CASA Vertiport????

- CASA AC139.V-01 Guidance on Vertiport Design (2023)
- CASA Guide to Vertiport Design (2024)

CASA AC139.V-01 Guidance on Vertiport Design (2023)

ADVISORY CIRCULAR AC 139.V-01v1.0

Guidance for vertiport design

Advisory circulars are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.

Advisory circulars should always be read in conjunction with the relevant regulations.

Audience

This advisory circular (AC) applies to:

persons involved in the design, construction, and operation of vertiports

proponents of vertiports

AAM aircraft owners/operators

planning authorities

aerodrome operators

the Civil Aviation Safety Authority (CASA).

Purpose

This AC provides initial guidance in the planning and physical design of vertiports to support the safe and efficient operation of vertical take-off and landing (VTOL) capable aircraft operating with a pilot on board in visual conditions only.

This AC is not intended to restrict or limit a pilot from determining the most suitable area for landing or take-off for the VTOL-capable aircraft operation.

Where possible, outcome-based guidance is provided. While regulations were previously written in a prescriptive manner , organisations are now also required to develop processes that will deliver an effective outcome.

For more information on understanding outcome-based legislation see AC 1-01 - Understanding the legislative framework.

For further information

For further information, contact CASA’s Personnel Licensing, Aerodromes and Air Navigation Standards (telephone 131 757).

Unless specified otherwise, all subregulations, regulations, Divisions, Subparts and Parts referenced in this AC are references to the Civil Aviation Safety Regulations 1998 (CASR).

Status

This version of the AC is approved by the Branch Manager, Flight Standards.

Version Date		
v1.0	July 2023	Details Initial AC.

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1 Reference material

1.1 Acronyms

The acronyms and abbreviations used in this AC are listed in the table below.

Acronym	Description
AAM	Advanced Air Mobility
AC	advisory circular
AFM	aircraft flight manual
AIP	aeronautical information publication
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations 1998
FATO	final approach and take-of area
FOD	foreign object debris
FPA	FATO protection area
FPAGLS	Flight path alignment guidance lighting system(s)
ICAO	International Civil Aviation Organization
MOS	Manual of Standards
MTOW	maximum take-off weight
NASF	national airports safeguarding framework
OFV	obstacle free volume
OLS	obstacle limitation surface
RTODRV	rejected take-off distance required (for VTOL-capable aircraft)

SARPS	standards and recommended practices
TDPC	touchdown/positioning circle
TDPM	touchdown/positioning marking
TLOF	touchdown and lift off area
UCW	undercarriage width
VCA	VTOL-capable aircraft
VPS	vertical procedure surface
VPT	vertiport
VTOL	vertical take-off and landing

1.2 Definitions

Terms that have specific meaning within this AC are defined in the table below. Where definitions from the civil aviation legislation have been reproduced for ease of reference, these are identified

by 'grey shading'. Should there be a discrepancy between a definition given in this AC and the civil aviation legislation, the definition in the legislation prevails.

Term	Definition
Aerodrome	An area on land or water (including any buildings, installations, and equipment), the use of which as an aerodrome is authorised under the regulations, being such an area intended to be used either wholly or in part for the arrival, departure, and movement of aircraft.
Barrette	means 3 or more lights closely spaced in a transverse line so that from a distance they appear as a short bar of light.
D	for VTOL-capable aircraft, means the diameter of the smallest circle enclosing the aircraft projected on a horizontal plane, while the aircraft is in the take-off or landing configuration, with lift/thrust units turning, if applicable.
	Note: If the aircraft changes dimensions during taxing or parking (e.g. folding wings), a corresponding Dtaxing or Dparking should also be provided.
Design D Design aircraft	the D of the design aircraft. means a virtual aircraft type that has the largest set of dimensions, the
	greatest maximum take-off weight (MTOW), and the most critical obstacle avoidance criteria of the aircraft that the vertiport, or for a defined area within the vertiport, is intended to serve.

Downwash protection zone	The downwash protection zone is designed to protect the general public, other aircraft and those working in the immediate vicinity of operating VCA from the effect of buffeting.
D-Value	A limiting dimension, in terms of D, for a vertiport, or for a defined area within the vertiport.
Elevated vertiport	is a vertiport with a FATO location that would introduce a risk of fall from height or introduces a hazard to aircraft operations or to other people within the structure under the vertiport.
Elongated	when used with TLOF or FATO, elongated means an area which has a length more than twice its width.
Essential objects permitted	includes, but may not be limited to, around the touchdown and lift-off area (TLOF), perimeter lights and floodlights, guttering and raised kerb, foam monitors or ring-main system, handrails and associated signage, other lights.
off area (FATO) a.	Final approach and take- For the operation of a VTOL-capable aircraft, is defined as a solid area: from which a take-off is commenced;
Lighting element	or b. over which the final phase of approach to hover is completed. A lighting element is a light source within a lighting segment that may be
	discrete (e.g., a Light Emitting Diode (LED)) or continuous (e.g., fibre optic cable, electro luminescent panel). An individual lighting element may consist of a single light source or multiple light sources arranged in a group or cluster and may include a lens/diffuser.
Lighting segments	Lighting segments are low profile lighting fixtures that consists of a line of lighting elements within unit or frame. For the purposes of this circular, the dimensions of a lighting segment are the
	(LPs) are examples of lighting segments.
Obstacle	An object (whether temporary or permanent) or part of such an object that:
	a. is located on an area provided for the movement of aircraft; or
	b. extends above a defined surface designated to protect aircraft in flight
Obstacle free volume (OFV)	is a defined volume of airspace between the FATO protection area and the VPS, designed to protect aircraft conducting vertical procedures.
Protection area	means a defined area on a vertiport, which surrounds either the FATO or a stand, intended to reduce the risk of damage to an aircraft diverging from the

Reference circle	FATO or stand. is a horizontal circle, of the specified dimension, that is centred on any intended position/flight path at or above the applicable area/surface.
Rejected take-off distance required (RTODRV)	means the horizontal distance that is required from the start of the take-off to the point where the aircraft comes to a full stop, following a critical failure that is recognised at the TDP.
Take-off decision point (TDP)	means the first point that is defined by a combination of speed and height from which a safe take-off can be continued following a critical failure and is the last point in the take-off path from which a rejected take-off is ensured.
Touchdown and lift-off area (TLOF)	an area where a VTOL-capable aircraft may touch down or lift off.
Touchdown/positioning circle (TDPC)	a TDPM in the form of a circle, which is used for omnidirectional positioning in a TLOF.
Touchdown/positioning marking (TDPM)	a marking or set of markings that provide visual cues for the positioning of an aircraft.
Vertical procedures	take-of and landing procedures that include an initial and/or final vertical profile. The profile may or may not include a horizontal component.
Vertical procedure surface (VPS)	a surface at which a VTOL-capable aircraft either: a. begins its arriving vertical procedure,
	or b. ends its departing vertical procedure.
Vertiport elevation	the highest point of the FATO, or where there are multiple FATOs, the highest point of the highest FATO.
Vertiport	an area of land, water, or structure that is used or intended to be used for the landing, take-off, and movement of VTOL-capable aircraft, that meets or exceeds the specifications contained within this advisory circular.
	For the purposes of this AC the term vertiport also includes vertihubs and
vertistops: a.	Vertihub: a vertiport with infrastructure for maintenance, repair, fuelling, and parking spaces for storage of VTOL-capable aircraft.
	b. Vertistop: a vertiport intended for take-off and landing of VTOL- capable aircraft to drop off or pick up passenger or cargo, but where
Vertiport clearway	means a defined horizontal surface selected and/or prepared as a suitable area over which an aircraft, capable of continued safe flight after a critical failure, may operate between the FATO/VPS and the approach/climb-out surface inner edge.

VCA (VTOL-capable aircraft)	a heavier-than-air aircraft, other than aeroplane or helicopter, capable of performing vertical procedures by means of more than two lift/thrust units.
VCA stand	a defined area that is intended to accommodate aircraft for loading or unloading passengers, mail, or cargo, fuelling/charging, parking, or
VCA taxi-route	maintenance. a defined path that is established for the movement of aircraft from one part of a vertiport to another:
	a. an air taxi-route: a marked taxi-route that is intended for air taxing; and
	b. a ground taxi-route: a taxi-route that is intended for ground movement of aircraft centred on a VCA taxiway.

1.3 References

Advisory material

CASA's advisory materials are available at https://www.casa.gov.au/publications-and-resources/guidance-materials

Document	Title
AC 1-01	Understanding the legislative framework

2 Introduction

2.1 Background

2.1.1 This advisory circular (AC) provides guidance on the design elements of vertiports. This document assumes initial operations of pilot-on-board vertical take-off and landing (VTOL) capable aircraft (VCA) flying visual operations only.

2.1.2 With Advanced Air Mobility (AAM) evolving rapidly, these specifications have been prepared to support the progress of necessary aerodrome infrastructure. The guidance outlined below is flexible and structured such that it can evolve with this emerging industry.

2.1.3 However, it should be noted that these specifications are subject to change as aircraft performance and other data becomes available. Likewise, international standards are also in development and may impact on this guidance. Any significant revision of this guidance will be subject to industry consultation.

2.1.4 In addition to this, the introduction of AAM may impact and be impacted by considerations outside of aviation safety. Vertiport owners and operators should refer to local, state and other federal agencies to ensure appropriate adherence to their requirements.

2.1.5 As the following specifications are focused on VCA, runway-type final approach and take-off areas (FATO) have not been considered in the development of this AC.

2.1.6 This AC is the first in a collection of guidance material to be published. Additional ACs and supplementary material will provide further detail on design concepts as well as address operational considerations such as inspections, emergency response, aeronautical data and obstacle control.

2.2 Site selection

2.2.1 Fundamental considerations

2.2.1.1 The selection of a vertiport site involves the consideration of a range of variables including intended aircraft types, area available, vertiport configuration and obstacle environment.

Note: Limitations and restrictions to certain activities, such as aviation, may be imposed by State, Territory or Local Government on properties or locations through planning schemes or environmental planning instruments.

Site locations for proposed vertiport locations should consider suitability from a land-use planning perspective including any limitations or restrictions that could apply to the site.

Information in this advisory circular is additional to any limitation or restriction to the use of a site imposed by State, Territory or Local Government.

2.2.1.2 Full consideration of some of these variables relies on effective engagement with a range of stakeholders. Vertiport operators should establish open communication channels with aircraft operators, government stakeholders, nearby aerodrome (including certified aerodromes, non-certified aerodromes, helicopter landing sites and vertiport) operators and, where appropriate, the local community.

2.2.1.3 The aircraft type or types that are expected to use the vertiport form the basis for most design considerations when developing a vertiport. Where the vertiport owner intends on supporting a single aircraft type, that aircraft type will be the design aircraft. For vertiports intended to service multiple aircraft, the design aircraft is a virtual aircraft composed of the most demanding characteristics of these aircraft include including the largest set of dimensions, the greatest maximum take-off weight (MTOW), and the most critical flight path requirements (i.e., approach/climb-out gradient and/or horizontal flight requirements following a critical failure).

Note: Additional considerations of design aircraft may include considerations other than those mentioned in 2.2.1.3. Other considerations may include undercarriage width, landing distance requirements, rejected take-off distance requirements and the impact of downwash and outwash when VCA are landing, manoeuvring on the vertiport or at take-off.

2.2.1.4 The vertiport area available and the intended scope of operations may impact on the vertiport configuration. The number of facilities, such as FATOs, taxi routes, stands and associated buildings, may be limited by the physical environment. This AC provides specifications for each vertiport facility associated with the operation of aircraft without establishing a standard vertiport layout.

2.2.1.5 The potential for vertiports to be constructed in a complex wind (turbulent) environment means that specific considerations should be made when a vertiport is to be established in the vicinity of buildings, and significant terrain.

2.2.1.6 For vertiports within obstacle-rich environments or that may be impacted by future development, careful consideration of preferred and/or future flight paths should be made in consultation with appropriate stakeholders.

2.2.1.7 A gap analysis has identified that potential vertiport locations may be subject to multiple federal, state and local government regulatory requirements, as well as requirements from non-government sources, and these requirements may vary between different vertiport locations and jurisdictions.

2.2.1.8 This AC does not, and cannot, cover all vertiport development considerations. Vertiport owners and operators should consult with appropriate stakeholders (such as federal, state and local government agencies) on topics that are outside of CASA's remit including but not limited to noise, security, environmental concerns, weather reporting and privacy.

2.2.1.9 A vertiport and VCA compatibility study should be undertaken as part of the introduction of a new VCA, or when the mode of VCA operation changes to ensure the facilities at the vertiport remain suitable for all VCA using the vertiport.

2.2.2 Proximity to other vertiports or other aerodrome infrastructure

2.2.2.1 Where vertiports are located within the vicinity of other vertiports or aerodromes, the siting and design of FATOs and their associated flight paths should carefully consider interactions between own vertiport traffic, and other vertiport and aerodrome traffic.

2.2.3 Downwash and outwash protection

2.2.3.1 The characteristics and impacts of VCA downwash and outwash type effects1 are still unknown, however vertiport designers and operators will need to take into consideration their potential effects during the design process.

2.2.3.2 A vertiport and its facilities should be designed and located to protect the following from damage or injurious effects of downwash/outwash type effects associated with VCA operating to/from the vertiport:

people

other aircraft

buildings

vehicles

equipment.

2.2.3.3 An evaluation of downwash/outwash type impacts should be carried out. The evaluation should consider the VCAs downwash/outwash characteristics, the specific local conditions and relevant wind comfort criteria for affected persons and facilities.

2.2.3.4 At vertiports intended to service multiple types of VCA, or VCA operated by different operators, a detailed safety assessment and an operational evaluation of individual aircraft types operating to/from a given vertiport may need to be considered.

2.2.3.5 Information on potential downwash and outwash characteristics may be sought from VCA manufacturers and VCA operators. The manner in which a VCA may be operated could vary the actual downwash/outwash experienced.

2.2.3.6 To avoid or reduce the potential of incidents and accidents associated with VCA downwash/outwash, downwash protection zones2 around vertiports in the form of boundaries, or areas of restriction/control on movement of persons during VCA operations, should be considered.

2.2.3.7 This downwash protection zone should recognise that, in addition to the hover over the landing point, downwash/outwash will be prevalent during the final approach to the hover, the initial take-off, and whenever the VCA is positioning to or away from the FATO.

Note: The combined risk from an aviation safety and occupational health and safety perspective may require supervision of vehicular and pedestrian traffic during VCA movements, provision of robust maintenance and foreign object damage (FOD) prevention processes, and safeguarding of the downwash/outwash protection zone from future development to reduce the likelihood of injury or third-party damage.

3 Vertiport physical characteristics

3.1 General

3.1.1 A vertiport consists of set of essential components or defined areas as well as some optional components. These are the basic building blocks of a vertiport, as shown in Figure 1, and include:

a. one or more FATO

b. one or more touch down and lift-off areas (TLOF)

c. protection areas

d. taxiways and/or taxi-routes

e. stands

3.1.2 The following specifications are based on the design assumption that no more than one VCA will be in the FATO at the same time.

3.1.3 Further, it is also assumed that operations to/from a FATO in proximity to another FATO will not be simultaneous. If simultaneous operations are planned, appropriate separation distances between FATOs should be determined with due regard to issues such as downwash, flight paths and other airspace limitations.

3.1.4 Safety devices to mitigate the risk of fall from height at elevated vertiports should not penetrate the OLS or exceed the height of the protection area.

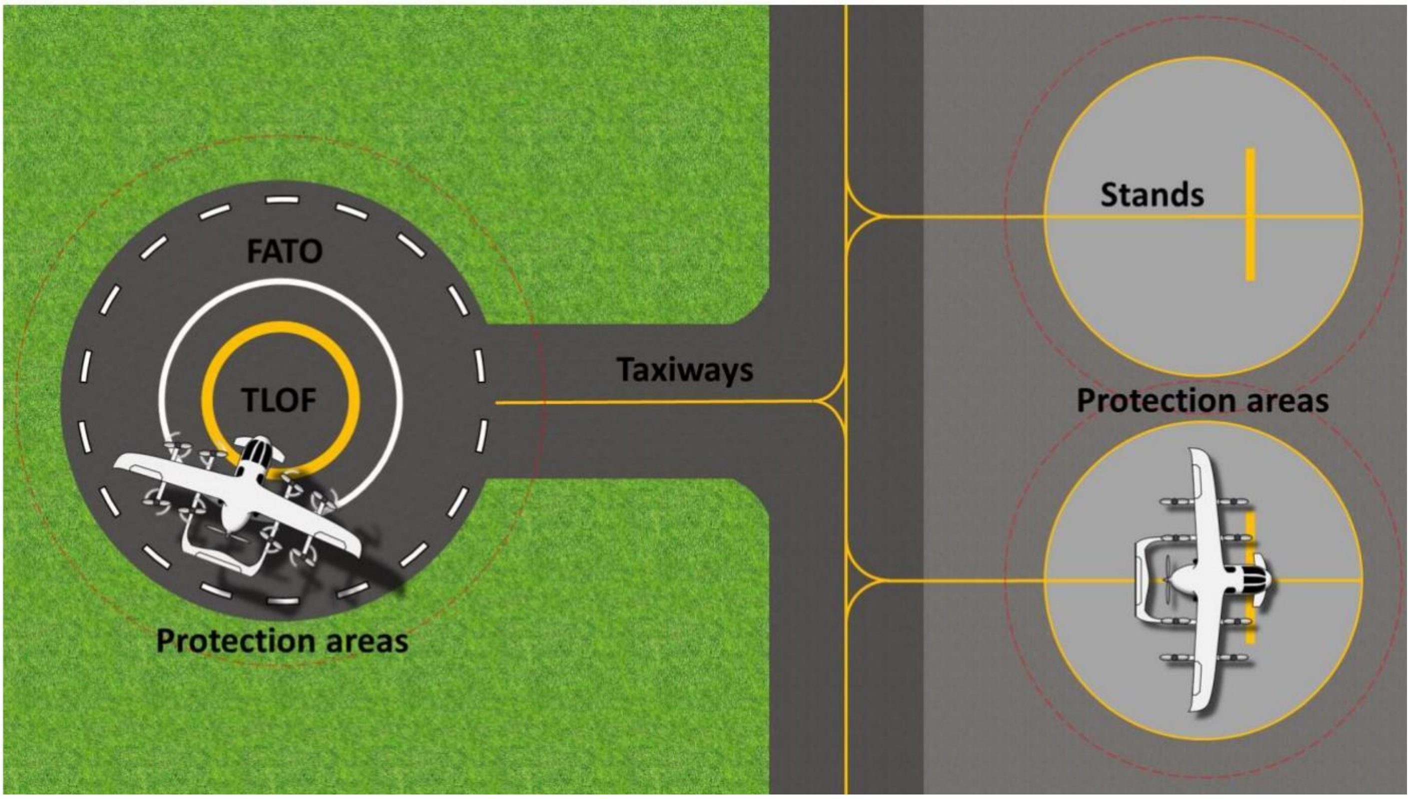


Figure 1 – Vertiport components

3.2 Essential vertiport components

3.2.1 Final approach and take-off (FATO) area

3.2.1.1 A vertiport should be provided with at least one FATO.

3.2.1.2 A FATO should have the following features:

a. A sufficient size and shape to ensure containment of every part of the design aircraft in the final phase of approach and commencement of take-off in accordance with the intended procedures. The shape of the FATO is optional as represented in Figures 1, 2 and 12.

b. When collocated with a touchdown and lift-off (TLOF) area, contiguous and flush with the TLOF, and meet the requirements of 3.2.2.3 b.

c. When non-collocated with a TLOF, free of obstacles, except for essential objects, free of hazards to a potential forced landing and resistant to the effects of downwash.

3.2.1.3 The dimensions of a FATO should be the:

a. length of the rejected take-off distance required (RTODRV) prescribed in the design aircraft flight manual (AFM), or 1.5 Design D, whichever is greater: and

b. width prescribed in the design aircraft AFM, or 1.5 Design D, whichever is greater.

3.2.1.4 Essential objects should not exceed 5 cm in height.

3.2.1.5 The slope of a FATO should not exceed 2 % in any direction.

3.2.1.6 A FATO should be located to minimize the influence of the surrounding environment, including turbulence, which could have an adverse impact on aircraft operations.

3.2.1.7 A FATO should be surrounded by a FATO Protection Area (FPA) as per 4.1.1.

3.2.1.8 Where a vertiport intends to have more than one FATO, the distance between any two proximate FATOs should be determined by a safety assessment that supports the safe operations of intended VCA movements.

Note: As VCA performance data becomes available, changes to FATO requirements such as minimum size or the requirement for the FATO being solid may be reviewed.

3.2.2 Touchdown and lift-off (TLOF) area

3.2.2.1 A vertiport should be provided with at least one TLOF.

3.2.2.2 A TLOF should be provided within a FATO as shown in Figure 2, or stand as shown in Figure 13c, whenever it is intended that the undercarriage of the VCA will touch down or lift off.

3.2.2.3 A TLOF should have the following features:

a. A sufficient size and shape to ensure containment of the undercarriage of the design aircraft aligned with the intended orientation.

b. An area which:

i. is free of obstacles

ii. has sufficient bearing strength to accommodate the dynamic loads associated with the design aircraft.

iii. is free of irregularities that would adversely affect the touchdown, lift-off or taxi of VCA

iv. has sufficient friction to avoid skidding of VCA or slipping of persons

v. is resistant to the effects of downwash

vi. ensures effective drainage while having no adverse effect on the control or stability of a VCA during touchdown, lift-off, or when stationary.

3.2.2.4 The minimum dimensions of a TLOF should be the dimensions prescribed in the design aircraft AFM, or 0.83 Design D, whichever is greater.

3.2.2.5 The slope of a TLOF should not exceed 2 % in any direction.

3.2.2.6 When a TLOF is within a FATO, it should be:

a. centred on the FATO, or

b. for an elongated FATO, centred on the longitudinal axis of the FATO.

3.2.2.7 When a TLOF is within a VCA stand, it should be centred on the stand.

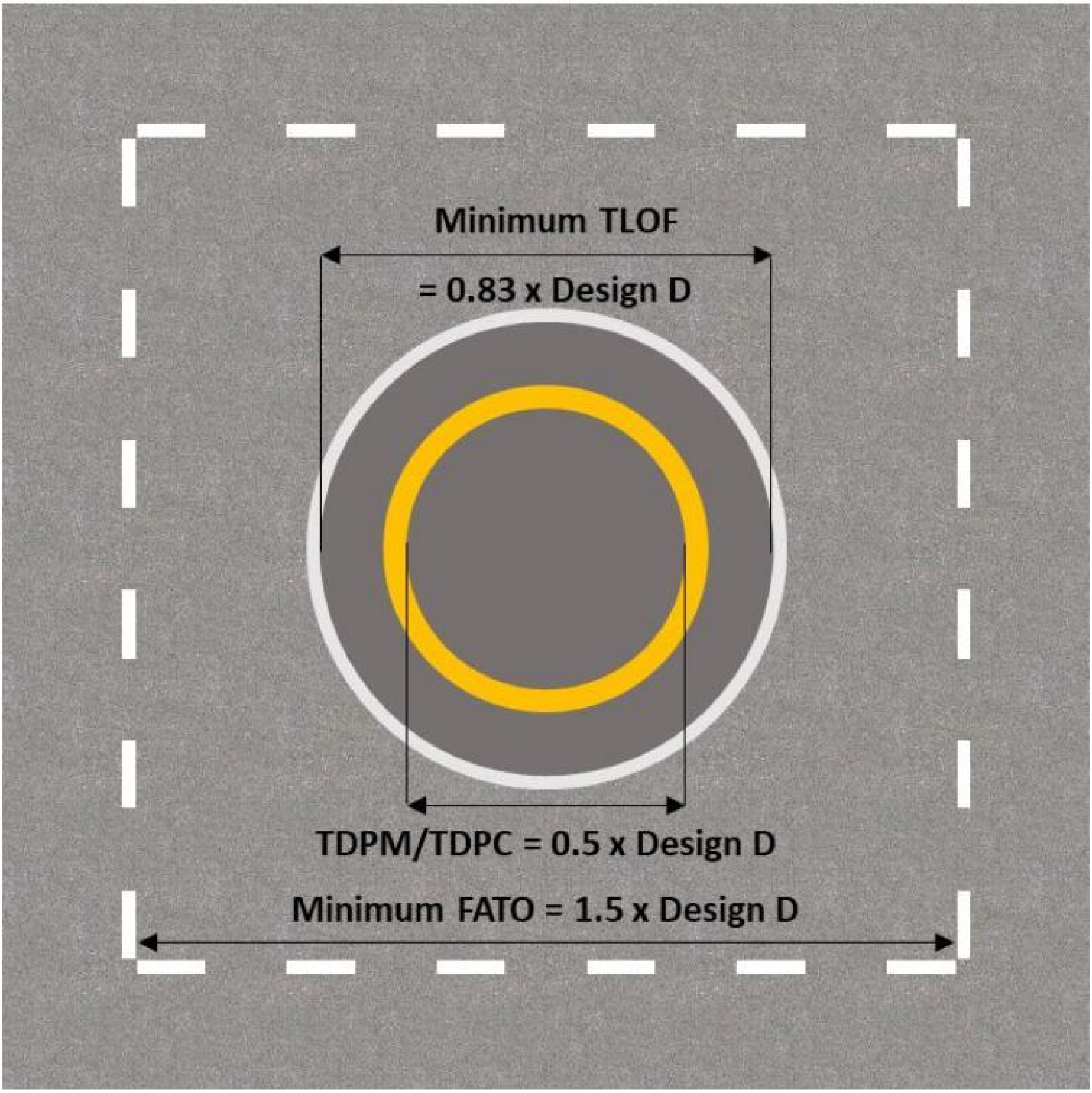


Figure 2 - FATO, TLOF (with TDPC)

3.3 Optional vertiport components

3.3.1 VCA taxiways

3.3.1.1 A VCA taxiway should be provided for the intended ground movement of a VCA within the vertiport under its own power or by means of ground movement equipment.

3.3.1.2 A VCA taxiway should be located within a taxi-route and have the following features:

a. sufficient width to ensure containment of the undercarriage of the design aircraft; b. area which:

i. is free of obstacles

ii. has the bearing strength to accommodate the taxiing loads of the aircraft the taxiway is intended to serve

iii. is free of irregularities that would adversely affect the ground taxiing of a VCA

iv. is resistant to the effects of downwash

v. ensures effective drainage while having no adverse effect on the control or stability of a VCA when being manoeuvred under its own power, or by ground movement equipment, or when stationary.

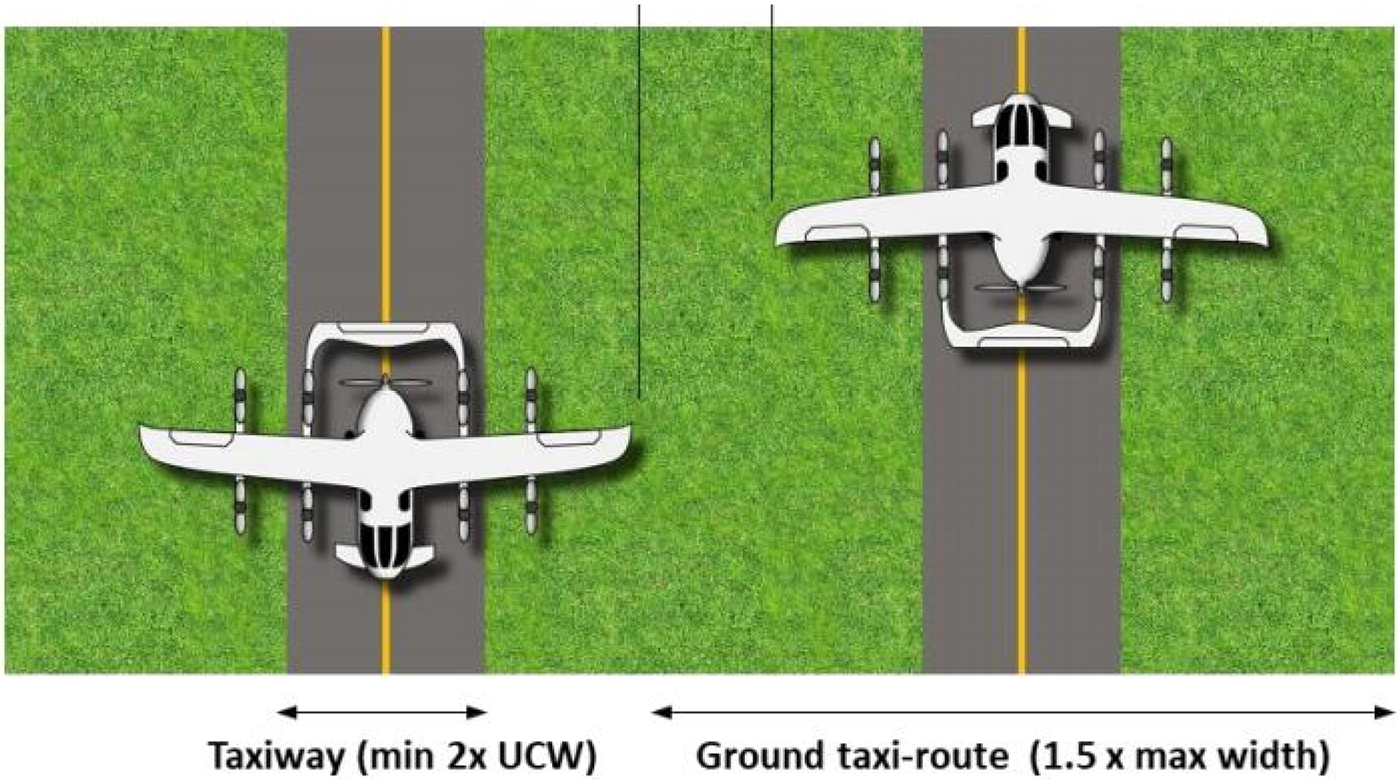
3.3.1.3 The minimum width of a VCA taxiway should be two times the undercarriage width (UCW) of the design aircraft, as shown in Figure 3.

3.3.1.4 The transverse slope of a taxiway should not exceed 2 % and the longitudinal slope should not exceed 3 %.

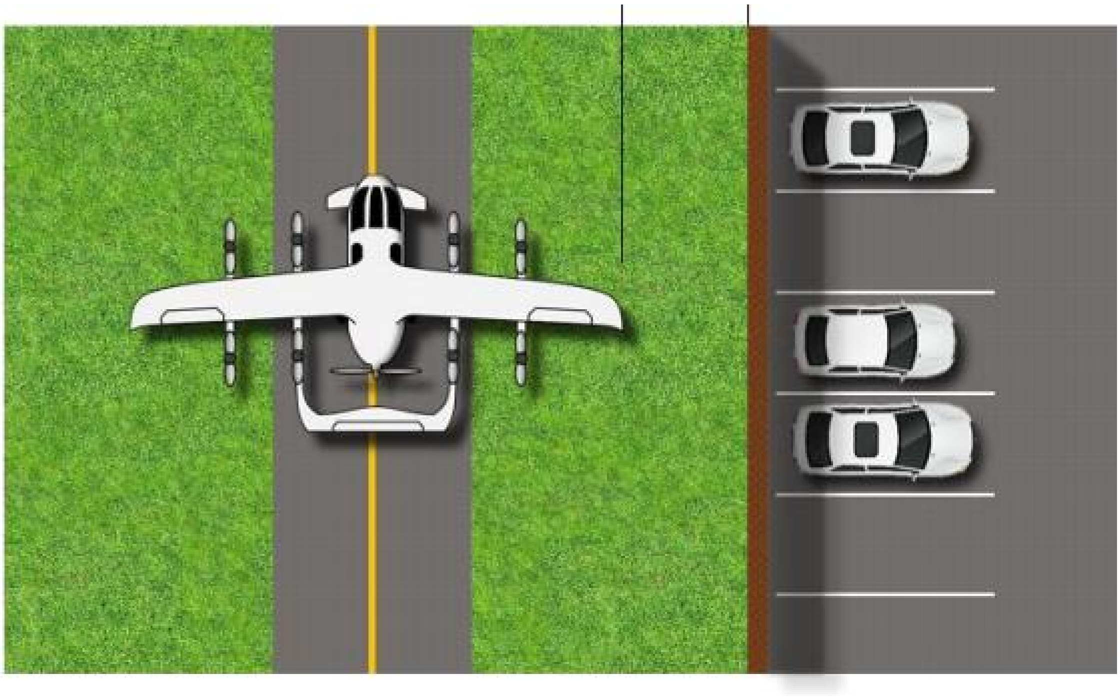
3.3.1.5 When defining the distance between ground taxiways, the separation distance between an aircraft on a ground taxiway and an aircraft on a parallel ground taxiway or an object should take into consideration a minimum wingtip clearance of at least 0.25 maximum width of the design aircraft.

Note: Where taxiways are intended to be used by vehicles and equipment considerations should be made to taxiway width and bearing strength.

Wing tip to wing tip clearance (min 0.25 x max width)



Clearance to object (min 0.25 x max width)



Ground taxi-route (1.5 x max width)

Figure 3 - VCA taxiways and clearance distances

3.3.2 Taxi routes for VCA

3.3.2.1 A VCA taxi-route should be provided for the intended movement of a VCA within the vertiport under its own power or by means of ground movement equipment.

3.3.2.2 A VCA taxi-route should have the following features:

a. sufficient width to ensure containment of the design aircraft

b. free of obstacles, except for essential objects

c. resistant to the effects of downwash

d. when collocated with a taxiway:

i. is contiguous and flush with the taxiway

ii. does not present a hazard to operations

iii. ensures effective drainage

iv. not exceed an upward transverse slope of 4 % outwards from the edge of the taxiway.

e. when not collocated with a taxiway, is free of hazards if a forced landing is required.

3.3.2.3 Where collocated with a taxiway, essential objects located in the VCA taxi-route should not:

a. be located at a distance of less than 50 cm outwards from the edge of the taxiway

b. penetrate a surface originating 50 cm outwards of the edge of the taxiway and a height of 25 cm above the taxiway and sloping upwards and outwards at a gradient of 5 % up to the outer edge of the ground taxi-route.

Note: Consideration of low-mounted lift/thrust units may be required to ensure that appropriate clearances are maintained.

Ground taxi-routes for VCA

3.3.2.4 A VCA ground taxi-route should have a minimum width of 1.5 times the overall width of the design aircraft it is intended to serve and be centred on a taxiway, as shown in Figure 4.

Note: Where the VCA operating width differs (e.g. folding wings) while taxiing, the reduced width may be considered for defining the taxi-route width.

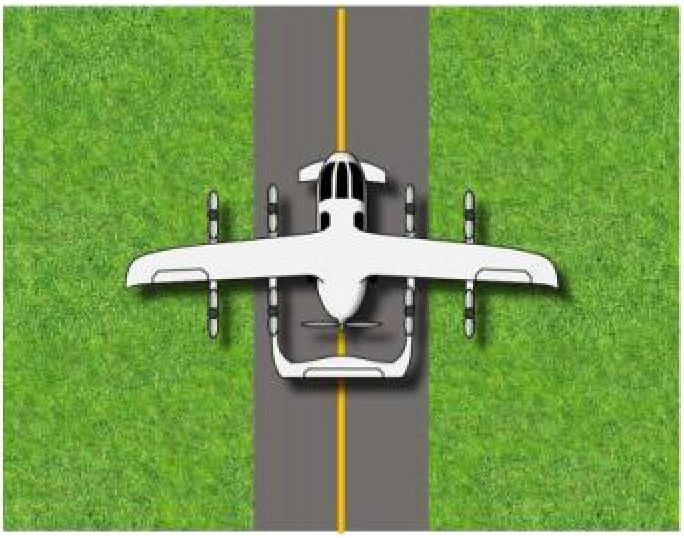
Air taxi-route for VCA

3.3.2.5 A VCA air taxi-route should have a minimum width of twice the overall width of the design aircraft it is intended to serve, as shown in Figure 4.

3.3.2.6 When not collocated with a taxiway, the slopes of the ground below an air taxi-route should not exceed the slope landing limitations of the design aircraft the taxi-route is intended to serve. In any event, the transverse slope should not exceed 10 % and the longitudinal slope should not exceed 7 %.

Note: When determining the width of an air taxi route, the potential impact of downwash or outwash from an of air-taxiing VCA should be considered.

Ground taxi-route = 1.5 x overall width



Taxiway (min 2x UCW)

Air taxi-route = 2 x overall width

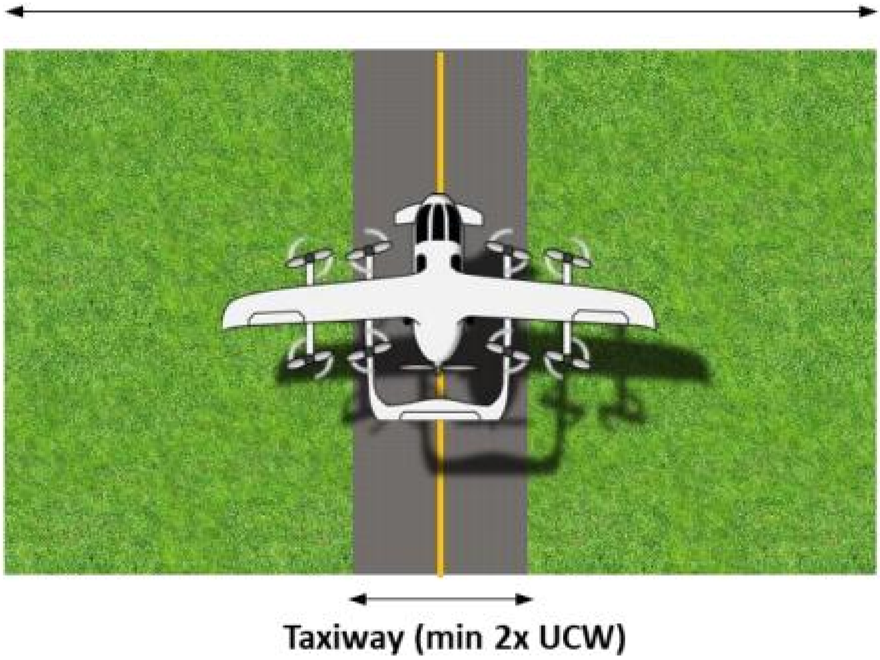
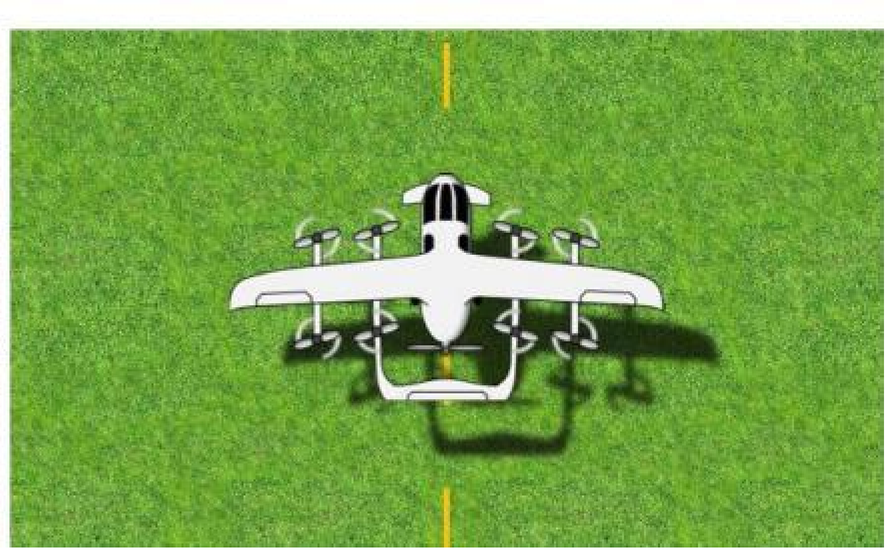


Figure 4 - VCA taxi-routes

Air taxi-route = 2 x overall width



3.3.3 VCA stands

3.3.3.1 VCA stands may be provided to permit the safe loading and off-loading of passengers and/or cargo, as well as the servicing of the VCA without interfering with other traffic.

3.3.3.2 A VCA stand, as shown in Figure 6, should have the following features:

a. sufficient size and shape to ensure containment of every part of the design aircraft when it is being positioned within the stand

b. An area which:

i. Is free of obstacles

ii. has bearing strength capable of withstanding the intended loads

iii. is free of irregularities that would adversely affect the manoeuvring of VCA

iv. has sufficient friction to avoid skidding of VCA or slipping of persons

v. is resistant to the effects of downwash

vi. ensures effective drainage while having no adverse effect on the control or stability of a VCA when being manoeuvred under its own power, when being moved by means of ground movement equipment, or when stationary.

3.3.3.3 The slope of a VCA stand should not exceed 2 % in any direction.

3.3.4 D-Value-based VCA stand

3.3.4.1 When the VCA stand design is based on D-value, the minimum dimensions should be:

a. a circle of diameter of 1.2 Design D

or

b. when there is a limitation on manoeuvring and positioning, of sufficient width to meet the requirement of 3.3.3.2 (a) above, but not less than 1.2 times overall width of design aircraft.

3.3.4.2 A D-value based VCA stand should be located within a protection area.

3.3.5 Geometry-based VCA stand

3.3.5.1 For VCA that enter/exit the stand with surface movement either under own power or by means of ground movement equipment, where practical, stands may be designed in accordance with the geometry of the aircraft, as shown in Figure 5, following the aerodrome apron concept.

3.3.5.2 The clearances should be based on the dimensions of all the VCAs expected to use the stand.

3.3.5.3 The clearance distance between a VCA and other adjacent VCA, buildings or objects on the apron should be sufficient to meet the requirement of 3.3.3.2 (a) above, but not less than:

a. For VCA with a width of less than 18 m:

i. 3 m

or

ii. 0.25 the overall width of the widest VCA expected to use the stand, whichever is greater

b. For VCA with a width greater than 18 m not less than 4.5 m.

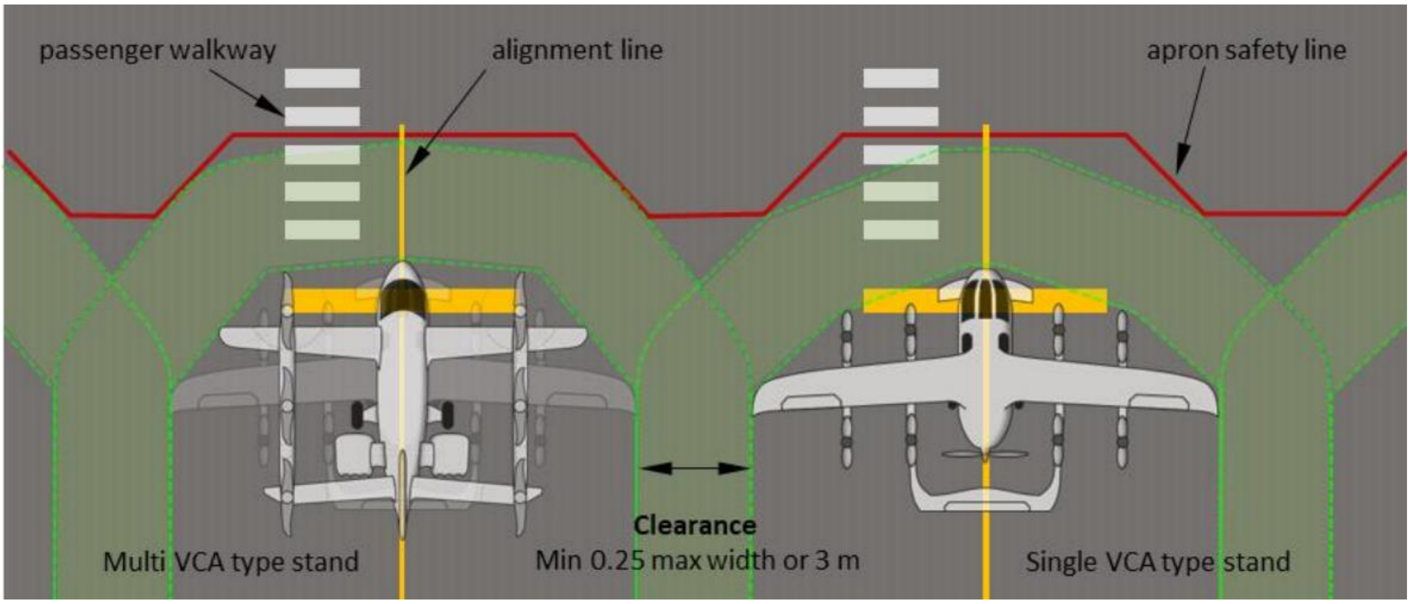


Figure 5 - Example of geometry-based stands (VCA less than 18m in width)

3.3.6 Protection areas for D-value-based VCA stands

3.3.6.1 A stand protection area should be provided for D-value-based VCA stands, as shown in Figure 6.

3.3.6.2 A protection area should have the following features:

a. free of obstacles, except for essential objects

b. resistant to the effects of downwash

c. when solid, flush with the stand, not exceed an upward slope of 4 % outwards from the edge of the stand and ensures effective drainage.

3.3.6.3 When associated with a stand designed for turning, the protection area should extend outwards from the periphery of the stand for a distance of 0.4 Design D. Otherwise, the minimum width of the stand and the protection area should not be less than the width of the associated taxi-route.

3.3.6.4 When associated with a stand designed for non-simultaneous aircraft operations:

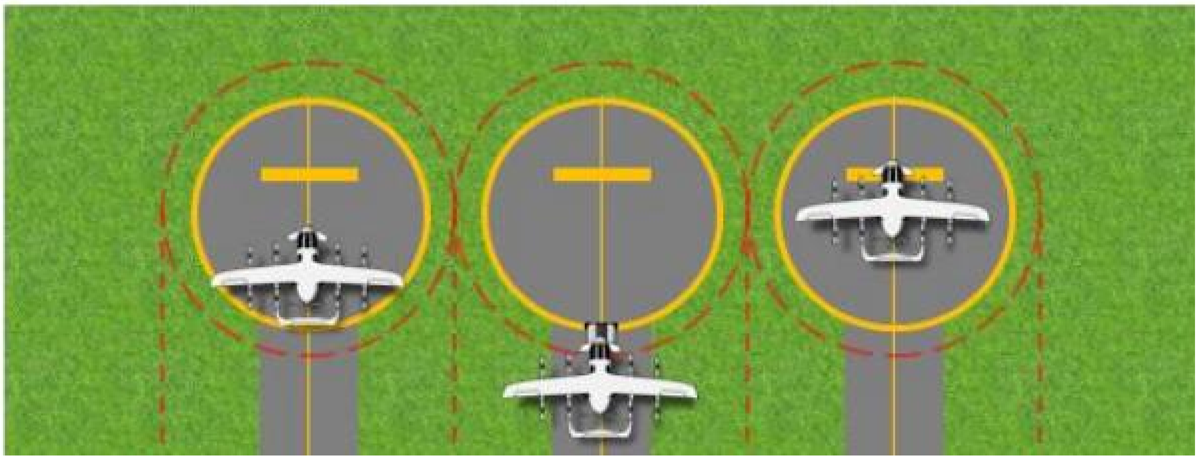
a. the protection area of adjacent stands may overlap but should not be less than the required protection area for the larger of the adjacent standards

b. the adjacent stand may contain a static aircraft.

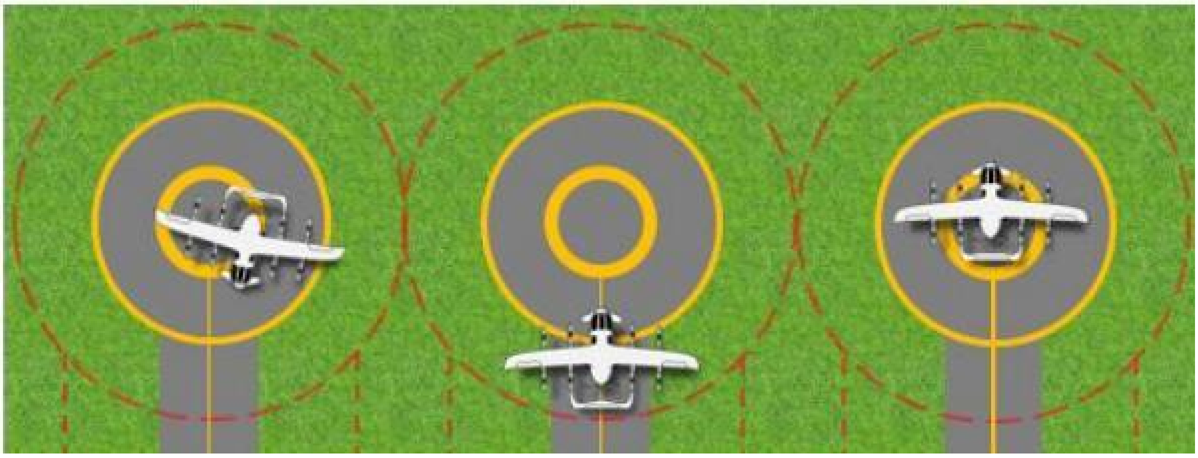
3.3.6.5 Essential objects located in the protection area should not:

a. If located at a distance of less than 0.75 Design D from the centre of the VCA stand, penetrate a surface at a height of 5 cm above the level of the stand.

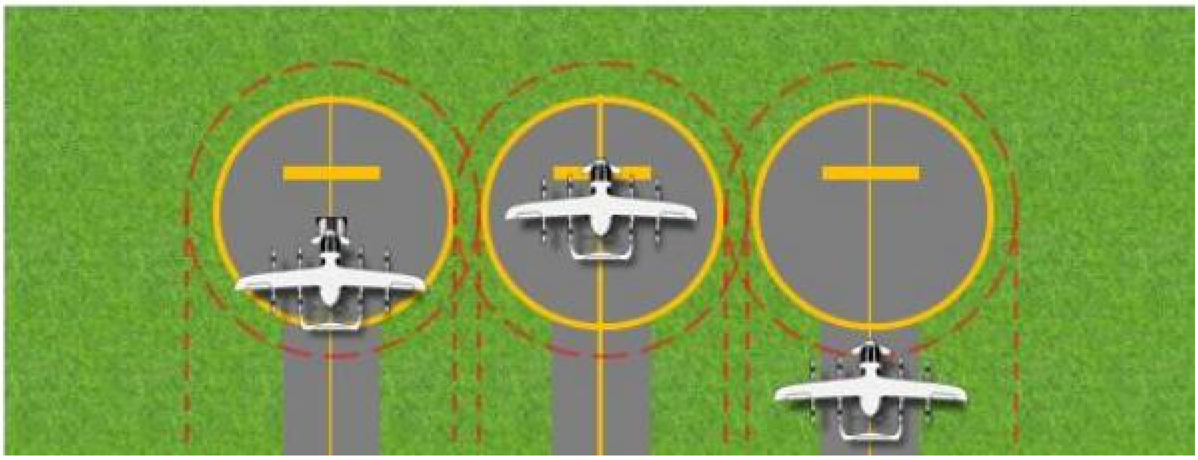
b. If located at a distance of 0.75 Design D or more from the centre of the VCA stand, penetrate a surface at a height of 25 cm above the level of the stand and sloping upwards and outwards at a gradient of 5 %.



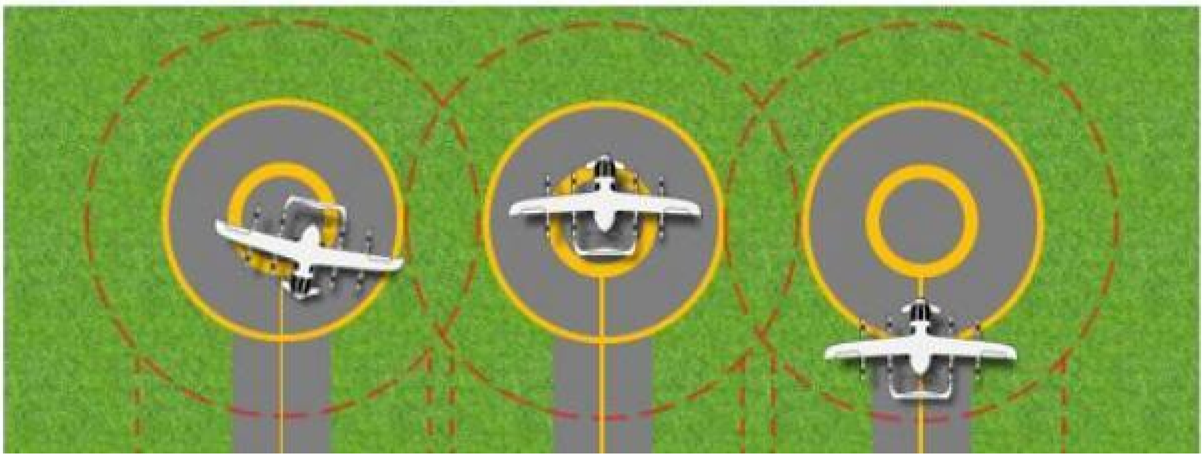
Example A: Ground taxi. Simultaneous taxi-on/push-back stands



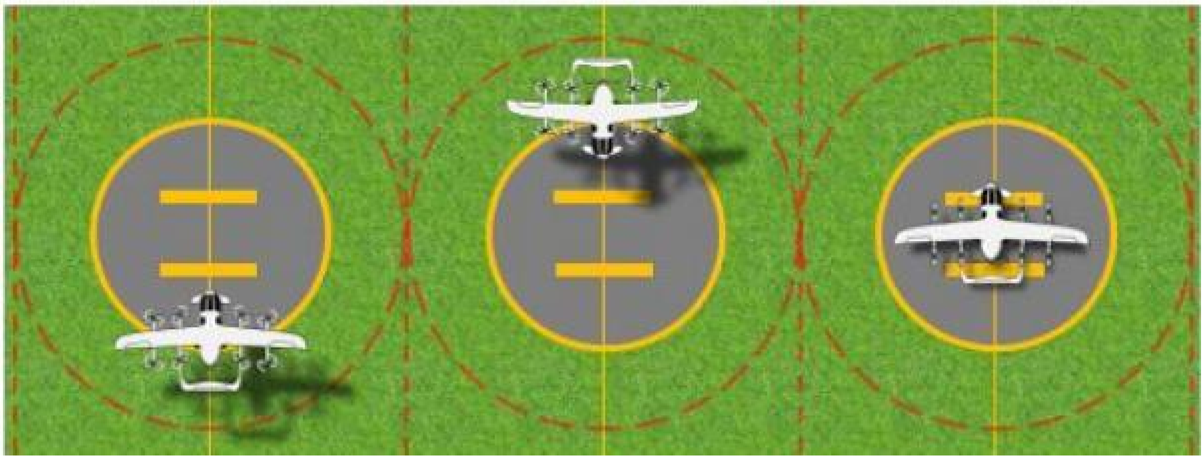
Example B: Ground taxi. Simultaneous turning stands



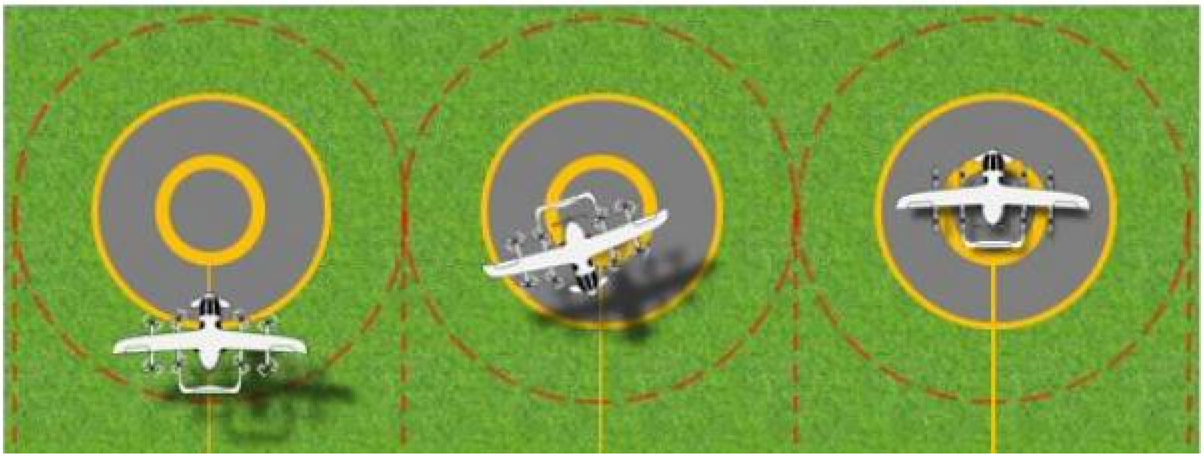
Example C: Ground taxi. Non-simultaneous taxi-on/push-back stands dependent on other stand being clear or with static aircraft



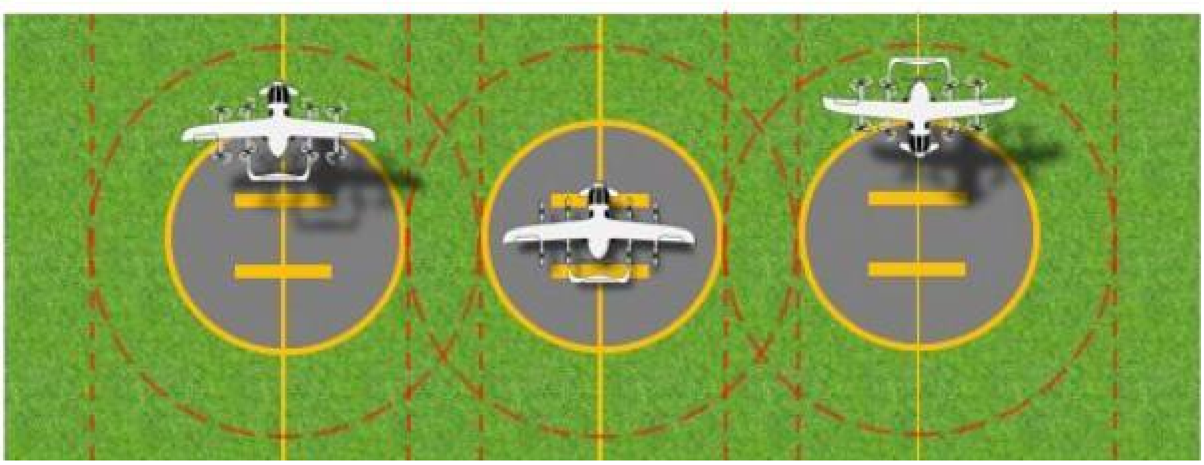
Example D: Ground taxi. Non-simultaneous turning stands dependent on other stand being clear or with static aircraft only



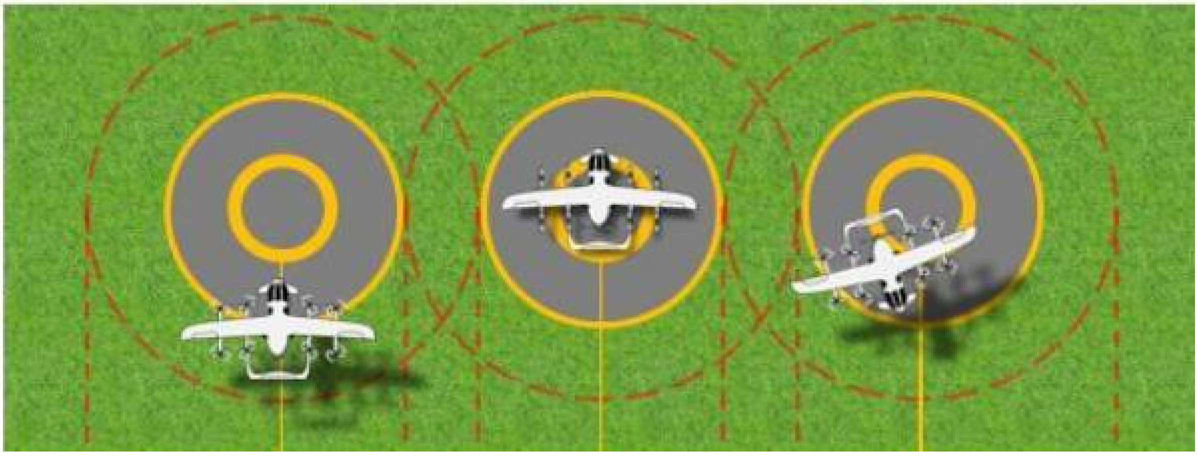
Example E: Air taxi. Simultaneous taxi-through stands



Example F: Air taxi. Simultaneous turning stands



Example G: Air taxi. Non-simultaneous taxi-through stands dependent on other stand being clear or with static aircraft only



Example H: Air taxi. Non-simultaneous turning stands dependent on other stand being clear or with static aircraft only

Figure 6 - Protection areas for VCA stands and the associated VCA taxi-routes for different operational scenarios

4 Obstacle limitation surfaces (OLS)

4.1 Introduction

4.1.1 Establishing obstacle limitation surfaces

4.1.1.1 A vertiport operator should establish the obstacle limitation surfaces (OLS) applicable to the critical performance of the design VCA.

Note: Refer to AC 139.V-02 for the monitoring of obstacles in navigable airspace in the vicinity of the vertiport.

4.2 Obstacle limitation surfaces origins

4.2.1 The following section outlines the protected areas from which obstacle limitation surfaces (OLS) originate. The dimensions of the OLS serve a general objective of protection of approach, climb-out and balked landing manoeuvres in the visual phase of the approachto-land below a height of 152 m above the FATO elevation.

4.2.2 FATO Protection Area (FPA)

4.2.2.1 An FPA should be provided for each FATO, as shown in Figure 7.

4.2.2.2 An FPA should have the following features:

a. free of obstacles, except for essential objects

b. where solid, flush with the edge of the FATO, resistant to the effects of downwash and ensures effective drainage.

4.2.2.3 Where a FATO supports landing/take-off without vertical procedures, the FPA is an area surrounding the FATO that encompasses:

a. the area(s) bordered by a circumscribed square aligned with the landing/take-off flight path(s) centred on the FPA reference circle(s)

b. any area contained within the direct common tangents of any multiple FPA reference circles.

4.2.2.4 Where a FATO supports landing/take-off with vertical procedures only, the FPA is an area surrounding the FATO that encompasses:

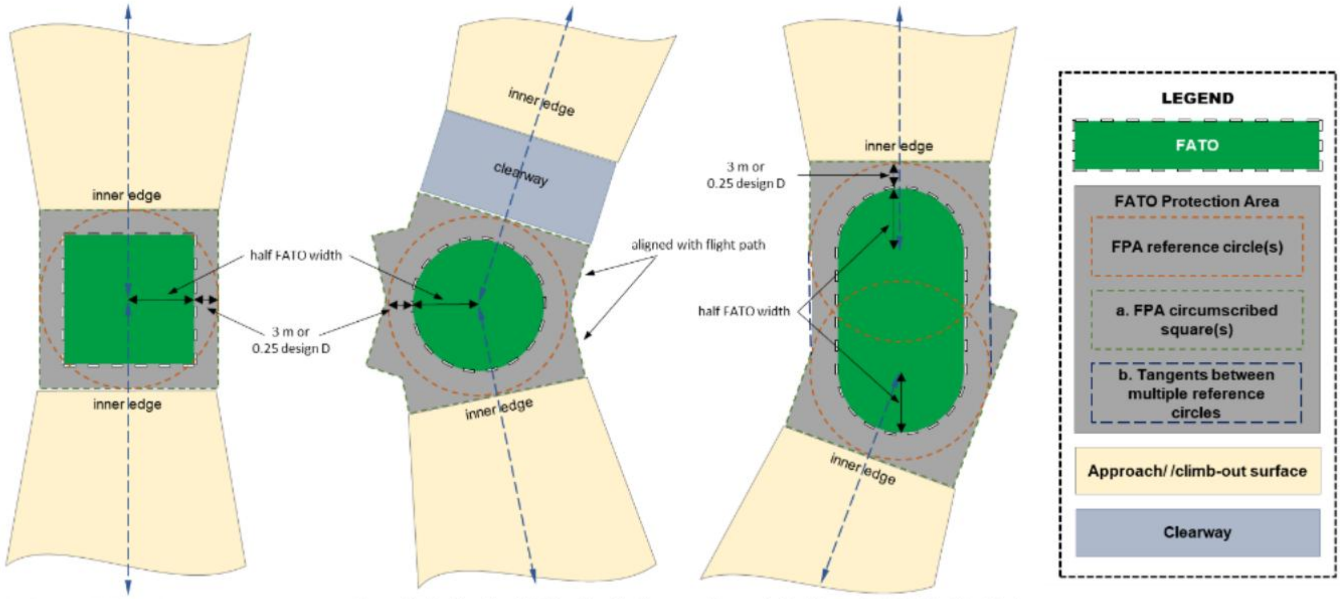
a. the FPA reference circle(s)

b. any area contained within the direct common tangents of any multiple FPA reference circles.

4.2.2.5 The radius of an FPA reference circle should be half the FATO width plus 3 m or 0.25 Design D, whichever is greater.

4.2.2.6 Where the FATO length is greater than its width, separate FPA reference circles are centred on the FATO centreline at a distance of half the FATO width from the FATO ends, as shown in Example C of Figure 7.

4.2.2.7 Essential objects located in the FPA should not exceed 25 cm in height and should be frangibly mounted.



Example A: Square FATO with straight-through approach / climb-out paths

Example B: Circular FATO with offset approach / climb-out paths

Example C: Elongated FATO with offset approach / climb-out paths

Figure 7 - Protection surfaces for vertiports without vertical procedures

4.2.3 Vertical Procedure Surface

4.2.3.1 A vertical procedure surface (VPS) should be established for where vertical procedures are used for landing or take-off from the vertiport.

4.2.3.2 The VPS is a surface that encompasses the area bordered by a circumscribed square(s) aligned with the intended aircraft flight path(s) centred on the VPS reference circle, as shown in Figures 8, 9 and 11.

4.2.3.3 A VPS should be free of obstacles.

4.2.3.4 A VPS reference circle should be established above and centred on the FATO.

4.2.3.5 The diameter of a VPS reference circle should be the diameter of the associated FPA reference circle, plus 1 Design D per 100 ft increase in height above the FATO.

4.2.3.6 The vertiport operator should determine the elevation of the VPS subject to the performance characteristics of the most demanding VCA intended to use the vertiport or the VCA operator’s intended operational requirements.

4.2.4 Obstacle Free Volume (OFV)

4.2.4.1 An OFV should be established between a VPS and the associated FPA.

4.2.4.2 An OFV should be free of obstacles.

4.2.4.3 The OFV is a truncated cone extending between the edge of the FPA reference circle to the edge of the VPS reference circle, as shown in Figure 8, 9 and 11.

4.2.5 Vertiport clearway

4.2.5.1 A vertiport clearway should be established when a VCA needs to manoeuvre, horizontally, between the FPA/VPS outer edge and the approach/climb-out surface inner edge.

4.2.5.2 A vertiport clearway should have the following features:

a. sufficient size and shape to ensure containment of the design aircraft when it is operating between the FPA/VPS and the approach/climb-out surface

b. free of obstacles, except for essential objects

c. resistant to the effects of downwash

d. when at ground level, contiguous surface flush with the FPA, and free of hazards should a forced landing be required.

4.2.5.3 The width of a vertiport clearway should not be less than that of the associated FPA/VPS and centred on the intended flight path, as shown in Figure 7 and 11.

4.3 Surfaces

4.3.1 Approach/Climb-Out Surface

4.3.1.1 An approach/climb-out surface should be established for each approach and climb-out flight path to and from the vertiport, as shown in Figures 8 to 11.

4.3.1.2 The approach/climb-out surface consists of an inclined plane or a combination of planes or, when turns are involved, a complex surface, sloping upwards from the inner edge and centred on the intended flight path that must be clear of obstacles.

4.3.1.3 The limits of an approach/climb-out surface should comprise:

a. an inner edge coincident with and of equal length to the outer edge of the associated FPA/VPS/clearway

b. two side edges originating at the ends of the inner edge and diverging uniformly at a specified rate from the vertical plane, aligned with the intended flight path to a specified width and continuing thereafter at that width for the remaining length of the approach/climb-out surface

c. an outer edge horizontal and perpendicular to the centre line of the approach surface intended flight path at a specified height above the vertiport elevation.

4.3.1.4 The specified values of the above characteristics are outlined in table 2.

Table 2 - OLS surface values - Approach/climb-out surface characteristics

Characteristics Value	
Inner edge width:	Width of FPA/VPS/clearway
Day use only final width:	7x Design D
Day use only divergence:	10%
Night use final width:	10x Design D
Night use divergence:	15%
Outer edge height above FATO elevation	500'(152m)

4.3.1.5 In the case of an approach/climb-out surface involving turns, the surface is a complex surface containing the horizontal normals to its centre line and the slope of the centre line should be the same as that for a straight approach surface.

4.3.1.6 The slope(s) of the approach/climb-out surface should be measured in the vertical plane containing the centre line of the surface.

4.3.1.7 The approach/climb-out surface slope or combination of slopes and section lengths should be determined with reference to the obstacle environment and intended aircraft performance capabilities. If multiple slope/sections are established, the divergent portion of the approach/climb-out surface should be a single consistent slope.

4.3.2 Transitional surface

4.3.2.1 A transitional surface should be established on each side of an approach/climb-out surface and its associated clearway/VPS/FPA, as shown in Figures 8 to 11.

4.3.2.2 The transitional surfaces should be clear of obstacles.

4.3.2.3 The transitional surface should comprise:

a. a lower edge beginning at the point on the outer edge of the approach/climb-out surface where it reaches its final width then extending downwards and along the side of the approach/climb-out surface to the inner edge and from there

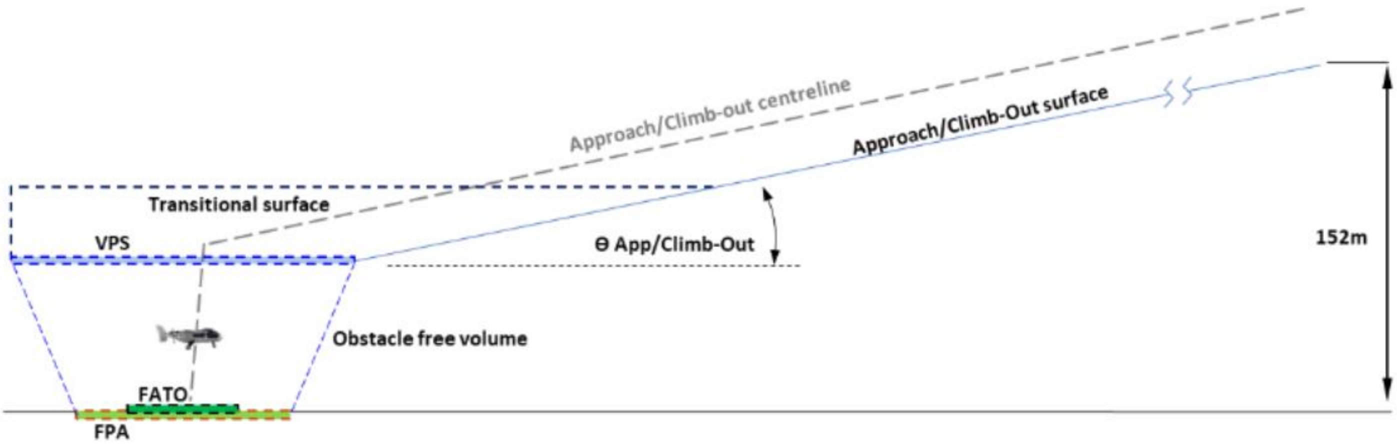
b. where provided, along the side of the clearway parallel to intended flight path

c. along the length of the side of the VPS

d. along the length of the side of the FPA parallel to the intended flight path

e. an upper edge beginning at the point where the outer edge of the approach/climbout surface reaches its final width and then parallel to the intended flight path at a constant height.

Note: As the transitional surface is dependent on the approach/climb-out angle and Design D, it may extend the full length of the approach/climb-out surface. It may also be impacted by the extent of any vertical procedure such that it is no longer present.



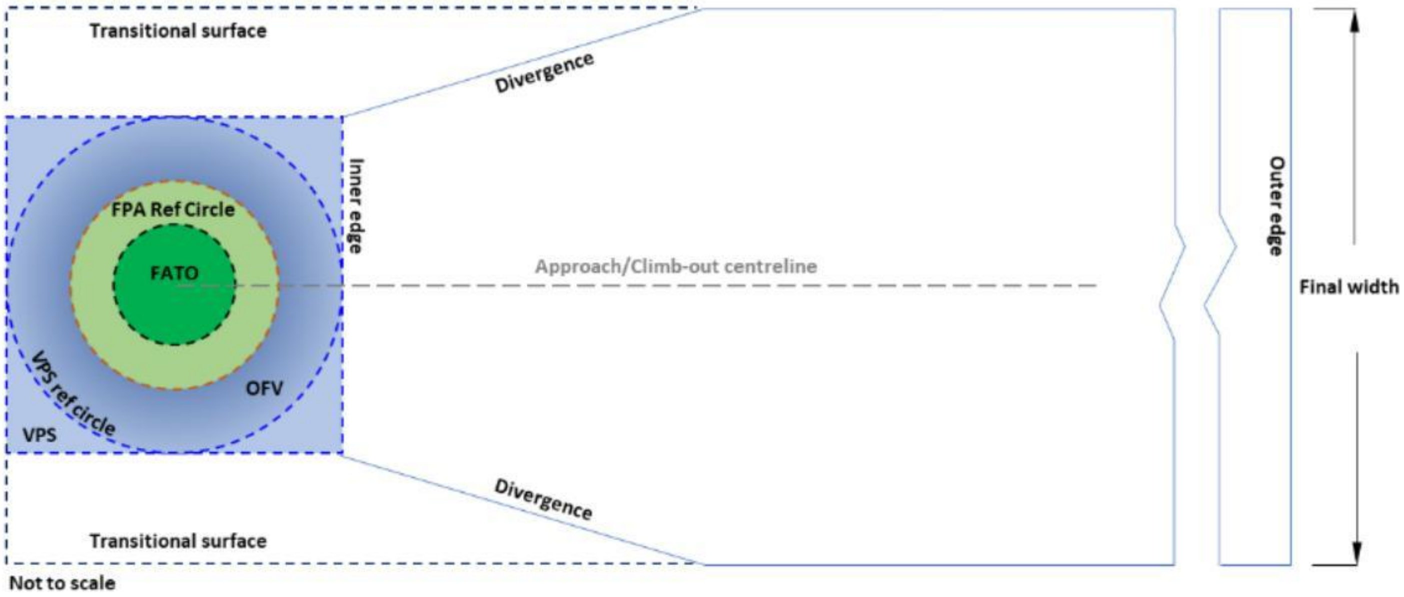


Figure 8 - An example OLS design for a vertiport accommodating vertical procedures

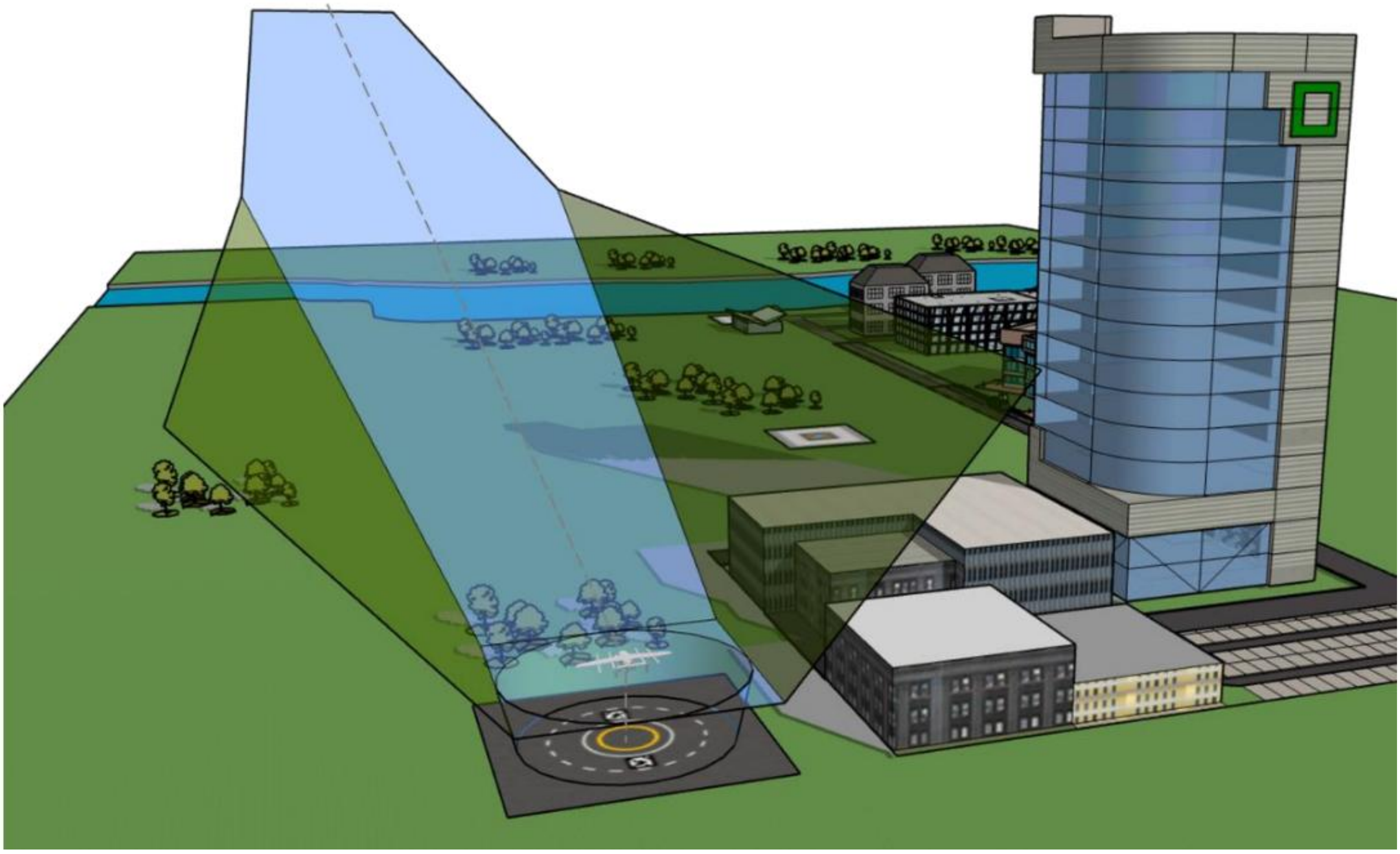


Figure 9 - Illustration of a simple vertiport OLS. Showing an OFV, VPS, VPS reference circle, a single approach/climb-out surface and transitional surfaces

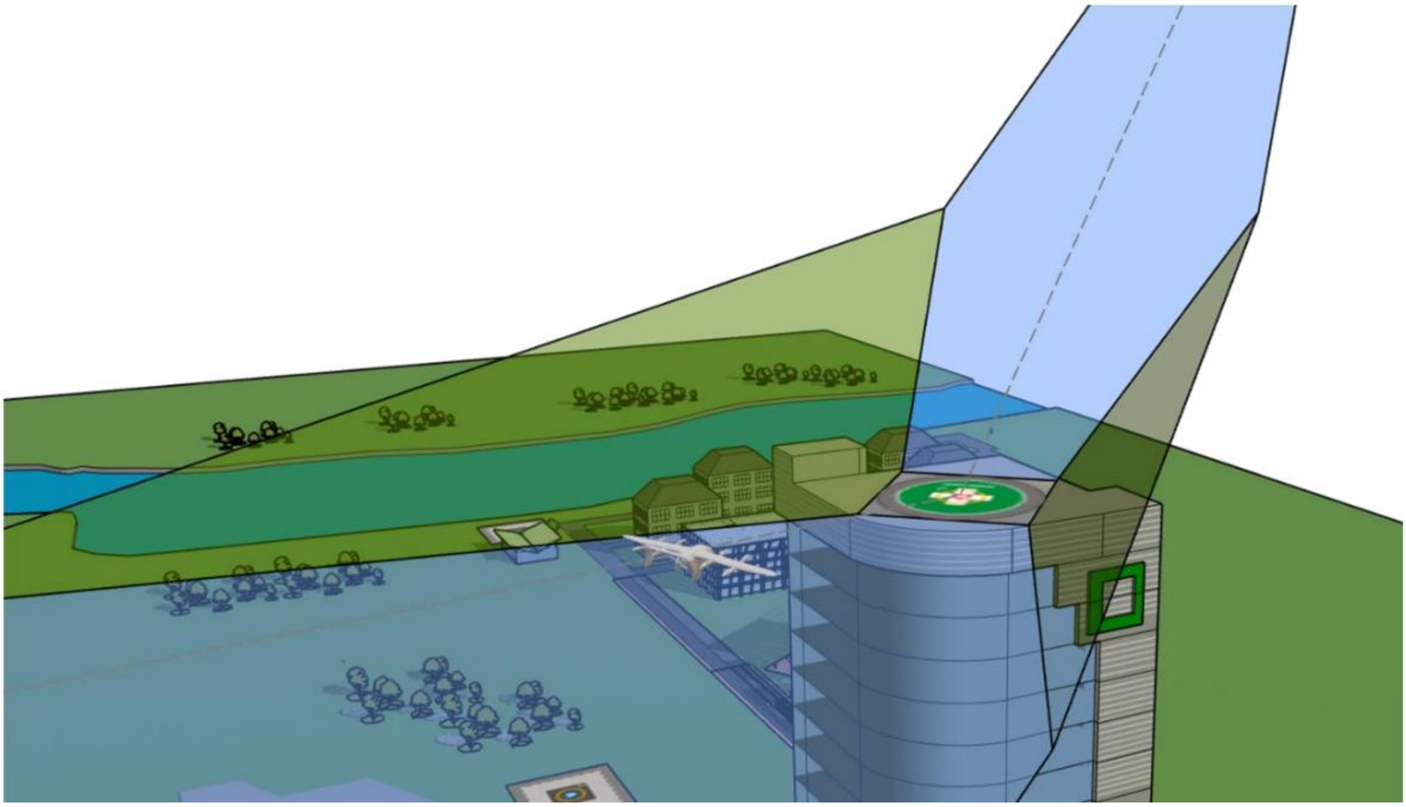


Figure 10 - Illustration of a simple elevated vertiport OLS. Showing an FPA, dual approach/climb-out surfaces and transitional surfaces

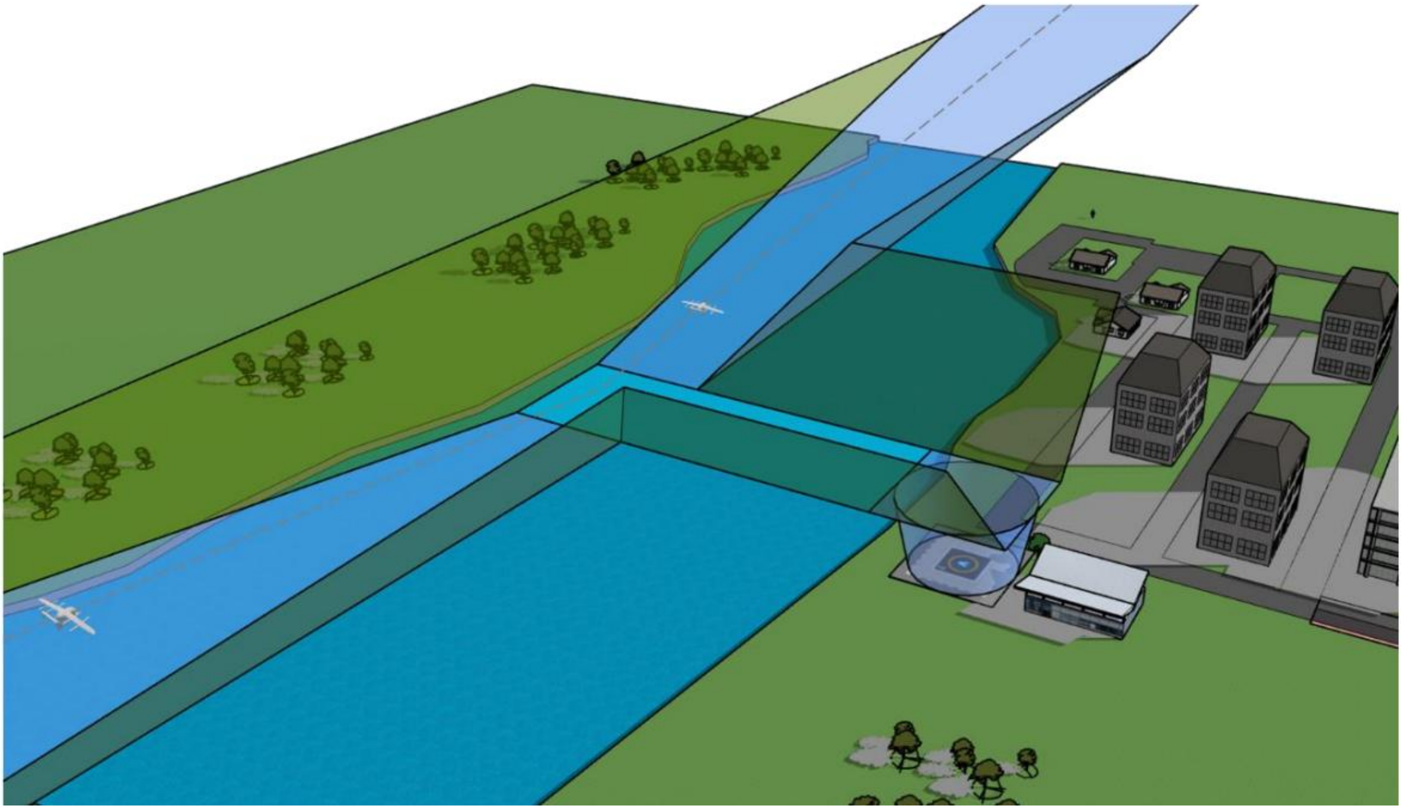


Figure 11 - Illustration of a complex vertiport OLS. Showing an FPA, OFV, FPA, clearway, dual approach/climb-out surfaces over the river and transitional surfaces

5 Visual aids

5.1.1 Wind direction indicators

5.1.1.1 A wind direction indicator should be provided at a vertiport to provide a visual indication of the wind direction and speed.

5.1.1.2 A wind direction indicator should be located to indicate the wind conditions over the FATO in such a way as to be free from the effects of airflow disturbances caused by nearby objects or downwash from the lift/thrust units. It should be visible from a VCA in flight, in hover or on the movement area.

5.1.1.3 A wind direction indicator sleeve should be a truncated cone made of lightweight fabric and should have the dimensions of 1.2 m in length, with a diameter of 0.3 m (at the larger end) to 0.15 m (at the smaller end).

5.1.1.4 The colour(s) of the wind direction indicator sleeve should such that it is clearly visible against its visual background.

5.1.1.5 A wind direction indicator at a vertiport intended for use at night should be lit such that it is clearly visible against its visual background.

5.2 Markers and markings - General

5.2.1.1 Markers and markings should be installed, in accordance with the following specifications, at a vertiport used or available for operations in daylight or at night.

5.2.1.2 Markers and markings should be clearly visible to the vertiport user by way of:

a. provision of a contrasting background marking (a box or border)

b. where allowed for in the specifications below, the selection of an appropriate contrasting colour

c. any other method that would increase the conspicuity of the marking or marker in operational conditions.

5.2.1.3 The night-time visibility of markers and markings may be supplemented by reflective/refractive material and/or electroluminescent paint providing that such material does not pose a hazard if dislodged.

5.3 Markers and markings - FATOs

5.3.1 Flight path alignment guidance marking

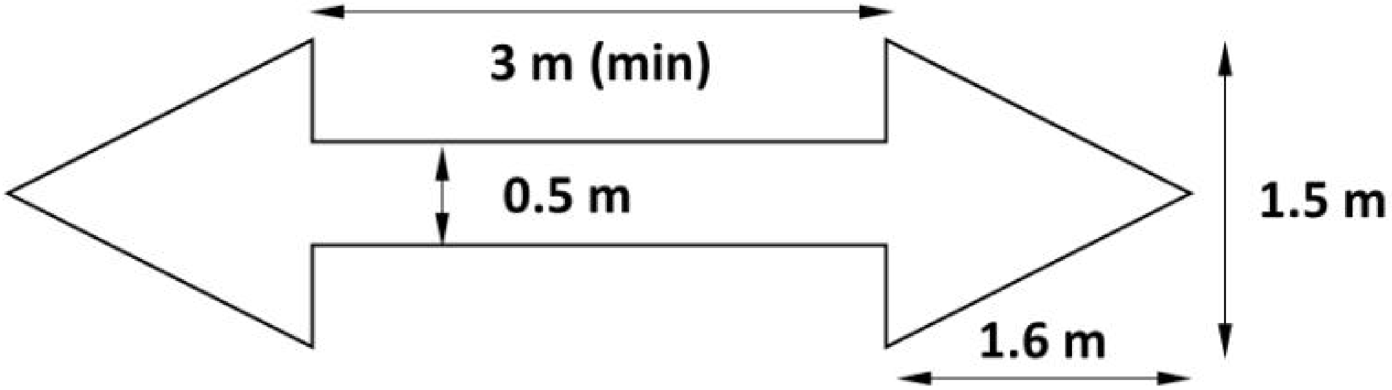


Figure 12 - Flight path alignment guidance marking

5.3.1.1 Flight path alignment guidance marking(s) should be provided at a vertiport where it is desirable and practicable to indicate available approach and/or departure path direction(s).

5.3.1.2 The flight path alignment guidance marking should be located in a straight line along the direction of landing and/or take-off path to the FATO.

5.3.1.3 A flight path alignment guidance marking should consist of each of the following characteristics:

a. one or more arrows marked on the TLOF, FATO and/or FPA

b. the stroke of the arrow(s) shall be 0.5 m in width and at least 3 m in length

c. take the form shown in Figure 12 which includes the scheme for marking ‘heads of the arrows’ which are constant regardless of stroke length.

5.3.1.4 In the case of a flight path limited to a single landing direction or single take-off direction, the arrow marking may be unidirectional. In the case of a vertiport with only a single landing/take-off path available, one bidirectional arrow is marked. Both cases are shown in Figure 16b.

5.3.1.5 The marking should be white.

5.3.2 FATO Perimeter marking or markers

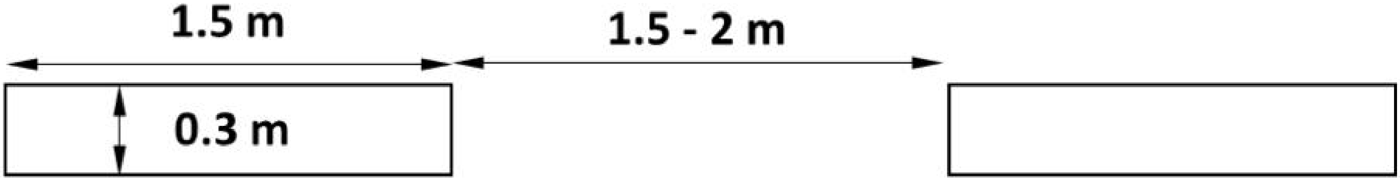


Figure 13 – FATO perimeter markings/markers

5.3.2.1 FATO perimeter markings or markers should be provided at a vertiport where the extent of a FATO is not self-evident as shown in Figures 16a and 16d.

5.3.2.2 For an unpaved FATO, the perimeter should be defined by flush in-ground markers.

5.3.2.3 For a paved FATO, the perimeter should be defined with a painted dashed line.

5.3.2.4 The FATO perimeter marking, or markers should have the following characteristics:

a. be located on the edge of the FATO

b. be 30 cm in width, and 1.5 m in length, as shown in Figure 13

c. have end-to-end spacing of not less than 1.5 m and not more than 2 m with corners of a square or rectangular FATO defined

d. coloured white.

5.3.3 TLOF perimeter marking

5.3.3.1 A TLOF perimeter marking should be displayed if the perimeter of the TLOF is not selfevident, as shown in Figures 16a to 16d.

5.3.3.2 A TLOF perimeter marking should be located along the edge of the TLOF.

5.3.3.3 A TLOF perimeter marking should consist of a continuous white line with a width of 30 cm.

5.3.4 Touchdown positioning marking (TDPM)

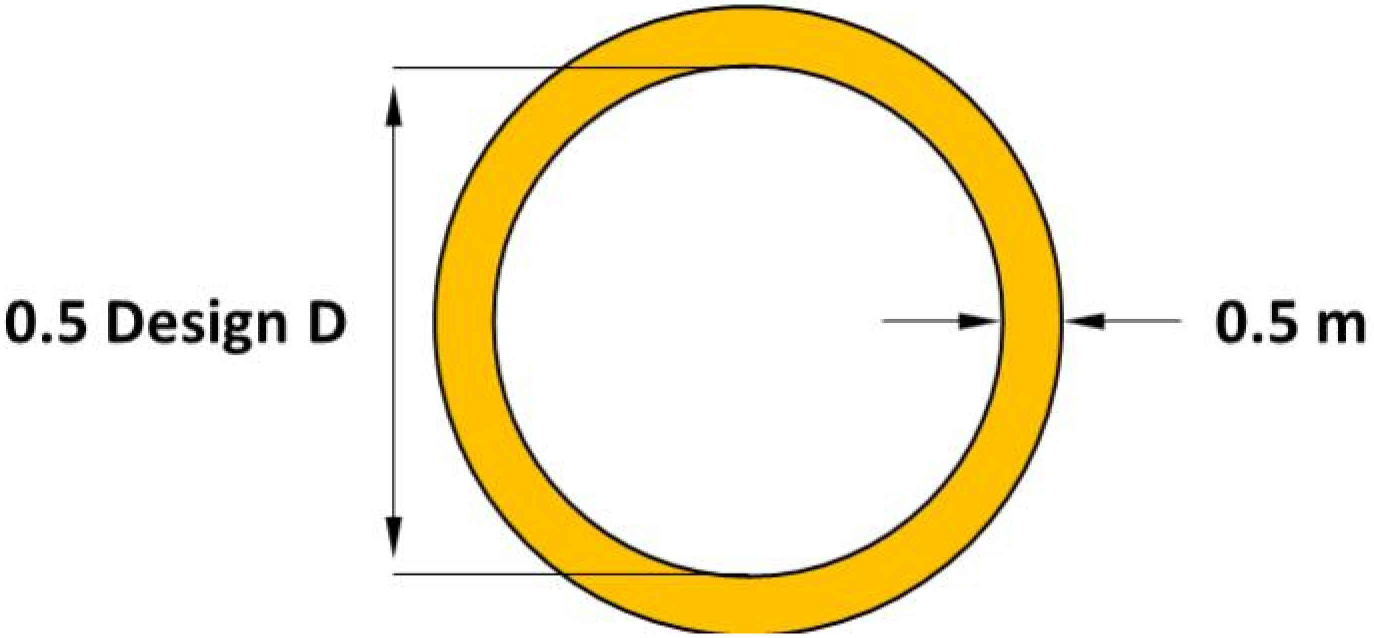


Figure 14 – Touchdown positioning circle marking

5.3.4.1 A TDPM should be provided where a VCA is to touchdown or be accurately placed in a specific position, as shown in Figures 16a to 16d.

5.3.4.2 The TDPM should be:

a. when there is no limitation on the direction of touchdown/positioning, a touchdown/positioning circle (TDPC) marking

b. when there is a limitation on the direction of touchdown/positioning a single shoulder line with an associated centreline

c. be a yellow line with a width of at least 0.5 m.

5.3.4.3 The TDPM should have the following characteristics:

a. the inner edge/inner circumference of the TDPM should be at 0.25 Design D from the centre of the area in which the VCA is to be positioned

b. when a shoulder line, the length of the marking should be 0.5 Design D

c. be a yellow line with a width of at least 0.5 m.

5.3.4.4 The TDPM should be the primary marking when used in conjunction with other markings on the TLOF.

5.3.5 Aiming point marking

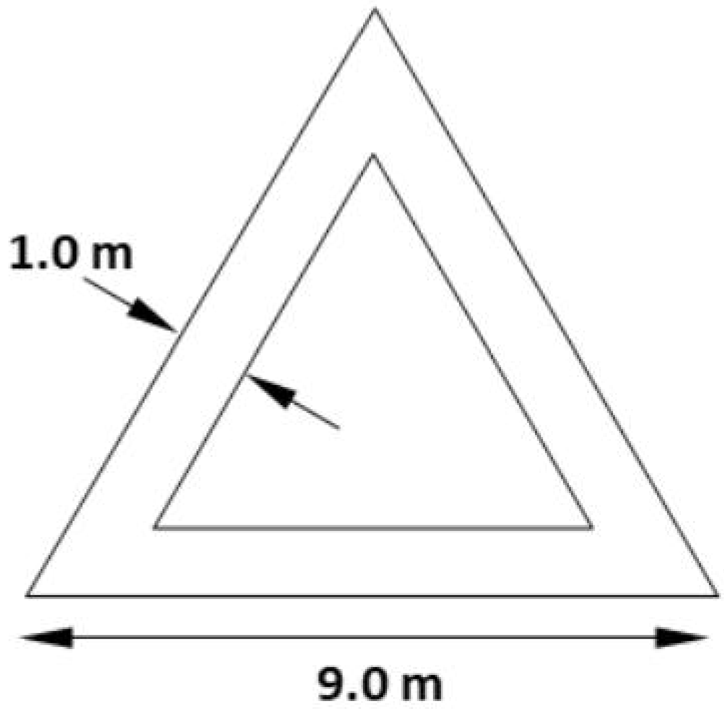


Figure 15 – Aiming point marking

5.3.5.1 An aiming point marking should be provided at a vertiport where it is necessary for a pilot to make an approach to a particular point above a FATO before proceeding to a TLOF,

as shown in Figure 16c. The aiming point marking should be located at the centre of the FATO.

5.3.5.2 The aiming point marking should be located at the centre of the FATO

5.3.5.3 The aiming point marking should have the following characteristics:

a. be an equilateral triangle with the bisector of one of the angles aligned with the preferred landing direction

b. consist of continuous lines

c. the dimensions of the marking should conform to those shown in Figure 15.

5.3.6 Vertiport identification marking

5.3.6.1 A vertiport identification marking may be provided within a FATO, as shown in Figures 16a, 16b and 16d.

5.3.6.2 Where a TDPC is provided, the vertiport identification marking should be in the centre of the TDPC. Otherwise, the vertiport identification marking should be located at or near the centre of the FATO.

5.3.6.3 A vertiport identification marking should have the following characteristics:

a. a form that identifies the vertiport

b. have colour(s) that do not conflict with or detract from the TDPC where used

c. have a size that not less than 3 m and not greater than 0.5 Design D in its longest dimension

d. have a form that allows the marking to be aligned with the preferred landing direction.

5.3.6.4 The use of the letter "H" and "X" should be avoided as to not conflict with the heliport identification marking and an unserviceability marking. Markings with a white cross should also be avoided.

Note: The vertiport identification marking need not be limited to a single form for all vertiports, however the marking used should be consistent across a facility. For example, a vertiport operator may choose to use a vertiport identification marking defined by another aviation authority, or they may choose to use a corporate logo or brand that aligns with the characteristics in 5.3.5.3.

5.3.6.5 Where a vertiport is equipped with two or more FATOs, vertiport identification markings may be supplemented or replaced with an ordinal number marking, as shown in Figure 16d.

5.3.6.6 An ordinal number marking should consist of the following characteristics:

a. arranged as to be readable from the preferred landing direction

b. a number, beginning with 1 and ending in the last of the numbered FATOs

c. have a colour consistent with the vertiport identification marking

d. have a size not less than 1.5 m and not greater than 0.5 Design D in its longest dimension.

5.3.7 Vertiport name marking

5.3.7.1 A vertiport name marking may be provided at a vertiport, as shown in Figure 16d.

5.3.7.2 A vertiport name marking should consist of the name or the alphanumeric designator of the vertiport.

5.3.7.3 A vertiport name marking intended for use at night should be illuminated, either internally or externally.

5.3.7.4 The characters of the marking should be not greater than 1.2 m in height.

5.3.8 Maximum allowable weight marking

5.3.8.1 A maximum allowable weight marking may be displayed to provide the weight limitation of the TLOF, as shown in Figures 16a and 16d.

5.3.8.2 A maximum allowable weight marking should be located within the TLOF.

5.3.8.3 A maximum allowable weight marking should consist of a one-, two- or three-digit number.

5.3.8.4 The maximum allowable weight should be expressed in tonnes to the nearest 100 kg. The marking should be presented to one decimal place and rounded to the nearest 100 kg followed by the letter 't'.

5.3.8.5 The maximum allowable weight marking should consist of the following characteristics:

a. arranged as to be readable from the preferred landing direction

b. have a size that not less than 0.6 m in its longest dimension.

5.3.9 D-Value marking

5.3.9.1 A D-value marking may be displayed to provide the pilot with the limiting D of the FATO or TLOF, as shown in Figures 16a and 16d.

5.3.9.2 A D-value marking should be located within the FATO or TLOF and so arranged as to be readable from the preferred landing direction(s).

5.3.9.3 The D-value marking should be rounded to the nearest whole metre with 0.5 rounded down.

5.3.9.4 The D-Value marking should consist of the following characteristics:

a. arranged as to be readable from the preferred landing direction

b. have a size that not less than 0.6 m in its longest dimension.

5.3.10 Vertiport marking examples

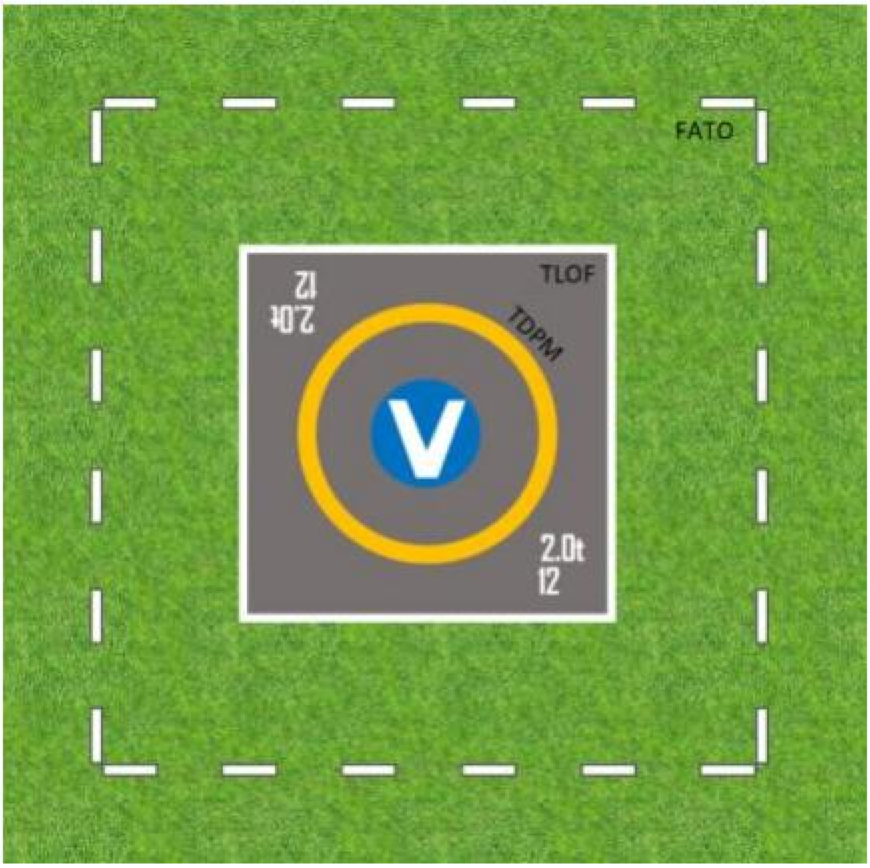


Figure 16a – Vertiport marking example 1

Figure 16a illustrates an example of marking a FATO on a natural surface and includes:

FATO – Natural surface. White flush markers (1.5m x 0.3m)

TLOF – Grey painted square with edge marked by continuous white line (>0.3m)

TDPM – Always an internal diameter 0.5 of Design D. Marked by a continuous yellow circle (0.5-1m wide)

vertiport identification – European Union Aviation Safety Agency (EASA) white V on a blue background

D-Value and maximum allowable weight markings.

Note: The image is an example only and does not limit possible marking combination on a natural surface.

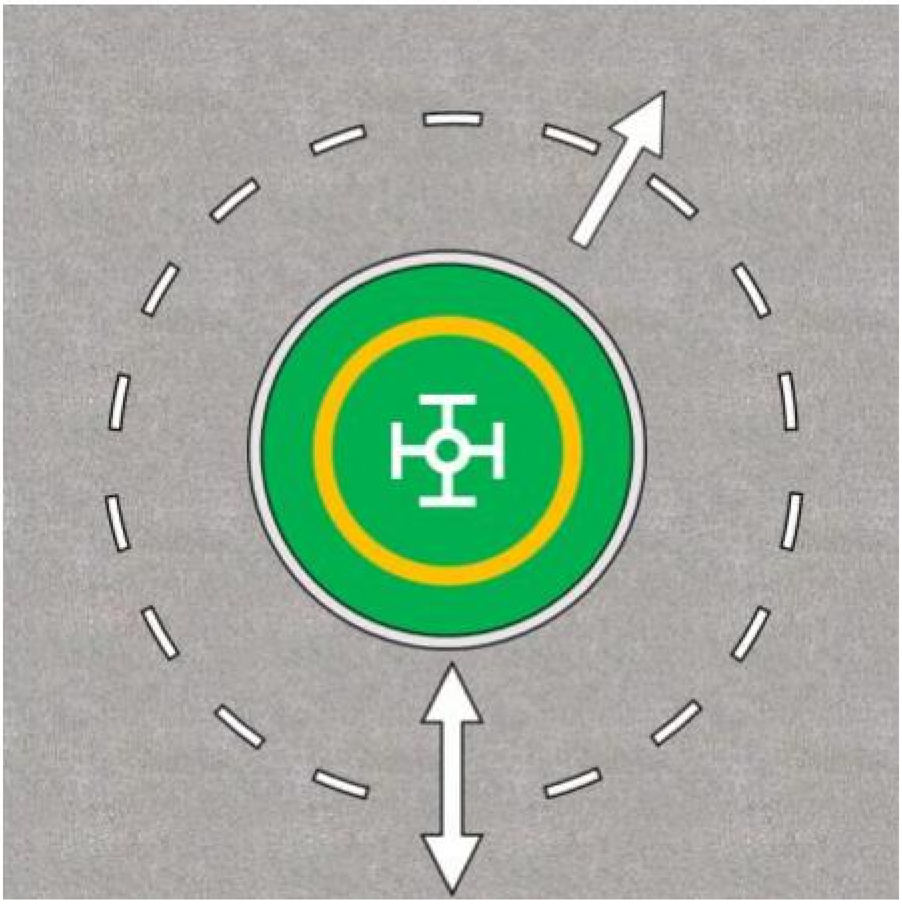


Figure 16b – Vertiport marking example 2

Figure 16b illustrates an example of marking a FATO on a paved surface and includes:

FATO – Light coloured paving. White markings (1.5m x 0.3m) with black outline for contrast with paving

TLOF – Green painted circle with edge marked by continuous white line (>0.3m) and a black outline for contrast with paving

TDPM – Always an internal diameter 0.5 of Design D. Marked by a continuous yellow circle (0.5-1m wide)

vertiport Identification – Federal Aviation Administration broken wheel

- 2 types of flight path alignment guidance markings.

Note: The image is an example only and does not limit possible marking combination on a paved surface.

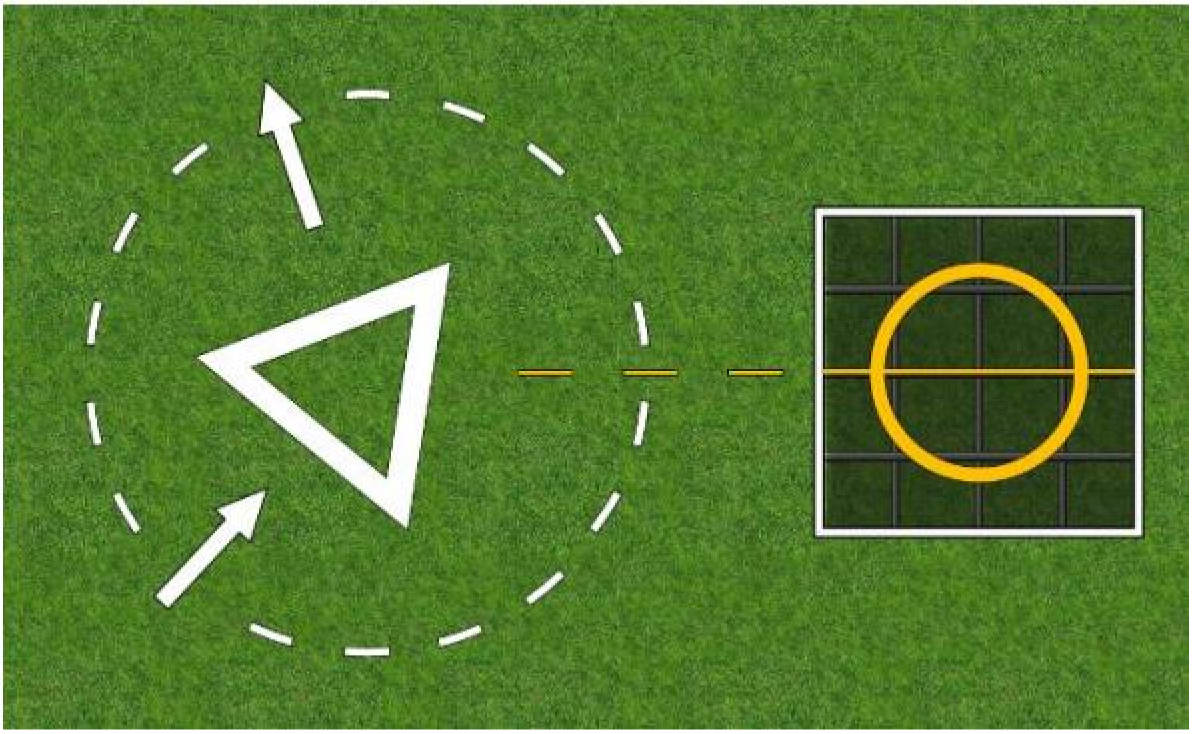


Figure 16c – Vertiport marking example 3

Figure 16c illustrates an example of marking a FATO with an aiming point and stand and includes:

FATO – Natural surface. White flush markers (1.5m x 0.3m)

Air-taxi route markers – 1.5 m x 0.15 m yellow markers

TLOF – Mesh deck with edge marked by continuous white line (>0.3m)

- TDPM – Internal diameter 0.5 of Design D, marked by a continuous yellow circle (0.5-1m wide)

vertiport identification – none

flight path alignment – white arrow markings.

Note: The image is an example only and does not limit possible marking combinations.

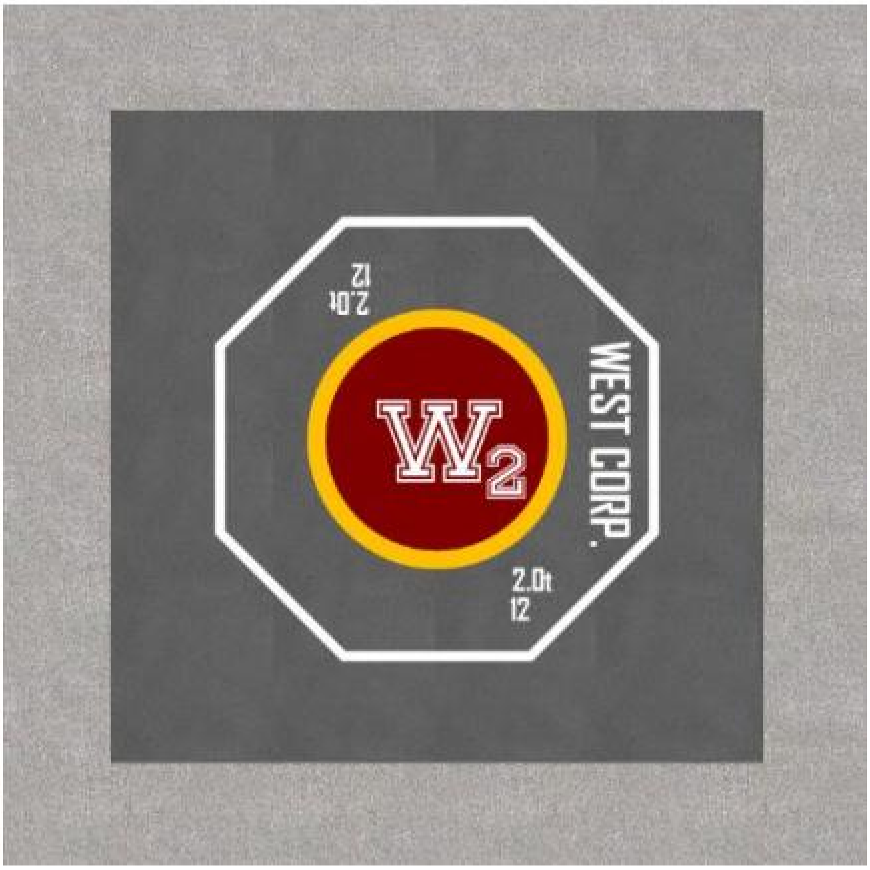


Figure 16d – Vertiport marking example 4

Figure 16d illustrates an example of marking a FATO on a paved surface and includes:

FATO – Self-evident as dark paving against light concrete

- TLOF (at 1 Design D) – Painted paved octagon with edge marked by continuous white line (>0.3m.)

- TDPM – Internal diameter 0.5 of Design D marked by a continuous yellow circle (0.5-1m wide)

vertiport identification – Corporate logo with ordinal number

vertiport name marking.

Note: The image is an example only and does not limit possible marking combinations.

5.4 Markers and markings - taxiways and stands

5.4.1 VCA taxiway markings and markers

5.4.1.1 The centreline of a VCA taxiway should be marked, as shown in Figure 4.

5.4.1.2 A VCA taxiway centre line marking should be a continuous yellow line 15 cm in width.

5.4.1.3 A VCA taxiway that will not accommodate painted markings should be marked with flush in-ground yellow markers, 15-cm-wide and approximately 1.5 m in length, spaced at intervals sufficient to provide directional guidance to pilots.

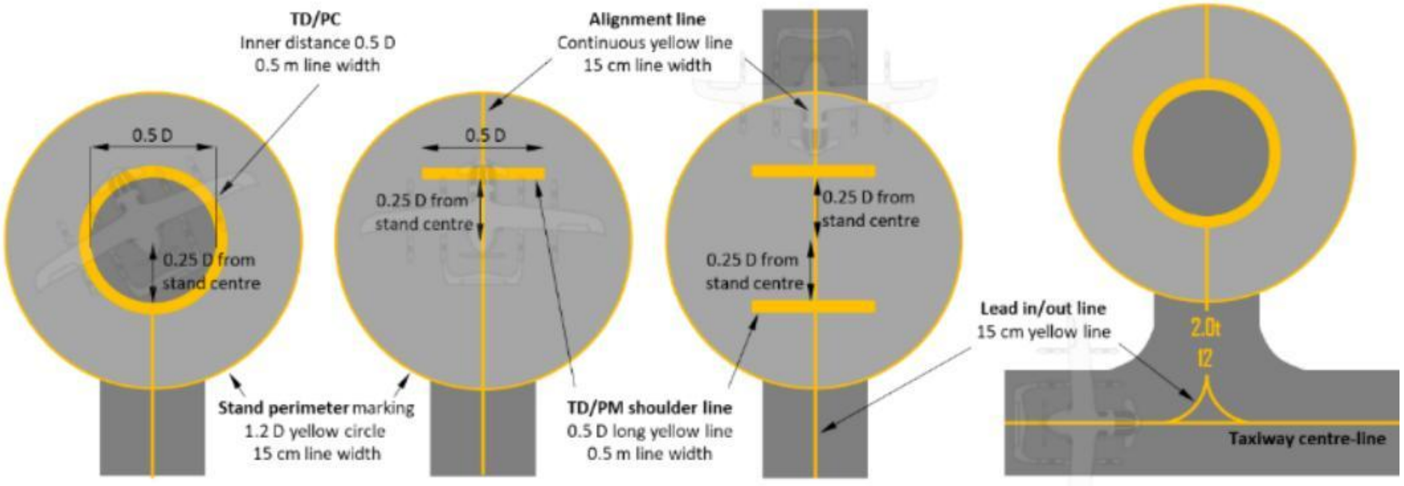
5.4.2 VCA air taxi-route markings and markers

5.4.2.1 The centre line of a VCA air taxi-route should be marked, as shown in Figure 4.

5.4.2.2 A VCA air taxi-route centre line marking should be a continuous yellow line 15 cm in width.

5.4.2.3 A VCA air taxi-route that will not accommodate painted markings should be marked with flush in-ground 15 cm-wide and approximately 1.5 m in length yellow markers, spaced at intervals sufficient to provide directional guidance to pilots.

5.4.3 VCA stand markings



TD/PC for multi direction positioning

TD/PM and alignment line for single direction positioning

TD/PM and alignment line for dual direction positioning and taxi-through

Size and weight restricted stand

Figure 17 – D-value-based stand markings

5.4.3.1 A VCA stand should be marked, as shown in Figure 17 and consist of the following elements: a. a TDPM b. a stand perimeter marking c. lead-in/lead-out markings.

5.4.3.2 VCA stand markings may also include: a. an alignment line b. a stand designation marking c. stand limitation markings d. apron safety lines.

Touchdown positioning marking (TDPM)

5.4.3.3 A stand should be provided with the appropriate TDPM, according to 5.3.4.

Stand perimeter marking

5.4.3.4 A VCA stand perimeter marking should consist of a continuous yellow line and have a line width of 15 cm.

5.4.3.5 When unpaved, the stand perimeter should be marked with flush in-ground markers.

Lead-in/lead-out lines and alignment line

5.4.3.6 The TDPM, alignment lines and lead-in/lead-out lines should be located such that every part of the VCA can be contained within the VCA stand during positioning and permitted manoeuvring.

5.4.3.7 Curved portions of alignment lines and lead-in/lead-out lines should have radii appropriate to the design aircraft or the ground equipment used to position aircraft for that stand.

5.4.3.8 Alignment lines and lead-in/lead-out lines should be continuous yellow lines and have a width of 15 cm. Where it is intended that VCA proceed in one direction only, arrows indicating the direction to be followed may be added as part of the alignment lines.

Stand designation marking

5.4.3.9 VCA stand designation markings may be provided where there is a need to identify individual stands.

5.4.3.10 A stand designation marking should consist of the following characteristics:

a. arranged as to be readable from the preferred approach direction/s

b. an ordinal designation of alphanumeric characters

c. be yellow in colour

d. have a size that not less than 0.5 m and not greater than 0.25 Design D in its longest dimension.

Stand limitation marking

5.4.3.11 Where a stand is designed to accommodate a design aircraft with a smaller D-value, or a lesser weight than is accommodated by other vertiport facilities, the marking showing the limiting D-value or weight should be displayed on the lead-in line to that stand.

5.4.3.12 The stand limitation marking should consist of the following characteristics:

a. arranged as to be readable prior to entering the stand

b. be yellow in colour

c. have a size that not less than 0.5 m and not greater than 0.25 D in its longest dimension

d. centrally located on the lead-in line, with the lead in line broken to accommodate the marking.

5.4.3.13 A weight-based stand limitation marking should be consistent with 5.3.8.

5.4.3.14 A D-value based stand limitation marking should be consistent with 5.3.9.

Apron safety line marking

5.4.3.15 Apron safety lines may be provided on an apron as required by the parking configurations and ground facilities.

5.4.3.16 Apron safety lines may be located to define the areas intended for use by ground vehicles and other aircraft servicing equipment, passengers and pedestrians, etc., to provide safe separation from aircraft.

5.4.3.17 Apron safety lines should have the following characteristics:

a. be of a conspicuous colour, preferably red, which should contrast with that used for VTOL-capable aircraft stand markings

b. be continuous in length and at least 10 cm in width.

5.5 Visual aids - Lighting

5.5.1 General

5.5.1.1 Lights and lighting systems should be installed, in accordance with the following specifications, at a vertiport used or available for operations at night.

5.5.1.2 The photometrics for vertiport lights and lighting elements (including light output, vertical and horizontal distribution, and chromaticity) should be appropriate to the vertiport environment and intended operations without being visually distracting or confusing to pilots.

Note: Annex 14 Volume II may be used as a starting point for vertiport designers and operators to gain an understanding of legacy heliport lighting systems and from there determine the appropriate photometrics (such as light output, vertical and horizontal distribution, and chromaticity) that will provide the safest outcome for their intended VCA operations.

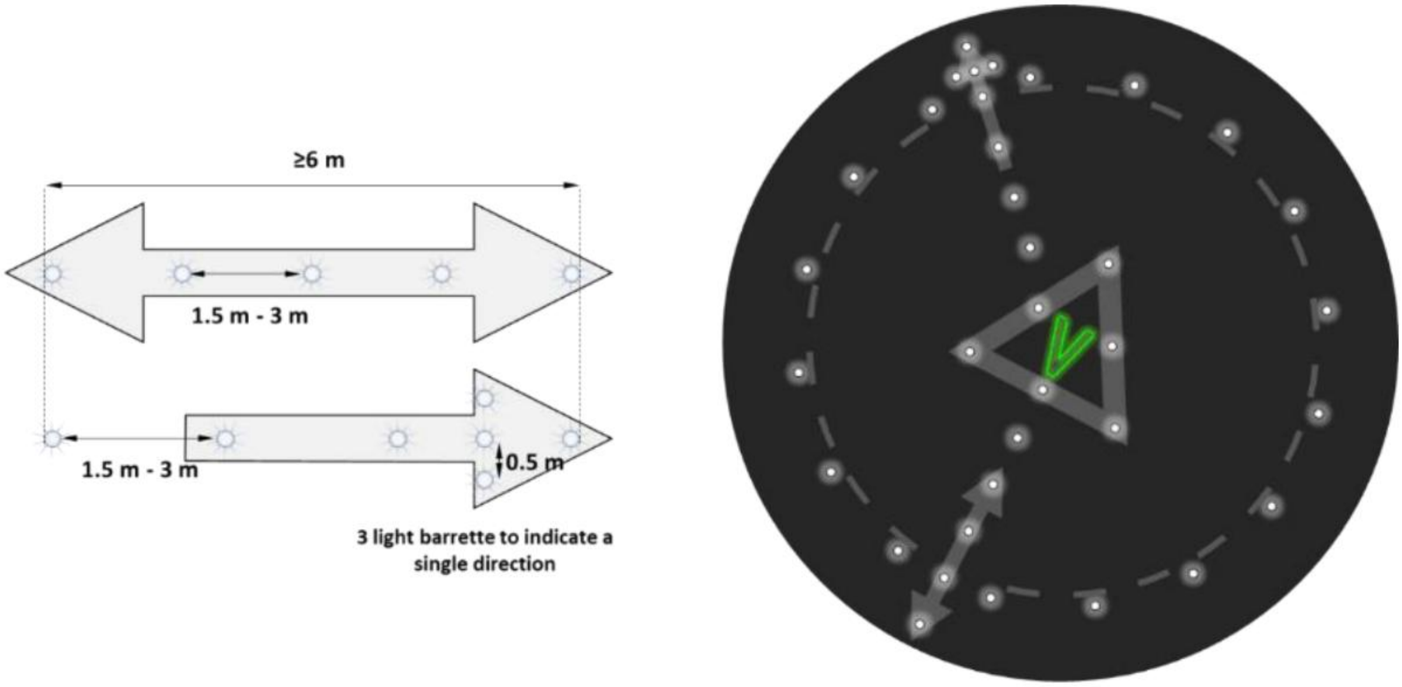
However, the application of Annex 14 Volume II may not suit VCA operations or the location of a vertiport where vertical procedures are intended or the vertiport is in a community sensitive location.

5.5.1.3 If the operating environment varies, lighting systems should be adjustable in order to achieve the appropriate intensity, if needed.

5.5.2 Approach lighting system

Reserved

5.5.3 Flight path alignment guidance lighting system



Note - Markings have been shaded to emphasise the lighting

Figure 18 - Flight path alignment guidance lights and arrangement for aiming point lights

5.5.3.1 Flight path alignment guidance lighting system(s) (FPAGLS) should be provided at a vertiport where it is desirable and practicable to indicate available landing and/or take-off path direction(s), as shown in Figure 18.

5.5.3.2 The flight path alignment guidance lighting system should be located in a straight line along the direction(s) of approach and/or departure path to/from the TLOF or FATO within FATO, TLOF or protection area.

5.5.3.3 If combined with a flight path alignment guidance marking, as far as is practicable the lights should be located inside the “arrow” markings.

5.5.3.4 A flight path alignment guidance lighting system should consist of the following characteristics:

a. a row of three or more lights spaced uniformly with a total minimum distance of 6 m

b. intervals between lights should not be less than 1.5 m and should not exceed 3 m

c. where space permits, there should be 5 lights

d. be steady omnidirectional inset white lights.

5.5.3.5 Where a FPAGLS is for an approach only or departure only (but not both), additional lights can be added to indicate the desired direction. These lights should have the following characteristics:

a. a barrette of 3 lights, spaced 0.5 m apart

b. perpendicular to the line of the FPAGLS

c. located centrally between the last and second to last light to form an arrow-head.

5.5.3.6 The system should allow an adjustment of light intensity to meet the prevailing conditions and to balance the flight path alignment guidance lighting system with other vertiport lights and general lighting that may be present around the vertiport.

5.5.4 Visual alignment guidance system

Reserved

5.5.5 Visual approach slope indicator

Reserved

5.5.6 FATO Perimeter lights

5.5.6.1 Where a FATO is established at a vertiport for use at night, the FATO should be provided with perimeter lights

5.5.6.2 FATO perimeter lights should be placed along, outside and within 0.3 m of the edge(s) of the FATO. The lights should be uniformly spaced as follows:

a. for a straight edge, a light at the end of each edge, then with lights evenly spaced at not more than 5 m apart

b. for a curved edge, lights evenly spaced and not more than 5 m apart.

5.5.6.3 FATO perimeter lights should have the following characteristics:

a. be fixed omnidirectional lights

b. white in colour

c. be inset where the FATO and TLOF are collocated and accessed by a taxiway, otherwise, be not more than 25 cm in height.

5.5.7 Aiming point lights

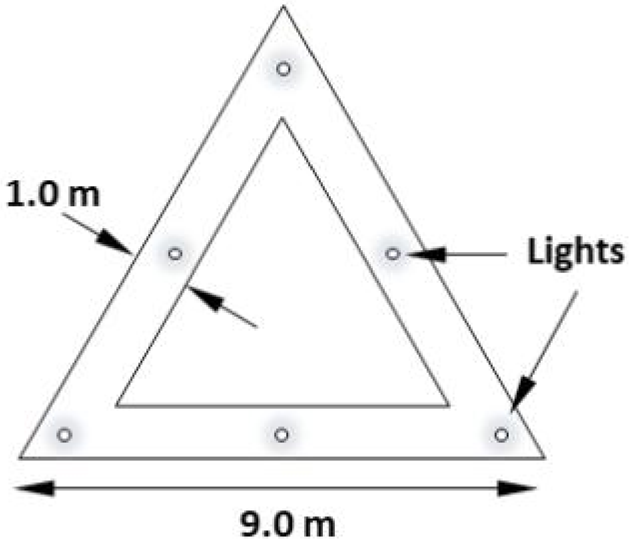


Figure 19 – Arrangement for aiming point lights

5.5.7.1 Where an aiming point marking is provided at a vertiport intended for use at night, aiming point lights should be provided, as shown in Figure 18 and 19.

5.5.7.2 Aiming point lights should be collocated with the aiming point marking.

5.5.7.3 Aiming point lights should form a pattern of at least six omnidirectional white lights. The lights should be inset when a light extending above the FATO could endanger VCA operations.

5.5.8 TLOF lighting system

5.5.8.1 Where a TLOF is established at a vertiport for use at night, the TLOF perimeter should be lit, unless the TLOF is centrally located within the FATO, the TDCP is lit, or is located within a stand lit by floodlighting, as shown in Figures 20a and 20c.

5.5.8.2 The lighting for the TLOF should consist of:

a. TLOF perimeter lights

and/or

b. TDPC lighting segments.

TLOF - perimeter lights

5.5.8.3 TLOF perimeter lights should be placed along, outside and within 0.3 m of the edges of the TLOF. The lights should be uniformly spaced as follows:

a. for a straight edge, a light at the end of each edge, then with lights evenly spaced between at not more than 3 m apart

b. for a curved edge, light evenly spaced and not more than 3 m apart.

5.5.8.4 TLOF perimeter lights should have the following characteristics:

a. be fixed omnidirectional lights

b. green in colour

c. be inset where the TLOF is accessed by a taxiway, otherwise, be not more than 5 cm in height.

TLOF - lighting segments

Reserved

TDPC - lighting segments

5.5.8.5 Lighting segments should have the following characteristics:

a. a width no larger than the marking it defines

b. a frame the same colour as the marking it defines

c. have a finish that does not reduce surface friction of the TLOF.

5.5.8.6 Lighting segments, where provided to identify the TDPC, as shown in Figure 20b, should have the following characteristics:

a. a total length of lighting segments, in a pattern, of between 50% and 75% of the length of the pattern

b. be evenly spaced with gaps between lighting segments of not less than 0.5 m

c. be placed within the marking designating the TDPC such that the lighting segments are within 10 cm of the inner edge of the marking

d. show yellow light.

5.5.9 Vertiport identification marking lighting

5.5.9.1 The vertiport identification marking may be lit.

5.5.9.2 Vertiport identification marking lighting should not adversely impact the TLOF surface.

5.5.10 VCA taxiway/air taxi-route lighting

5.5.10.1 Where a taxi-route is established at a vertiport for use at night, the taxi-route centreline should be lit.

5.5.10.2 Taxi-route lights should be placed along the taxiway centreline spaced at intervals sufficient to provide directional guidance to pilots.

5.5.10.3 Taxiway lighting should be yellow, and air taxi-route lighting should be alternating yellow and green, as shown in Figure 20c.

5.5.11 VCA stand lighting

5.5.11.1 VCA stand lighting should be provided on a stand intended to be used at night by VCA.

5.5.11.2 VCA stand lighting floodlights, as shown in Figure 20c, should be located to provide adequate illumination, with a minimum of glare to the pilot of an aircraft in flight and on the ground, and to personnel on the stand. The arrangement and aiming of floodlights should be such that a VCA stand receives light from two or more directions to minimise shadows.

5.5.11.3 The spectral distribution of stand floodlights should be such that the colours used for surface and obstacle markings can be correctly identified.

5.5.11.4 Horizontal and vertical illuminance should be sufficient to ensure that visual cues are discernible for required manoeuvring and positioning, and essential operations round the VTOL aircraft can be performed expeditiously without endangering personnel or equipment.

5.5.12 Vertiport lighting examples

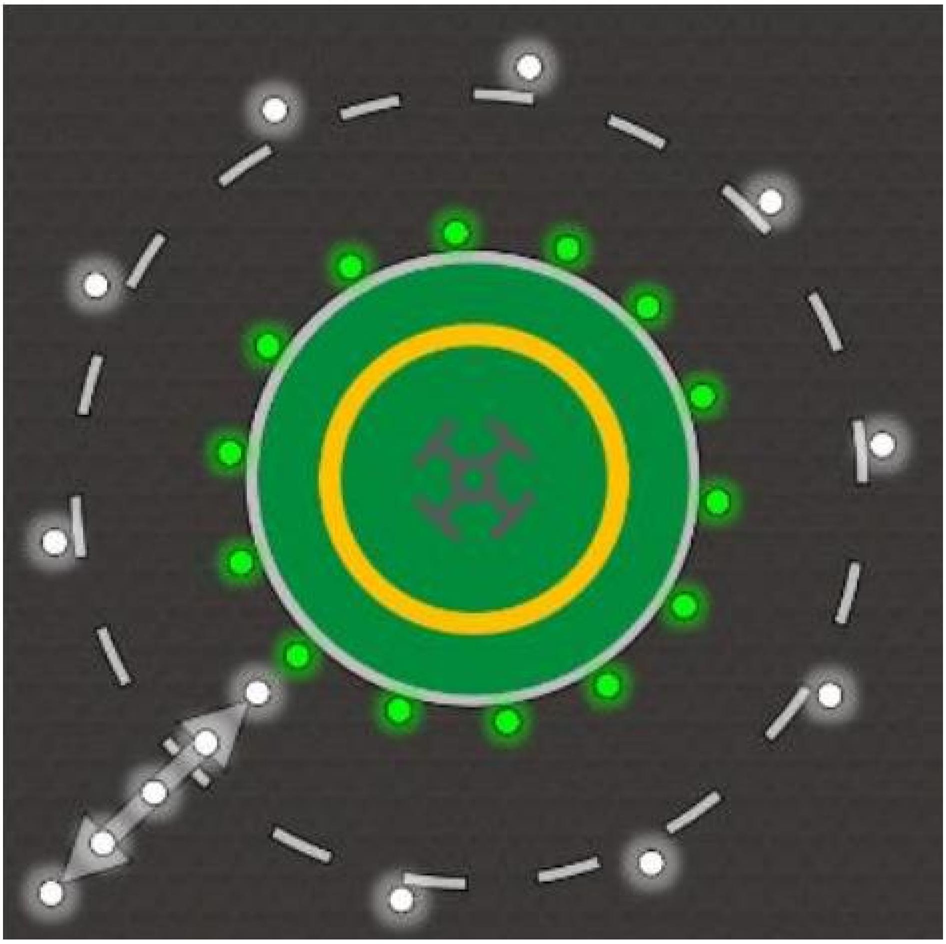


Figure 20a – Vertiport lighting example 1

Figure 20a illustrates an example of lighting a FATO that includes:

FATO - white omnidirectional lights not more than 5 m apart

TLOF - green omnidirectional perimeter lights not more than 3 m apart

TDPC - in this case not lit

flight path alignment guidance lighting - 5 white omnidirectional lights.

Note: The image is an example only and does not limit possible vertiport lighting combinations.

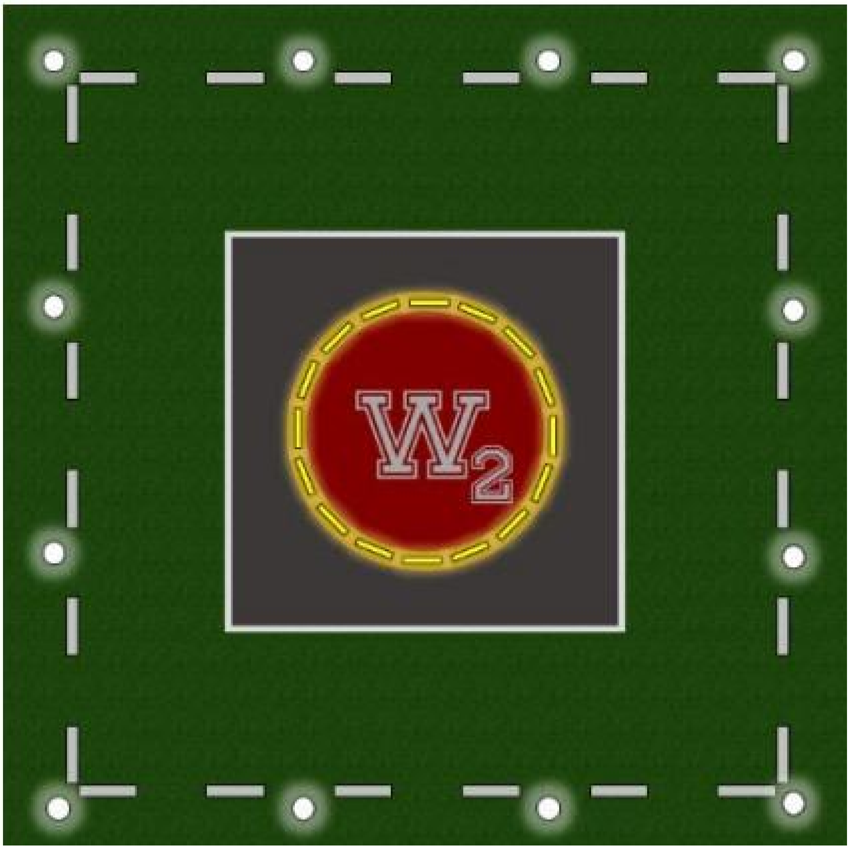


Figure 20b – Vertiport marking example 2

Figure 20b illustrates an example of lighting a FATO that includes:

- FATO - white omnidirectional lights not more than 5 m apart

TLOF - not lit as the TDPC is lit

TDPC - yellow lighting segments.

Note: The image is an example only and does not limit possible vertiport lighting combinations.

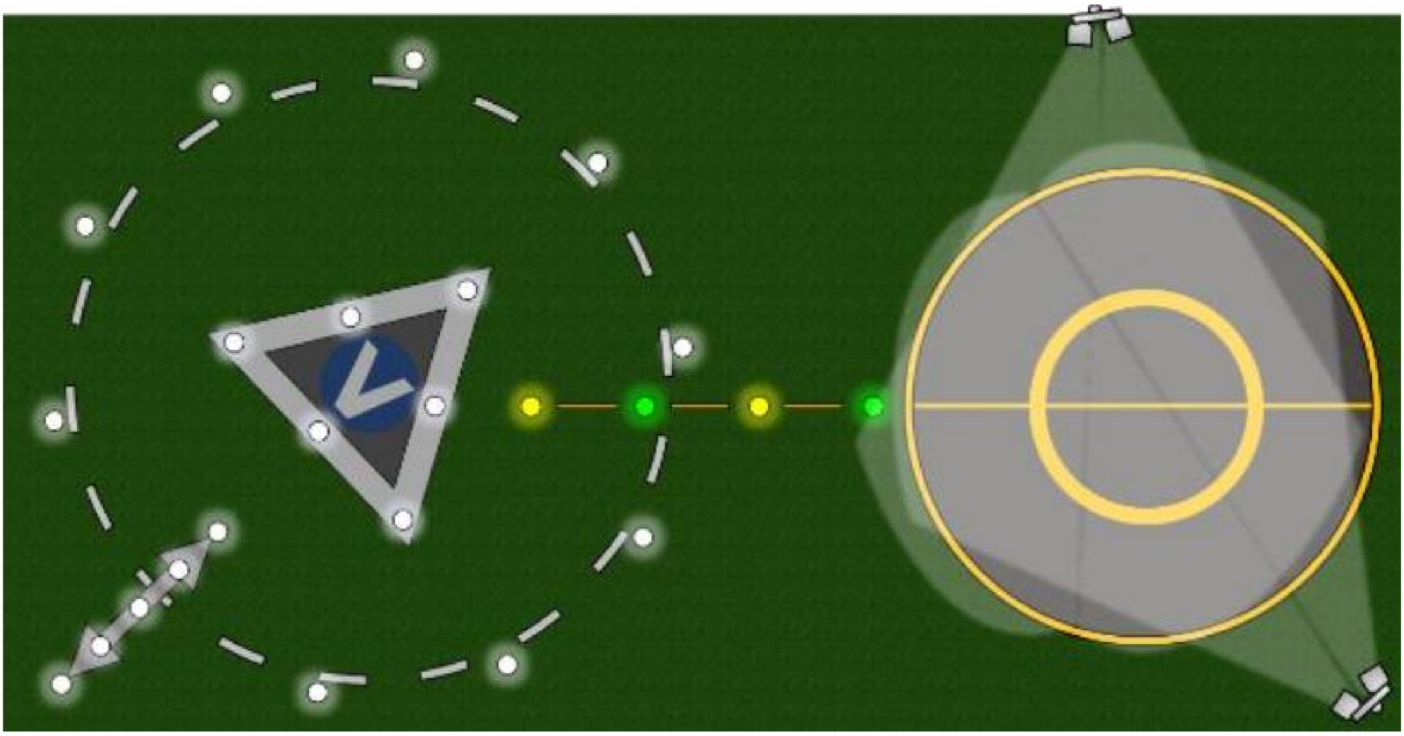


Figure 20c – Vertiport marking example 3

Figure 20c illustrates an example of lighting a FATO and stand that includes:

aiming point with 6 white omnidirectional lights

- FATO white omnidirectional lights evenly spaced not more than 5 m apart

flight path alignment guidance lights of 5 white omnidirectional lights

air-taxi route markers – yellow/green alternating omnidirectional lights

stand TLOF & TDPM – stand floodlights

vertiport identification is not lit.

Note: The image is an example only and does not limit possible vertiport lighting combinations.

5.6 Machine-readable visual aids

Nothing in the specifications above preclude the use of machine-readable aids, such as QR codes, being used for aircraft or vehicle guidance on a vertiport.

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Guide to vertiport design

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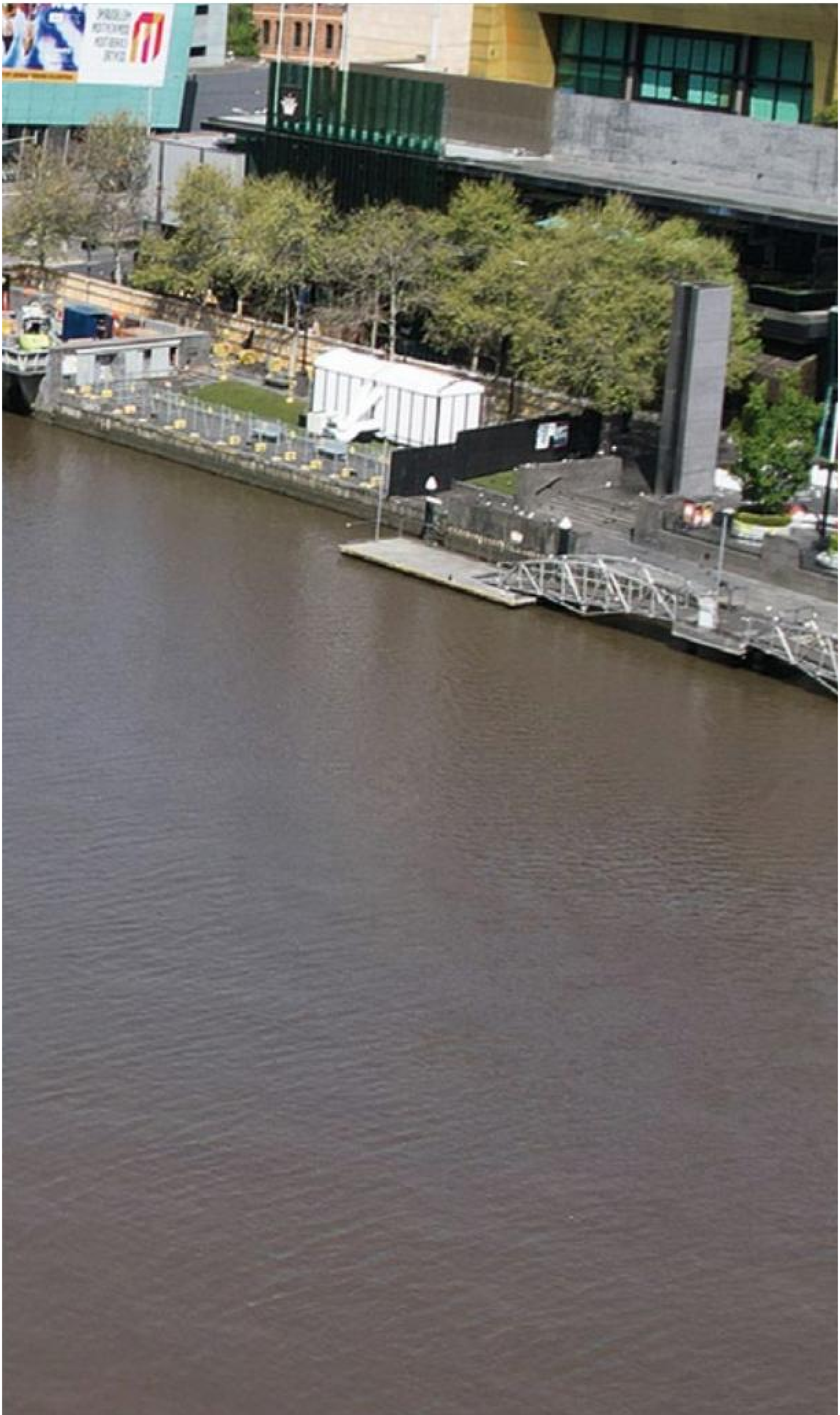

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Who this guide is for?

This guide is for:

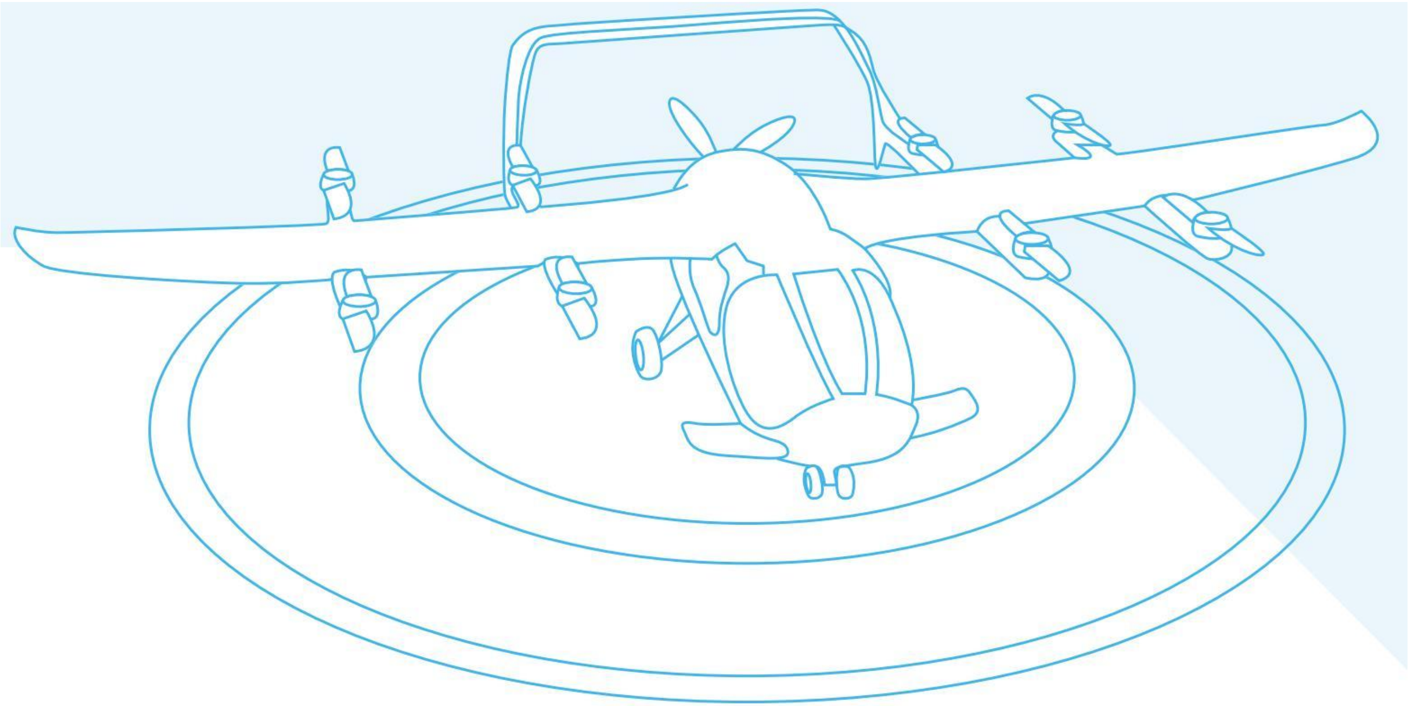
people and organisations involved in the design, construction and operation of vertiports

• planning authorities

• aerodrome operators

• VTOL-capable aircraft operators and manufacturers.

The terms and abbreviations used in this guide are found in Appendices A and B.



About this guide

This guide to vertiport design provides easy to understand explanations and examples to compliment the Civil Aviation Safety Authority (CASA) advisory circular AC 139.V–01 Guidance for vertiport design. It is not intended to be an exhaustive description of the specifications in the AC.

The AC, and this guide, are for the initial planning and design of vertiports intended for vertical take-off and landing (VTOL) capable aircraft (VCA) operating with a pilot on board in visual conditions only. The following operations are not covered by this guidance:

flights in instrument flight conditions (where the conditions are not good enough for the pilot to use outside visual references)

flights operating under digital flight rules (as proposed by NASA)

• flights operating with any form of autonomy.

AC 139.V–01 is largely based on experience with helicopter operations. At the time of publication, no VCA have been certified by any country and it is not possible to be certain that the capabilities of future VCA will match those of currently certified helicopters.

Guidance on vertiport operations, maintenance, serviceability, emergency response, as well as safety and risk management systems, are in development. They are not included in this guide.

As the industry evolves, new guidance will be produced and current guidance will be updated. Please keep in touch at the CASA website:

Advanced air mobility (AAM) – overview

Advanced air mobility (AAM) is the term used to describe an evolving aviation transport ecosystem, based on new and emerging aircraft types incorporating the following advances in technology:

- lightweight and powerful electric motors

high power, yet light weight, battery systems with longer endurance

- distributed electrical propulsion

- hydrogen fuel cell and hybrid power systems

fly-by-light (fibre-optic data transfer) control systems

- low noise profile designs.

These technologies are enabling small start-up companies to compete with large aircraft manufacturers to design AAM aircraft. The aircraft will probably be produced and operated at lower costs than legacy hydrocarbon fuelled aircraft.

We envisage that a variety of aircraft will suit a range of missions including:

- urban air mobility:

– inner-city rooftop-to-rooftop air taxis

– city to airport transfers

- regional air mobility:

– linking regional towns and cities.

Vertical take?off and landing (VTOL) capable aircraft (VCA)

Vertical take-off and landing (VTOL) capable aircraft (VCA) are heavier-than-air aircraft capable of vertical take-off or landing procedures by means of more than two thrust units. VCA do not include aeroplanes or helicopters.

Note: A vertical take-off or landing may also include a horizontal component.

VCA designs are many and varied, with the Vertical Flight Society (VFS) listing over 800 concepts on their website (https://evtol.news/aircraft).

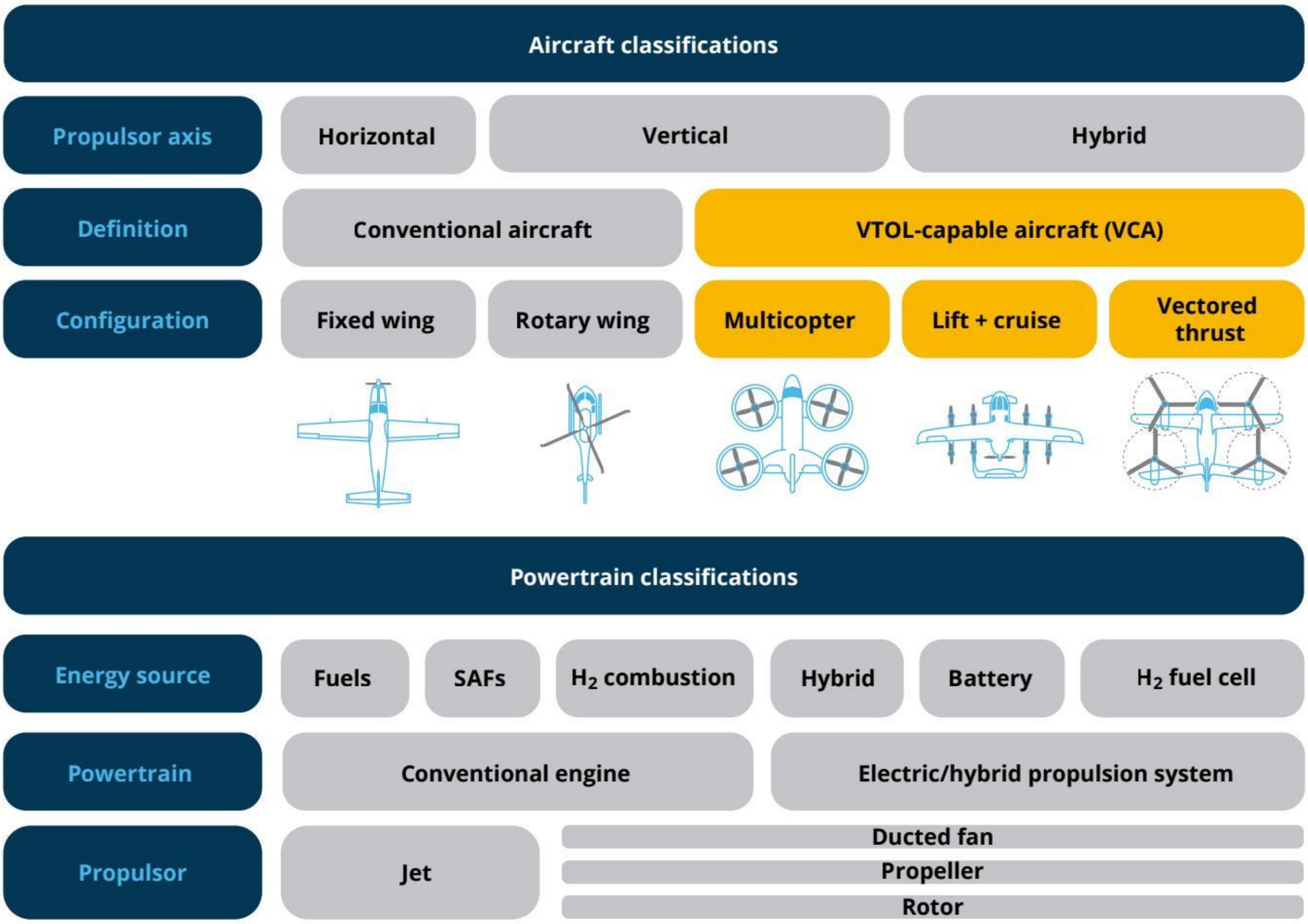
There are organisations that track VCA as they progress through development, testing and towards the delivery of a certified product at a commercial scale. Their statistics indicate that the number and variety of VCA that progress from concept to successful certification will be an important consideration for prospective vertiport operators.

The advanced air mobility reality index, aamrealityindex.com, is a tracking tool which is based on a propriety formula that uses publicly available information and expert knowledge. It helps assess an industry entrants' progress toward the delivery of a certified product at commercial scale.

Components of a vertiport will need to be designed to accommodate the VCA that will operate from it. This is covered in detail later in this guide.

Figure 1 provides an overview of different aircraft types, including conventional aircraft and VCA, as well as their possible sources of power and propulsion systems. Aircraft types addressed by this guide are colour coded yellow.

Figure 1: Aircraft and powertrain classifications



Aircraft classifications

Propulsor axis
Horizontal
Vertical
Hybrid

Definition
Conventional aircraft
VTOL-capable aircraft (VCA)

Configuration
Fixed wing
Rotary wing
Multicopter
Lift + cruise
Vectored thrust

Powertrain classifications

Energy source
Fuels
SAFs
H_2 combustion
Hybrid
Battery
H_2 fuel cell

Powertrain
Conventional engine
Electric/hybrid propulsion system

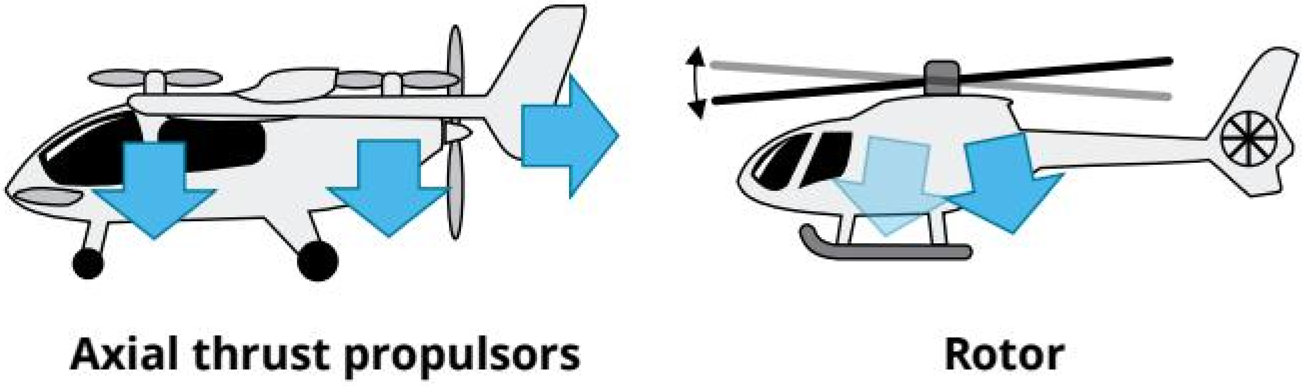
Propulsor
Jet
Ducted fan
Propeller
Rotor

Multicopter (pure lift)

A multicopter is a VTOL-capable aircraft (VCA) with more than two lift-generating propulsors and with no fixed-wing surface for horizontal flight.

Current discussion within the AAM industry has suggested that a multicopter should be labelled as an axicraft. The rationale is based on the way lift is only generated along the propulsor axis (axial thrust). This is different from rotorcraft (helicopters or gyrocopters), where lift produced by the rotor can be tilted to direct thrust along, and off, its spin axis.

Figure 2: Thrust control: axial thrust propulsors versus rotor



Axial thrust propulsors

Rotor

Examples of multicopter VCA are the eHang EH216-S and the Volocopter VoloCity.

Figure 3: VoloCity Volocopter (image www.volocopter.com)

Lift plus (+) cruise

Lift plus (+) cruise VCA have a set of propulsors for generating lift for vertical flight and an additional set of propulsors combined with a fixed-wing surface for cruising in horizontal flight. It is a popular VCA design concept as there is no need for complex titling mechanisms for vectored thrust. Having a fixed wing for cruise provides better range than can be achieved by a pure multicopter. Examples of lift + cruise VCA are the Wisk Generation 5 (Cora), Eve Air Mobility’s EVE-100 and Beta’s ALIA-250. Below is the CASA reference VCA – an example of a fictitious lift + cruise VCA.

Figure 4: Example of a lift + cruise VCA

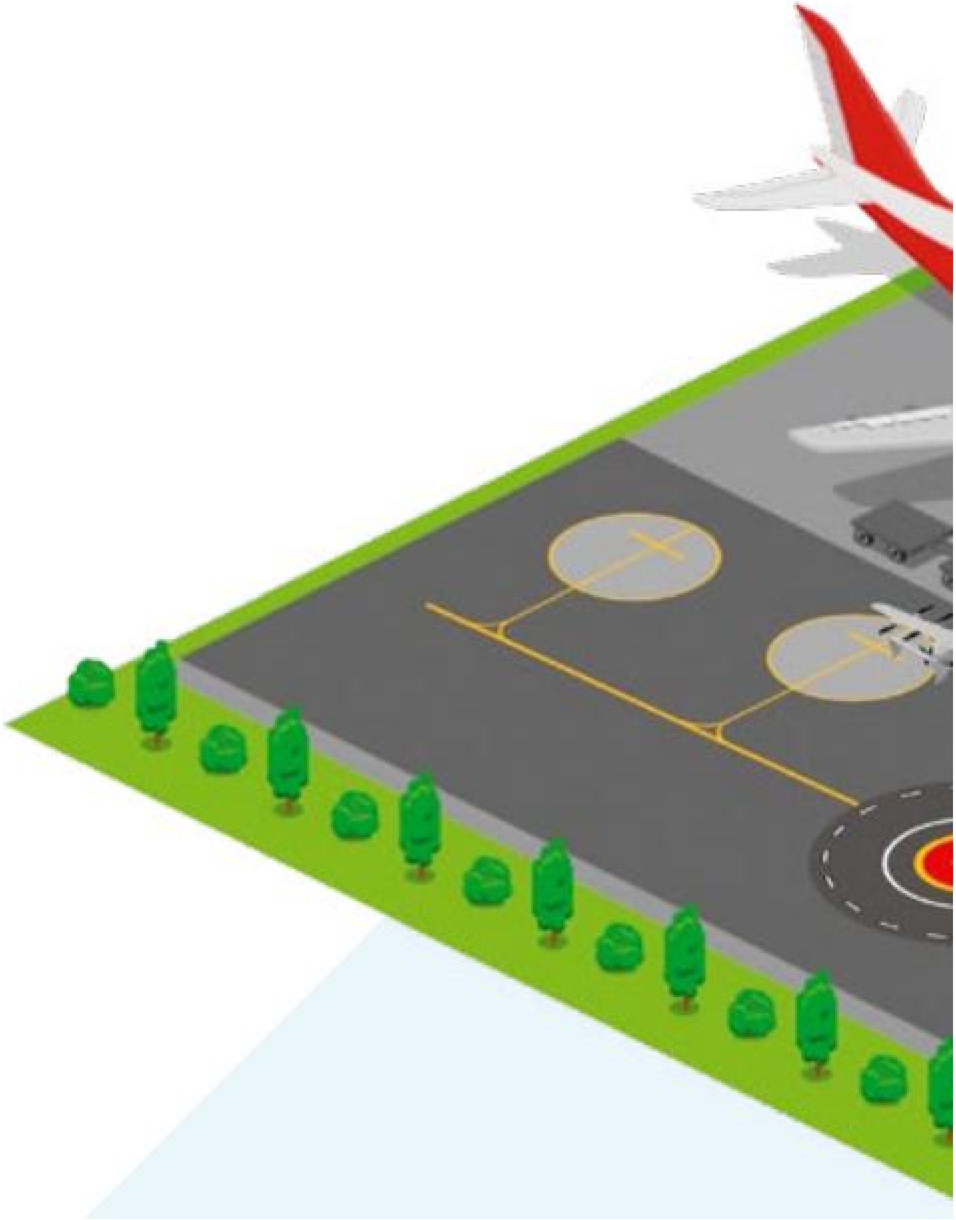
Vectored thrust

Vectored thrust VCA have propulsors that can change the direction of thrust during flight, enabling a transition from vertical to horizontal flight. The thrust propulsors provide thrust for both lift and for cruise, either by having the propulsors themselves tilt or by having the wing (with propulsors attached) tilt. Examples of vectored thrust VCA are the Joby S4 and AMSL Aero’s Vertiia.

Figure 5: Joby S4 (image www.jobyaviation.com)

There is technically a subcategory of vectored thrust that is a lift (axial thrust) plus vectored thrust. This is a popular design configuration, where we see a high winged aircraft with a series of tilting propulsors in front of the wing augmented, during vertical procedures, by a series of lift propulsors behind the wing. Examples of this lift + vectored thrust configuration are the Vertical Aerospace VX–4, Wisk Gen 6 and Archers Midnight.

Figure 6: Vertical VX–4 (image www.avweb.com)



Vertiports – overview

Vertiports are an important infrastructure element of the advanced air mobility (AAM) ecosystem. Existing airports and heliports will continue to be used, however, there will eventually be a requirement for new infrastructure to accommodate emerging VCA types. A vertiport is different from a heliport (which can accommodate all vertical lift aircraft) as a vertiport facility will exclude use by helicopters.

Key driver for new infrastructure

The majority of VCA will be electrically powered and are therefore expected to generate less noise than traditional powered aircraft. The AAM industry wants to operate in urban areas. Typically in these areas, the construction of a heliport would not be accepted by the public, due to the noise associated with helicopter operations. Lower noise VCA present a viable alternative option, thus the requirement for vertiports.

Location

Some vertiports may be situated in large open areas that can accommodate runway-type final approach and take-off areas (FATOs). Others will be situated on small sites within a congested urban environment that are inaccessible to traditional fixed wing aircraft. These areas are where VCA can demonstrate their unique benefits and advantages.

Size

The size of a vertiport will need to suit the VCA types that will operate from it. Sizes will vary from small vertiports, with space for one aircraft and minimal infrastructure (vertistops), to large vertiports with infrastructure that can accommodate multiple aircraft. These vertiports would have facilities to accommodate larger passenger numbers and freight, with some large enough to offer maintenance and storage facilities for fleets of aircraft (vertihubs).

Figure 7: Vertiport located at a freight handling facility

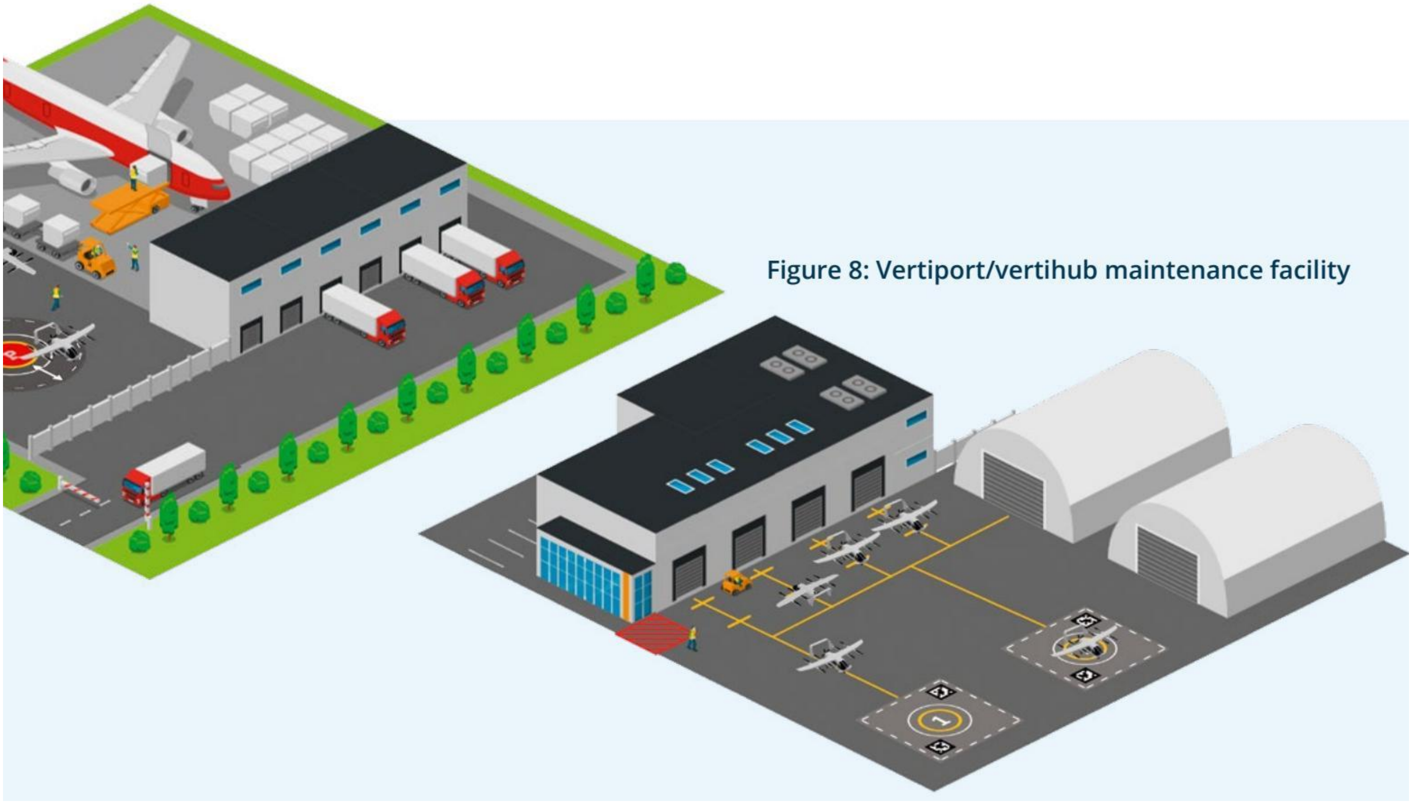


Figure 8: Vertiport/vertihub maintenance facility

Why do we need vertiport specifications when we already have heliport standards?

Vertiport specifications provide a clear separation between building a facility for all vertical lift aircraft (a heliport) and a facility that excludes helicopters (a vertiport).

This will give the AAM industry an opportunity to demonstrate to the community that a vertiport (catering only for VCA) may be more desirable than a heliport. If communities are going to accept AAM as an industry, then gaining this ‘social licence’ is vitally important. With the guidance for vertiports clearly excluding the use of helicopters then we hope that local councils and communities will be more accepting to AAM in their localities.

Also, vertiports are unlikely to cater for conventionally fuelled aircraft (for example, jet fuel or Avgas) and may not require liquid fuelling facilities or liquid fuel fire-fighting equipment. The International Civil Aviation Organization’s (ICAO) guidance for heliports (ICAO Doc 9261) recommends operators have access to firefighting foam, with quantities proportional to the size and complexity of their operation. The guidance also includes suggested deck designs which allow for safe drainage of liquid fuel from the surface. This is known as a passive fire-retarding system. Current research suggests foam and passive fire-retarding decks may be ineffective against lithium battery fires. Instead, vertiports will more likely need to be able to deliver high quantities of water for an extended period to cool runaway batteries. Future guidance will cover emergency response requirements for vertiports.

Table 1: Heliports versus vertiports

Heliports	
perceived as noisy	expected to be quieter
hydrocarbon-fuelled aircraft often have fuelling facilities so need to meet the requirements to contain and fight	unlikely to cater for hydrocarbon-fuelled aircraft so won't need to consider such fire-retarding systems a hydrocarbon-based liquid fuel fire – for likely to need to provide large quantities
existing stigma of undesirable noise, which is not welcome in the community	runaway batteries VCA operators and manufacturers will need to demonstrate that VCA may be more desirable in the community

Combined vertiports/heliports

If VTOL-capable aircraft (VCA) and helicopter operations are required at a single facility, the facility would need to comply with both heliport and vertiport specifications.

Vertiport site selection – considerations

Vertiport operators will need to consider many factors, including those that are outside CASA’s remit. CASA may only provide guidance on aviation safety matters, so vertiport operators will need to reach out to many other agencies and entities to cover all the different considerations. The following table shows sample considerations and suggested agencies to contact.

Table 2: Considerations for vertiport operators, and the relevant agencies

Sample considerations for vertiport operators

CASA

Airservices

Department of Infrastructure

Department of Environment

Home Affairs

Australian Communications and Media Authority

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Vertiport operator

State & local governments

Aviation safety – vertiport design, VCA certification, pilot licensing

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Physical and cyber security, screening

Communication & data – approvals, bandwidths & infrastructure

Weather recording and reporting

Land use planning approval (including noise and environmental impacts), zoning, existing transport networks, community impact and acceptance, emergency response

Vertiport concept (agnostic or bespoke), design, layout, energy storage, local community engagement, emergency response, ground handling, OLS design and monitoring

Influences on vertiport design

Aircraft type

The types of aircraft that will operate from the vertiport will be one of the most important considerations in influencing vertiport design. Many of the design considerations (for example size, surface, layout) will be determined by the VCA design type (Design VCA), a concept described in detail later in this publication. A vertiport design that supports all VCA types would be an optimal approach.

VCA power source

Figure 9: A VCA parked at a vertistop being charged

VCA power sources will influence different aspects of vertiport design. These include:

power grid impact and peak power availability

under apron, or on apron services, for on-stand charging or fuelling

storage area design and location for battery swapping vehicles

hydrogen fuel storage requirements

emergency response equipment – for example, roof top hydrants.

CASA will provide guidance on considerations for emergency response in future guidance material.

VCA manufacturer information

VCA manufacturers and operators should be an integral part of the discussion regarding the design of a vertiport. Manufacturers and operators should share the following information:

aircraft performance capabilities and limitations

aircraft dimensions and specifications

flight characteristics

how an aircraft handles in turbulence, inclement weather and crosswinds

g-loading and passenger comfort during landing, take-off and taxi

downwash and outwash modelling

equipment requirements

types of aircraft power cell – for example, battery, hydrogen or hybrid

recharging facilities and methods – for example, battery swaps versus on-aircraft charging

emergency response requirements

ground service equipment – for example, steps, tugs or other towing devices

maintenance of VCA

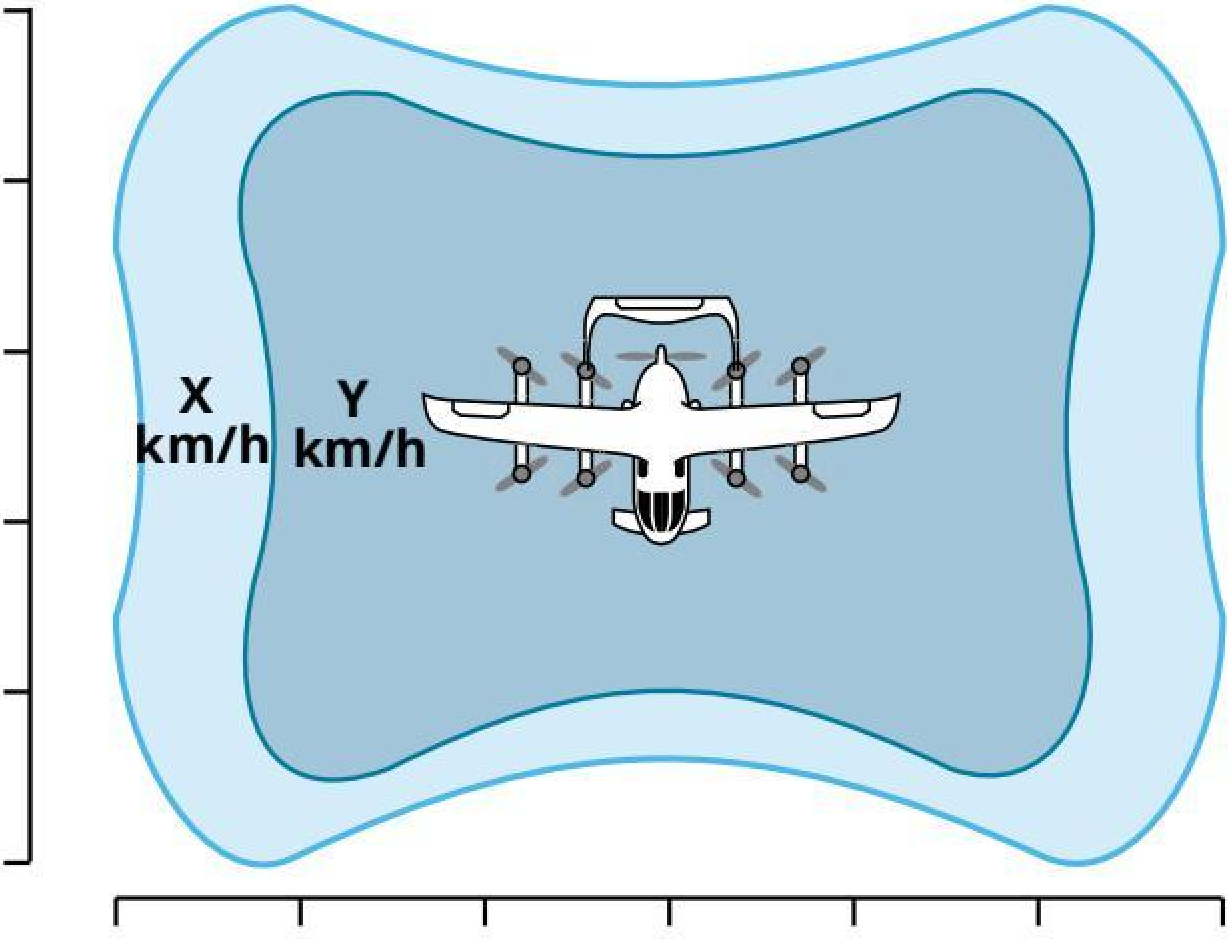
facilities for scheduled and unscheduled maintenance

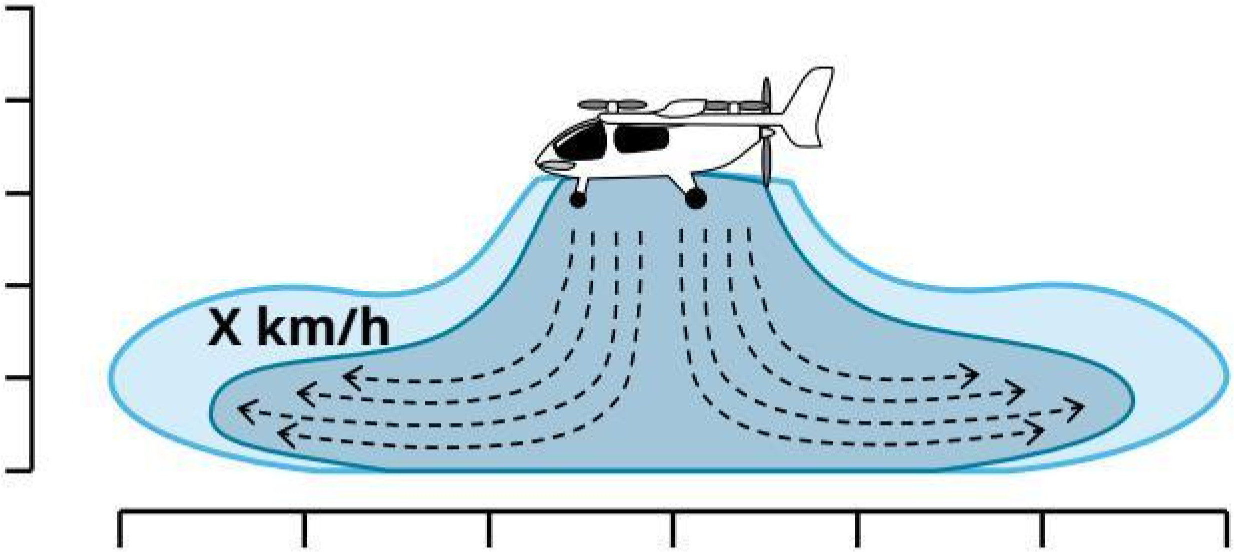
the location of service centres and their proximity to the vertiport if not on site.

Downwash and outwash considerations

A potential hazard for vertiport operations will be the downwash and outwash from VCA operating in and out of the vertiports. Currently, there is limited operational information on VCA downwash and outwash characteristics. Vertiport operators and designers will need to work closely with VCA operators, manufacturers or other sources of research to obtain this technical data. VCA manufacturers will probably publish downwash and outwash data similar to that available to airport designers when they assess jet blast areas.

Figure 10: Concept of possible downwash and outwash data





Vertiport operators and designers should assess the risk of possible injury or damage due to downwash, outwash and turbulence. This may include effects on locations under or near the approach and departure paths, both within and outside the boundary of the vertiport. Risks include:

injury to vertiport staff, passengers and the public

damage to other aircraft operating or parked at the vertiport

damage to buildings and structures

damage to vehicles

damage to equipment and utilities.

Localised downwash and outwash characteristics at a vertiport will be determined by local operational experience. Warning notices should be posted in appropriate locations to inform and warn of the dangers.

Downwash protection zone

A recent version of the Heliport Manual by ICAO includes a new section that focuses on the hazards of downwash and outwash. It has introduced the concept of a downwash protection zone. This area is specifically designed for the protection of the general public, other aircraft and those working in the vicinity of aircraft. The manual also provides new information on downwash and outwash, which quotes different caution and hazard limits for peak wind velocities.

Other systems of assessing wind comfort are also readily available online. For example, the Lawson Comfort Criteria (2001), which provides a baseline of generally acceptable wind velocities for the public.

Image: AMSL Aero

Designing a vertiport

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The Design VTOL-capable aircraft (Design VCA) concept

Before considering the details of vertiport design, it is essential to understand the concept of a Design VTOL-capable aircraft (a Design VCA) as it influences the dimensions for the physical infrastructure and airspace above and around the vertiport. The Design VCA is an imaginary aircraft that embodies the critical characteristics of every aircraft that will operate at the vertiport.

Suggested parameters for the Design VCA

The Design VCA should incorporate the characteristics of all the anticipated VCA that will operate at the proposed vertiport. For example:

the largest diameter (the Design D)

the highest maximum take-off weight (MTOW)

the widest undercarriage width (UCW)

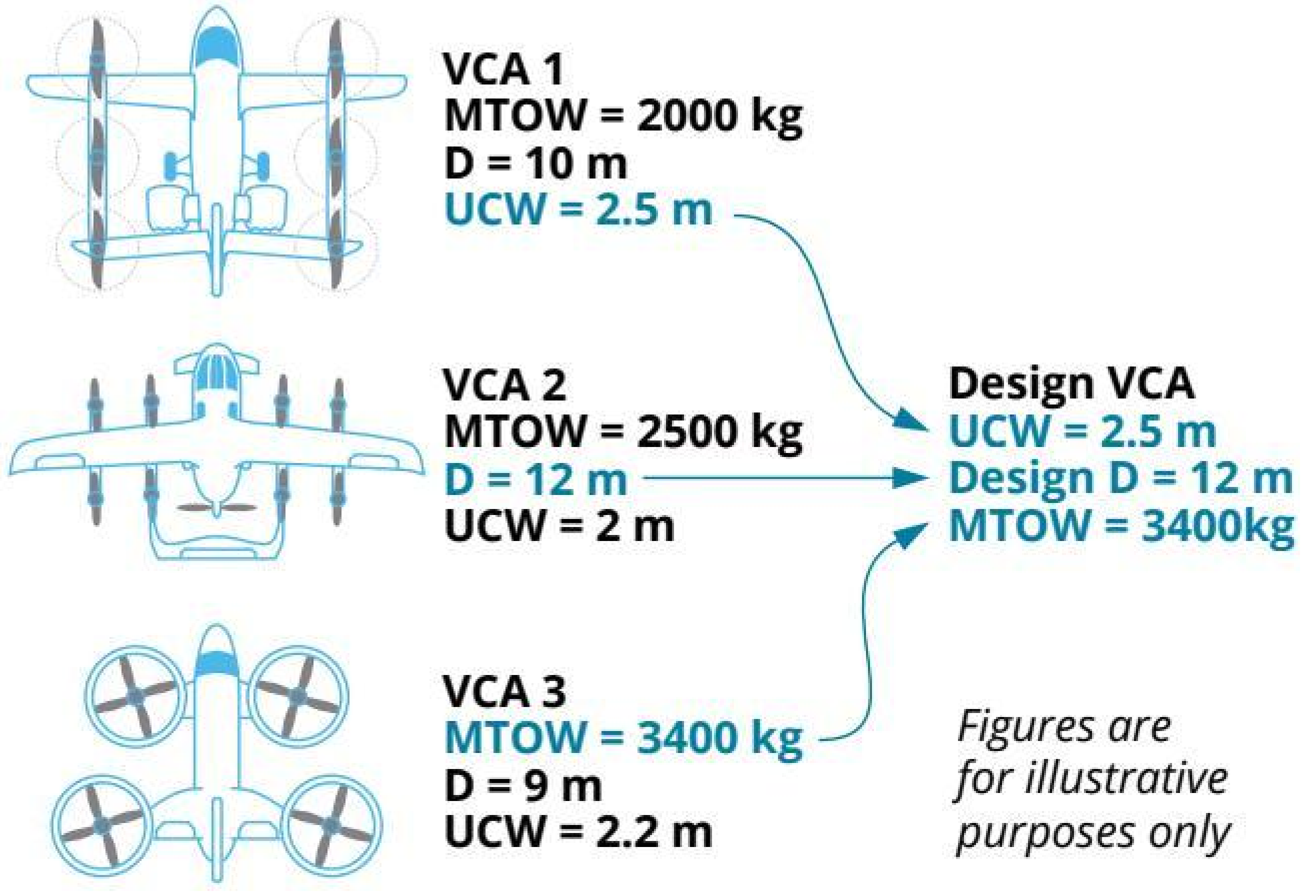
the longest take-off or landing distances

the most critical obstacle avoidance criteria

the most critical downwash and outwash criteria.

Figure 11 is an example of how Design VCA parameters can be derived from the possible VCA types that will operate from the vertiport.

Figure 11: How to derive the Design VCA parameters



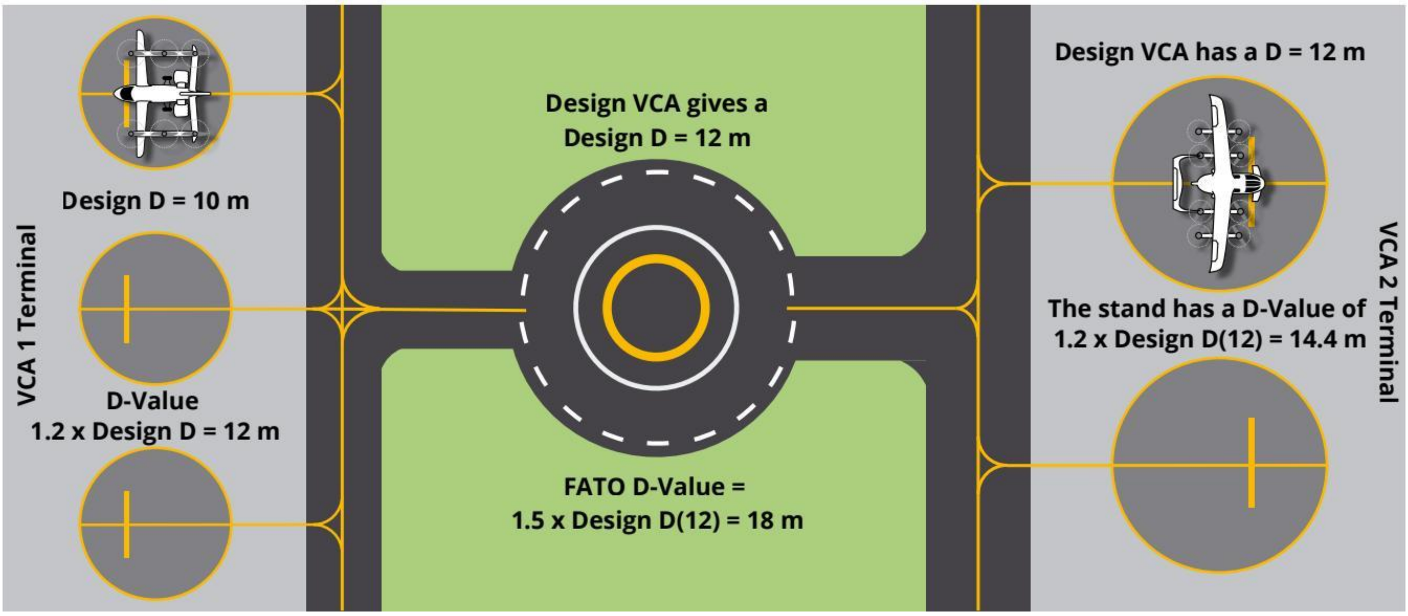
The diagram above is only an example of some of the parameters to be considered when formulating Design VCA specifications. Other criteria will also need to be considered and there can be more than one Design VCA for different facilities within a single vertiport.

Implementing the Design VCA

The example vertiport in Figure 12 demonstrates how to allow for two different Design VCA at one location.

The example has two terminals, each operating a specific VTOL aircraft. The vertiport has a single final approach and take-off (FATO) area that has been built using a Design D of 12 meters, as the Design VCA for the FATO area should have the most critical (largest) Design D of the two VCA.

Figure 12: Example vertiport design using two Design VCA



The taxi-routes and the stands leading to the VCA1 terminal have been built with a D-value based on a Design D of 10 m (from the Design VCA) and the characteristics of VCA1.

On the other side of the vertiport, the taxiways and stands leading to the VCA2 terminal are built with a D-value based on a Design D of 12 m and characteristics of VCA 2.

The term D-value is used for the dimension of a facility. For example, the D-value for size of a FATO (as specified in the AC) is 1.5 x Design D of the largest VCA.

Future-proofing the vertiport design

Future-proofing the vertiport design could prove challenging as the initial Design VCA used in a particular vertiport project may be different to the aircraft that operate in 5 to 10 years’ time. The risk is our inability to foresee the long-term operational model for vertiports and the future aircraft types that will operate from them. This might mean needing to restrict operations or needing to completely redesign and rebuild the vertiport so it can accommodate the new VCA types.

The introduction of the Airbus A380 is a good example: many airports around the world had to redesign aprons, taxiways and runways for an aircraft type that was significantly larger and heavier than anything envisaged when the airports were designed and built.

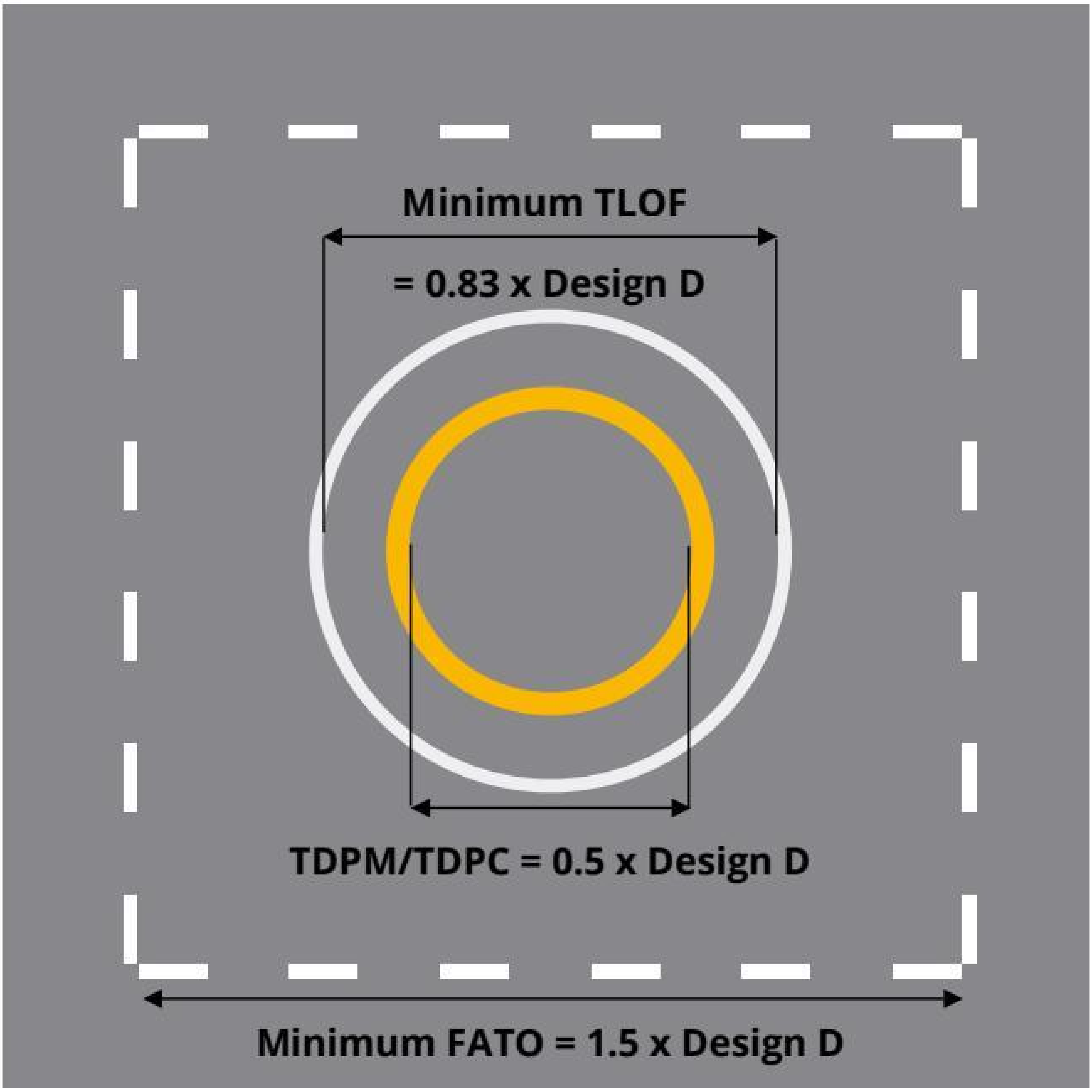
A building block approach to vertiport design

The concept of advanced air mobility (AAM) relies on an ecosystem of many landing sites that vary in location and design. This will range from a major vertiport with multiple stands and FATO areas, to a single pad vertistop in a semirural location. As such, the guidance for their design also needs to be flexible. CASA has taken the approach of looking at each of the vertiport physical components as building blocks consisting of essential and optional components.

Essential vertiport components

Regardless of size, a vertiport should have at least one final approach and take-off area (FATO) and one touchdown lift-off area (TLOF).

Figure 13: Basic dimensions of the FATO and TLOF



Final approach and take?off area (FATO)

The FATO has two main purposes:

to provide a visual reference of the vertiport from the air

to provide an area of containment for a VTOL-capable aircraft (VCA) in the event of a deviation, such as a rejected take-off.

The dimensions of the vertiport's FATO will be determined by the aircraft types that it needs to support. Using the Design VCA, the length and width of the FATO will be either:

1.5 times the Design D

the distance that has been specified in the aircraft flight manual for the VCA to conduct a rejected take-off (the rejected take-off distance required).

Solid FATO

The FATO should be solid. This is to ensure that, in the event of a critical failure during take-off, the landing of the VCA will be contained and supported until the VCA stops.

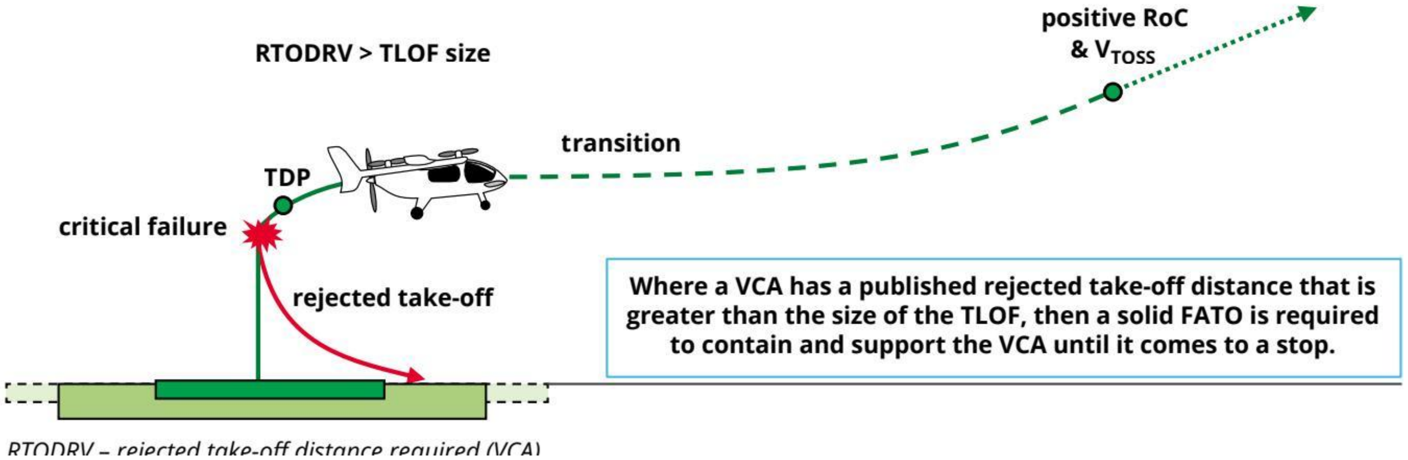
Current heliport guidance allows for a FATO to be non-solid. This is supported by many years of helicopter performance data and an understanding of their capabilities under certain circumstances. This includes helicopters operating with one engine inoperative and auto rotation capabilities. No such historical operational information is available for VCA.

Future guidance materials may allow non-solid FATOs or have smaller FATO size requirements if:

VCA are certified and shown to be able to continue safe flight and landing (in the event of a critical failure)

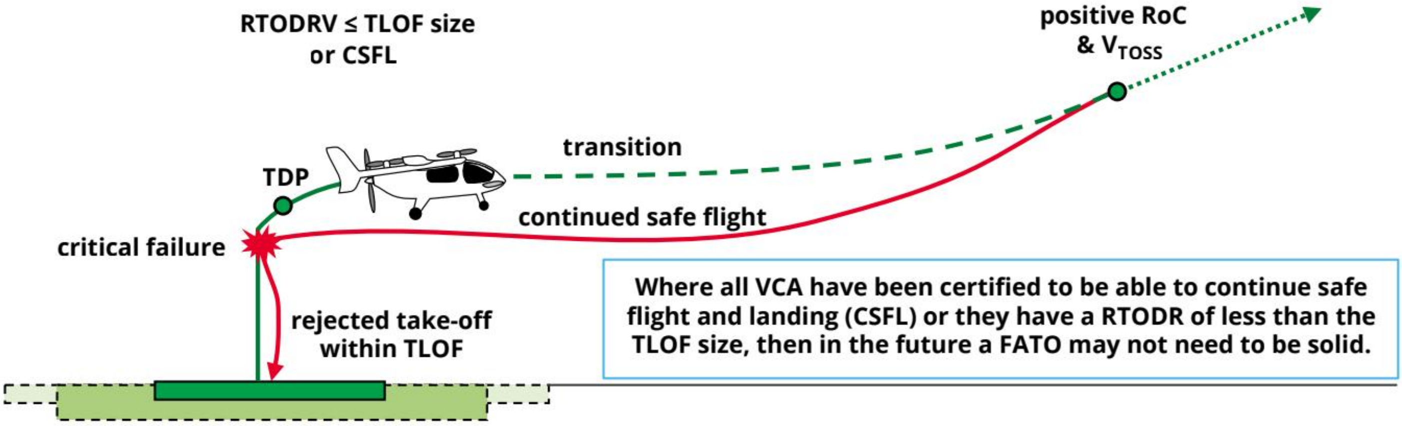
their required distance during a rejected take-off is less than the current FATO specifications cater for.

Figure 14: FATO size versus rejected take-off distance requirements



Where a VCA has a published rejected take-off distance that is greater than the size of the TLOF, then a solid FATO is required to contain and support the VCA until it comes to a stop.

RTODRV – rejected take-off distance required (VCA)



RTODRV – rejected take-off distance required (VCA)

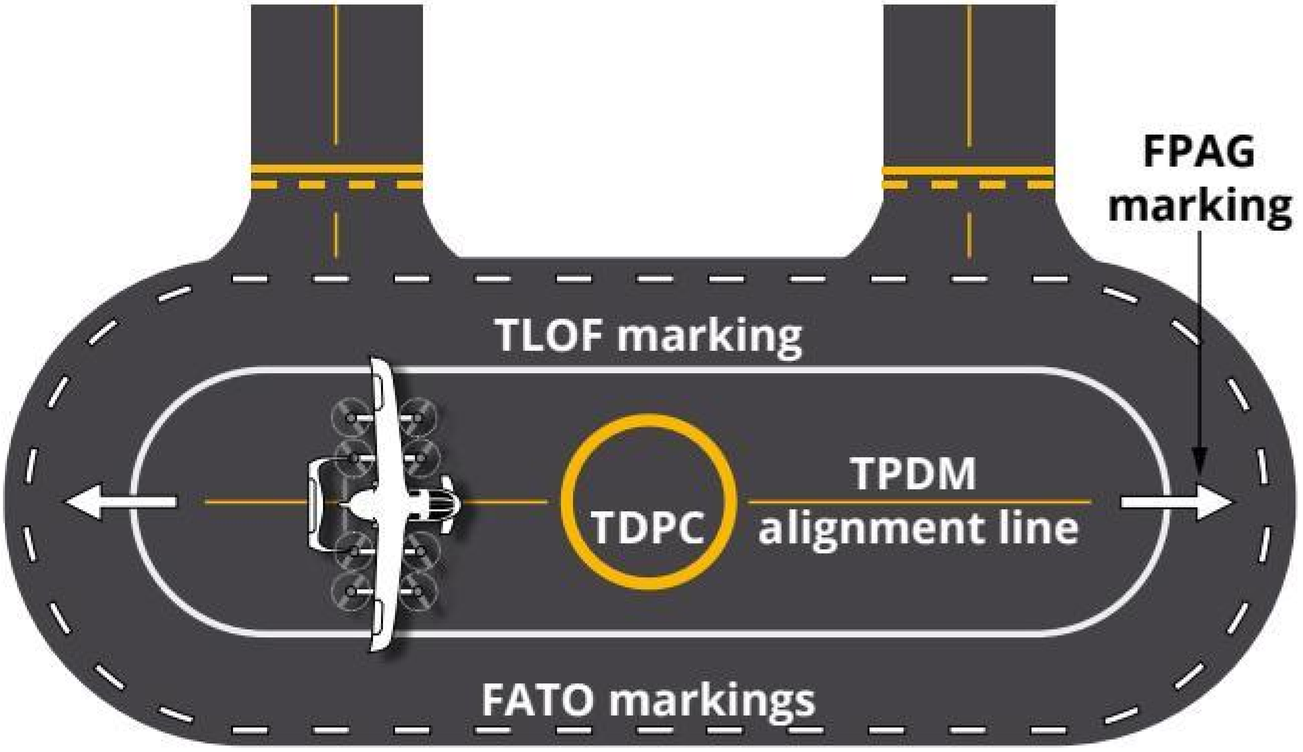
Like a runway, a FATO may only be occupied by one aircraft at a time. Once occupied, the FATO is not available for landing or take-off by another VCA until the first aircraft is clear of the FATO protection area.

The FATO should be free of all but essential objects, such as visual aids (lights) or emergency equipment like in-deck firefighting nozzles. These items should not be higher than 5 cm above the FATO unless the TLOF is accessed by a taxiway; then they should be flush mounted.

Elongated FATOs

A FATO size is sometimes determined by the rejected take-off distance required. This means that the length of the FATO sometimes needs to be greater than 1.5 times the Design D. The vertiport may operate many VCA, but if one of the VCA requires a FATO longer than 1.5 of its D, then this will be the VCA that determines the FATO length.

Figure 15: An elongated FATO



In the above fictitious example, the VCA has a rejected take-off distance that requires a FATO length greater than twice its width. These departure directions are bi-directional in opposite directions. If the departures were omnidirectional, then the FATO would need to be larger or there would need to be additional operational procedures and restrictions.

Touchdown and lift-off area (TLOF)

The touchdown and lift-off area (TLOF) is required to provide a safe touchdown location for VCA. This may be within the FATO or a stand. (A stand is a location within a vertiport where an aircraft can be parked, passengers can embark and disembark, or maintenance can be performed.)

The main purpose of a TLOF is to contain the VCA undercarriage. The minimum dimensions of a TLOF should be 0.83 times the Design D. This is derived from heliport recommendations which are based on the study of helicopter designs.

Figure 16: Minimum and oversized touchdown and lift-off area (TLOF)

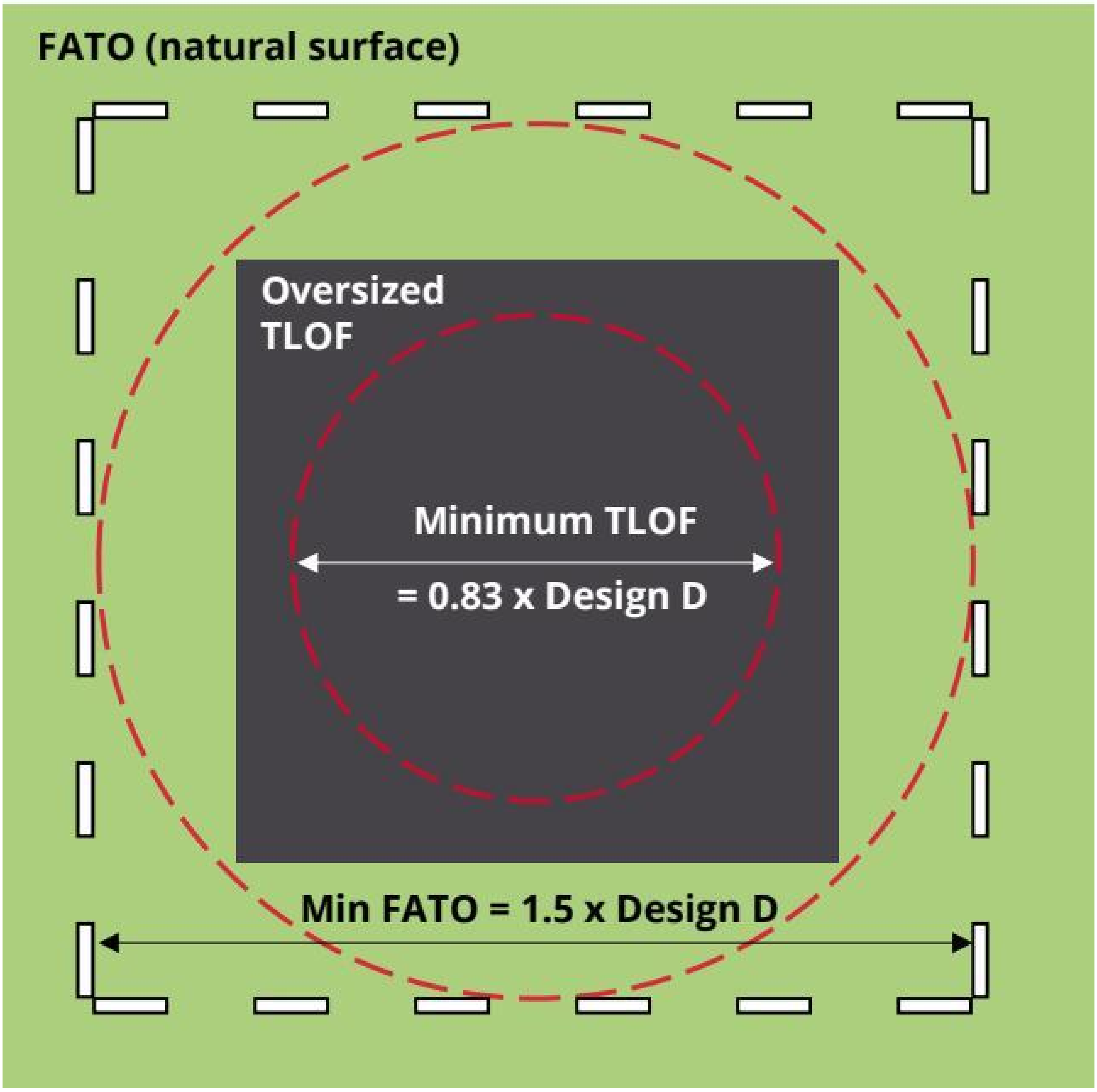


Illustration only, not all recommended markings shown

Based on the current understanding of VCA designs, this minimum dimension will accommodate the undercarriage of the majority of VCA currently in development. If a size larger than 0.83 times the Design D is required, vertiport operators can have an oversized TLOF. There are no upper size constraints other than cost and space availability.

The TLOF should be completely free of obstacles regardless of size.

FATO protection area (FPA)

The FATO protection area (FPA) is an area extending beyond the FATO set aside to ensure that there are no obstacles encroaching the FATO.

For heliports, this is known as the safety area. However, for vertiports, it has been decided to move away from this terminology due to potential confusion with general health and safety requirements. FATO protection areas are covered in more detail later in this guide.

Vertiport movement areas

Vertiport movement areas are prepared for the ground movement of VCA or VCA ground handling equipment such as tugs. They include:

the final approach and take-off area (FATO)

the touchdown and lift-off area (TLOF)

taxiways

aprons.

Movement area surfaces should:

be free of obstacles, including transient (for example, wind-blown) debris

have sufficient strength for the expected static (parked vehicle) and dynamic (emergency landing) loads

be smooth and free of irregularities (lumps and bumps)

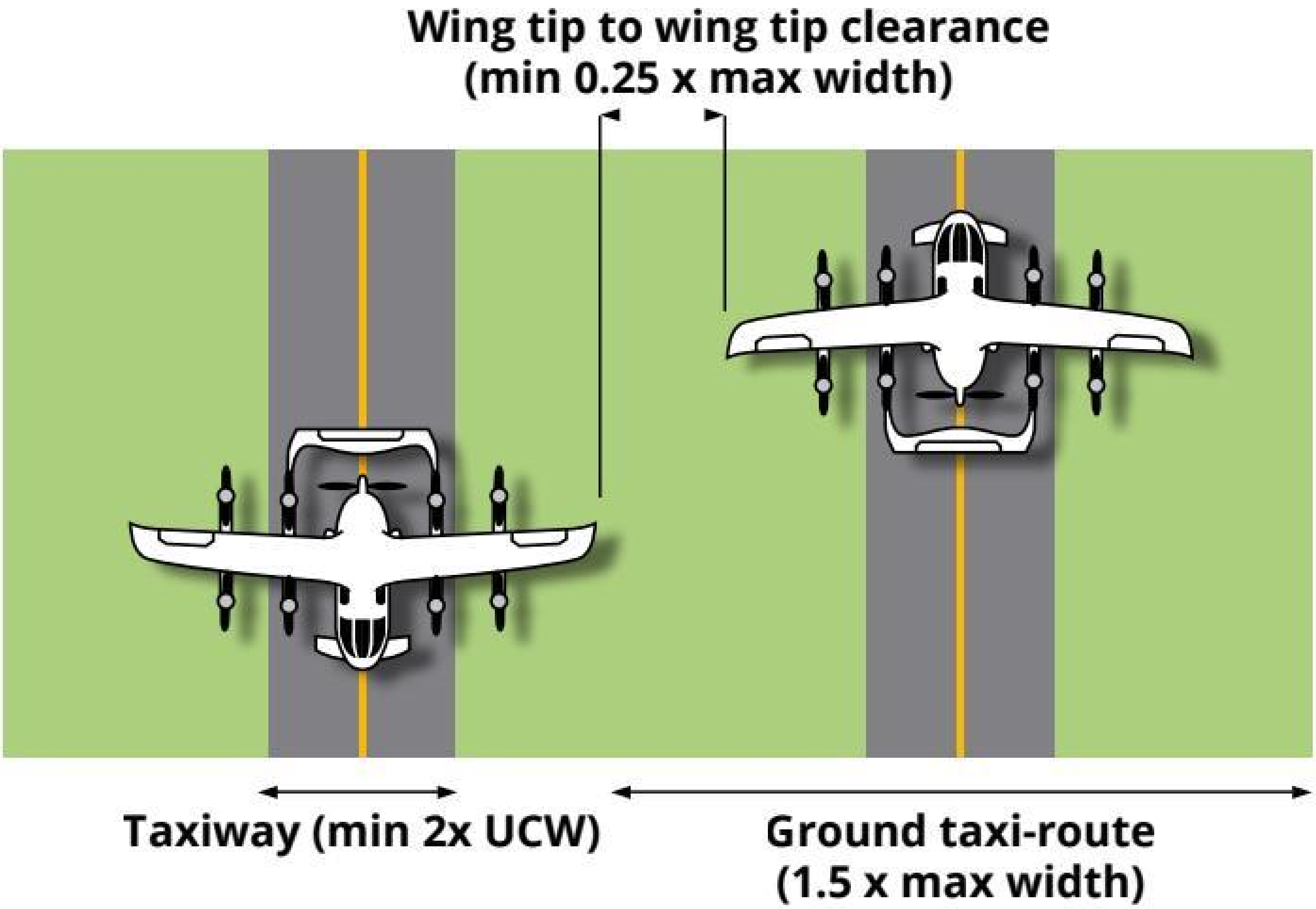
provide enough friction to ensure aircraft and vehicles have good grip and braking performance

be resistant to downwash and outwash effects from VCA

have a shape or contour to ensure effective drainage while still ensuring the safe control and stability of VCA when touching down, lifting off or manoeuvring generally

not have a surface slope exceeding 2% (longitudinal slopes on a taxiway may be not more than 3%).

Figure 17: Vertiport taxiway clearance dimensions



Optional vertiport components

Taxiways

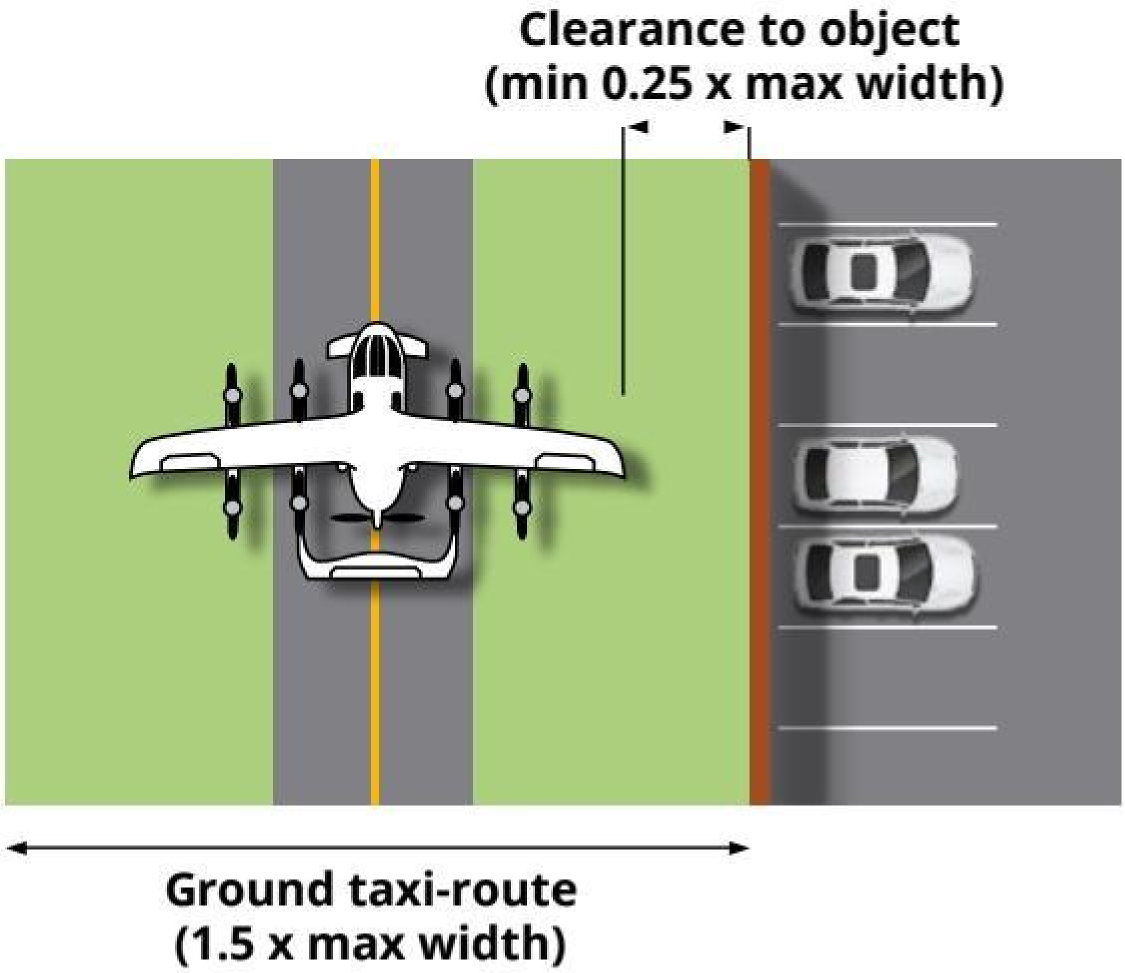
Vertiport taxiways allow VCA to taxi under their own power or to be towed. Taxiway dimensions are based on the width of the widest VCA undercarriage that will be operated from the vertiport. In cases where large vehicles and other pieces of ground servicing equipment are to be used, these dimensions will also need to be considered. Clearance distances between VCA on the taxiways and objects, for example parked aircraft, are also an important design consideration:

Taxiways should be at least two times the undercarriage width of the Design VCA.

The distance between a VCA and an object should be at least 0.25 times the maximum width of the Design VCA.

The distance between the wingtips of two VCA should be at least 0.25 times the maximum width of the Design VCA.

Figure 17 below demonstrates required taxiway clearances.



Taxi-routes

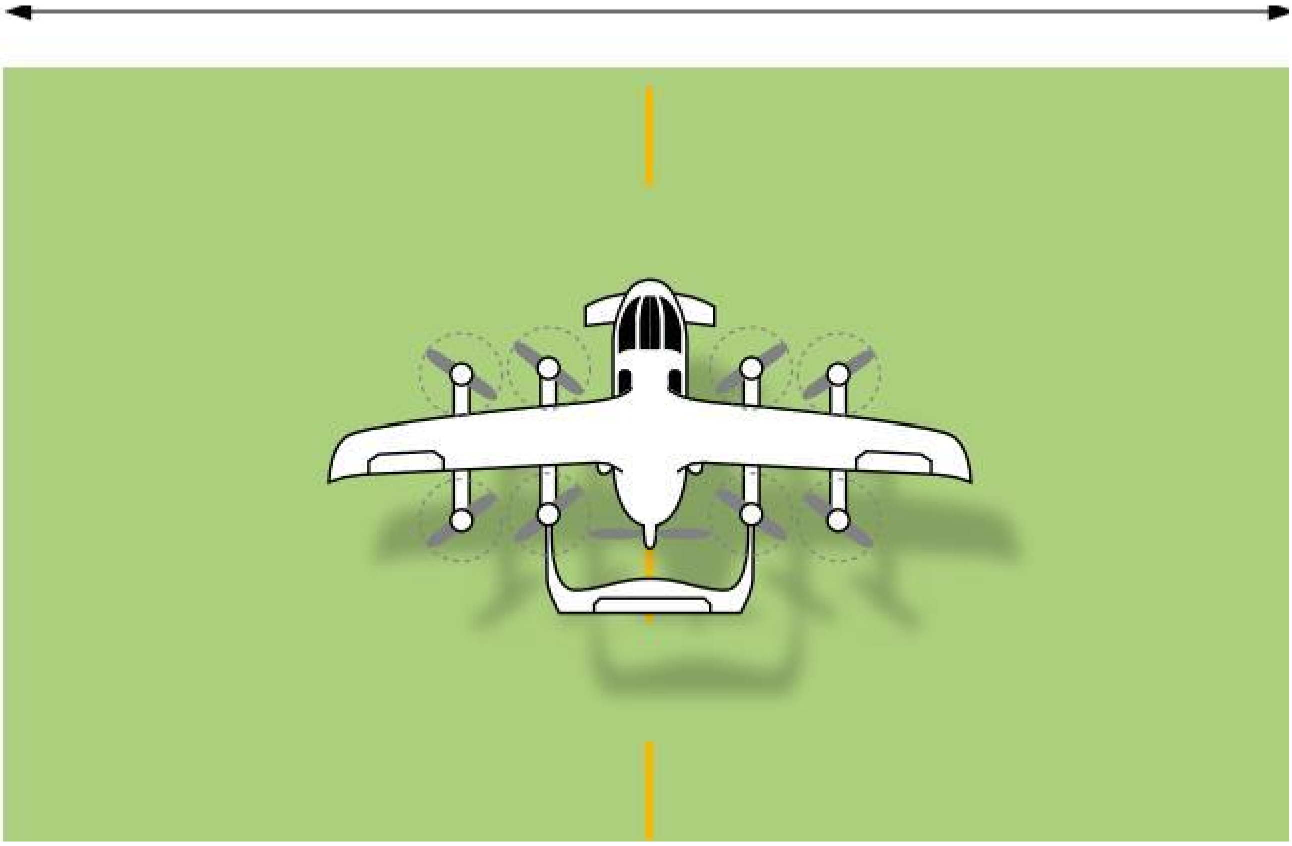
A taxi-route is the protected area surrounding a taxiway and is a buffer area for VCA taxiing on the taxiway. It is the equivalent to a taxiway strip at a conventional aerodrome.

There are two types of taxi-routes:

Type	Purpose	Width
Ground taxi-	provide protection	1.5 times the maximum
routes	for taxiways that only / accommodate	width of the
	ground taxing VCA and ground d vehicles	Design VCA
Air taxi- routes	provide protection	2 times the
	for taxiways that	maximum
	accommodate air	width of the
	taxi operations	Design VCA

Note: For taxiway dimensions, maximum width is used. This is not necessarily equal to the D.

Figure 18: Taxi-route and taxiway dimensions



For vertiports accommodating air taxi operations (airborne taxiing of a VCA), air taxi-routes will need to be wider than ground taxi-routes to allow for the potential sideways movement of the VCA.

Air taxiing of helicopters is conducted at a height of not more than two times D above the ground at a speed of less than 20 knots. It is expected that VCA air taxiing will have similar flight performance requirements.

The ground beneath an air taxi-route may be an actual taxiway, or it may be another surface. In both cases it should be:

resistant to downwash and outwash effects

free of non-essential objects

a surface on which a VCA can conduct a forced landing.

Stands

Stands are areas that may be provided to permit the safe loading and off-loading of passengers and cargo, as well as the servicing of the VCA, without interfering with other traffic.

Stands should all:

provide a space to safely conduct turn-around operations

be free of obstacles

have sufficient strength to support the VCA, ground servicing equipment and personnel

- be free of irregularities (i.e. should be smooth)

have a surface with sufficient friction to prevent skidding or slipping

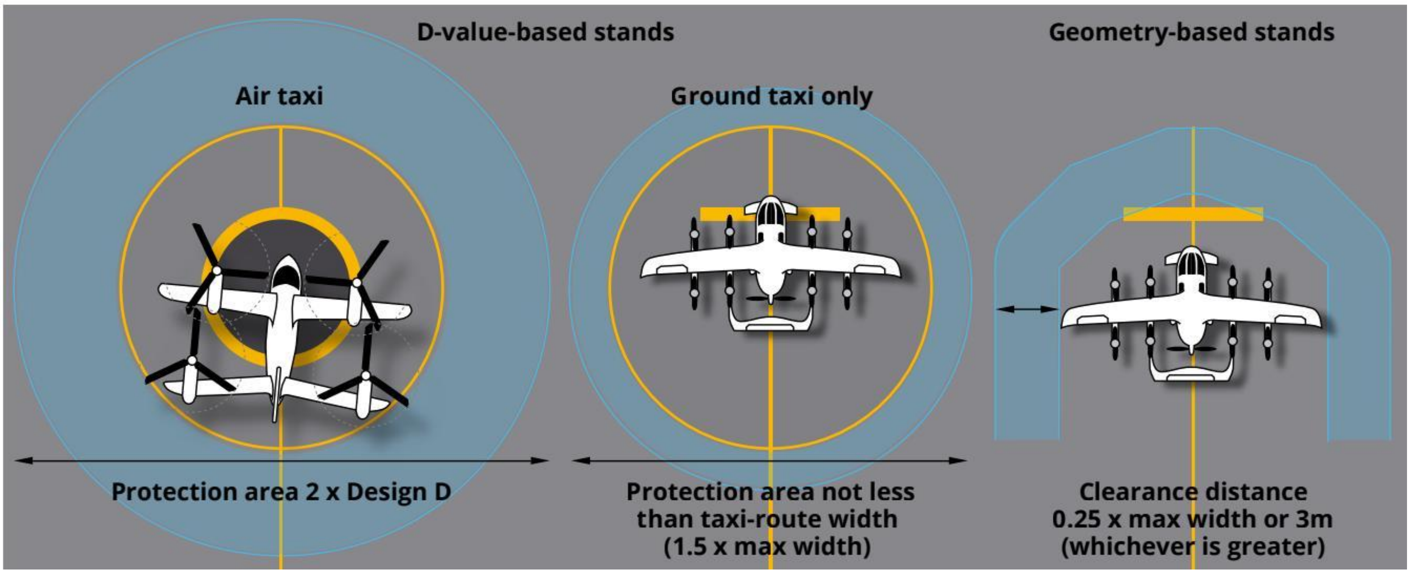
be designed to ensure it is safe for the personnel working around the aircraft and for the passengers embarking and disembarking the aircraft.

There are two ways to design stands for a vertiport:

stands based on the heliport concept using the value of Design D (D-value stands)

stands based on the geometry of the aircraft, like at traditional airports (geometry-based stands).

Figure 19: D-value based stands and a geometry-based stand



D-value stands are the circular stands that we see at heliports. They are designed to be omnidirectional to accommodate a helicopter turning itself into the wind. On aprons with multiple stands, these will often become taxi-through type stands placed next to each other.

D-value stands require an additional protection area. This gives a larger area requirement than the geometry-based stand design. This requirement is based on a typical helicopter conducting a powered taxi to the stand, either on the ground or by air-taxi.

Geometry-based stands are limited to operations where access to the stand is by ground taxiing or by being towed onto the stand. This provides increased safety because the hazards associated with downwash and outwash are significantly reduced or eliminated when the VCA can taxi without the need to produce lift. There is also less risk of a deviation from the centreline during ground taxiing or towing.

Designing geometry-based stands requires an imaginary boundary of either 3 m or 0.25 times the maximum width of the Design VCA (whichever is greater). This should then be used to work out the space needed between stands, buildings and other objects.

The 3 m or 0.25 times maximum width figures above apply to VCA with a maximum width that is less than 18 m. This covers the majority of VCA currently in development. If VCA with widths greater than 18 m are developed, then a minimum clearance distance of 4.5 m will apply.

Obstacle limitation surfaces

A vertiport operator needs to be able to ensure that the vertiport has safe airspace that can be kept free from obstacles such as buildings, cranes or other structures. This is achieved by establishing a series of obstacle limitation surfaces (OLS) that define a volume of airspace around and above the vertiport and its surrounds.

OLS are designed to protect VCA performing visual approach-to-land or take-off procedures below 152 m above the elevation of the FATO. They comprise:

origin surfaces

approach/climb-out surfaces

transitional surfaces.

OLS origin surfaces

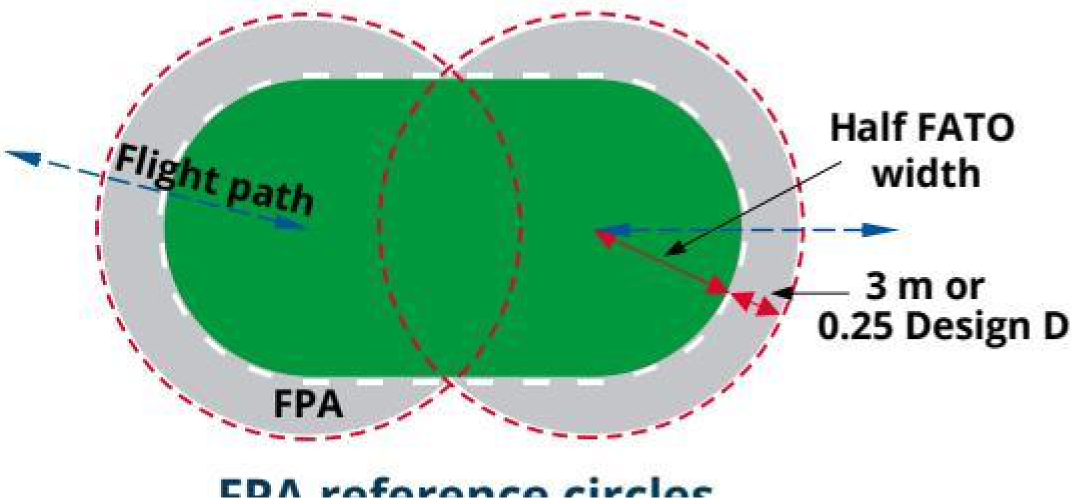
OLS origin surfaces are the protection surfaces immediately around the FATO from which the rest of the surfaces are built. They include FATO protection areas, vertical protection surfaces and vertiport clearways.

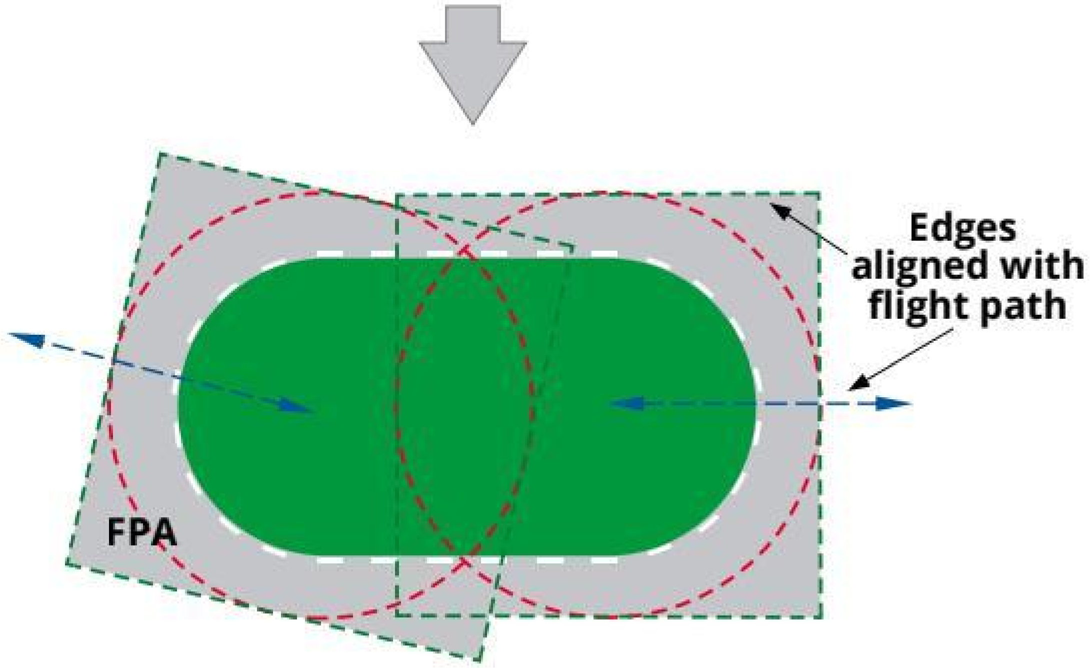
The FATO protection area (FPA) is an obstacle-free space surrounding the FATO. It provides extra protection to an airborne VCA if it experiences a variation in flight path (for example, caused by a wind gust). The FPA design is based on simple geometry using FPA reference circles, circumscribed squares and common tangents:

Figure 20: FATO protection areas – reference circles, circumscribed squares and common tangents

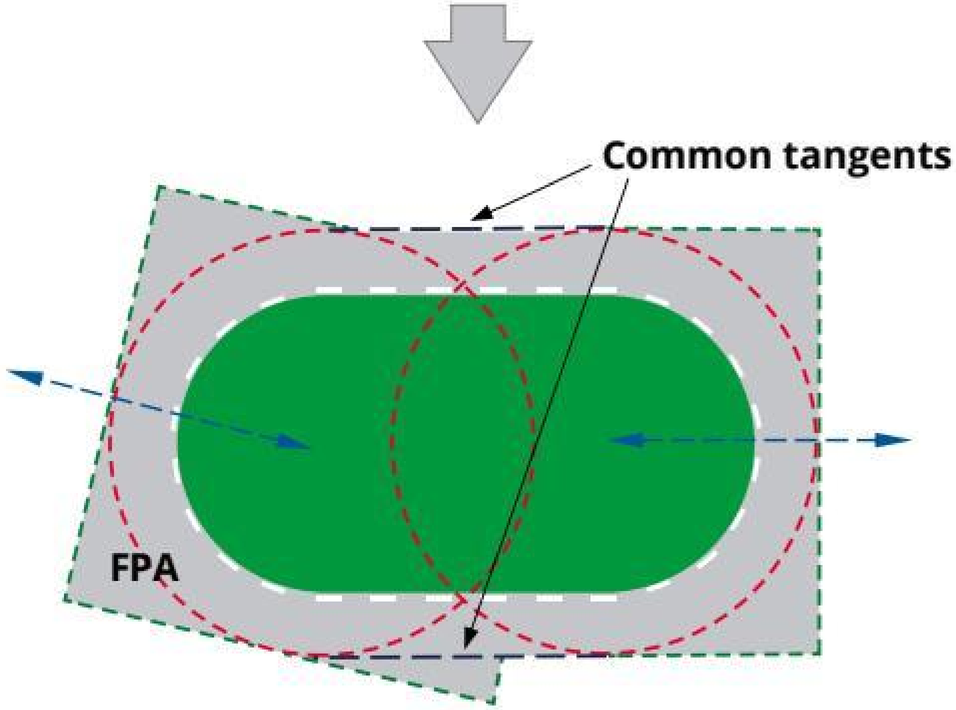
Part	DescriptionDraw a final approach and take-off protection area(FPA) circle, centred on the FATOThe FPA reference circle has a radius of half the FATOwidth plus the greater of:•3mor0.25 Design D.If you have an elongated FATO, draw the FPAreference circle for each FATO end.
FPA	
reference	
circles	
Circum-	
scribed	
squares	
Common With an elongated FATO, the protection area (FPA)tangents needs to encompass the full length of the FATO. Thisis done by drawing direct common tangents betweenall the FATO protection area reference circles.	

Building the FPA for a FATO without vertical procedures





Circumscribed square



Common tangents

Vertical procedure surface (VPS)

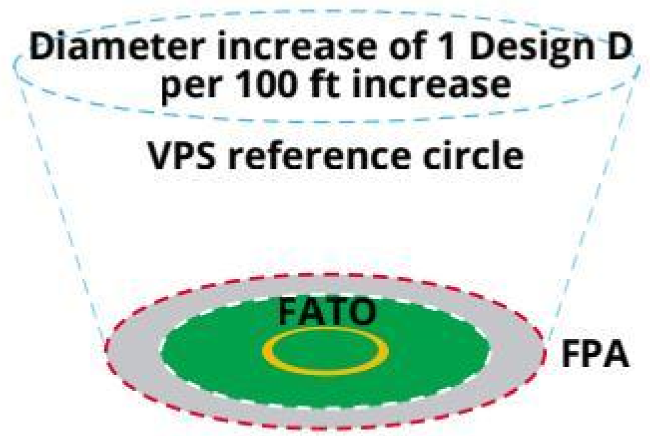
For a FATO that supports vertical procedures, the FATO protection area is just the reference circle. The closer the VCA is to the FATO during landing and take-off phases, the slower and more precise the movements of the VCA should be. Procedures therefore require a protection surface that increases in size as the distance from the FATO increases.

Figure 21: Building a vertical procedure surface

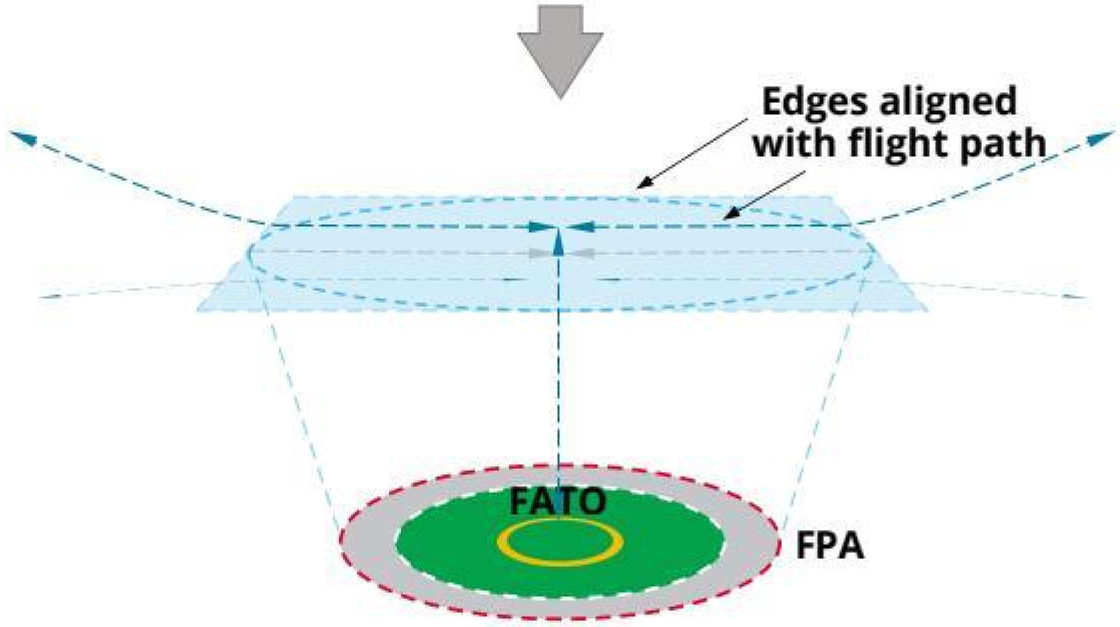
Part Description	
VPS Draw a reference circle above andReference centred on the FATO. The diameter ofcircle the reference circle is determined by itsheight above the FATO.For every 100 feet above the FATO,the diameter of the VPs referencecircle increases by 1 Design D from thediameter of the FPA reference circle.For example: a VPs height of 20 feetwould mean a reference circle that is0.2 times the Design D larger than theFPA reference circle.	
VPS circum- scribed square	In the same way as for the FAToprotection area, the vertical protectionsurface will require a circumscribedsquare aligned with each flight path.This will define the inner edges of theapproach/climb-out surface and loweredges of the transitional surfaces.
Obstacle free volume (OFV)	The obstacle-free volume is the spacethat is created by the truncated conethat is formed between the referencecircle of the FATO protection area (FPA)and the reference circle of the verticalprocedure surface (VPS).

The vertical procedure surface (VPS) is an obstacle limitation surface (OLS) that is located at the height at which the VCA either begins its arriving vertical procedure, or where it ends its departing vertical procedure. This height will be determined by the performance characteristics of the most demanding VCA. For example, if one VCA has a vertical departing procedure that ends at 20 feet, and another VCA has an arriving procedure that starts at 30 feet, then the lowest, most limiting height (20 feet) is the one that needs to be protected.

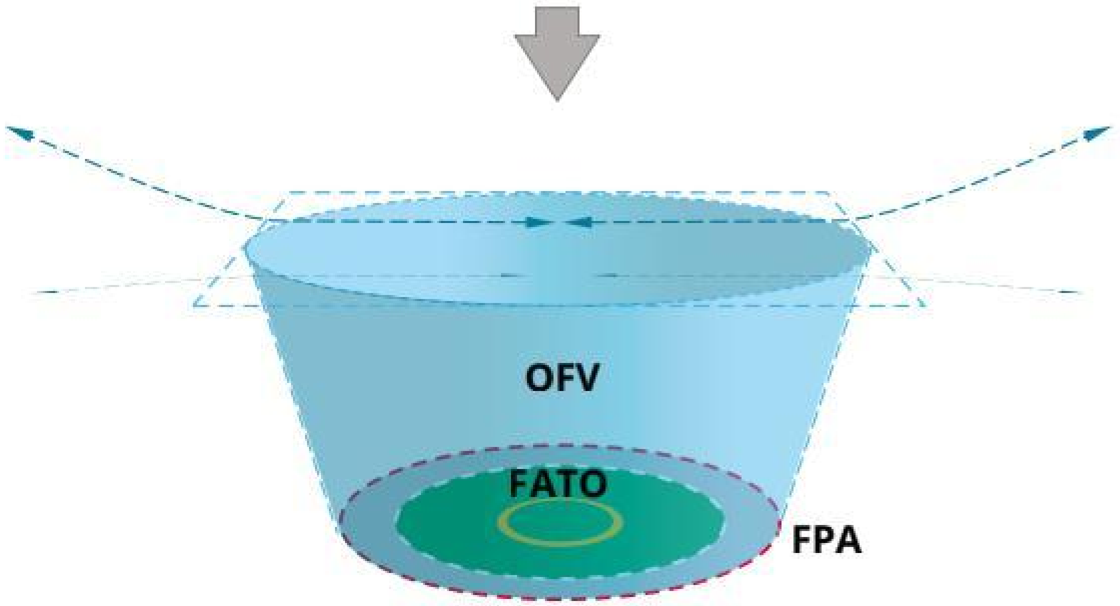
Building the VPS



VPS reference circle



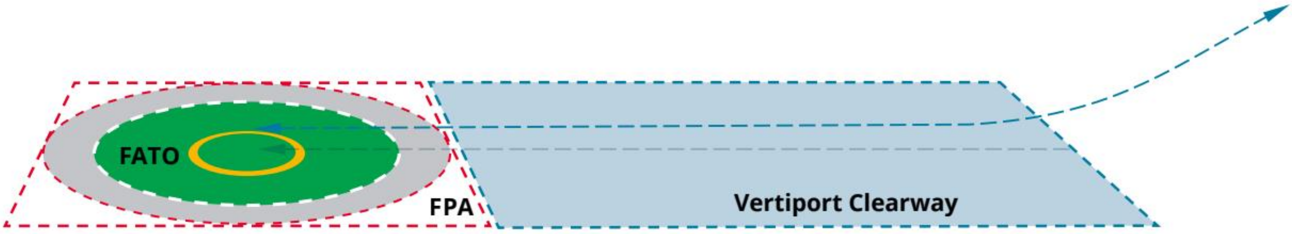
VPS circumscribed square



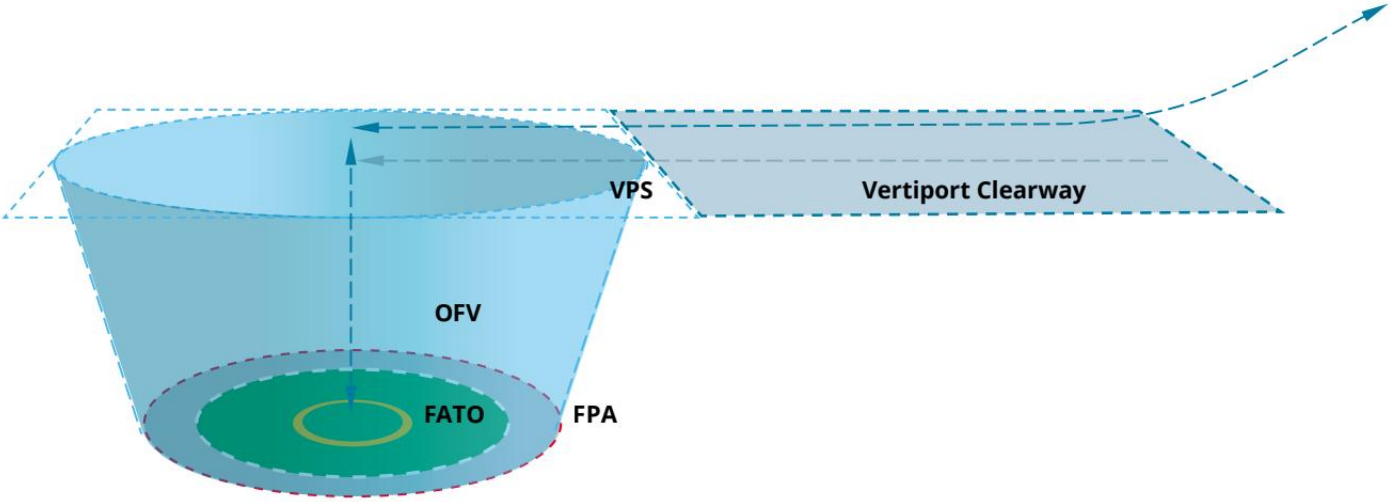
The vertiport clearway

The next element for the vertiport obstacle limitation surfaces (OLS) is the clearway. The clearway is a protected surface that should be established where there is a need for a VCA to manoeuvre horizontally between the outer edge of either the FATO protection area (FPA) or the vertical protection surface (VPS), and the inner edge of the approach/climb-out surface.

Figure 22: Vertiport clearways



Clearway extending from the FPA



Elevated clearway extending from the VPS

The centreline of the clearway should align with the flight path and will have a width that is not less than the width of the FATO protection area or the vertical protection surface (VPS). If the flight path between the protection area or VPS and the approach/climb-out surface needs to curve or make a change in direction, then the clearway will do the same.

It is expected that clearways will become a common feature of vertiport OLS to protect VCA as they transition from vertical to horizontal flight before continuing their initial climb out.

Approach/climb?out surfaces

The approach/climb-out surface consist of an inclined plane, or a series of inclined planes, or a complex surface that slopes up from inner edge of the FATO protection area (FPA) or the vertical protection surface (VPS).

Figure 23: Approach/climb-out surface

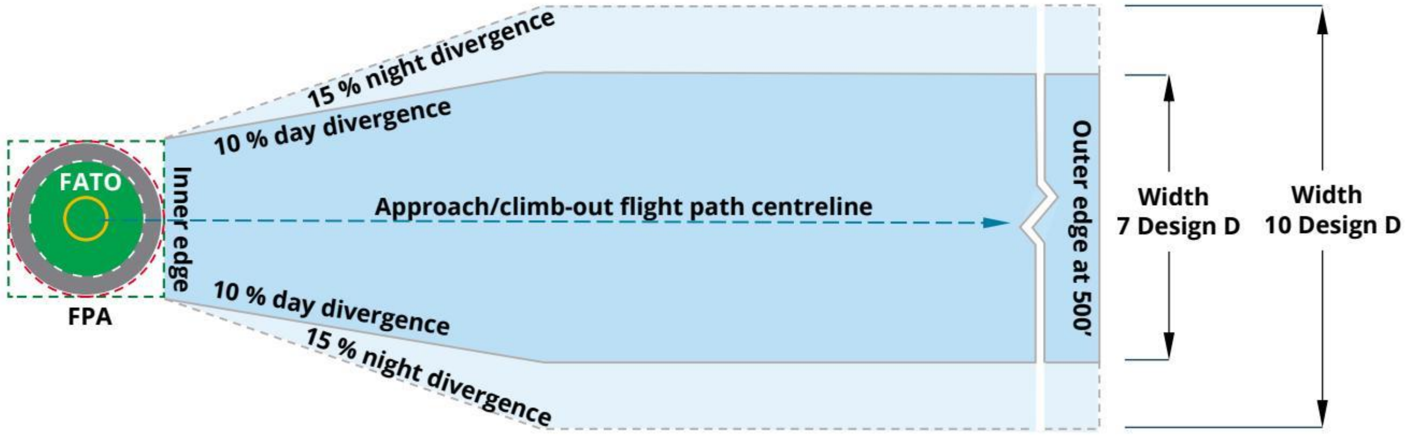


Table 3: Elements of approach/climb-out surfaces

Part	Description
Inner edge	This should be coincident with, and equal to, the length of the edge of the circumscribed square of either the FATO protection area or the vertical protection surface (whichever has been established for the flight procedures relevant to the vertiport).
sides	Divergent The two sides of the surface extend from the ends of the inner edge and they diverge outwards uniformly at a rate of: 10% for day operations only 15% for day and night operations. The edges continue to splay outwards until they reach a final width of either 7 × Design D for day only operations or 10 × Design D for flightpaths to be used at night.
Outer edge	Once the surface reaches its final width, it will continue at that width until it reaches a final height of 152 m or 500 ft above the FATO. At that height, the surface ends at its outer edge, which will be horizontal and perpendicular to the flight path.
Surface slope	The upward slope of the surface is determined by the performance capabilities of the Design VCA and clearance requirements that are published by manufacturers in flight manuals. The slope or slopes will be measured in the vertical plane that contains the centreline of the approach/climb-out surface.

Notes on approach/climb-out surfaces:

CASA has not received any flight performance documentation from any manufacturer currently developing VCA. Therefore, at this stage we are not providing slope guidance for the purposes of vertiport obstacle limitation surfaces design. This will be provided when actual performance data is available.

Rather than having one set of design specifications for approach surfaces and a different set for climb-out surfaces, the specifications for the surfaces are the same.

If the flight path on approach requires a shallower angle than the reciprocal climb-out, then it is the lower flight path (the approach) that needs to be protected and it would be the approach surface that forms the obstacle limitation surface (OLS).

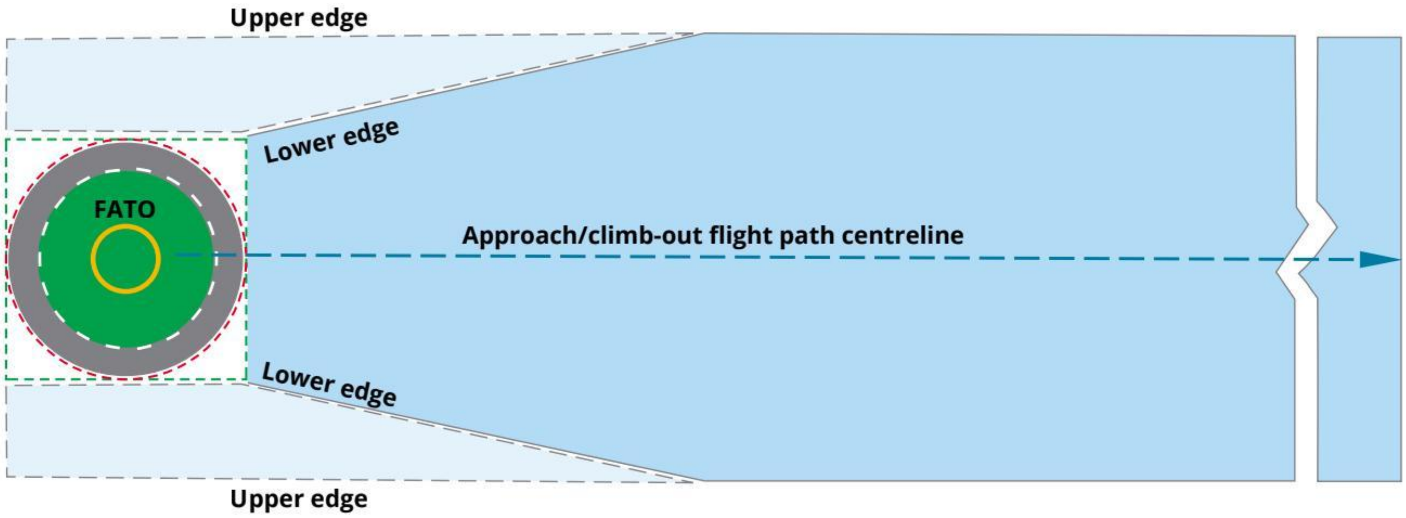
As with the clearway design considerations, an approach/climb-out surface is aligned with a flight path. For example, if the flight path is curved then so is the OLS.

Transitional surfaces

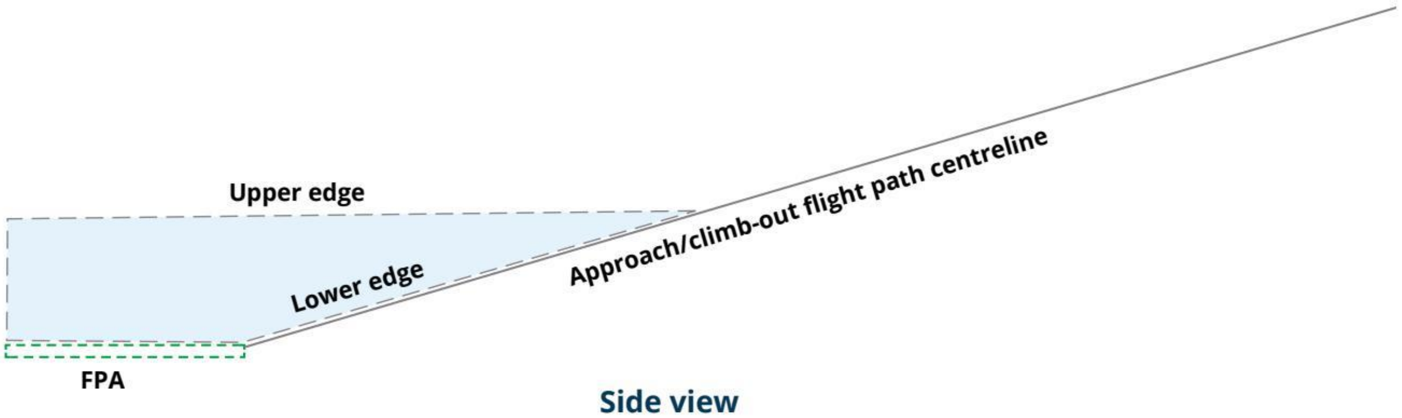
The transitional surfaces provide protection parallel to the flight path from the FATO protection area (FPA) or the vertical protection surface (VPS) upwards and outwards.

The transitional surfaces protect an aircraft from obstacles if they move laterally from their intended flightpath.

Figure 24: Transitional surfaces



Top view



Side view

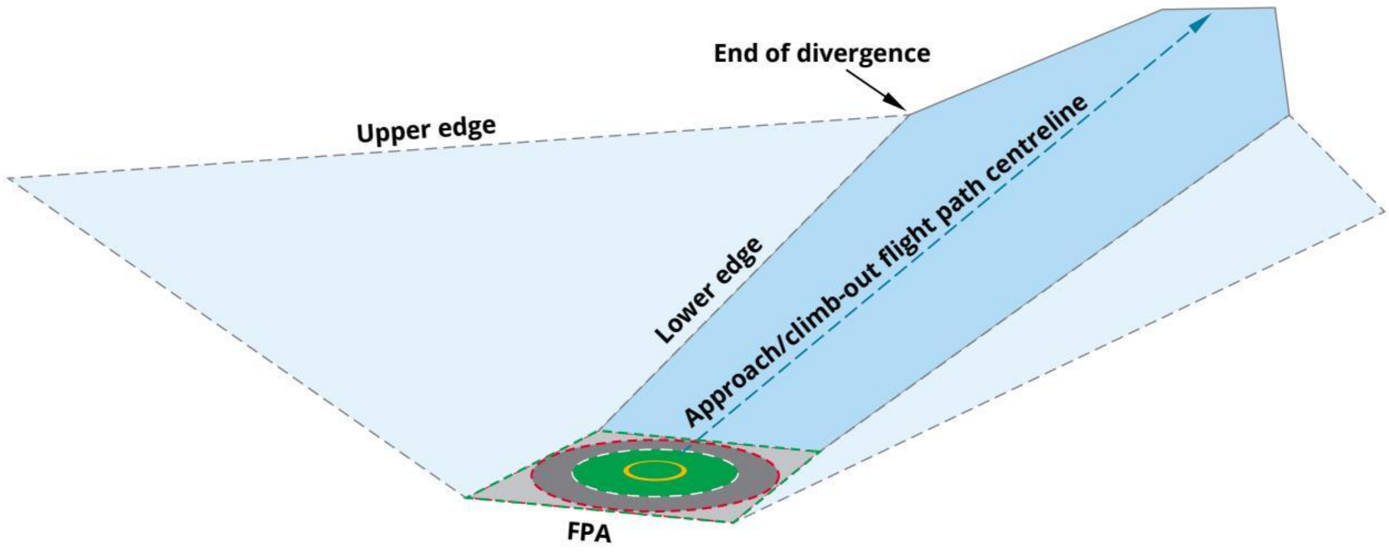


Table 4: Elements of transitional surfaces

Part	Description
Lower edge	The lower edge of a transitional surface is drawn from the point where the approach/climb-out surface reaches its final width, then follows the edge of the approach/climb-out surface until it reaches the corner (where the splay meets the end of the inner edge). From there, the lower edge will follow the side of any clearway until it meets the vertical protection surface (VPs) or the FATO protection area (FPA). The last part of the lower edge will be along the edge of the VPs or FPA circumscribed square and any
Upper edge	common tangents. The upper edge also starts at the point where the approach/climb-out surface reaches its final width, but it then maintains a constant height whilst paralleling the flight path. The upper edge should end aligned with the lower edge.

Notes on transitional surfaces:

Traditionally, the transitional surface has had its own separate set of dimensions. However, because of the possible combinations of slopes, turns and final widths of the approach/climb-out surfaces, the intersection with a traditional transitional surface would be complex. CASA has, therefore, simplified the process to ensure a neat OLS design.

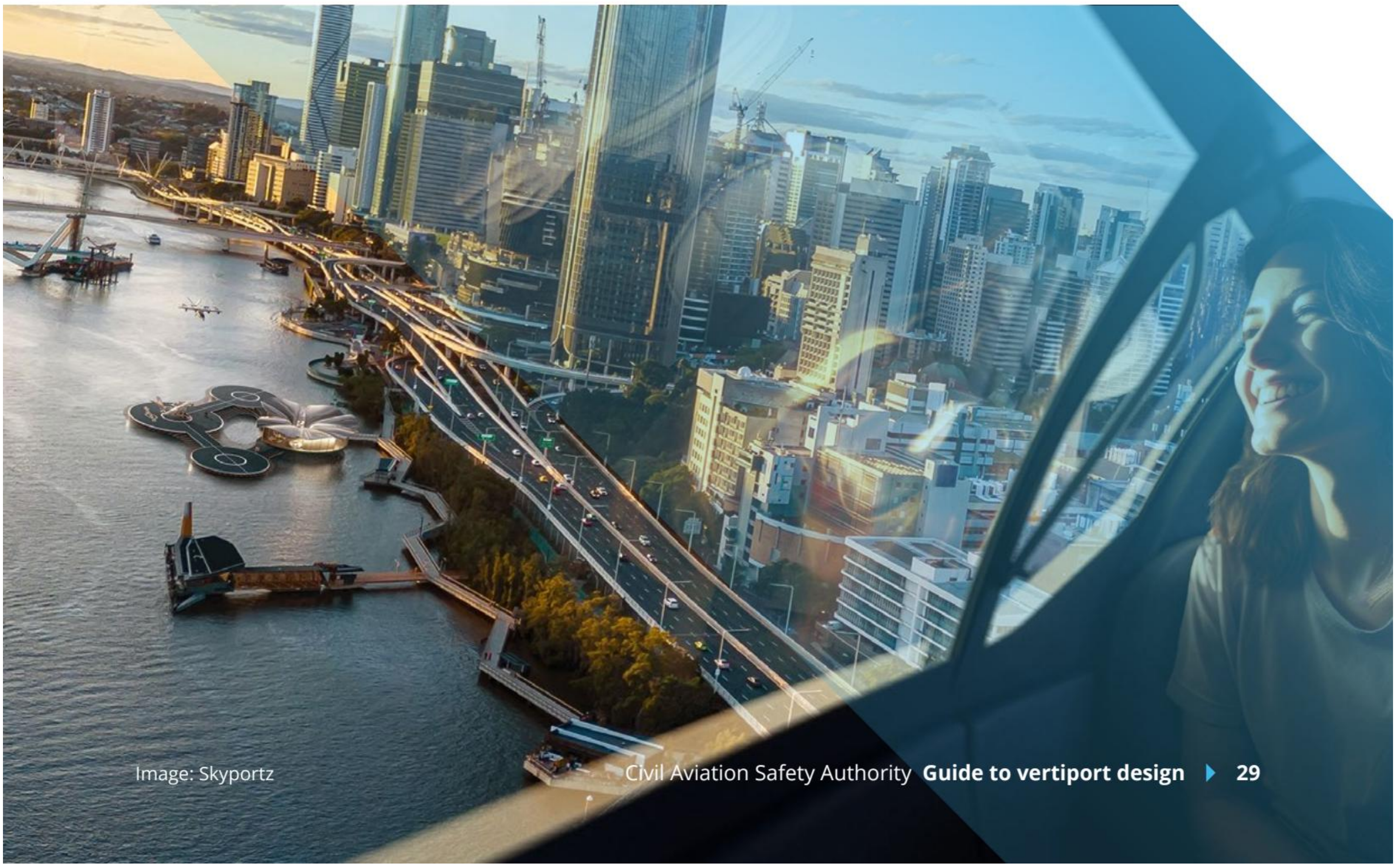


Image: Skyportz

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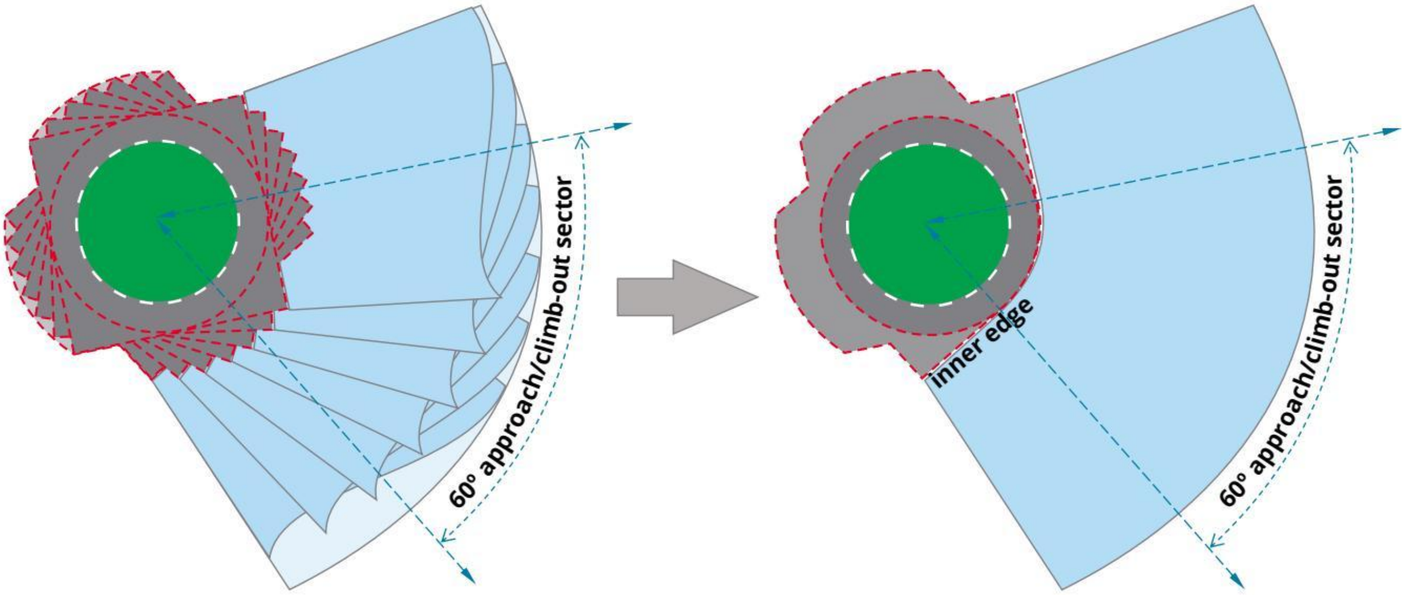
Complex obstacle limitation surface (OLS) designs

With the building block design methodology, vertiport operators and OLS designers will be able to construct OLS for more complex flight profiles if required.

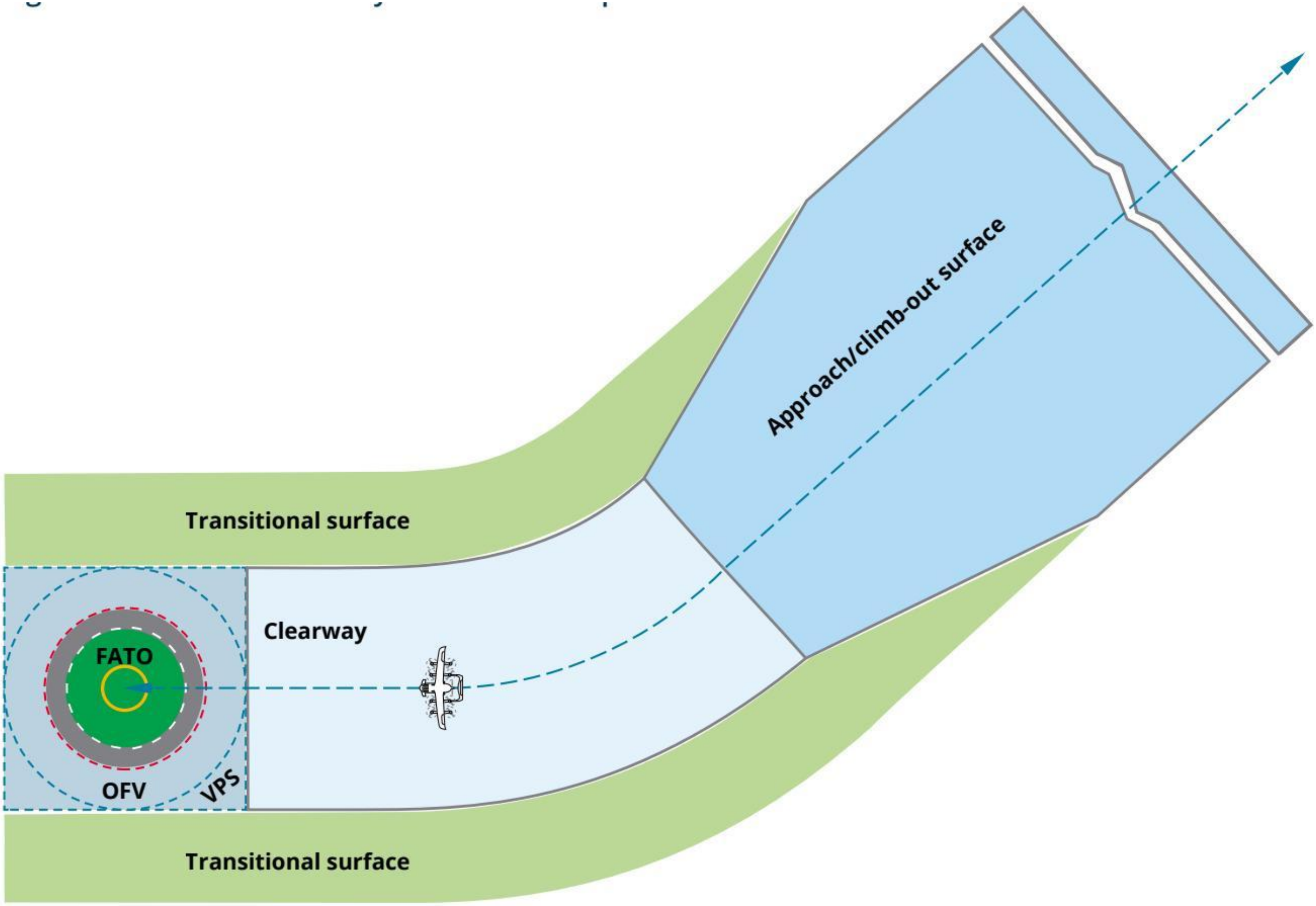
The figures below show how a sector (or even an omnidirectional) approach can be designed by creating an arc of splays rotated around the FATO Protection Area (FPA) reference circle.LS for a sector

Figure 25: Building an OLS for a sector approach or departure



The figure below shows a curved clearway. Because the transitional surface follows the edge of the clearway on the bottom edge, it should be relatively straight forward to create a transitional surface for any shaped flightpath.

Figure 26: A curved clearway from a vertical procedure surface



Visual aids

In the world of aerodromes, the term ‘visual aids’ covers all the infrastructure that provides a form of information to pilots and ground operations staff around the aerodrome. These visual aids include wind indicators, ground markings and markers, lights and (on some aerodromes) movement area guidance signs.

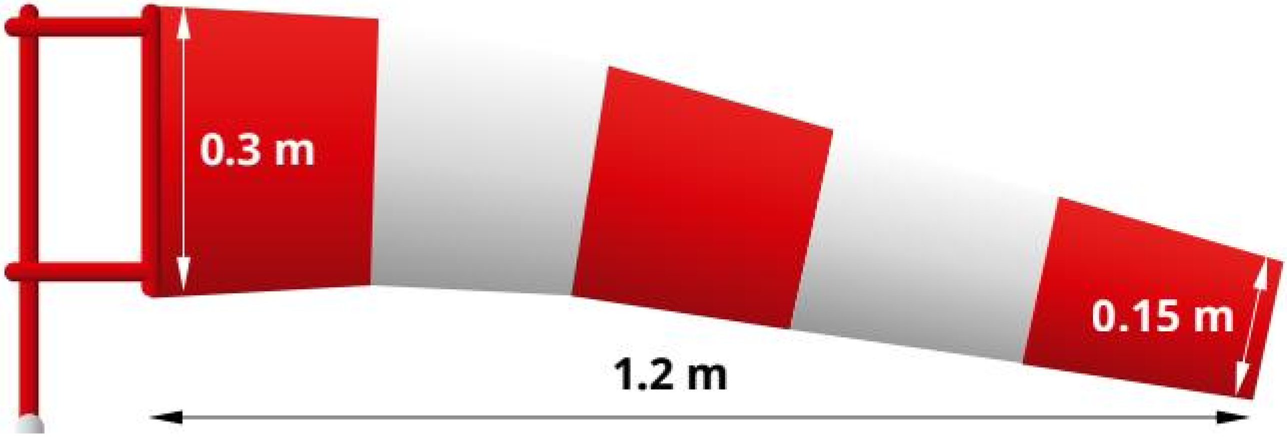
At CASA, we tried to get a balance between outcome-based guidance and prescriptive guidance for vertiports. This is necessary for describing things like colours, shapes and patterns. We know things are going to change in this developing AAM space so we’ve tried to be flexible and to simplify the specifications wherever we could.

Advisory circular AC 139.V–01 provides details of recommended specifications for different types of visual aids. Like all the guidance in the advisory circular, the specifications are just recommendations and are not enforced by legislation. This means that a vertiport operator may choose to use other guidance material for the markers and markings, for example from the Federal Aviation Administration (FAA), the European Union Aviation Safety Agency (EASA) or ICAO. However, we hope that the guidance in the AC will give vertiport operators some flexibility in design. This will help vertiports stand out from each other visually while keeping a level of consistency so that a VCA pilot can readily identify each visual aid and its purpose.

Wind direction indicators

Wind direction indicators are an important visual aid for a pilot to assess wind direction and strength in the vicinity of the vertiport during the critical phases of flight. Considerations for the design of a wind indicator include length, diameter, colour and colour contrast. Future technologies such as non-crewed aircraft may lead to the physical wind indicators being replaced by real-time digital weather information.

Figure 27: Wind Direction Indicators



Colour/s that are clearly visible against its background

Markings and markers

The general specifications for the design of ground markings and markers have been kept very simple and outcome-based. The only general requirements are that markings and markers need to be clearly visible to the vertiport user and that they may be supplemented by reflective or refractive materials or even electroluminescent type paints if appropriate.

‘Clearly visible’ means that markings and markers need to contrast to their background or need to have a contrasting box or boundary as a background for the marking.

Markings need to be identifiable to various vertiport users, whether a pilot, operational/ ground personnel or the public.

Each marking or marker has a specific meaning or purpose:

Marker type	Meaning or purpose	Example	
Flight path alignment guidance markings	used to show when there are defined approach and/or departure flight paths into or out from the vertiport provide important flight path information so should be the prominent marking where it overlaps with another marking, such as the FATO perimeter of TLOF		d4217b08e68a95b4d9886fec 15f98c37986b6fc2db616389b
FATO perimeter markings or markers	used to show the outer edge of the FATO the marking for the edge of a FATO is a dashed line required when the edge of the FATO is not self-evident for example when the FATO is part of a much larger concrete or asphalt surface should have contrast (consider a black background to the white dotted line) markers can be used where the surface cannot take a painted marking (such as grass) – they should be flush to the ground and resistant to downwash and outwash	ff1db6df37e7c784574b91709 15acb6a5d51ce842d463b7ebe	
Marker type	Meaning or purpose		
TLOF perimeter markings or markers	only recommended when the TLOF is not self-evident the marking for the edge of a TLOF is a solid line - otherwise same as FATO perimeter specifications	should be white	8d3b5069a80a60e96506a5e2

Aiming point markings	used when a FATO is provided but where there is no TLOF if there is a preferred approach direction, this triangular marking should be aligned to that direction should be white		5b8008764a68d080864900c6
Touchdown positioning marking (TDPM)	the marking that the pilot uses to align and position their aircraft within the TLOF (or a stand). By positioning the pilot's seat over the touchdown positioning marking, the pilot ensures that the aircraft is correctly contained, the undercarriage is safely within the TLOF and the aircraft itself is wholly contained within the boundary of the FATO includes the touchdown positioning circle used	where touchdown direction	ccd36299dc3444275655300b

Vertiport identification marking

Meaning or purpose

doesn’t have a safety purpose; more about identification. (In the future, when VCA are autonomous, the identification will mainly be for the passengers.)

needs to identify the vertiport and be readable when aligned with the preferred approach

should be centred within the touchdown positioning circle

should not be an H or an X (already used for heliport identification)

may use ordinal numbers to identify multiple FATOs within the vertiport

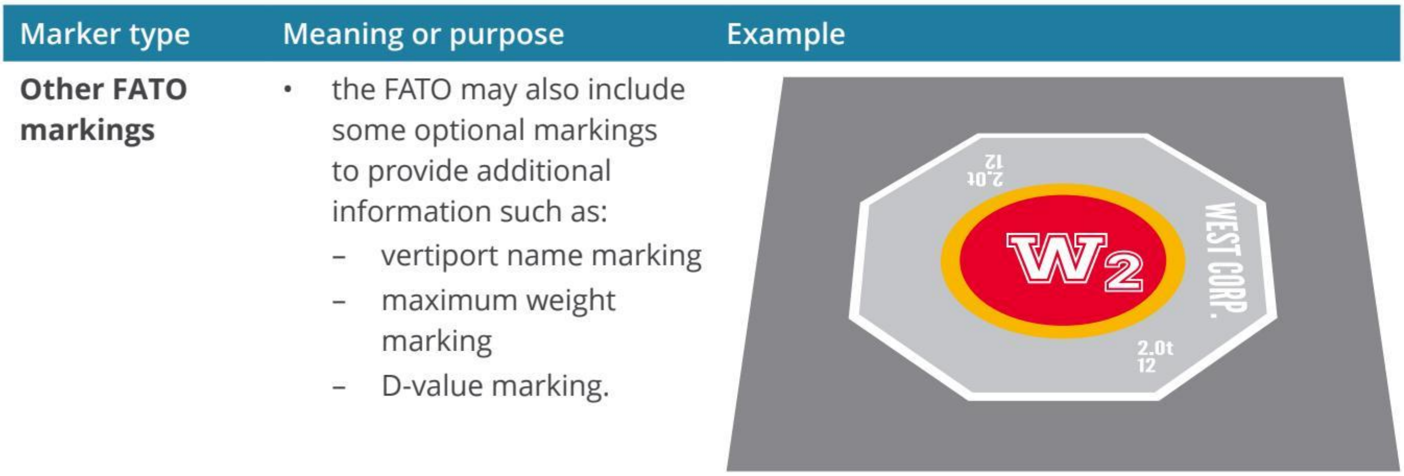
Example

FAA broken wheel marking

EASA V on blue marking

3 corporate marking examples

Ordinal numbering example



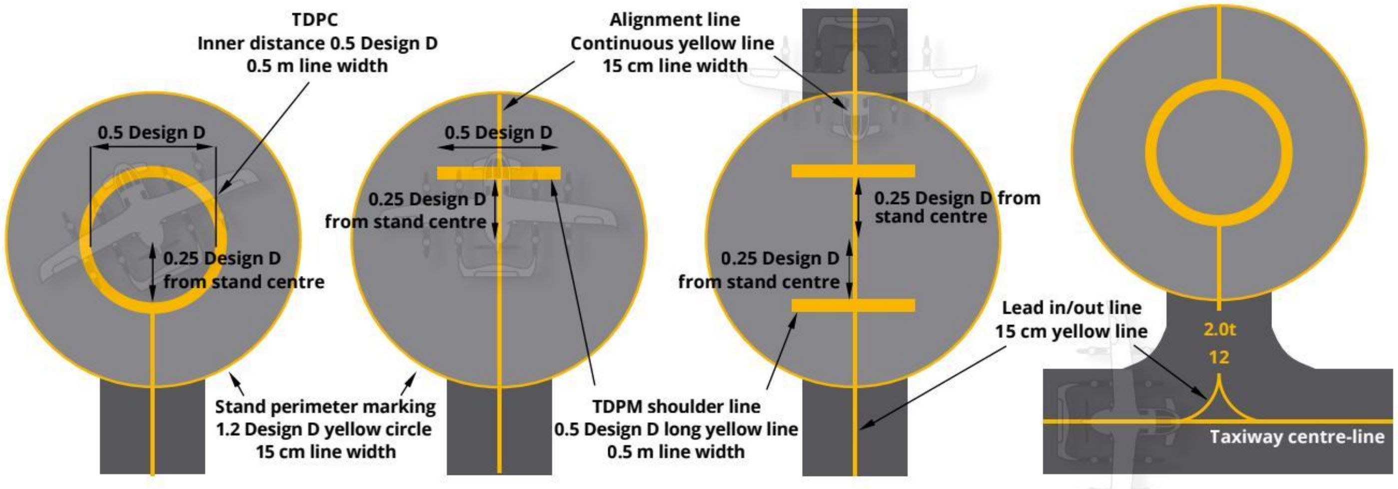
Marker type	Meaning or purpose	Example
Other FATO markings	• the FATO may also include some optional markings to provide additional information such as: – vertiport name marking – maximum weight marking – D-value marking.	

Taxiway and stand markings

Taxiway and stand markings provide manoeuvring guidance and are yellow in colour. The specifications for these markings have been kept consistent with traditional aerodrome (and heliport) guidance.

In general, white markings provide guidance information to the pilot for the direction of approach, acquiring the FATO area, and whether to approach to a hover (where there is an aiming point marking) or to prepare to conduct a landing. All the yellow markings take the next step and provide manoeuvring and positioning information to the pilot.

Figure 28: Stands



TDPC for multi-direction positioning

TDPM and alignment line for single direction positioning

TDPM and alignment line for dual direction positioning and taxi-through

Size and weight restricted stand

Marker type Meaning or purpose		
Taxiways		a continuous yellow centreline if the surface can be painted
		in-ground, flush-mounted markers if the surface cannot be painted (for example on clay or grass surfaces)
		where there is no physical taxiway (where there are air-taxi routes), the ground under the air-taxi route should still be marked in the same way as a physical taxiway
VCA stands		the most important markings are:
		a touchdown positioning marking: shoulder line type is the most common and is used where the apron design is based on a single direction parking of aircraft
		a stand perimeter marking: provides an indication of the edge of the stand
		perimeter where the stand is designed using the Design D lead-in/lead out markings: an extension of the taxiway centrelines leading
		into the stand optional markings include:
		alignment lines: assist in keeping the correct alignment for the last part of the

	taxi onto the stand up to the parking position a stand designation and limitation markings: provide information to pilots
	taxing into the apron. They can be used to show stand numbering or to
	indicate where there is a limitation on the stand such as a maximum weight limit or a maximum wingspan apron safety lines: general markings used to show a safe limit of aircraft

Other markings

Vertiport operators may also reference other guidance for providing airside visual aids. The Part 139 Manual of Standards has several other markings and visual aids that might be suitable for a vertiport such as:

pedestrian walkways (zebra crossings)

equipment storage and equipment clearance lines

apron edge lines

movement area guidance signs (MAGS).

Vertiport lighting

CASA’s guidance on lighting in the advisory circular AC 139.V–01 is limited as our initial brief for the AC is for VCA operating in visual conditions (so lights associated only with instrument conditions were not included). However, once there is a better understanding of operations in instrument conditions, then additional lighting guidance will be added to the AC.

Traditional lighting guidance may not be appropriate

We used outcome-based specifications for light photometrics in our guidance as traditional lighting guidance may not be appropriate.

The photometrics for vertiport lights and lighting elements (including light output, vertical and horizontal distribution, and chromaticity) should be appropriate to the vertiport environment and intended operations without being visually distracting or confusing to pilots.

Traditional aerodrome lighting guidance has been based on aerodrome environments that are typically wide-open areas outside an inner city. At night, the important lights from the perspective of a pilot approaching the airport are viewed within a void of other light. However, we expect that vertiports may be in areas where:

there will be far more light pollution around the vertiport, requiring a different or stronger light output

excess light pollution from the vertiport could cause a disturbance to nearby residents in and around residential high rises.

Also, there have been many leaps in lighting technology since aerodrome lighting specifications were written and the technology is likely to continue evolving. There could be any number of different solutions to designing an appropriate lighting system for a vertiport, and one vertiport may require a different solution to another depending on the environment within which they are located and how VCA operate to and from the vertiport.

Different lights for different purposes

Light systems should follow a colour philosophy that matches a purpose of the lights with a particular colour.

Light colour	Purpose
white lights	provide initial acquisition of, and guidance to, the vertiport and include the FATO perimeter lights, the flight path alignment lights orthe aiming point lights
yellow lights	provide alignment guidance for touching down and alignment for taxing
green lights	define the TLOF or provide guidance for an aircraft air-taxiing to a TLOF

Use of light	Description	Example	
Flight path alignment guidance lighting system (FPAGLS)	The FPAGLS provides an indication of available landing and take-off path directions. These are the lights that match with the alignment guidance markings and should be located within the marking as far as practicable. With	bf850718b9d56ae160e5c441003f2e2c7cba747a2653df2f0c	
distance between the first and last of the lights being 6 m, there will be instances where			

FATO perimeter lights	
Aiming point lights	pilots with a visual means to acquire the FATO while on approach to the vertiport. This system is a series of six white lights located within the white line of the triangular aiming point marking, one light
located at each point and one light located between each pair of corner lights. TLOF lighting systems	There are a few options for TLOF lighting systems. The options are dependent on the locations of the TLOF. TLOFs within a FATO should by lit by green perimeter lights or yellow TDPC lighting segments, while TLOFs within a parking stand are
TLOF perimeter lighting	lit by flodlighting. Green TLOF perimeter lights should be outside, but within 0.3 m of the TLOF edge. They should be spaced evenly around the TLOF not more than 3 m apart.

Use of light Lighting	Description	Example
segments and lighting elements	Lighting segments are any low-profile lighting fixture that consists of a line of lighting elements within a frame or a unit. These lighting elements could be LEDs, fibre optic cable or electro luminescent panels. There may be a single light source or there may be many. Lighting segments are used to create patterns of lights to mimic the marking they are conveying. In the case of	simplified example of a lighting segment, with three individual lighting elements. oolo □ ≤0.1 m 0.5m
Lighting taxiways and taxi-routes	Guidance is outcome-based: The centreline should be lit, preferably yellow for consistency with the touchdown positioning circle to prevent confusion with the green TLOF perimeter light. The lights should be sufficiently spaced to provide guidance. Air taxi-routes could be lit with alternating green and yellow lights to help visually distinguish between a taxi-route that does not support air-taxing (ground	6669039f7be7ca6d12fba3cd14d199c526986ab5cf8cdd2b39

Flood lighting for stands	Light sources from multiple angles reduce the likelihood of having shadowed areas on the apron. Consider the horizontal and vertical components of the lighting to ensure the stand is adequately lit but that there is not a risk of glare to the pilots (or nearby

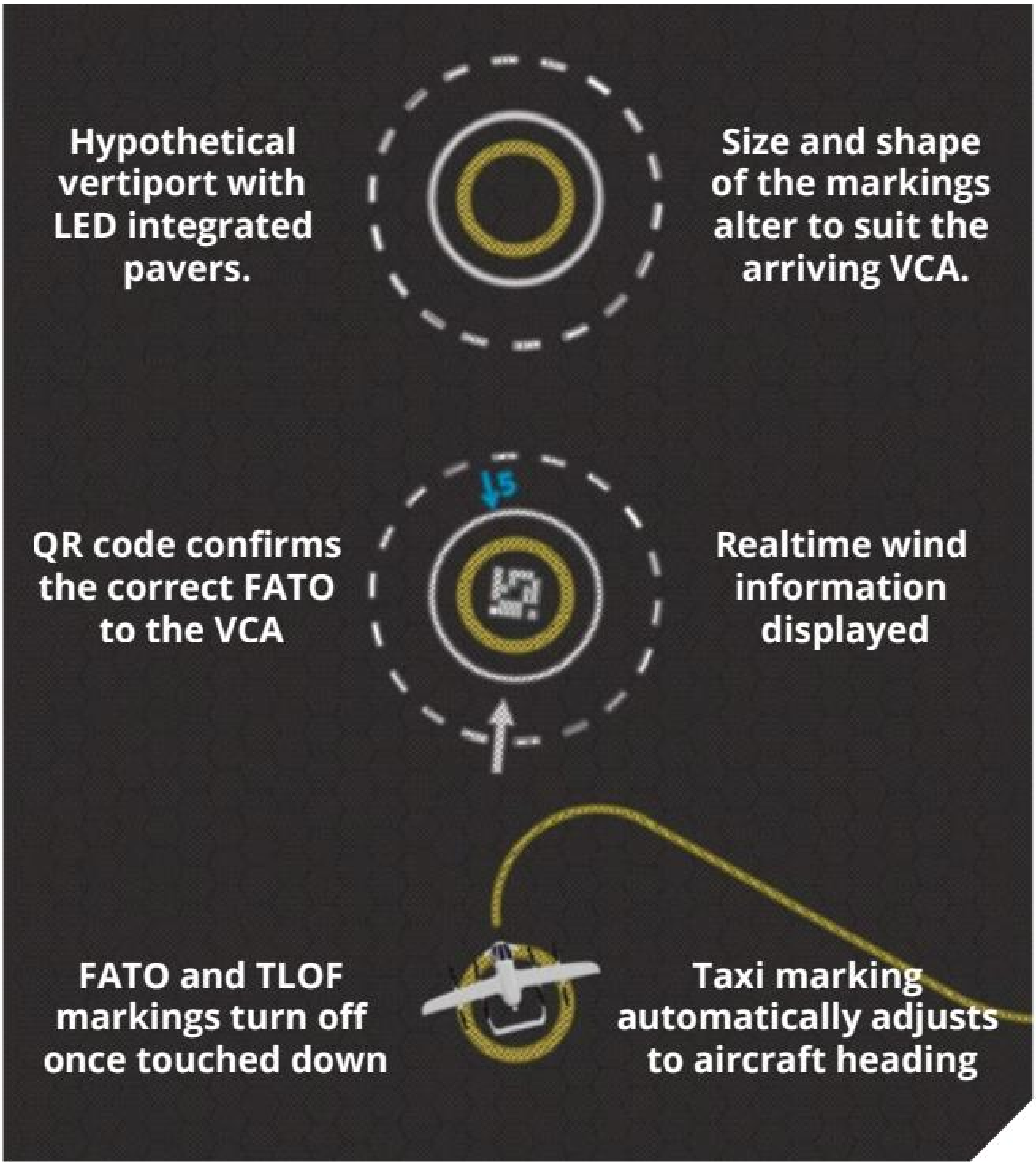
Thinking outside the box

The lighting guidance that has been provided in the AC is generally based on historical lighting guidance for heliports as well as trying to mirror some initial guidance from a few overseas regulatory agencies. However, these historical specifications are all based on pre-existing technologies. LED technology has come a long way since there has been any update to heliport or aerodrome guidance. There is nothing in the AC that precludes a vertiport operator from looking at new technologies for lighting the vertiport so long as the specified outcomes are met.

Hypothetical examples:

Example 1:

Paving technology proposed for roadways and paths is being developed that has integrated LEDs. Providing all the physical specifications such as strength, friction, drainage can be met, this could revolutionise how vertiports are marked and lit. This kind of ‘digital FATO’ could project its markings in real time to the FATO, the approach path and wind data could be displayed within the FATO area. Also, you could turn off FATO edge markings to indicate a FATO is occupied, and then bring up passenger markings to guide passengers to and from the terminal.



Example 2:

FATO information could be shared in real time with aircraft operators and aircraft in flight, allowing fine adjustment for departure, flight and arrival time to match the usage of the FATO.

Example 3:

Future fully-autonomous aircraft may mean that markings and lights will become superfluous. Visual aids are to be seen – by a pilot. Machine readable aids such as QR codes may be used on vertiports to guide aircraft. What will a future vertiport need to be able to guide a VCA safely and accurately?

Where to from here?

Advisory Circular AC139.V–01 provides greater detail of the design requirements and methods for vertiport design and should be used for actual design work.

CASA has not received (at time of publication) any flight performance documentation from any manufacturers currently developing VCA. We hope the guidance provided in the AC is specific enough to guide vertiport designers and operators in developing a safe and operationally effective facility yet open enough to promote new thinking in this evolving industry.

So, what does this mean for vertiport operators? In short, it means start talking to prospective VCA manufacturers and other stakeholders as soon as possible: the design of the vertiport may take some time.

To even start designing a vertiport, you will need to get a very good understanding of:

the sort of operations you are planning for your vertiport – both initially and in the future

- the types of VCA you want to cater for

how the flight performance of these VCA is going affect the possible flight paths

the obstacle environment that exists around your vertiport

the future development plans in the area and whether they impact the design of the vertiport.

As the industry evolves, new guidance will be produced and current guidance will be updated. Please keep in touch at the CASA emerging technologies program webpage: www.casa.gov.au/resources-and-education/publications-andresources/corporate-publications/emergingtechnologies-program.

Image: Eve Air Mobility

Appendix A – Acronyms and initialisms

Term	Definition
AAM	advanced air mobility
AC	advisory circular
D	(largest) diameter (see definitions table)
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Administration
FATO	final approach and take-off (area)
FPA	FATO protection area
FPAGLS	flight path alignment guidance lighting system(s)
ICAO	International Civil Aviation Organization
MTOW	maximum take-off weight
NASA	National Aeronautics and Space Administration
OFV	obstacle free volume

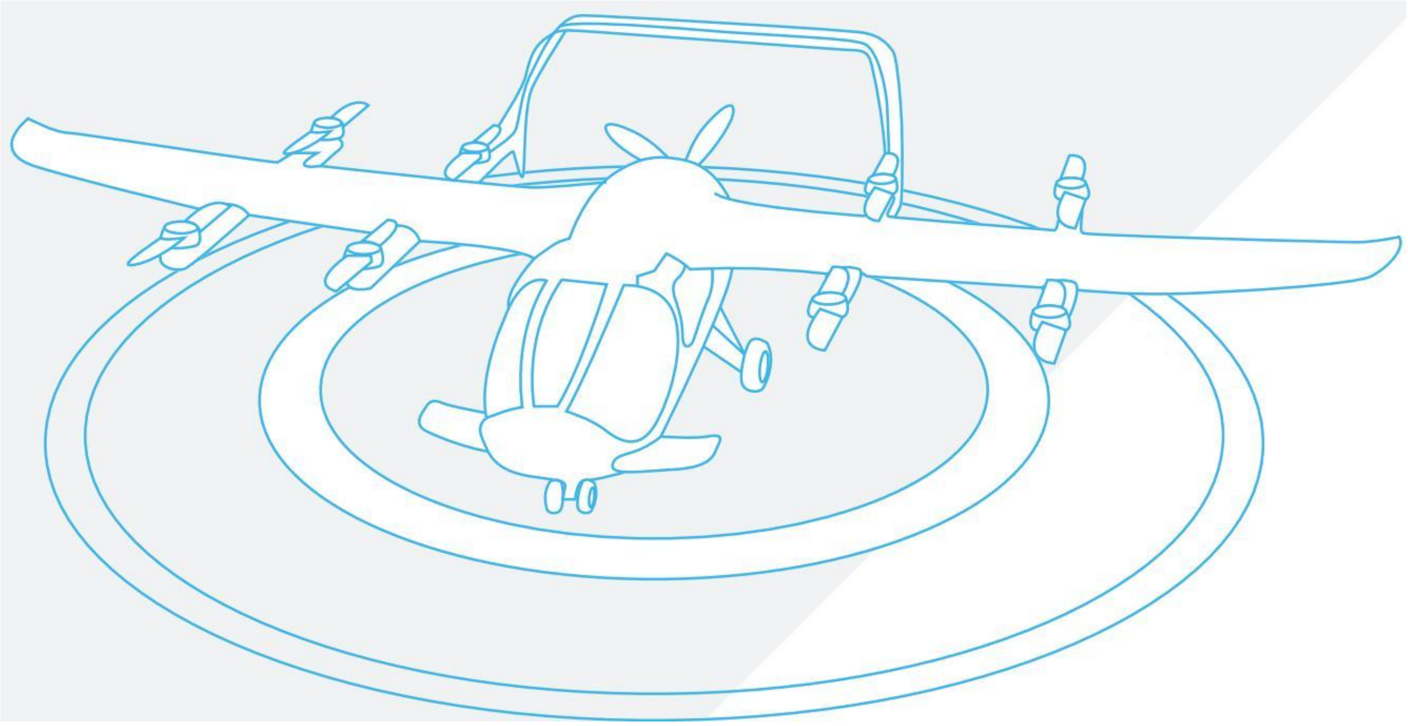
OLS	obstacle limitation surface
RTODRV	rejected take-off distance required
SAF	sustainable aviation fuel
STOL	short take-off and landing
TDPC	touchdown positioning circle
TDPM	touchdown positioning marking
TLOF	touchdown lift-ff (area)
UCW	undercarriage width
VCA	VTOL-capable aircraft
VPS	vertical procedure surface
VTOL	vertical take-off and landing

Appendix B – Definitions

Term	Definition
aerodrome	an area on land or water (including any buildings, installations and equipment) which is authorised under the regulations to be used as an aerodrome for the arrival, departure and movement of aircraft
D	for VCA: the diameter of the smallest circle enclosing the aircraft projected on a horizontal plane, while the aircraft is in the take-off or landing configuration, with lift/thrust units turning, if applicable Note: If the aircraft changes dimensions during taxing or parking (for example, folding
Design VCA	wings), a corresponding D(taxing) or D(parking) should also be provided a virtual aircraft type that has the largest set of dimensions, the greatest maximum take-off weight (MTOW) and the most critical obstacle avoidance criteria of the aircraft that the vertiport, or for a defined area within the vertiport, is intended
Design D	to serve the D of the Design VCA
elongated	when used with TLOF or FATO, elongated means an area which has a length more than twice its width
final approach and take-off area (FATO)	for the operation of a VCA, a solid area: • from which a take-off is commenced
instrument meteorological conditions	• over which the final phase of approach to hover is completed means meteorological conditions other than visual meteorological conditions (see below)

obstacle obstacle limitation surfaces	an object (whether temporary or permanent) or part of such an object that: • is located on an area provided for the movement of aircraft • extends above a defined surface designated to protect aircraft in flight a series of planes associated with each FATO at a vertiport, which define the desirable limits to which objects or structures may project into the airspace around the vertiport so that aircraft operations at the vertiport may be conducted safely. The obstacle limitation surfaces are as follows: • FATO protection area (FPA)
	reference circle a horizontal circle, of the specified dimension, that is centred on any intended position/flight path at or above the applicable area/surface
rejected take-off distance required (RTODRV)	the horizontal distance that is required from the start of the take-of to the point where the aircraft comes to a full stop, following a critical failure that is recognised at the to take-off decision point
touchdown and lift-off area (TLOF)	an area where a VTOL-capable aircraft may touchdown or lift off
touchdown positioning circle (TDPC)	a TDPM in the form of a circle, which is used for omnidirectional positioning in a TLOF
touchdown positioning marking (TDPM)	a marking or set of markings that provide visual cues for the directional positioning of an aircraft
vertical	a take-off and landing procedure that includes an initial and/or final vertical profile. The profile may or may not include a horizontal component
procedure vertical	a surface at which a VTOL-capable aircraft either:
procedure	• begins its arriving vertical procedure
surface (VPs) vertiport	• ends its departing vertical procedure the highest point of the FATO, or where there are multiple FATOs, the highest point
elevation vertiport	of the highest FATO an area of land, water or structure that is used or intended to be used for the landing, take-of and movement of VTOL-capable aircraft
	vertiports also include vertihubs and vertistops: • vertihub: a vertiport with infrastructure for maintenance, repair, fuelling and
	vertistop: a vertiport intended for take-off and landing of VCA to drop off or
	parking spaces for storage of VCA
	pick up passengers or cargo, but where there are no facilities for fuelling,

	defuelling, scheduled maintenance, scheduled repairs or storage of aircraft
vertiport	a defined horizontal surface selected and/or prepared as a suitable area over
clearway	which an aircraft, capable of continued safe flight after a critical failure, may
	operate between the FATO/VPS and the approach/climb-out surface inner edge
visual meteorological conditions	meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling, equal to or better than specified minima
VTOL-capable aircraft (VCA)	a heavier-than-air aircraft, other than aeroplane or helicopter, capable of performing vertical procedures by means of more than two lift/thrust units
VCA stand	a defined area that is intended to accommodate aircraft for loading or unloading passengers, mail, or cargo, fuelling/charging, parking or maintenance
VCA taxi-route	a defined path that is established for the movement of VCA from one part of a vertiport to another: • an air taxi-route: a marked taxi-route that is intended for air taxing • a ground taxi-route: a marked taxi-route centred on a taxiway that is intended for ground movement
VCA taxiway	a defined path on a vertiport that is intended for the ground movement of VCA from one part of a vertiport to another



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