraft represents a VTOL aircraft that integrates certain performance and design features of nine emerging aircraft currently in development. This Reference 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 aircraft 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 takeoff and 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 Reference Aircraft type to inform this EB. The design characteristics, performance, and operating conditions that make up this reference VTOL aircraft will be reviewed in the future as the FAA continues to engage with emerging VTOL aircraft manufacturers.

2.0 Vertiport Design and Geometry.

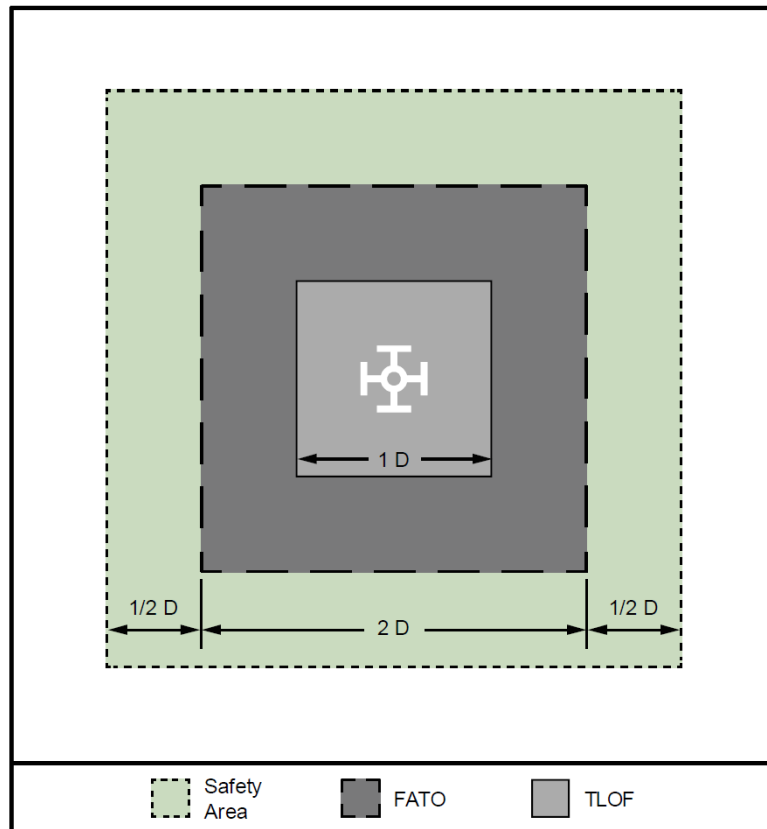
2.1. Overview.

The takeoff and 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 (D) of the design VTOL aircraft as defined for each vertiport facility. The D is the diameter of the smallest circle enclosing the VTOL aircraft projection on a horizontal plane, while the aircraft is in the takeoff or landing configuration, with rotors/propellers turning, if applicable. See [Figure 1-1](#). 1D 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: Takeoff and Landing Area Dimensions

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

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



Note: As empirical validated performance data for individual VTOL aircraft is analyzed and understood, this criteria may be adjusted appropriately.

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 VTOL 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.
 - b. Supports the dynamic loads based on 150 percent of the maximum takeoff weight of the design VTOL aircraft. For design purposes, assume the dynamic load at 150 percent of the maximum takeoff weight applied over the whole landing gear for a landing gear with wheels, and at the single point of contact for a landing gear with skids.
 - c. Accounts for rotor/propeller downwash load in load-bearing capacity.
5. Centered within its own FATO.
6. Minimum width is $1D^{\dagger}$.
7. For a circular TLOF, minimum diameter is $1D$.
8. Minimum length is $1D^{\S}$.
9. Circular, square, or rectangular in shape[‡]. The TLOF should have the same shape as the FATO and Safety Area.
10. Design the distance between the TLOF, FATO and Safety Area perimeters to be equidistant regardless of the shape of the TLOF.
11. Meets general surface characteristics and pavement guidelines including the following:

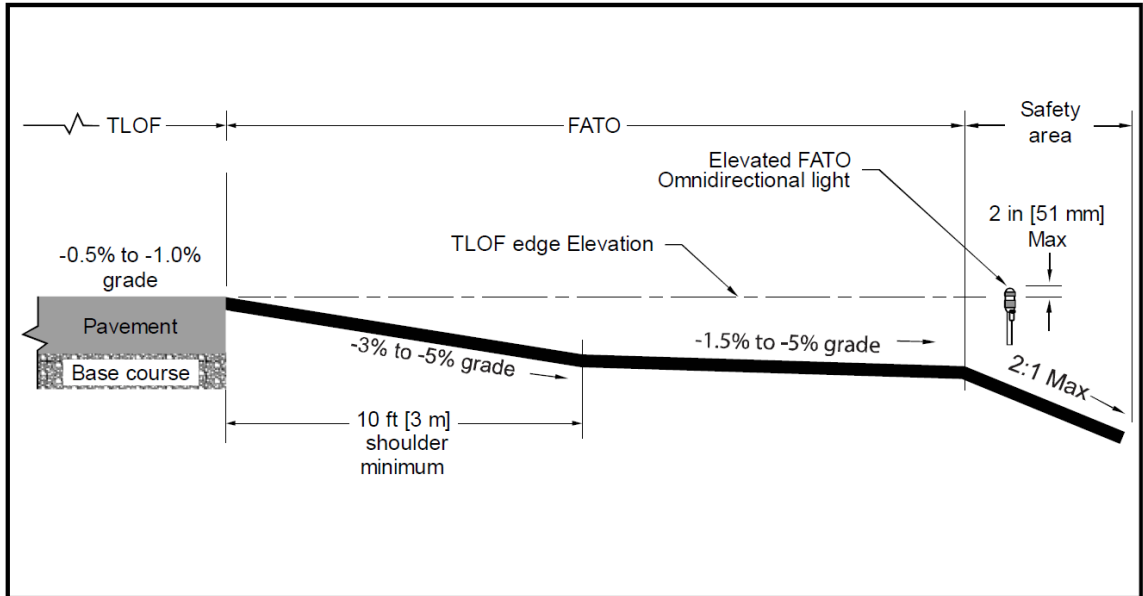
^{*} A vertiport is considered elevated if it is located on a rooftop or other elevated structure where the TLOF and FATO are at least 30 inches (0.8 m) above the surrounding surface.

[†] The controlling dimension (D) 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. $1D$ is equal to the longest distance described above. $2D$ 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.

- a. Has a paved or aggregate-turf surface (see AC 150/5370-10, *Standard Specifications for Construction of Airports*, items P-217, Aggregate-Turf Runway/Taxiway, and P-501, Cement Concrete Pavement).
 - b. Uses cement concrete pavement 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/propeller 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 or metal. If the surface is conductive, it may need to be insulated and/or grounded to the extent feasible to eliminate the threat of conducting electricity in cases of a short circuit or lightning strike. If the surface is metal, it should be grounded. Insulation is permissible if grounding is not feasible. Construct rooftop and other elevated TLOFs of metal, concrete, or other materials subject to local building codes.
 - g. Elevated TLOFs comply with 29 CFR Section 1926.34, *Means of Egress*, and 29 CFR Section 1910.25, *Stairways*, as applicable.
12. Gradient provides positive drainage (between -0.5 and -1.0 percent) off of and away from the pavement as shown in Figure 2-2.
13. 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.
 - d. See paragraph 6.4, Turbulence.

Figure 2-2: Vertiport Gradients and Rapid Runoff Shoulder



Note 1: The slope direction is based on the topography of the site.

Note 2: Grade the TLOF, FATO, and Safety Area to provide positive drainage of the entire area for the TLOF, FATO, and Safety Area.

Note 3: 2:1 maximum Safety Area gradient for vertiports at ground level or where applicable at elevated structures.

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 (e.g., flight path alignment marking and lighting, approach lighting, TLOF lights)[§], which must be on frangible mounts.

Note: While there is no accepted standard for frangibility regarding VTOL operations, remove all objects from a FATO and Safety Area except those of the lowest mass practicable and frangibly mounted objects no higher than 2 inches (51 mm) above the adjacent TLOF elevation, to the extent practicable.

3. Load bearing (static and dynamic for design VTOL aircraft), including the following features:

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

- 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/propeller downwash load is accounted for in load-bearing capacity.
4. Centered within its own Safety Area.
5. Minimum width is 2D.
6. Minimum length is 2D.
7. For a circular FATO, minimum diameter is 2D.
8. The same geometric shape as the TLOF** 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. Paved or aggregate-turf surface (see [AC 150/5370-10](#), items P-217, Aggregate-Turf Pavement and P-501, Cement Concrete Pavement).
 - b. Uses cement concrete pavement 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.
 - e. Surface is stabilized to prevent erosion of damage from rotor/propeller 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 lightning strike.
 - g. Elevated FATOs should be metal or concrete and comply with 29 CFR [Section 1926.34](#) and 29 CFR [Section 1910.25](#), as applicable.
11. The FATO surface prevents loose stones and any other flying debris caused by rotor/propeller downwash or outwash.

** 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.

12. Gradient provides positive drainage (between 1.5 and 5.0 percent) off of and away from the pavement, with a minimum 10-foot wide (3 m wide) rapid runoff shoulder sloped between 3.0 and 5.0 percent, as shown in [Figure 2-2](#). Design a negative gradient of not more than 2 percent in any areas where a VTOL is expected to land.
13. The edge of the FATO abutting the TLOF is the same elevation as the TLOF.
14. If the FATO is located on a rooftop or other elevated structures:
 - a. The 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 [Section 1910.28](#), *Duty to Have Fall Protection and Falling Object Protection*, requires the provision of fall protection if the platform is elevated 4 feet (1.2 m) or more above its surroundings. The FAA recommends such protection 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 is 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. **Note:** See paragraph [2.3](#).

^{††} An air navigation aid that must be positioned in a particular location to provide an essential benefit for aviation is fixed-by-function.

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. **Note:** See paragraph 2.3.
4. Minimum width is $\frac{1}{2}$ D from the edge of the FATO.
5. Minimum length is $\frac{1}{2}$ D 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. If at ground level, 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 Section 1910.28.

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.

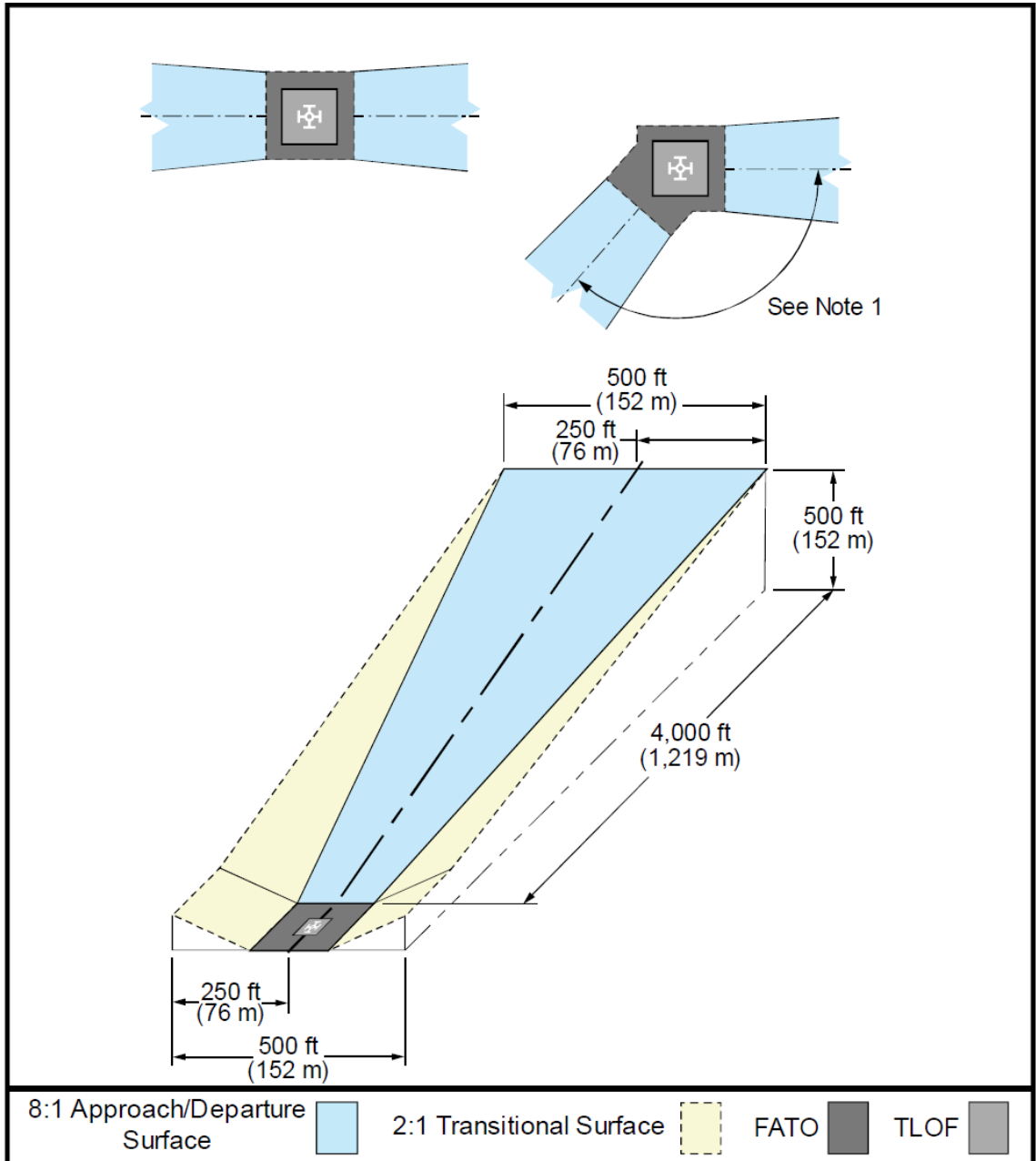
The following applies to these imaginary surfaces:

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.
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 taking off 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 degrees and 360 degrees).
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.
6. To the extent practicable, design vertiport approach/departure paths to be independent of approaches to, and departures from, active runways if separate vertiport takeoff and landing areas are needed.
7. The approach and departure path may be curved but only the VFR approach/departure and transitional surfaces outlined in paragraph 2.5.1 are addressed in 14 CFR Part 77, *Safe, Efficient Use and Preservation of the Navigable Airspace*. Therefore, while they may be used, curved approaches are not evaluated by the FAA for the effect of objects (temporary or permanent, existing or new) on aeronautical operating procedures. These curved approaches are also not considered in aeronautical charting for new objects.

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

3.0 Marking, Lighting, and Visual Aids.

This section provides guidance on marking, lighting, and visual aids that identify the facility as a vertiport. This guidance applies to new vertiports or to heliports that are altered 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 and/or night vision goggles.
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) solid 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 the standard vertiport marking.

Figure 3-1: Standard Vertiport Marking

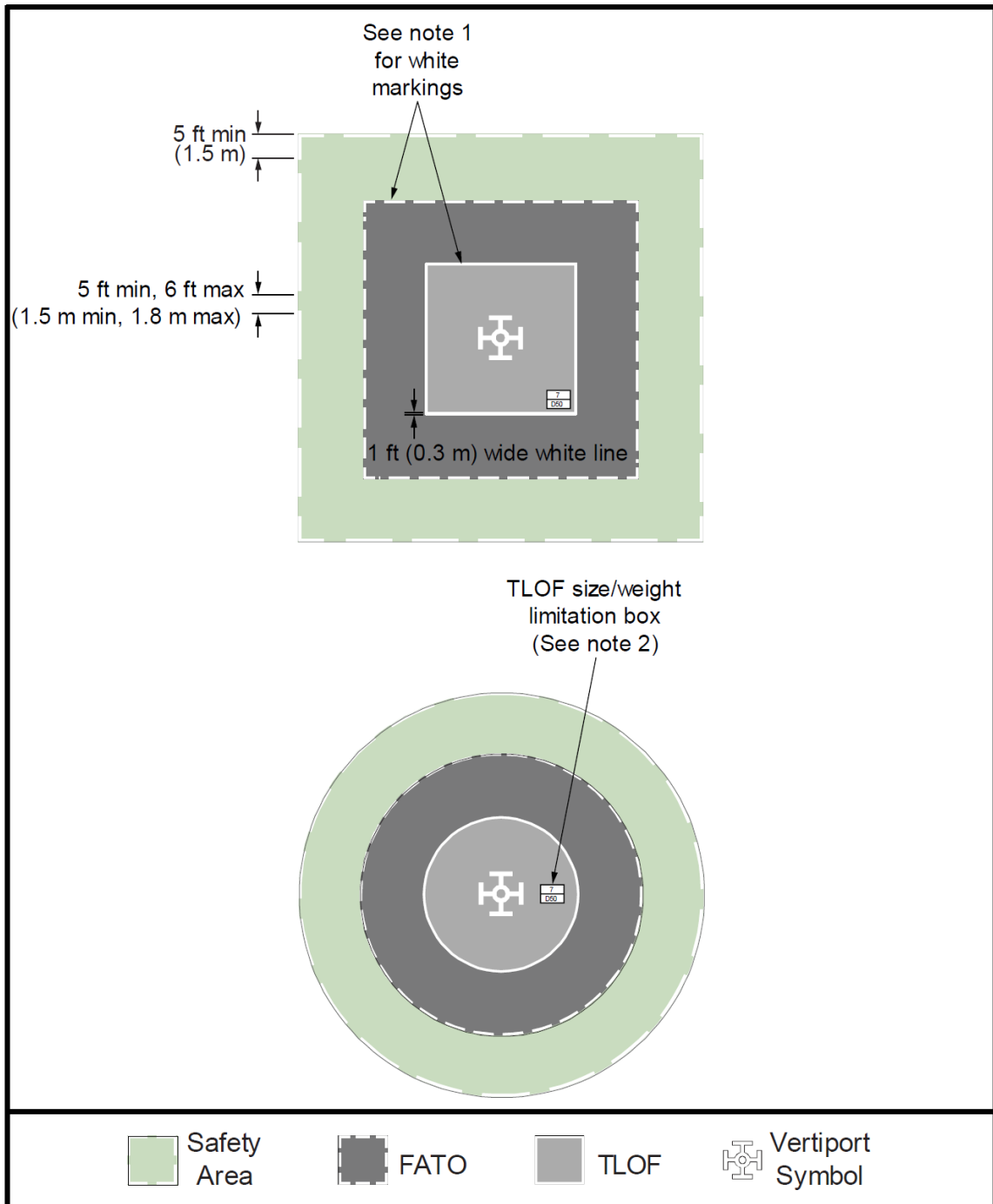


Figure is configured for 50-foot (15.2 m) TLOF.

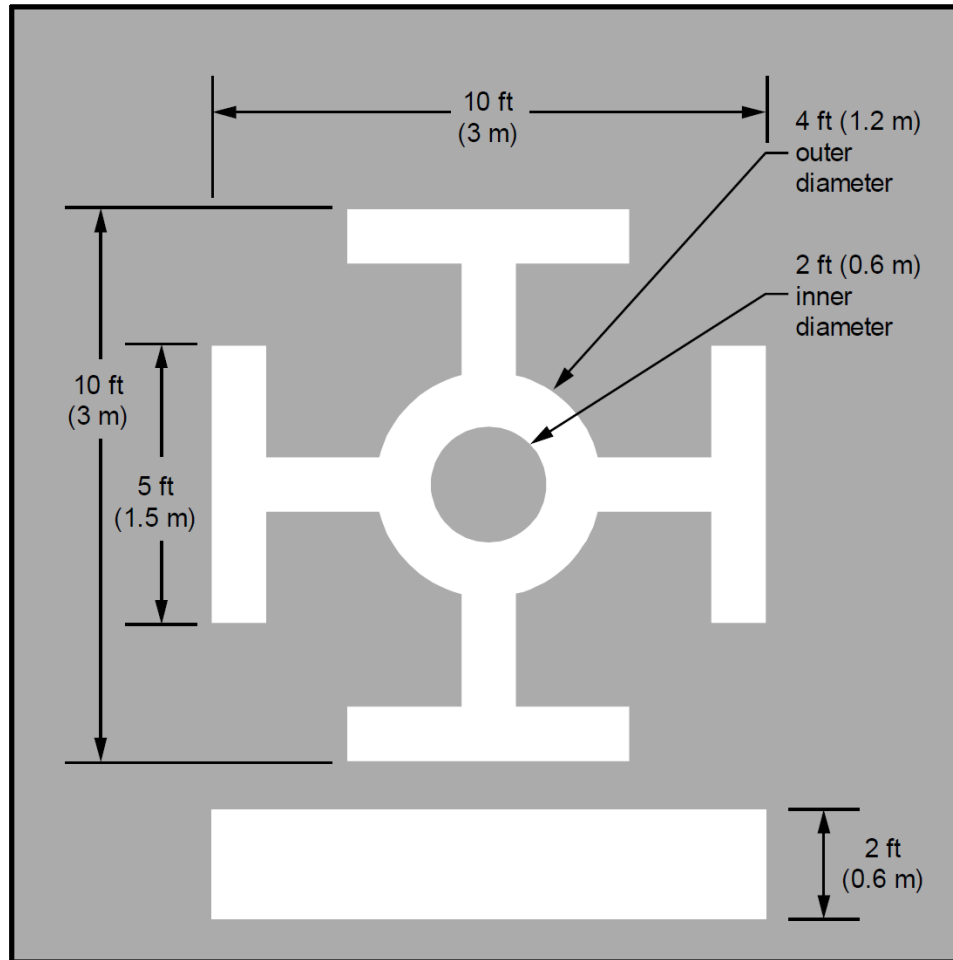
Note 1: Solid and dashed white lines are 12 inches (305 mm) in width. Dashed lines are 5-foot (1.5 m) in length with 5-6-foot (1.5-1.8 m) spaces.

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. Paint a 2-foot-wide (0.6 m wide) bar, of the same color as the broken wheel, 2 ft (0.6 m) below the broken wheel symbol when necessary to distinguish the preferred approach/departure direction.

Figure 3-2: Vertiport Identification Symbol



Note 1: White lines on the vertiport identification symbol at 12 inches (305 mm) wide.

Note 2: White bar, 10 ft × 2 ft (3 m × 0.6 m), denotes preferred approach/departure direction.

^{‡‡} 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).

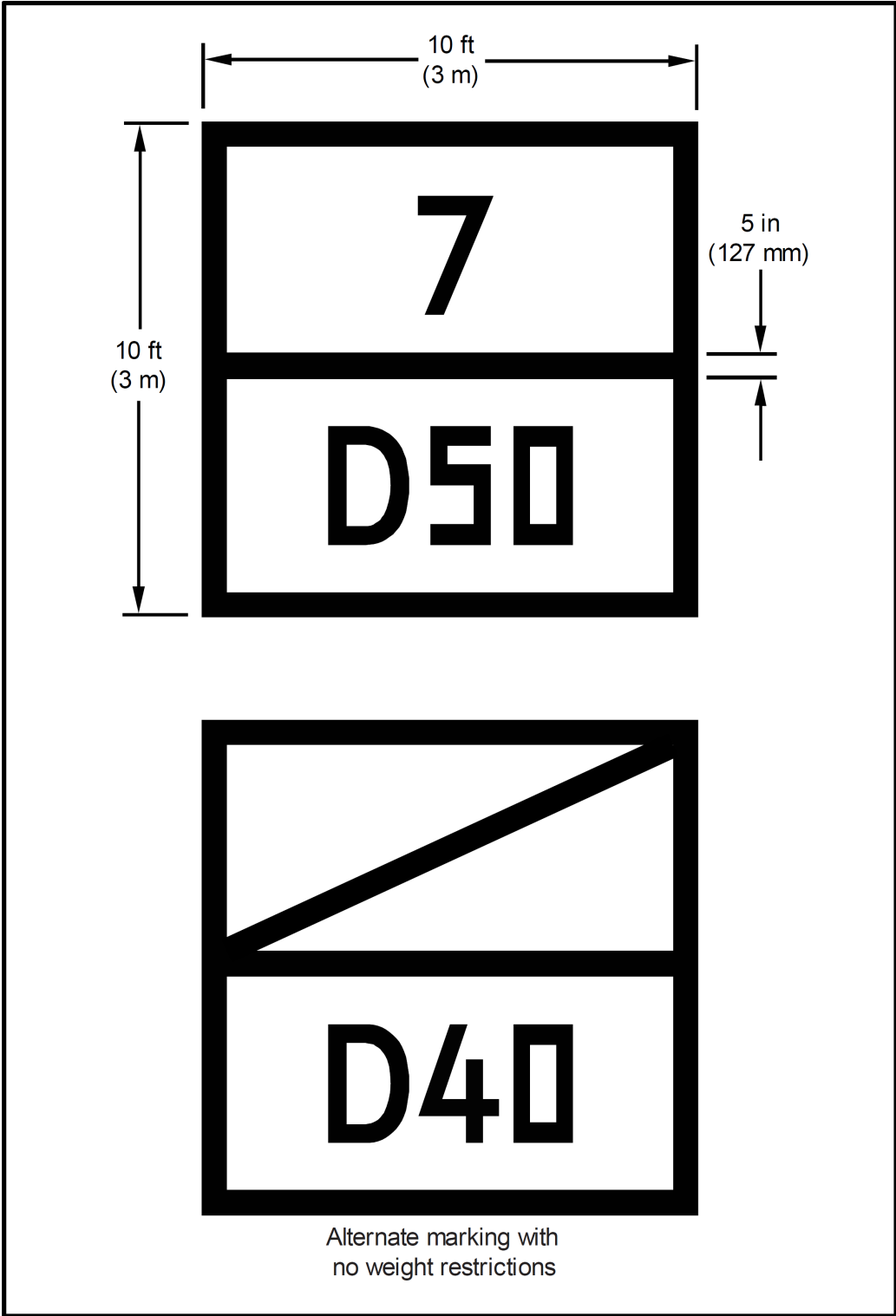
3.3. TLOF Size/Weight Limitation Box.

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 letter “D” 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 for the design VTOL the TLOF will accommodate. 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 letter “D.”
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.

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: Make the minimum size of the box 5 ft (1.5 m) square. Where possible, increase this dimension to a 10 ft (3 m) square for improved visibility.

Figure 3-4: Form and Proportions of 36-inch (914 mm) Numbers for Marking Size and Weight Limitations

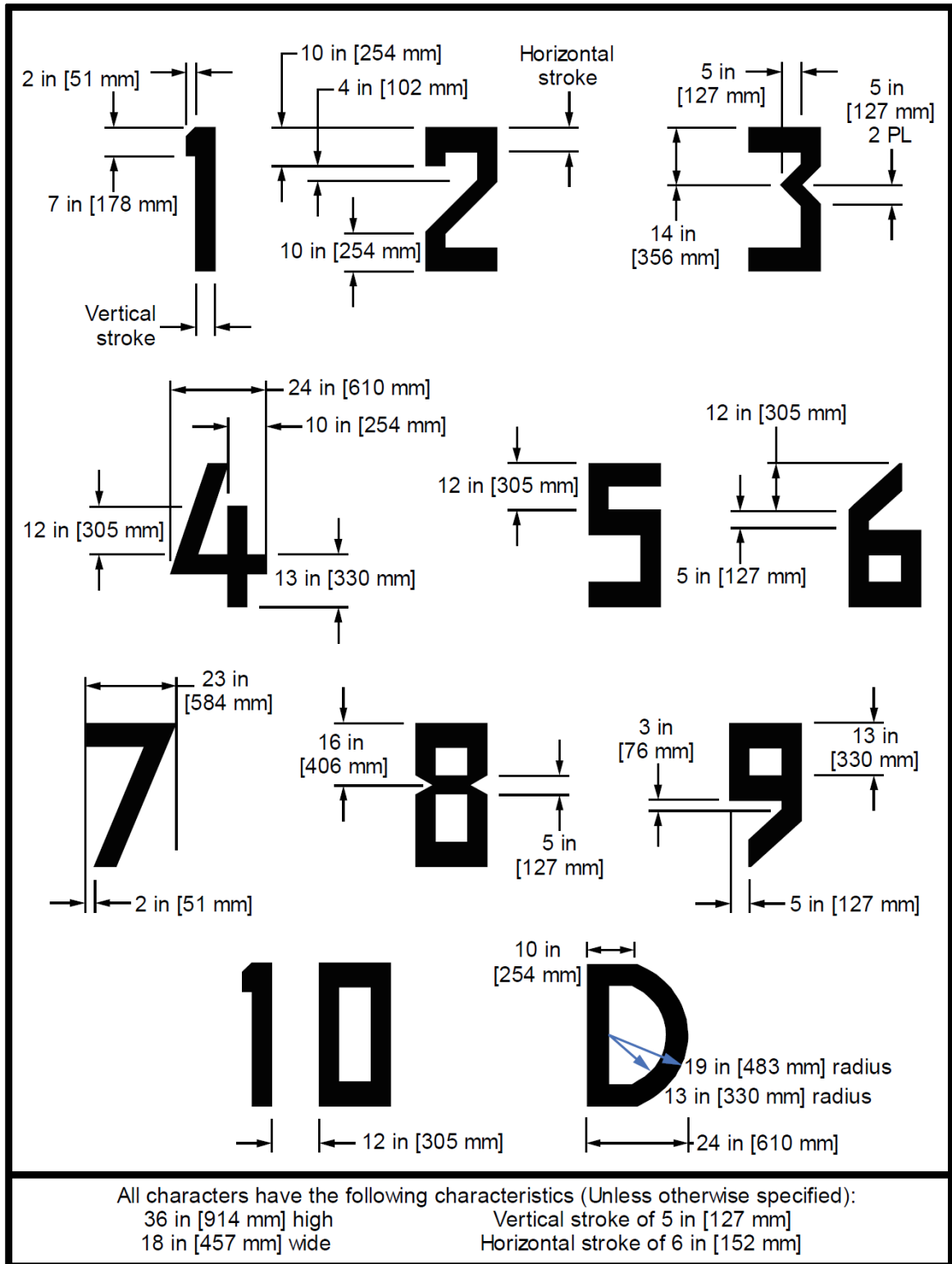
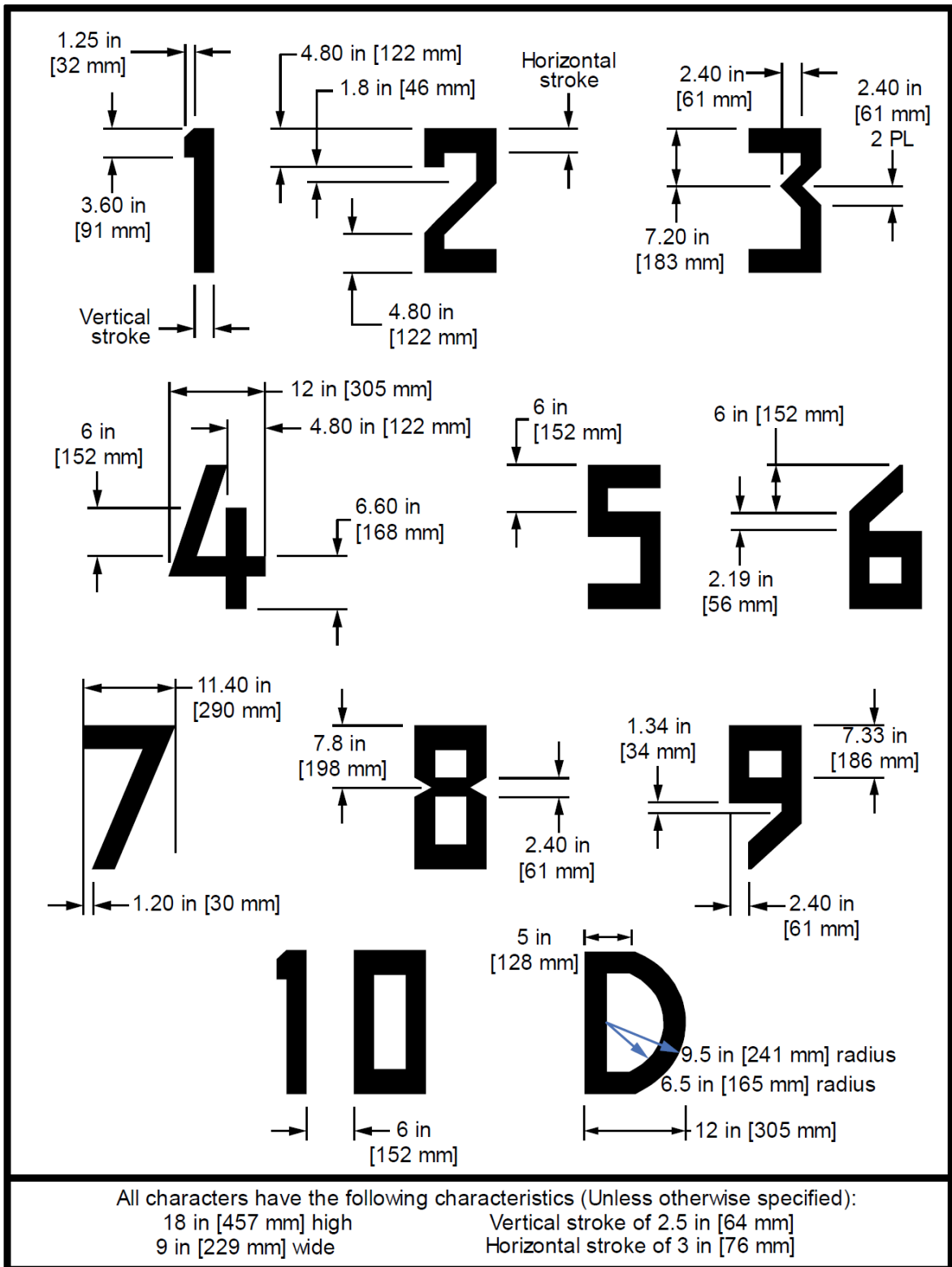


Figure 3-5: Form and Proportions of 18-inch (457 mm) Numbers for Marking Size and Weight Limitations



3.4. Flight Path Alignment Optional Marking and Lighting.

Flight path alignment marking and lighting 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 1.5 ft (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. See paragraph [3.5](#) for additional guidance. For elevated lights, if the TLOF light conflicts with a flight path alignment light, remove the conflicting flight path alignment light fixture.
7. For a vertiport with a flight path limited to a single approach direction or a single departure path, the arrow marking is unidirectional (i.e., one arrowhead only). For a vertiport with only a bidirectional approach/takeoff flight path available, the arrow marking is bidirectional (i.e., two arrowheads).

See [Figure 3-6](#) for additional guidance.

Figure 3-6: Flight Path Alignment Marking and Lighting

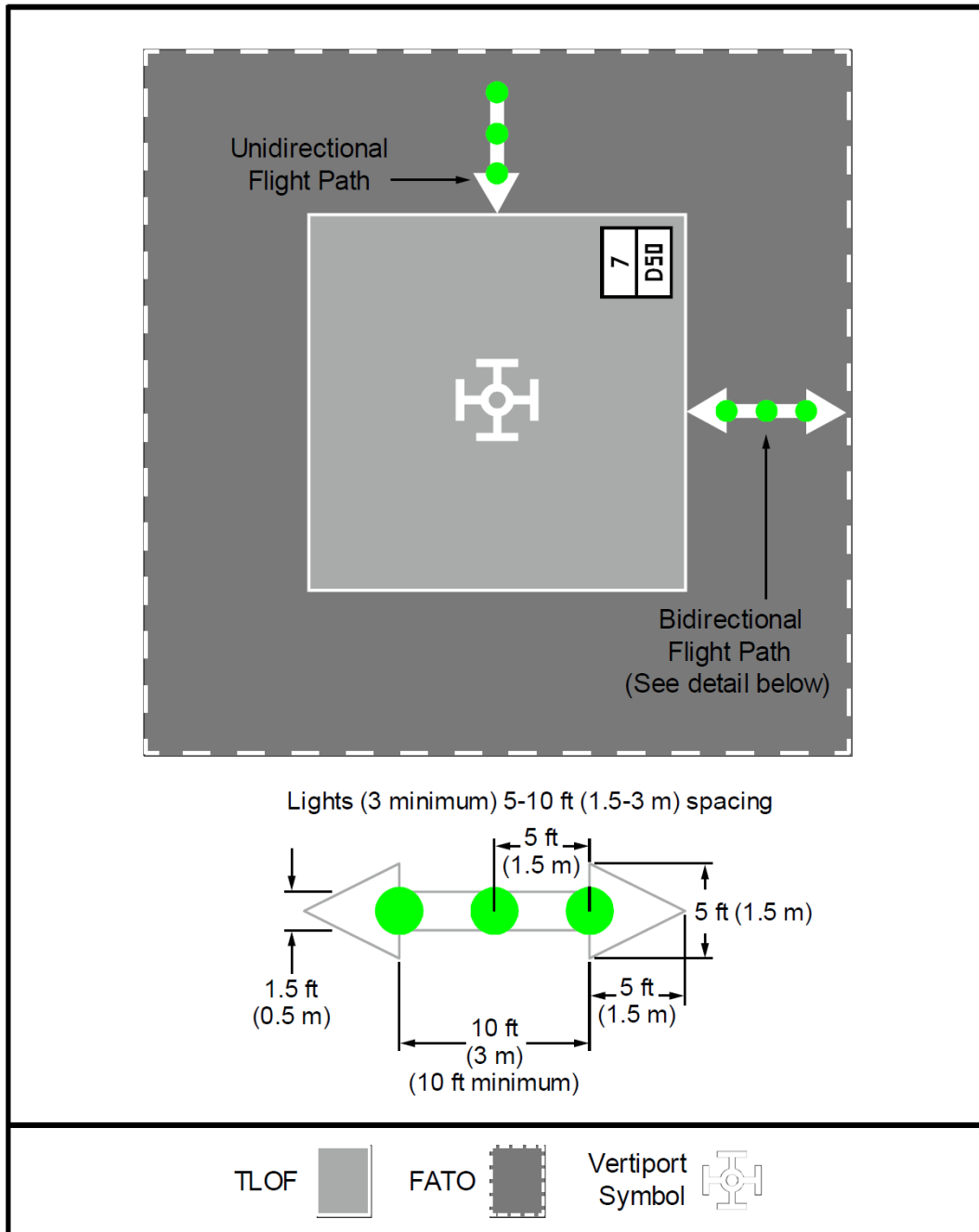


Figure is configured for 50-foot (15.2 m) TLOF

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-861H 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.

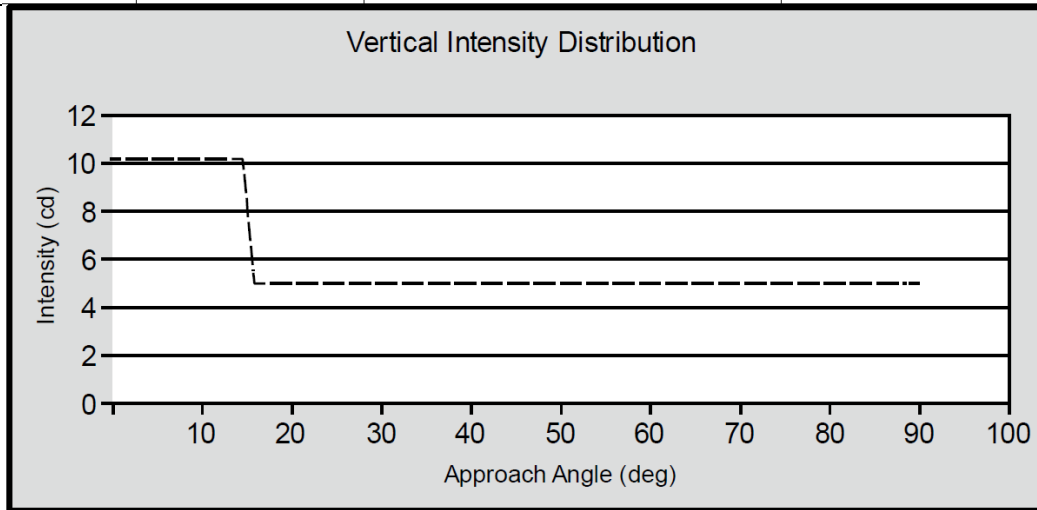
Lighting is required for vertiports that support night operations. The lighting should enable the pilot to both establish the location of the vertiport and identify the perimeter of the operational area. In-pavement lighting is preferred to elevated lighting. The following guidelines apply to lighting:

3.5.1. General.

1. The FAA type L-861H omnidirectional perimeter light fixture supports all possible directions of approach. AC 150/5390-2 provides the standards for the FAA type L-861H light fixture.
2. For reference, the light fixtures are listed in AC 150/5390-2 as FAA type L-861H, elevated heliport perimeter light, and Type L-852H, in-pavement heliport perimeter light.
3. With light fixture FAA type L-861H as the base, elevated (FAA type L-861H) and in-pavement (FAA type L-852H) fixtures will be established in the next update of AC 150/5345-46, Specification for Runway and Taxiway Light Fixtures. Use FAA type L-861H for TLOF and FATO perimeter applications and for Flight Path Alignment Lights and Landing Direction Lights. See AC 150/5390-2 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-861H (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 EB 67, 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

Color	Approach Angle 0 to 15 degrees		Approach Angle 16 to 90 degrees
	Minimum	Minimum average intensity	Minimum
Green	10 cd	15 cd	5 cd



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.

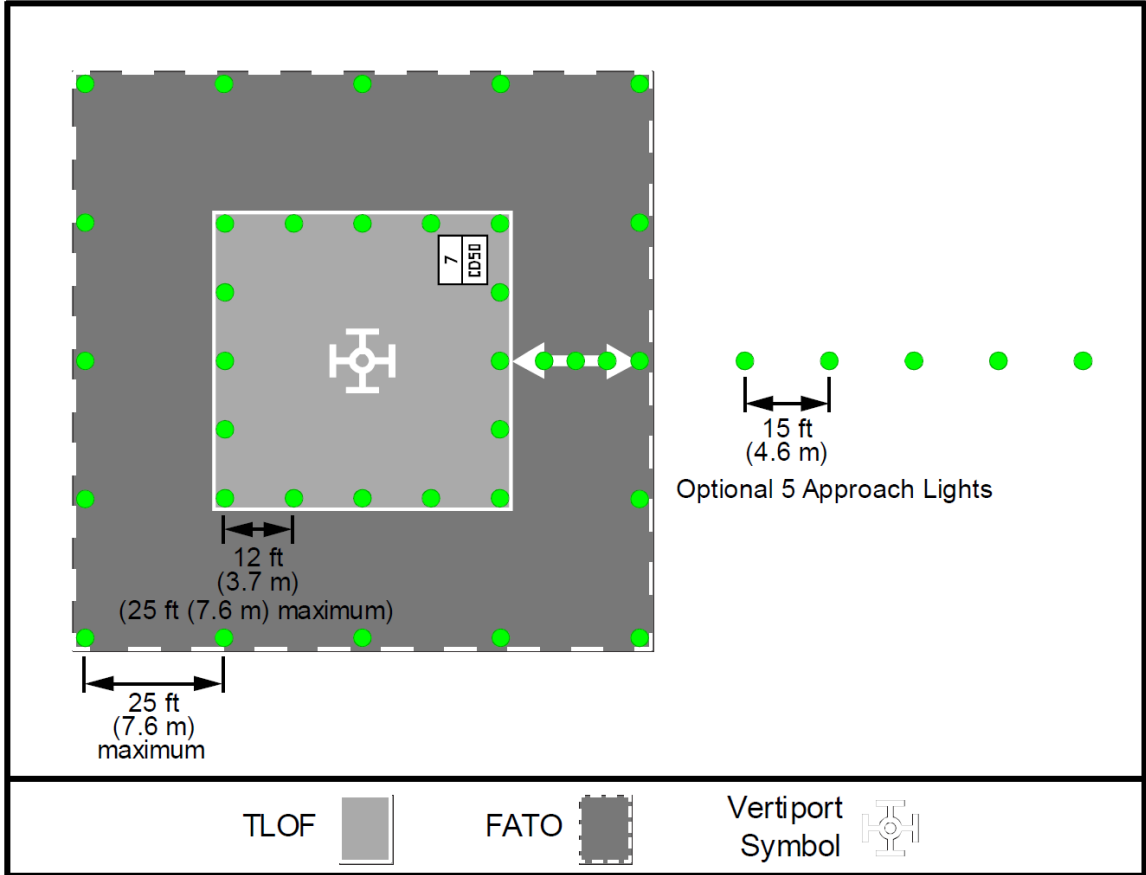
3.5.2. In-Pavement Perimeter Lights on TLOF and FATO.

1. TLOF perimeter lights are green and FAA type L-861H (AC 150/5345-46) or FAA type L-852H. LED versions of FAA type L-861H 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:
 - a. An even number of lights
 - b. Minimum of eight lights 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-861H (AC 150/5345-46) or FAA type L-852H. LED versions of FAA type L-861H 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. A circular FATO has:
 - a. An even number of lights
 - b. Minimum of 8 lights uniformly spaced.
11. FATO lights are within 1 foot (0.3 m) of the inside or outside of the perimeter line.
12. 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

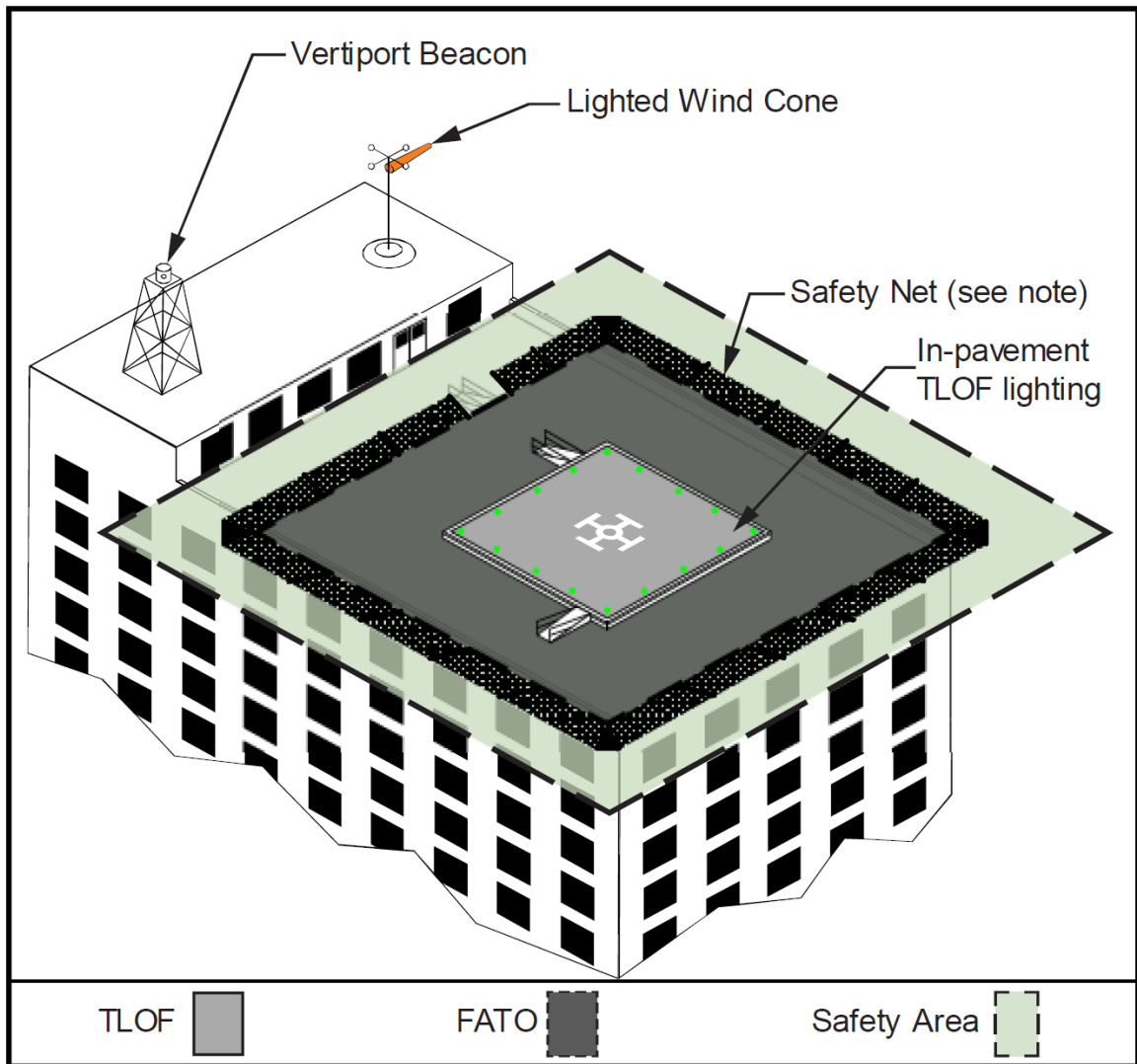


Note 1: In-pavement lights are within 1 foot (0.3 m) of the inside or outside of the TLOF and FATO respective perimeters.

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

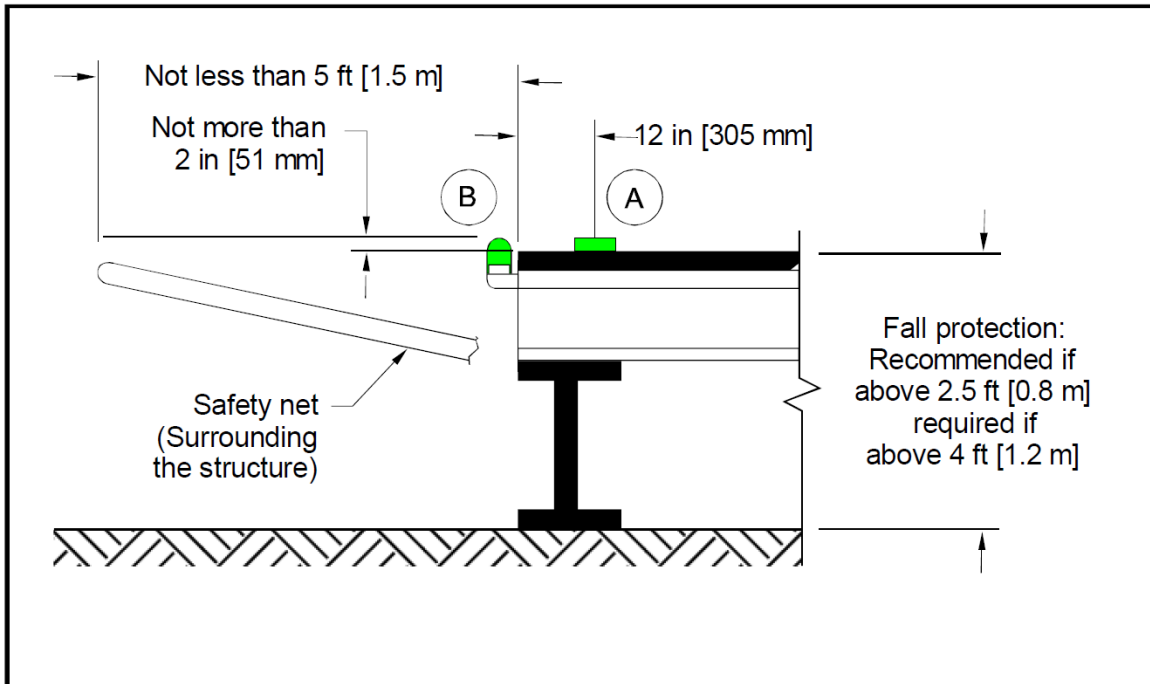
Note 3: Exhibit is configured for 50-foot (15.2 m) TLOF.

Figure 3-8: Elevated Vertiport Configuration Example



Note: See [Figure 3-9](#) for safety net and lighting details.

Figure 3-9: Elevated FATO Perimeter Lighting



Note 1: Install either “A” Type L-852H, or “B” Type L-861H.

Note 2: In-pavement edge light fixture **A** (Type L-852H).

Note 3: Omnidirectional light **B**, mounted off the structure edge (Type L-861H).

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.

3.5.4. Visual Glideslope Indicators (VGSI).

A VGSI provides pilots with visual vertical course and descent cues. Install the VGSI such that the lowest on-course visual signal provides a minimum of one degree of clearance over any object that lies within ten degrees of the approach course centerline.

3.5.4.1. **Siting.**

1. The optimum location of a VGSI is on the extended centerline of the approach path at a distance that brings the VTOL to a hover with the undercarriage between 3 and 8 feet (0.9 to 2.4 m) above the TLOF.
2. To properly locate the VGSI, estimate the vertical distance from the undercarriage to the pilot's eye.

3.5.4.2. **Control of the VGSI.**

Design the VGSI to be pilot controllable such that it is “on” only when needed as an option.

3.5.4.3. **VGSI Needed.**

A VGSI is an optional feature. However, install a VGSI if one or more of the following conditions exist, especially at night:

1. Obstacle clearance, noise abatement, or traffic control procedures necessitate a slope to be flown.
2. The environment of the VTOL provides few visual surface cues.

3.5.4.4. **Additional Guidance.**

Additional guidance is provided in AC 150/5345-52, *Generic Visual Glideslope Indicators (GVGI)*, and AC 150/5345-28, *Precision Approach Path Indicator (PAPI) Systems*.

3.5.5. Floodlight Option.

The FAA has not evaluated floodlights for effectiveness in visual acquisition of a vertiport. Guidelines for the use and installation of floodlights include:

1. Install floodlights to illuminate the TLOF, the FATO, and/or the parking area if ambient light does not suitably illuminate markings for night operations.
2. Mount these floodlights on adjacent buildings to eliminate the need for tall poles, if possible. Place floodlights clear of the TLOF, the FATO, the Safety Area, the approach/departure surfaces, and transitional surfaces and ensure floodlights and their associated hardware do not constitute an obstruction hazard.
3. Aim floodlights down to provide adequate illumination on the apron and parking surface.
4. Ensure floodlights that might interfere with pilot vision during takeoff and landings are capable of being turned off by pilot control or at pilot request.

Note 1: Floodlights do not replace TLOF or FATO lighting recommendations.

Note 2: White lighting for heliport applications should not be activated until the aircraft has landed and deactivated prior to takeoff.

3.6. Identification Beacon.

An identification beacon is required for night operations. The identification beacon is flashing white/yellow/green with a rate of 30 to 45 flashes per minute. On-airport vertiports are not required to have a vertiport identification beacon. Install beacons per the heliport guidance below:

1. AC 150/5345-12, *Specification for Airport and Heliport Beacons*, 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 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) horizontal 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, for meeting operational characteristics of higher capacity batteries and novel systems, manufacturers and operators may implement, along with fixed-charger equipment, alternate charging methods including mobile charging systems, fixed battery storage, cable and/or on-board battery cooling, battery swapping, or other concepts.

At the time of this publication, consensus has not been achieved 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 the AAM industry continues to evolve.

Battery charging must be done in a safe and secure manner. Any aircraft batteries stored on site should be stored safely away from TLOF, FATO, and Safety Areas. As additional research is developed, further recommendations will be released.

4.1. Standards.

4.1.1. Airport/Vertiport Fire Fighting and Safety Considerations.

- 2021 International Fire Code (IFC): To implement alternative energy vectors, there is the need for general precautions, emergency planning and preparedness, and storage of hazardous materials.
- NFPA 110, Standard for Emergency and Standby Power Systems: To ensure the continuity of electric aircraft operations, uninterrupted power supply is needed thus creating a need for guidelines on emergency and backup power supply systems.
- 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 70, Article 706 - Energy Storage Systems: This article applies to all energy storage systems (ESS) having a capacity greater than 3.6 MJ (1 kWh) that may be standalone or interactive with other electric power production sources. These systems are primarily intended to store and provide energy during normal operating conditions.
- 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.

4.1.2. Occupational Safety and Health Administration Considerations.

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

4.1.3. 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.
- IEEE 1826-2020, IEEE Standard for Power Electronics Open System Interfaces in Zonal Electrical Distribution Systems Rated Above 100 kW: Airports require power, monitoring, information exchange, control, and protection of interfaces that are based on technological maturity, accepted practices, and allowances for future technology insertions such as the integration of electric aircraft.

4.1.4. 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 2251, Standard Testing for Charging Inlets and Plugs: Covers plugs, receptacles, vehicle inlets, and connectors rated up to 800 amperes and up to 600

volts AC or DC, and intended for conductive connection systems, for use with electric vehicles.

- UL 2580, Batteries for Use in Electric Vehicles: Covers electric equipment storage assemblies in electric powered vehicles.
- UL 9540, Energy Storage System (ESS) Requirements - Evolving to Meet Industry and Regulatory Needs: This key standard encompasses the design, commissioning, operation, decommissioning, and emergency operations for all energy storage systems.
- UL 9540a, Test Method.

4.1.5. Vehicle to Infrastructure Considerations.

- SAE J1772, SAE Electric Vehicle and Plugin Hybrid 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 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 15118-1:2019, 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 for its intended purpose 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 must follow all guidance detailed in this EB.

For facilities being built on non-federally obligated airports, in compliance with [Part 157](#), the sponsor or proponent must submit [Form 7480-1](#) at least 90 days in advance of the day that construction work is to begin on the vertiport takeoff and 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. If needed, locate the TLOF away from but with access to fixed-wing aircraft movement areas (the runways, taxiways, and other areas of an airport that are used for taxiing, takeoff, and landing of aircraft, exclusive of loading ramps and aircraft parking areas).

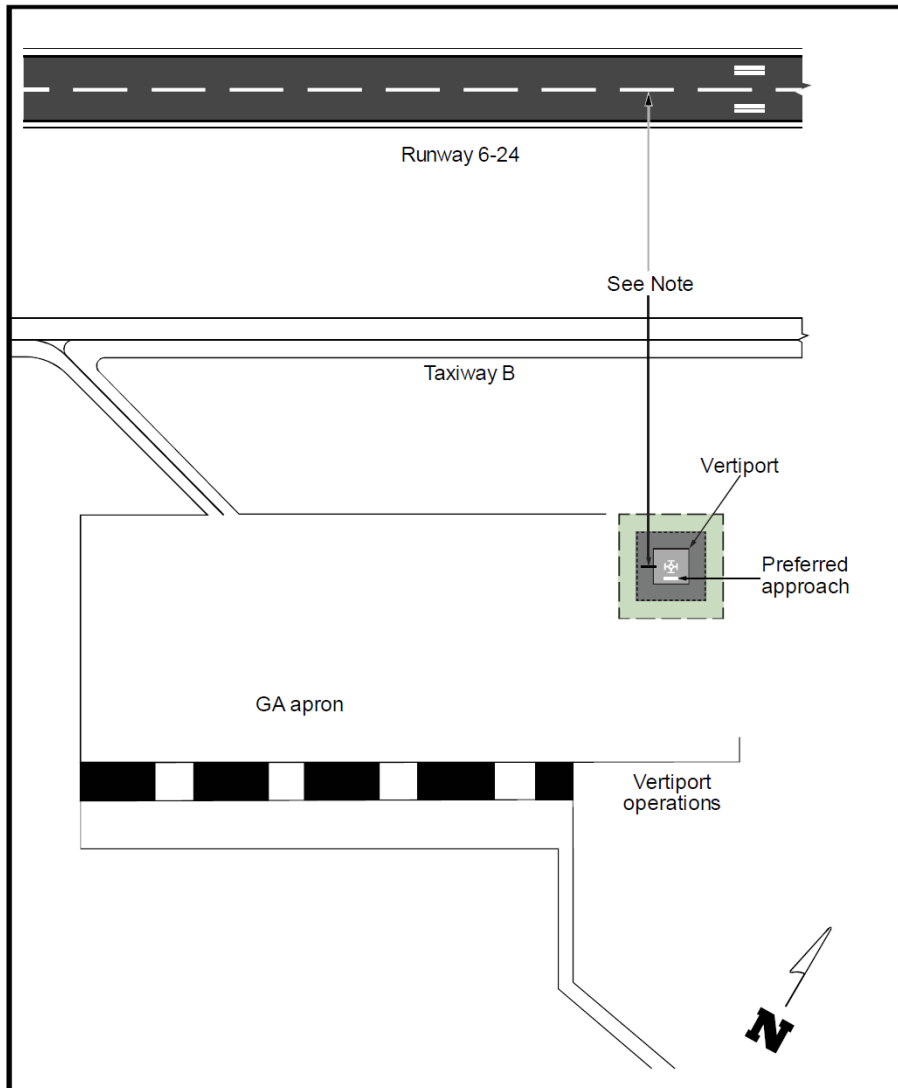
5.2. On-Airport Location of FATO.

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. The FATO should be located outside of all object free areas (OFAs), Safety Areas, runway protection zones, and safety critical navigational aid areas.

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

Reference VTOL Aircraft MTOW	Airplane Size	Distance From Vertiport FATO Center to Runway Centerline
12,500 pounds (5,670 kg) or less	Small Airplane (12,500 pounds (5,670 kg) or less)	300 feet (91 m)
12,500 pounds (5,670 kg) or less	Large Airplane (12,500-300,000 pounds (5,670-136,079 kg))	500 feet (152 m)
12,500 pounds (5,670 kg) or less	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.

Note: Figure does not reflect every type of configuration.

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 foam 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.

Vertiport operators may need to comply with applicable local fire, environmental, and zoning regulations. Vertiport operators will need the means to control 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. NFPA 855-2020, *Standard for Stationary Energy Storage Systems*, provides safety standards for stationary and mobile energy storage systems. Chapters on emergency response provide relevant guidance for fire protection engineers, system designers, code officials, and emergency responders.

6.2. Security and Safety.

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.

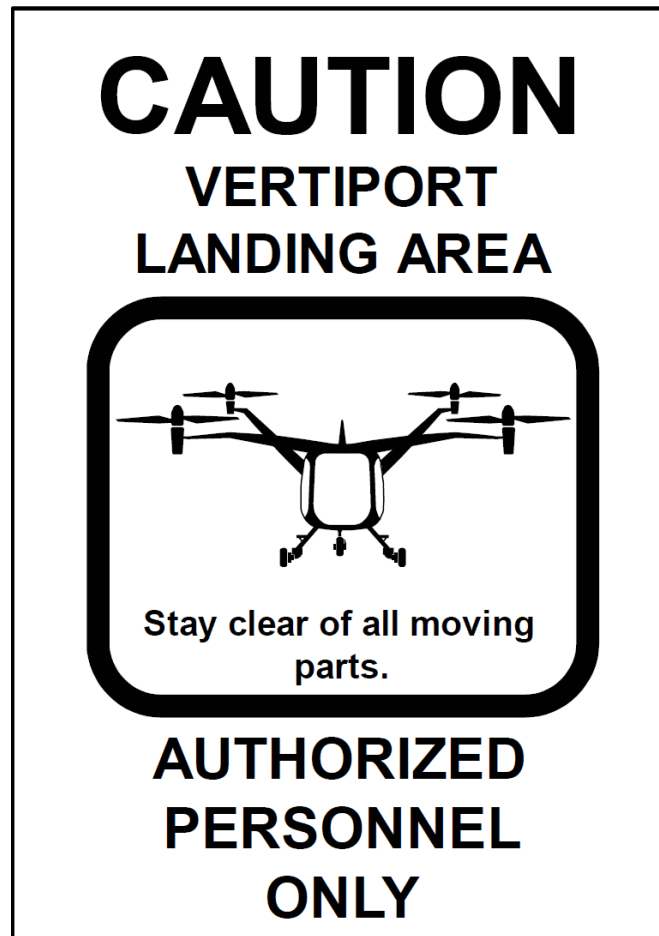
passenger screening and/or cargo needs. General information about passenger screening is available on the Transportation Security Administration website, www.tsa.gov/public/.

Controlling vertiport access and keeping operational areas clear of people, animals, equipment, debris, and vehicles is important for safety and security. The following guidance 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/Outwash.

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/propeller 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, other aircraft operators, 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 turbduent 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 optional 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/propeller 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/propeller wash can cause the pilot to lose sight of the intended landing point and/or obscure objects that need to be avoided. Elevated heliports may use a resistive heating system.

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.

6.7. Access to Vertiports by Individuals with Disabilities.

Congress has passed various laws concerning access to airports. Since vertiports are a type of airport, these laws are similarly applicable. Find guidance in AC 150/5360-14, Access to Airports by Individuals with Disabilities.

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
D	controlling dimension
DC	direct current
EB	Engineering Brief
ESS	energy storage system
ETL	effective translational lift
EV	electric vehicle
eVTOL	electric vertical takeoff and landing
FAA	Federal Aviation Administration
FATO	final approach and takeoff area
FC	failure condition
GA	general aviation
HOGE	hover out of ground effect
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
IFR	instrument flight rules

ISO	International Organization for Standardization
LAP	Landing Area Proposal
LDR	landing distance required
LED	light emitting diode
LOB	line of business
MCS	megawatt charging system
MSL	mean sea level
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
OFA	object free area
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
VGSI	Visual Glideslope Indicator
VMC	visual meteorological conditions
VTOL	vertical takeoff and landing