Australian Government
Civil Aviation Safety Authority

ADVISORY CIRCULAR
AC 133-01 v4.2

Performance class operations

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March 2025

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:

- commercial and air transport helicopter pilots
- current and future Air Operator's Certificate (AOC) holders who are, or wish to be authorised to conduct air transport helicopter operations
- current and future Part 142 of CASR operators
- current and future aerodrome and heliport operators
- aerodrome and heliport designers.

Note: Single engine rotorcraft are required by Part 133 of CASR to be operated in performance class 3 (PC3). Additionally, operators and pilots of multi-engine rotorcraft carrying less than a maximum operational passenger seat configuration of 10 passengers and operating VFR by day, may be operated in PC3. Operators and pilots operating rotorcraft in PC3 need only refer to section 2.1, chapter 4, sections 5.1 and 6.1 and chapter 8 of this AC, unless they wish to gain further information on PC2WE, PC2 and PC1.

Purpose

The purpose of this AC is to provide advice in the form of Guidance Material (GM) and, where relevant, suggest an Acceptable Means of Compliance (AMC) for Subpart 133.F of the *Civil Aviation Safety Regulations 1998 (CASR)* and the associated Chapter 10 of the Part 133 Manual of Standards (MOS); which outline the requirements for rotorcraft take-off, initial climb, en-route, approach and landing performance.

The intention is to translate the requirements of the regulations and MOS into language that is easily understood, and where necessary expand the information to ensure the intent of the legislation is clear.

It is recommended that this AC be read in conjunction with the relevant Part 133 of CASR and the Part 133 MOS to ensure maximum understanding.

Any AMC outlined will allow an Air Operator's Certificate (AOC) holder to satisfy the Civil Aviation Safety Authority (CASA) of the regulatory requirement if they choose to use and follow the AMC material, however AOC holders may also propose alternative means of compliance to the AMC if they so desire. This alternative means will need to be assessed and found acceptable for the purpose by CASA.

For further information

For further information or to provide feedback on this AC, visit CASA's contact us page.

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 National Manager, Flight Standards Branch.

Note: Changes made in the current version are annotated with change bars.

Table 1. Status

Version	Date	Details
v4.2	March 2025	Added advisory information to certain locations about some risk assessments being able to be done for a series of flights rather than each individual flight which arose from industry questions. This extra information is contained in section 8 of this main AC document and also in 2 locations in Annex C.
v4.1	December 2024	The following changes have been made: • references to exemption CASA EX84/21 have been replaced with references to its replacement exemption CASA EX70/24 • updated legislative references in section 8.5 due to changes in Part 133 MOS • additional PC3 AMC content added to Annex C.
v4.0	September 2024	The following key changes have been made: • new Annex B has been added containing specific worked examples of PC3 operations over water and over populous areas • new Annex C has been added containing PC3 sample exposition content developed by CASA which can be used by operators, subject to them ensuring it is appropriate for their operational circumstances, until the CASR Flight Operations Sample Exposition / Operations Manual is updated • added further guidance about exposition content in sections 6.9, 7.5 and 8.6 • section 7 has been amended to clarify that a PC2 approach and landing is acceptable to a suitable forced landing area of a lesser length than the Category A landing distance required, provided the rotorcraft mass is below the Clear Area Category A weight limit and, appropriate pilot techniques are used • numerous editorial adjustments due to the new AC format.
v3.1	August 2023	Added guidance on PC3 enroute suitable force landing area availability (main additions are in sections 8.3 and 8.5 with section 4.2 being deleted due to being merged into section 8.5). Other minor editorial adjustments to some section titles and paragraphs,
v3.0	July 2021	Clarification of PC1 MOPSC requirement. Additional text relating to adequate vertical margin and requirements for PC3 over populous areas.
v2.0	March 2021	Amendment adding links to take-off profile spreadsheets and instructions annexures.
v1.0	December 2020	Initial AC.

Contents

Acknowledgement of Country

The Civil Aviation Safety Authority (CASA) respectfully acknowledges the Traditional Custodians of the lands on which our offices are located and their continuing connection to land, water and community, and pays respect to Elders past, present and emerging.

Artwork: James Baban.

1 Reference material

1.1 Acronyms

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

Table 2. Acronyms

Acronym	Description
AC	advisory circular
AEO	all engines operating
AGL	above ground level
AMC/GM	acceptable means of compliance/guidance material
AOC	Air Operator's Certificate
CAR	*Civil Aviation Regulations 1988*
CASA	Civil Aviation Safety Authority
CASR	*Civil Aviation Safety Regulations 1998*
CN	*code numbers*
CS	Certification Specification - EASA
DPATO	defined point after take-off
DPBL	defined point before landing
EASA	European Union Aviation Safety Authority
ERSA	En Route Supplement Australia
FAR	Federal Aviation Regulations
FATO	final approach and take-off area
fpm	feet per minute
ft	feet
HIGE	hover in ground effect
HLS	helicopter landing site
HOGE	hover out of ground effect
HV diagram	height-velocity diagram (as contained in the rotorcraft flight manual)
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	instrument meteorological conditions
ISA	International Standard Atmosphere

Acronym	Description
LDP	landing decision point
LSALT	lowest safe altitude
MOS	Manual of Standards
MTO	medical transport operations
MTOW	maximum take-off weight
MLW	maximum landing weight
MOPSC	maximum operational passenger seat configuration
MOS	Manual of Standards
MSA	minimum sector altitude
NVFR	night visual flight rules
NVIS	night vision imaging system
OEI	one engine inoperative
OLS	obstacle limitation surface
PC1	Performance Class 1
PC2	Performance Class 2
PC2WE	Performance Class 2 with exposure
PC3	Performance Class 3
PIC	pilot in command
QNH	the Q code reference for a barometric altimeter subscale setting that causes an altimeter to read height above mean sea level.
RFM	Rotorcraft Flight Manual
RTODAR	rejected take-off distance available - rotorcraft
RTODRR	rejected take-off distance required - rotorcraft
SARPS	Standards and Recommended Practices
SMS	Safety Management System
SOP	Standard Operating Procedures
SFL	suitable forced landing
SFLA	suitable forced landing area
STODA	supplementary take-off distance available
TDP	take off decision point
TLOF	touch down and lift off area
TODA	take-off distance available

Acronym	Description
TODAR	take-off distance available - rotorcraft
TODRR	take-off distance required - rotorcraft
VFR	Visual Flight Rules
VMC	visual meteorological conditions
WAT	altitude and temperature

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.

Table 3. Definitions

Term	Definition
Adequate vertical margin	For a rotorcraft, is the minimum vertical distance the rotorcraft must be from an object during a stage of a flight mentioned in: (a) the rotorcraft's flight manual, or (b) if paragraph (a) does not apply — the rotorcraft operator's exposition.
Authorised weather report	Refer to Part 1 of the CASR Dictionary
Avoid area of the HV envelope	Of a rotorcraft, means the area delineated on the height-velocity envelope diagram in the rotorcraft's flight manual that shows the parameters within which operations of the rotorcraft should be avoided.
Baulked Landing Distance	For the approach to land of a multi-engine rotorcraft, the baulked landing distance is the distance from the LDP to the point where a positive rate of climb at V_{TOSS} is achieved with 35 ft clearance above obstacles. This is on the assumption of one engine being inoperative at the LDP, and the remaining engines operating within the take-off operating limits prescribed by the RFM.
Category A	in relation to a rotorcraft, means a multi engine rotorcraft that is: (a) designed with engine and system isolation features stated for Category A requirements in any of the following: (i) Part 27 of the FARs (ii) Part 29 of the FARs (iii) EASA CS—27 (iv) EASA CS—29 (v) an equivalent airworthiness code of a Contracting State, and (b) capable of operation using take-off and landing data scheduled under a critical engine failure concept, which assures adequate designated ground or water area and adequate performance capability for continued safe flight, or safe rejected take-off in the event of engine failure, as mentioned in the rotorcraft's flight manual. **Note:** This definition is based on the ICAO, FAA and EASA definitions of the term Category A in relation to rotorcraft.

Term	Definition
Category A procedure	A procedure presented in the normal procedures, performance sections or performance supplement sections of the RFM referenced as being mandatory requirements in the limitations section (unless a HV diagram valid for category A operations is presented), which assures adequate designated ground or water area and adequate performance capability for continued safe flight or safe rejected take-off in the event of engine failure.
Category A rotorcraft	A rotorcraft that: (a) meets the requirements of the definition Category A; and (b) is type-certificated in accordance with any of the following: (i) Part 27 of the FARs (ii) Part 29 of the FARs (iii) EASA CS—27 (iv) EASA CS—29 (v) an equivalent airworthiness code of a Contacting State.
Category B rotorcraft	A rotorcraft that is not capable of operations as a Category A rotorcraft in accordance with paragraph (b) of the definition of Category A. **Note:** This definition is an expansion of the concept of category B certification within the transport category to include these characteristics in both normal and transport category rotorcraft for the purposes of the performance code. For example, a transport category certified rotorcraft that is not operated as a category A rotorcraft, due to operating above the weights required by or not to the procedures or limits specified by the rotorcraft's category A performance flight manual supplement, or which is a single engine. A normal category rotorcraft may either be single engine, or multi-engine and not have these capabilities, or may only have them when operated at very light masses.
Contracting State	A foreign country that is a party to the Chicago Convention.
Design Helicopter	For the design of a heliport, means a virtual or actual helicopter type having the largest set of dimensions, the greatest maximum take-off mass and the most limiting obstacle limit surface requirements the heliport is intended to serve, and which needs to be considered by the heliport designer when designing the heliport. **Note:** In some heliports designed for the upper limit of their use for a specific type of helicopter, a manufacturer’s production helicopter type can perform the role of a design helicopter in the design process.
Exposure time	For a rotorcraft that is flying in still air, means the period during which the rotorcraft, with one engine inoperative, may not be able to achieve a safe forced landing or continue the flight safely.
Field of View	This is the extent of the observable world that is seen at any given moment, normally from the aircraft's design eye position as defined by the manufacturer, or if undefined, the appropriate seated position of the pilot.
Flight manual	Refer to part 2 section 37 of the CASR dictionary.
Helicopter Clearway	For an aerodrome, means an area of open ground or water that is selected and prepared by the operator of the aerodrome as a suitable area over which a rotorcraft may accelerate and achieve a height mentioned in the rotorcraft’s flight manual
Helideck	An area intended for use wholly or partly for the arrival or departure of rotorcraft, on:

Term	Definition
	(a) a ship; or (b) a floating or fixed structure on water.

Heliport	An area:
	• intended for use wholly or partly for the arrival or departure of rotorcraft, on:
	  ○ land, or
	  ○ a building or other structure on land, and
	  ○ that meets the standards for a heliport set out in the Part 139 MOS
	
	Note: It is intended to insert standards equivalent to the ICAO Annex 14 Aerodromes Volume II Heliports - Standards and Recommended Practices (SARPs) into Part 139 MOS.

Inner Edge	The boundary of the take-off climb surface that is perpendicular to the departure end of the FATO or helicopter clearway. The inner edge may be at the level of the FATO or elevated where a raised incline plane or a virtual clearway is being applied.
Maximum take-off weight	Refer to Part 1 of the CASR Dictionary.
Maximum Landing Weight	Refer to Part 1 of the CASR Dictionary.
Medical transport operations	Refer to clause [70] of Part 2 of the CASR Dictionary.
Medical transport operating site	Refer to section 1.05 of the Part 133 MOS.
Min-Dip	The lowest point reached above the surface during a Category A procedure following an engine failure. Also known as the maximum drop-down.
Minimum flight altitude	Refer to chapter 1 section 4 of the Part 133 MOS.
Operations in performance Class 1 (ICAO definition)	Operations with performance such that, in the event of a critical engine failure, performance is available to enable the helicopter to safely continue the flight to an appropriate landing area, unless the failure occurs prior to reaching the take-off decision point (TDP), or after passing the landing decision point (LDP), in which case the helicopter must be able to land within the rejected take-off or landing area (ICAO Annex 6, Part III).
Performance class 1	Performance class 1, for a stage of flight of a rotorcraft, has the meaning given by the Part 133 Manual of Standards.
Operations in performance Class 2 (ICAO definition)	Operations with performance such that, in the event of critical engine failure, performance is available to enable the helicopter to safely continue the flight to an appropriate landing area, except when the failure occurs early during the take-off manoeuvre or late in the landing manoeuvre, in which cases a forced landing may be required (ICAO Annex 6, Part III).
Performance class 2,	Performance class 2, for a stage of flight of a rotorcraft, has the meaning given by the Part 133 Manual of Standards
Operations in performance Class 3 (ICAO definition)	Operations with performance such that, in the event of an engine failure at any time during the flight, a forced landing will be required (ICAO Annex 6, Part III).

Term	Definition
Performance Class 3	Performance class 3, for a stage of flight of a rotorcraft, has the meaning given by the Part 133 MOS.
Performance Class 1 helicopter (ICAO definition)	A helicopter with performance such that, in the case of critical power-unit failure, it is able to land on the rejected take-off area, or safely continue the flight to an appropriate landing area, depending on when the failure occurs (ICAO Annex 6, Part III).
Performance Class 2 helicopter (ICAO definition)	A helicopter with performance such that, in the case of critical power-unit failure, it is able to safely continue the flight, except when the failure occurs prior to a defined point after take-off, or after a defined point before landing, in which case a forced landing may be required (ICAO Annex 6, Part III).
Performance Class 3 helicopter (ICAO definition)	A helicopter with performance such that, in the case of critical power-unit failure at any stage in the flight profile, a forced landing must be performed (ICAO Annex 6, Part III).
Populous Area	A populous area includes a city and a town. **Note:** This definition is from the CASR Dictionary. CASA's interpretation of this definition can be found in the GM 91.265 entry of the Part 91 AMC/GM document. Different definitions of this term exist in CASR Parts 101 and 137 but these Part 101 and 137 definitions are not applicable to Part 133 operations.
Raised Incline Plane	A plane which describes a take-off climb surface that is elevated vertically above the departure end of the FATO or clearway.
Relevant obstacle	For the take-off stage, or the approach and landing, or baulked landing stage, of a flight of a rotorcraft flying in performance class 1 or 2, or performance class 2 with exposure, means an obstacle that is relevant, within the meaning of the Part 133.MOS, to that stage of the flight.
S	For a point in a flight of a rotorcraft, means the horizontal distance that the rotorcraft has travelled from the end of the take-off distance available - rotorcraft, for a take-off of the rotorcraft, to that point.
Splay	In this AC, means the Take-Off Climb Surface. **Note:** The boundary of the splay closest to the FATO is known as the inner edge, and the boundary furthest away from the FATO is known as the final width.
Suitable forced landing area	Refer to regulation 133.010 of CASR.
Take-Off Climb Surface	A surface that is based on an inclined plane located beyond the end of the FATO or clearway, identified for the purpose of determining relevant obstacles for the take-off.
Take-off decision point	for a take-off of a rotorcraft at an aerodrome, means the point mentioned in the rotorcraft's flight manual, if an engine failure is recognised: (a) up to, and at, which the take-off may be safely rejected; or (b) at, and after, which the take-off may be continued safely.
Take-off distance required - rotorcraft	(1) For a take-off of a multi-engine rotorcraft, is the distance, calculated in accordance with the factors mentioned in subsection (2), from the start of the take-off to the point at which the rotorcraft achieves all of the following: (a) V_{TOSS} for the rotorcraft; (b) a height of 35 ft above the take-off aerodrome;

Term	Definition
	(c) a positive climb gradient. (2) For subsection (1), the factors are that: (a) one engine of the rotorcraft is inoperative at the take-off decision point for the take-off; and (b) the remaining engines of the rotorcraft are operating within the operating limits mentioned in the rotorcraft's flight manual for a take-off.
Virtual clearway	A helicopter clearway that extends outside the boundary of the heliport and which complies with the helicopter clearway SARPs provided in Annex 14, Volume II, Chapters 3.1.16 to 3.1.20 inclusive and Appendix D to Chapter 3 of Part II of the Heliport Manual (ICAO Doc 9261).
V_{TOSS}	For a rotorcraft, means the minimum speed at which climb of the rotorcraft is achieved with one engine inoperative, and the remaining engines are operating within the operating limits mentioned in the rotorcraft's flight manual for a take-off.
V_Y	The speed for the best rate of climb with all engines operating.

1.3 References

Legislation

Legislation is available on the Federal Register of Legislation website https://www.legislation.gov.au/

Table 4. Legislation references

Document	Title
CASA EX70/24	Part 133 and Part 91 of CASR – Supplementary Exemptions and Directions Instrument 2024
Part 91 of CASR	General operating and flight rules
Part 91 MOS	General Operating and Flight Rules
Part 133 of CASR	Australian air transport operations—rotorcraft
Part 133 MOS	Australian Air Transport Operations—Rotorcraft
Part 138 of CASR	Part 138 - Aerial work operations
Part 138 MOS	Aerial Work Operations
Part 139 of CASR	Aerodromes
Part 139 MOS	Aerodromes

International Civil Aviation Organization documents

International Civil Aviation Organization (ICAO) documents are available for purchase from http://store1.icao.int/

Many ICAO documents are also available for reading, but not purchase or downloading, from the ICAO eLibrary (https://elibrary.icao.int/home).

Table 5. ICAO references

Document	Title
ICAO Annex 6 Part III	International Standards and Recommended Practices for Operation of Aircraft – International Operations - Helicopters
ICAO Annex 14 Volume II	International Standards and Recommended Practices for Aerodromes - Heliports
ICAO Doc 9261	ICAO Heliport Manual Parts I and II
ICAO Doc 10110	Helicopter Code of Performance Development Manual

Advisory material

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

Table 6. Advisory material references

Document	Title
AC 91-29	Guidelines for helicopters - suitable places to take off and land
AC 139.R-01	Guidelines for heliports - design and operation
EASA Annex to ED Decision 2012/018/R	Acceptable to Means of Compliance (AMC) and guidance material (GM) to Part-CAT
Part 91 AMC/GM	Acceptable means of compliance and guidance material – General operating and flight rules

2 Introduction to the performance classes

2.1 Why do we have performance class operations?

2.1.1 The performance class system establishes rotorcraft performance requirements for Part 133 operators that are scaled based on the following factors:

- the number of passengers
- the type of flight rules or conditions
- whether a flight is conducted as part of a medical transport operation.

2.1.2 The International Civil Aviation Organization (ICAO) Standards and Recommended Practices (the Chicago Convention), Standards and Recommended Practices (SARPs) for Annex 6, Part III, Section II, 3.1.1, 3.1.2 and 3.1.3 require a State (in our case, Australia) to ensure rotorcraft conducting commercial air transport operations are operated in accordance with a code of performance established by the State of the Operator.

2.1.3 The code of performance should consider situations in conditions where the safe continuation of flight is not ensured in the event of a critical engine failure. In doing so, rotorcraft operations must be conducted in a manner that gives appropriate consideration for achieving a safe forced landing.

2.1.4 The SARPs also outline that for circumstances where rotorcraft are operated to or from heliports in a populous area and where suitable forced landing areas are not available, the competent authority of the State in which the heliport is situated must specify requirements enabling these operations to be conducted in a manner that gives appropriate consideration for the risk associated with an engine failure.

2.2 What performance class do I have to operate in?

2.2.1 Table 7 summarises when each performance class (PC1, PC2, PC2WE, PC3) must be used and the elements of the Part 133 MOS that apply to each set of circumstances.

> **Note:** The table outlines the minimum performance related standards for different kinds of flights. Operators or pilots can elect to operate in a higher performance class at any time provided the requirements of that higher performance class are met.

Table 7. Part 133 of CASR performance class requirements

Operation	Performance class	MOS Chapter 10 Divisions that apply
MOPSC > 19 Any flight rules	PC1	Divisions 1, 2, 5, 6 and 7
MOPSC > 9 ≤ 19 Any flight rules	PC1, PC2 or PC2WE during the nominated stages of the flight PC1 en-route	Divisions 1, 2, 3, 5, 6, 7 and 8 **Note:** Divisions 2, 3, 7 or 8 are dependent on actual PC
MOPSC < 10	PC3	Divisions 1, 4, 5, 6 and 9

Operation	Performance class	MOS Chapter 10 Divisions that apply
VFR by day		
Passenger transport operation IFR or night	PC1, PC2 or PC2WE during the nominated stages of the flight PC1 en-route	Divisions 1, 2, 3, 5, 6, 7 and 8 **Note:** Divisions 2, 3, 7 or 8 are dependent on actual PC
Medical transport operation (MTO)	PC1, PC2 or PC2WE during the nominated stages of the flight PC1 en-route **Note:** Exempt from PCs at MTO operating sites, provided alternative risk-based procedures are in place in the exposition.	Divisions 1, 2, 3, 5, 6, 7 and 8 **Note:** Divisions 2, 3, 7 or 8 are dependent on actual PC
Cargo transport operation Any flight rules	PC3 PC1, PC2 and PC2WE remain optional and may be used	Divisions 1,4, 5, 6 and 9

2.3 Performance Class 1 (PC1)

2.3.1 ICAO Annex 6 Part III - describes operations in performance class 1 (PC1) as helicopter operations with performance such that, dependant on when the failure occurs in the case of a critical engine failure, the helicopter is able to land on the rejected take-off area, or safely continue the flight to an appropriate landing area and land safely using the remaining engine or engines.

2.3.2 The detailed requirements to achieve PC1 under Subpart 133.F of CASR and Chapter 10 of the Part 133 MOS are explained in this AC. In terms of safety following the failure of an engine, adhering to PC1 ensures there will be significantly reduced engine failure risk to the public or aircraft occupants throughout all stages of flight. This will be achievable without exceeding the normal limits of the rotorcraft and its systems.

2.3.3 Figure 1 provides a basic ICAO representation of PC1 from a generic surface level heliport. In the event of an engine failure at or prior to the Take-off Decision Point (TDP), the heliport must provide a Final Approach and Take-off Area (FATO) of sufficient dimensions to allow for a safe One Engine Inoperative (OEI) landing without exceeding the normal limits of the rotorcraft. Following an engine failure at or after the TDP, the rotorcraft must be capable of flying away OEI while maintaining at least 10.7 m (35 ft) of obstacle clearance until at the minimum flight altitude (refer to the Definitions section of this AC).

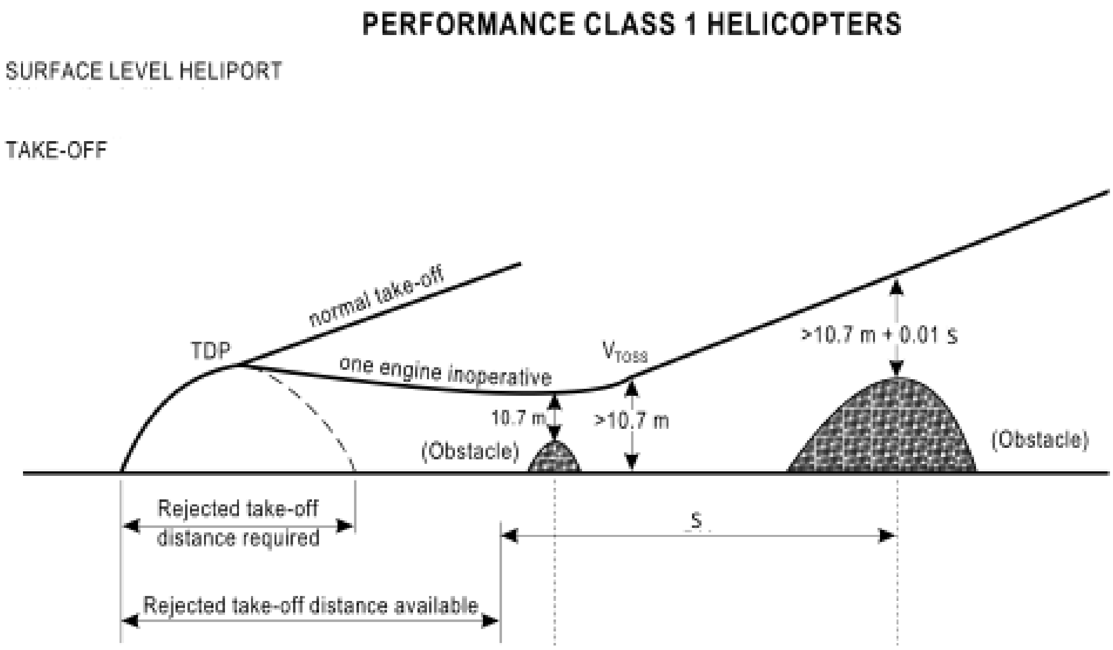

Figure 1. Surface Level Heliport PC1 Operations

2.4 Performance Class 2 (PC2)

2.4.1 ICAO Annex 6 - Part III describes operations in performance class 2 (PC2) as operating a helicopter with performance such that, in the case of critical engine failure, it is able to safely continue the flight, except when the failure occurs prior to a defined point after take-off (DPATO) or after a defined point before landing (DPBL), in which case a forced landing may be required.

2.4.2 While remaining within acceptable aviation safety risk limits, PC2 operations represent a higher risk to occupants and the public compared with PC1. In PC2 operations, during the take-off and landing phases of flight, there need not be the PC1 capability to either abort the take-off or landing or to safety continue to flight, provided a landing in a suitable forced landing area can be achieved. This must be possible from the point before which for a take-off, or after which for a landing, a safe fly-away cannot be conducted. The use of a suitable forced landing area (refer to definition in regulation 133.010 of CASR) is on the assumption that during the forced landing normal aircraft limits may be exceeded, but there remains a ‘reasonable expectation that there would be no injuries to persons in the rotorcraft or on the ground’.

2.4.3 In nominating a forced landing area as ‘suitable’, a pilot (based on the operator's policies and procedures for such operations) should be able to justify that the size, surface, slope and likely impact forces will allow a reasonable expectation of the rotorcraft remaining upright and no injuries as described in paragraph 2.3.2 of this AC.

2.4.4 Figure 2 provides a basic representation of PC2 from a generic surface level heliport. In the event of an engine failure at or prior to the Defined Point After Take-Off (DPATO), the surface must allow for a suitable (‘safe’ under ICAO) forced landing area for an OEI landing. At or after the DPATO, the rotorcraft must be capable of flying away OEI while maintaining at least 10.7 m (35 ft) of obstacle clearance until at the minimum flight altitude for the flight. PC2 requirements beyond DPATO are identical to those for PC1.

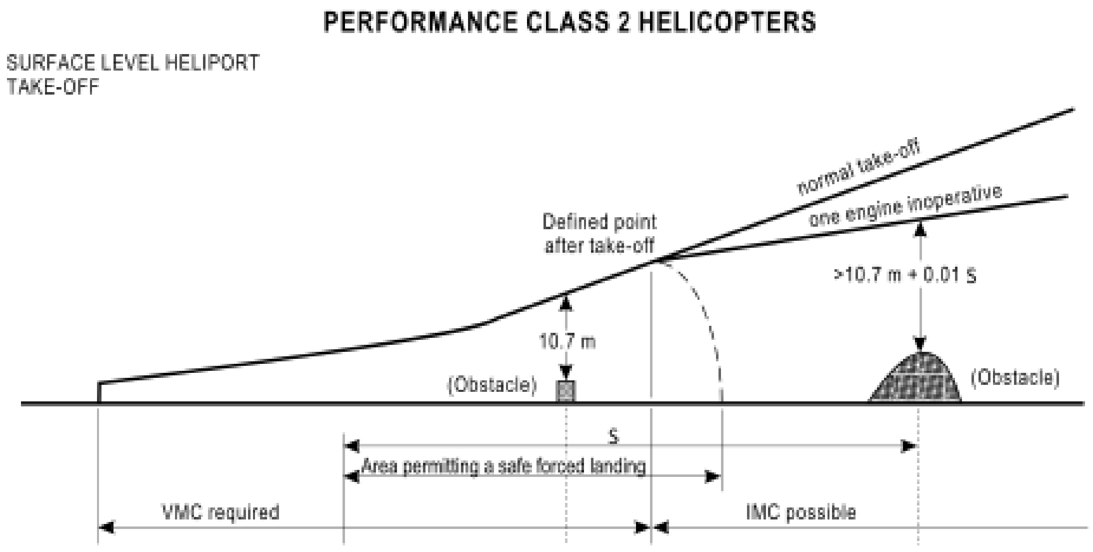

Figure 2. Surface Level Heliport PC2 operations

2.5 Performance Class 2 with exposure (PC2WE)

2.5.1 PC2WE is very similar to PC2 as mentioned in 2.4 above. The primary difference is that there need not be any provision for a suitable forced landing area during the take-off and landing phases of flight, within the designated exposure period for the rotorcraft.

2.5.2 To maintain a satisfactory level of safety assurance, the exposure time[1] where a suitable forced landing area is not available needs to be limited. Specific approval to operate with exposure is required from CASA and will require a number of mitigation strategies from the operator to gain that approval.

Note: PC2WE will not be discussed in detail in this AC this content will be detailed in *AC 133-02 - Performance Class 2 with exposure operations*.

2.6 Performance Class 3 (PC3)

2.6.1 ICAO Annex 6 Part III - describes operations in performance class 3 (PC3) as operating a helicopter with performance such that, in the case of critical power-unit failure at any stage in the flight profile, a forced landing must be performed.

2.6.2 In terms of safety following the failure of an engine, PC3 is the lowest acceptable standard within air transport operations. PC3 provides less assurance of engine failure safety throughout any stage of flight. However, there are certain phases of flight where a suitable forced landing area is required to provide additional risk reduction, particularly for third parties. In some circumstances, where no suitable forced landing area is available, other risk reduction methods may be applied.

[1] Refer to 1.2 - Definitions of this AC.

3 Performance class operating requirements

3.1 Rotorcraft must fly in a performance class

3.1.1 Regulation 133.315 of CASR requires a rotorcraft conducting air transport operations to be flown within one of the performance classes.

Exception

The only general exception[2] is for authorised medical transport operations (MTO) when arriving and departing from a location associated with an accident or incident scene, or when they are conducting winching associated with such operations.

An accident or incident scene is an ad hoc location, defined as a medical transport operating site[3], where a person is located that may need to be transported by a medical transport rotorcraft.

It includes, but is not limited to, sites such as sports grounds, industrial estates, farm land, roads, park lands other landing sites and winching areas where a patient may be located and that are not a hospital heliport, or an aerodrome used for the regular operation of aircraft of any sort.

The exception to not operate within a performance class is an integral element of MTO performance requirements. This exception is contingent on an operator having suitable risk-based standard operating procedures for operations into such locations outlined in their exposition.

Note: This exception does not extend to include the departure from the MTO operator's base, or the arrival at or a departure from a hospital heliport or other aerodrome with a patient or medical personnel.

PC2 and PC2WE operations are available for these locations where PC1 cannot be supported.

3.1.2 For a rotorcraft to be deemed as operating in a performance class, it must be meeting the relevant performance class requirements. These requirements are established as follows:

- The CASR Dictionary defines *performance class* to mean either performance class 1, performance class 2, performance class 2 with exposure, or performance class 3.
- The CASR Dictionary then defines each of these 4 terms as having the meaning given by the Part 133 MOS.
- The Part 133 MOS then defines these 4 terms by listing certain requirements that must be met for each stage of a rotorcraft's flight.
- Therefore, if any of the requirements for a particular class is not met, the rotorcraft is NOT flying in a performance class.

[2] The exceptions are specified in subregulation 133.315(2) of CASR.

[3] Refer to section 1.2 *Definitions* of this AC.

3.2 Specific rotorcraft permitted to fly in PC1, PC2 or PC2WE

Note: This section of the AC discusses which rotorcraft are **permitted** to fly in PC1, PC2 or PC2WE.

Section 3.5 of this AC discusses which rotorcraft **must** be operated in PC1, PC2 or PC2WE.

3.2.1 The performance classes exist to provide higher levels of safety assurance following an engine failure, when compared to operations outside of a performance code. A key component of this assurance is the knowledge that the rotorcraft being used meets a specified certification standard that represents redundancy of systems, quality of manufacture, and availability of performance data for pilots.

3.2.2 The certification requirements of Federal Aviation Regulations (FAR) Parts 27 and 29 and European Aviation Safety Agency (EASA) Certification Specification (CS)-27 and 29 facilitate the provision of a helicopter type that is certificated to ‘normal or small’, ‘transport or large’, and ‘Category A’ and ‘Category B’ certification categories, each with appropriate operational and performance procedures, as well as limitations outlined in the Rotorcraft Flight Manual (RFM).

3.2.3 The precise certification standard of any helicopter type reflects the revision status at the time that the type certificate was first issued. As certification standards develop, they are improved, and are typically not applied retrospectively. Later models of a type tend to have more capability than earlier versions. This developmental cycle is also true for performance procedures, such as a category A procedure, and some older or initial models of a rotorcraft type may have a limited range of category A procedures compared to later models.

3.2.4 How and when the RFM procedures (and in some cases limitations) are required to be applied are prescribed in in the operational regulations and MOS and are suited to the conduct of specific operations. Within this prescription, rotorcraft certification provides, in the RFM procedures, the necessary limitations and information to ensure safe operation of the rotorcraft based on an acceptable level of risk.

3.2.5 For these reasons, only rotorcraft that meet the definition of a category A rotorcraft, or others prescribed by a specific instrument issued under regulation 133.015 of CASR, and prescribed by regulation 133.320 of CASR and the Part 133 MOS, are permitted to be operated in PC1, PC2 or PC2WE.

3.2.6 Pilots often describe Category A as a procedure which, when flown according to the RFM, assures safety in the event of an engine failure – this is not strictly correct. Category A is actually a certification standard within the transport category rotorcraft certification system, which provides assurance of continued flight by the use of redundancy, design assessment and engine isolation to reduce the probability of, or provide tolerance to, engine failure. It also requires the provision of performance data and specific take-off and landing profiles within the RFM. A Category A procedure only provides safety assurances in the context of what the manufacturer has described for climb capability and obstacle avoidance and does not account for CASA requirements outlining from an operational safety perspective which obstacles are relevant to avoid and by how much they should be avoided.

3.2.7 The performance classes, in this case PC1, PC2 and PC2WE, ensure that the performance data provided by category A certification, or derivations thereof, can be used in the operational context, considering the obstacle environment and the operating conditions for a flight. Figure 3 provides examples of all engines operating (AEO), and OEI first, acceleration and second segment climb profiles, and criteria for a type of category A procedure from a surface level heliport.

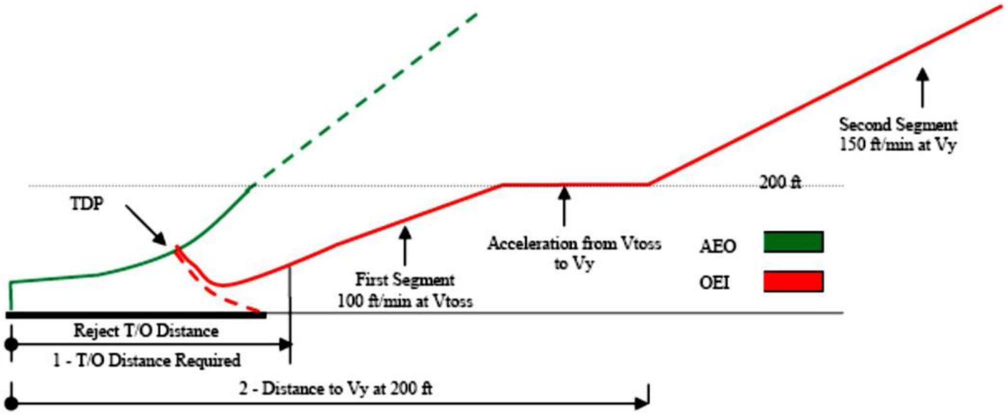

Figure 3. Surface level heliport Category A take-off

3.3 Flight in PC2WE

3.3.1 Regulation 133.325 of CASR enables the Part 133 MOS to prescribe requirements for operations in PC2WE. This regulation also states that an operator desiring to use PC2WE must hold an approval from CASA.

3.3.2 PC2WE permits operations without the safety assurance of a suitable forced landing area.

3.3.3 However, suitable forced landing areas are just one means of protecting persons and property against the engine failure risk. PC2WE offers operators alternative mitigation strategies based on:

- a defined exposure time limit
- demonstrated engine reliability
- engine maintenance standards
- pilot procedures and training
- operator risk assessments.

3.3.4 CASA will only approve these operations based on specific instruments of approval, due to complexities around the risk mitigation strategies for PC2WE.

3.3.5 Whilst PC2WE approvals may be general in nature, operators should not assume that approval is usable for every landing site due to significant variations in the consequence of engine failures across different sites.

Example

PC2WE may not be suitable for an operation and a rotorcraft to/from a heliport that has been designed and constructed with PC1 capability for the rotorcraft within a densely populated urban area.

However, it may be suitable for operations to/from an older, but strategically important community heliport with very complex obstacle avoidance requirements in the take-off splays, or a rural helicopter landing site (HLS) with few people routinely in the vicinity of the HLS.

3.4 Certain rotorcraft must fly in PC1

3.4.1 Part 133 of CASR introduces the concept of maximum operational passenger seat configuration (MOPSC) (refer to the CASR Dictionary - Part 1 - Definitions).

3.4.2 Regulation 133.330 of CASR outlines that, if the rotorcraft has a maximum operational passenger seat configuration of more than 19, the rotorcraft must be flown within PC1.

3.4.3 However, operators of large rotorcraft certified to carry more than 19 passengers can physically reduce the number of passenger seats to 19 or less to have a lower MOPSC, thus avoiding having to operate to PC1. This limitation must be included in their exposition and approved as an element of the entry control process for obtaining their AOC.

3.4.4 Selecting a MOPSC of 19 or less does not prevent operations in PC1 for such rotorcraft; it just avoids the mandated requirement to always operate in this performance class, which can be difficult from some locations, such as offshore facility helidecks.

3.5 Specific rotorcraft must fly in PC1, PC2 or PC2WE

Note: This section of the AC discusses which rotorcraft **must** be operated in PC1, PC2 or PC2WE.

Section 3.2 of this AC discusses which rotorcraft are **permitted** to fly in PC1, PC2 or PC2WE.

3.5.1 Regulation 133.335 of CASR applies to rotorcraft operated with a MOPSC of more than nine and not more than 19 operating under any flight rule, VFR by day, VFR by night or the IFR. It also applies to any MTO.

3.5.2 Subregulation 133.335(3) of CASR establishes that, for these applicable operations above, during specific stages of the flight, the rotorcraft must be flown in at least PC2WE, PC2 or PC1 as applicable. During any other stage of the flight, the rotorcraft must fly in accordance with PC1. The stages in which other than PC1 can used are:

- the take-off stage
- the take-off and initial climb stage
- the approach and landing, or baulked landing stage of a flight of the rotorcraft.

3.5.3 A maximum operational passenger seat configuration of between 10 and 19, inclusive, allows for operations in performance class 1, 2 or PC2WE, but mandates operations to at least PC2 or PC2WE during the stages of the flight outlined in paragraph 3.5.2 above. Operators of medium-sized rotorcraft that would normally be certified within this seating range may elect to have a reduced seating configuration of nine or less, which would then permit them to operate in the lesser class of PC3, provided they are not an MTO or an instrument flight rules (IFR), or night passenger transport operation.

3.5.4 Due to the potential operational circumstances and higher risk nature of MTO, and the usual inability of patients to make an informed transport choice, this regulation also requires MTO to comply with at least PC2 or PC2WE. It should be noted that this does not limit them to such operations as they can also comply with PC1 if this is operationally necessary, or if the operator chooses to do so. Therefore, for MTO, this is the case no matter what the passenger seating capacity.

3.5.5 Despite paragraph 3.5.4 above, and as outlined in the exception following paragraph 3.1.1, subregulation 133.315(2) of CASR permits an MTO to not have to be flown in a performance class of at least PC2WE during a stage of a flight conducted at a medical transport operating site. Such operations are permissible, provided the operator’s exposition includes:

- risk assessment and management procedures for when the rotorcraft is not flown in a performance class during a stage of the flight at the medical transport operating site
- the procedures are complied with for the flight by the rotorcraft's crew.

3.5.6 Air transport rotorcraft operating under the IFR or at night, and carrying passengers (a passenger transport operation), must always operate to either PC1, PC2 or PC2WE. This requirement rules out single-engine rotorcraft from such operations. However, it also prevents lower performing or older multi-engine rotorcraft, which do not have a category A performance supplement in their flight manual, from conducting IFR or night visual flight rules (NVFR) air transport passenger carrying operations.

3.6 Exception from height-velocity limitations

3.6.1 For rotorcraft certified within the transport category under FAR 29 or EASA CS-29, rotorcraft flight manuals have a height-velocity (HV) diagram. It describes an envelope, the avoid area of the HV envelope, and is designed to ensure that the rotorcraft's potential energy is sufficient, assuming a SFLA is available, to allow a safe forced landing following an engine failure.

3.6.2 This limitation is not relevant when multi-engine rotorcraft are operated in accordance with published Category A procedures and WAT limitations. This is typically the case for Category A vertical, short-field, lateral or back-up procedures, as these are the procedures that usually infringe on the avoid area of the HV envelope.

Note: Legitimate entry into the avoid area of the HV envelope could be conducted as part of either a PC1 or a PC2 take-off and landing, provided they are conducted in accordance with a published Category A procedure and weight limits.

3.6.3 Some PC2 operations at higher weights than category A WAT limits, all PC2WE vertical procedures, some PC3 flight paths and operations that are outside normal performance certification criteria, such as winching, may also require entry into the avoid area of the HV envelope. Additionally, some transport category rotorcraft types have specific 'operations in category B' flight manual supplements that impose passenger limitations of < 10 for operations that are not in accordance with the operational requirements of their category A flight manual supplement.

3.6.4 For this reason, it is necessary to provide an exception to these HV limitations for PC2WE and some other operations[4]. This exception only applies to multi-engine rotorcraft certificated in Category A:

- for any approved PC2WE operation during the take-off or the approach and landing, and baulked landing stage of a flight
- during operations to and from an MTO site, provided the operator has a risk assessment process for such operations and found the place to be suitable for the operation
- for a flight where the rotorcraft is conducting an MTO involving a winching operation, and the rotorcraft's operator has applied the risk assessment and management processes stated in the operator's exposition to the winching operation.

Note: This flight phase may already be allowed by references in the aircraft's flight manual supplement for winching operations.

[4] See section 2.02 of the Part 133 MOS, which is empowered by paragraph 133.030(2)(a) of CASR.

4 Restrictions over certain areas

4.1 What are suitable forced landing areas (SFLA) for rotorcraft flights (PC2 and PC3)?

4.1.1 A suitable area of ground nominated as being a SFLA needs to allow for a reasonable expectation that there would be no injuries to persons in the aircraft or on the ground. Any forced landing within close proximity to persons on the ground could reasonably result in injuries to those persons. However, the possibility of injuries to persons on the aircraft will be driven by the aircraft impact energy following an engine failure, pilot handling, and the quality of the landing area.

4.1.2 Some locations in populous and other areas could include rivers or small lakes as potential forced landing areas ('areas of water'). Key points relating to the use of an area of water as an SFLA include:

- subregulation 133.010(2) of CASR requires emergency flotation equipment or certification for water landings to allow an area of water to be considered as a suitable forced landing area
- subregulation 133.010(3) of CASR describes a non-exhaustive list of the requirements that the areas of water must meet for this purpose
- these requirements include the reasonable expectation that not only would there be no injures to persons but that the persons in the rotorcraft would also be able to survive in the area of water until rescued
- requirements are also included regarding the location of and the surface conditions of the area of water
- even though an injury-free landing in water may be within the pilot's and rotorcraft's capability, post-landing survival prospects must also be considered. Survival times in water will be a function of many factors, including training, clothing, water temperatures, wave heights and sea states, flotation aids, location aids, expected time to rescue, plus the factors mentioned in regulation 133.010(4) of CASR. All these factors must be considered prior to an operator defining the suitability or otherwise of an area of water.

4.1.3 The *rotorcraft flight manual* provides data in the form of HV envelopes and Category A weight, altitude and temperature (WAT) limiting envelopes. If the rotorcraft is flown according to the weight limits and flight paths specified by these performance envelopes, it should remain feasible to conduct a forced landing with a reasonable expectation of no injuries into a SFLA. Operations beyond these limits may result in unavoidable heavy landings beyond the 2.4 m/s (720 fpm (feet per minute)) ultimate aircraft load limit, resulting in undercarriage collapse and the likelihood of injury.

4.1.4 On the assumption that the flight proceeds within a performance envelope that allows the possibility of a suitable forced landing, there must be some assurance that the landing area itself is appropriate. In general, for a landing area to be a SFLA, it will need to be smooth, firm, level, and of an appropriate size. It should:

- be smooth and firm enough for the expected run-on speed
- if water, not have wave heights beyond the capability of the flotation system
- have a slope within the RFM limits
- be of sufficient dimensions to cater for the type of landing anticipated
- have a surface strength sufficient to avoid undercarriage break-through resulting in a roll over.

4.1.5 Boggy or swampy ground could be acceptable if the risk of roll over is minimal. The presence of small obstacles, such as bushes and fences, could be acceptable for larger rotorcraft if they are unlikely to disrupt the landing run.

4.1.6 Where regular HLS operations requiring SFLA are conducted, rotorcraft operators should identify such areas in their exposition. Otherwise, operators must detail the factors that a pilot must consider prior to identifying a forced landing area as suitable for their particular operations.

5 Rotorcraft performance – pre-flight

5.1 Pre-flight determination of performance

5.1.1 Before a rotorcraft begins a take-off or landing at an aerodrome, the Part 133 MOS[5] outlines that the pilot in command must be satisfied that the take-off or landing of the rotorcraft can be carried out safely. To achieve this, the performance of the rotorcraft should be determined prior to any take-off or landing. The factors used to determine performance must include pressure altitude, temperature, and wind speed and direction.

5.1.2 Determination of pressure altitude may be achieved either by a calculation based on reported QNH for the aerodrome, or by setting the International Standard Atmosphere (ISA) standard pressure on an aircraft altimeter. Where an altimeter is used in flight, a correction must be made for the rotorcraft height above or below the landing site.

5.1.3 The temperature must be obtained from an authorised weather report, or from an onboard temperature indicator. Where a pilot has observed the temperature in flight, this must have been observed within the vicinity of the landing site, and a correction must be made to allow for variations due to local factors at the landing site. For some confined area landing sites, there could be unexpectedly large increases in temperature compared with that observed from several hundred feet above.

5.1.4 Wind speed and direction must be obtained from an authorised weather report. This may include pilot observations of man-made or natural wind speed and direction indicators within the vicinity of the landing site.

5.1.5 Where the wind speed and direction indication is not from a source that provides precise and instantaneous readings, such as from an entity mentioned in subparagraphs (i), (ii), (iii), or (iv) of paragraph (a) of the definition of authorised weather report, for determination of rotorcraft performance the following apply:

- if the headwind is more than five knots, use only 50% of the headwind
- for any tailwind use, 150% of the tailwind.

It should be noted that some RFMs have these allowances already included in their performance charts, or do not permit downwind operations for Category A procedures. If this is the case with your aircraft type, follow the flight manual instruction in this regard.

5.2 Pre-flight identification of relevant obstacles

5.2.1 The operator and pilot in command (PIC) must ensure that, for any rotorcraft flown in PC1, PC2, or PC2WE, relevant obstacles have been identified. The rules for determining relevant obstacles are contained in section 10.32 of the Part 133 MOS. This applies to obstacles in the take-off and initial climb, as well as a baulked landing component of the approach and landing stages of the flight. The surface area, within which a relevant obstacle is to be identified, is known as the take-off climb surface (or splay) and is defined in the Part 133 MOS, *Table - Relevant Obstacles-distance requirements*. The table only describes relevant obstacles as those in the take-off direction beyond the FATO, or within back-up zones. No splay is defined for the approach, but the intent is that approach path obstacles allow the selected procedure to be flown, while maintaining an adequate vertical margin from obstacles. Additionally, at dedicated heliports or HLS, the approach path may coincide with a take-off climb surface for other departures in different wind conditions.

[5] See section 10.31 of the Part 133 MOS.

5.2.2 Only the most limiting obstacles need to be accounted for, and obstacles that are shielded by a more limiting obstacle, or result in lesser obstacle-free gradients, need not be considered (refer to section 7.4 of the MOS Part 139, for the principles of shielding.)

5.2.3 Figure 4 provides guidance on the interpretation of the Part 133 MOS *Table - Relevant Obstacles-distance requirements*. Two examples from actual rotorcraft are also detailed to assist with understanding the terminology.

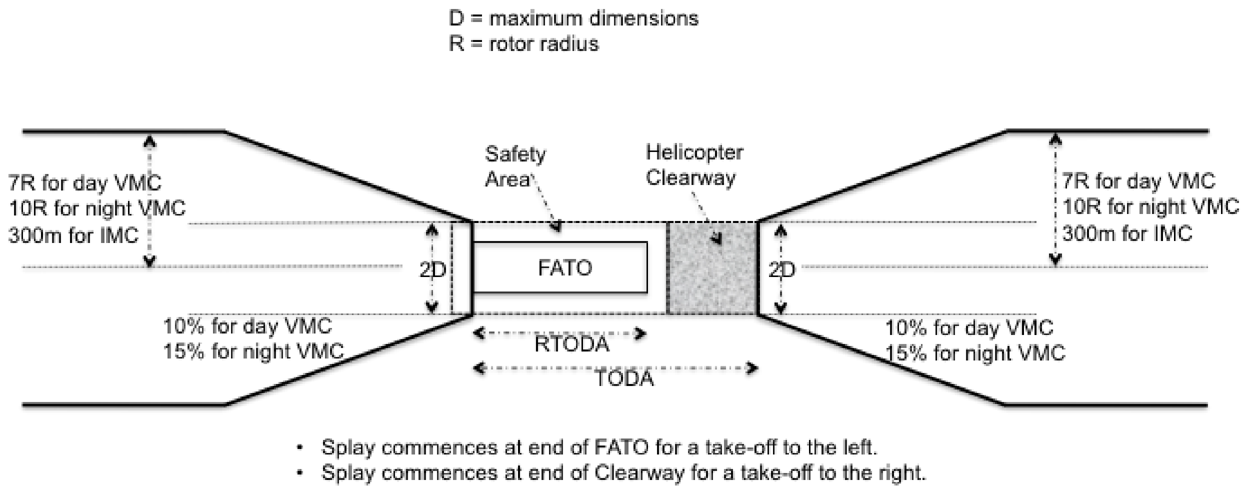

Figure 4. Relevant Obstacles-distance requirements

VFR BK117: Maximum dimension (D) of 13.0 m; Rotor radius (R) of 5.5 m:

Commencement width (inner edge) is (0.75D+0.25D) x 2 = 26.0 m.
(refer to Item 1 of - *Table-Relevant Obstacles-distance requirements*.)
Final width is 7R x 2 = 77.0 m
Splay parallels at (7R - D)/0.10 = 255 m from end of clearway or FATO

IFR AW139 at night in VMC: D = 16.6 m; R = 6.9 m:

Commencement width (inner edge) is (0.75D+0.25D) x 2 = 33.2 m
(refer to Item 4 of *Table-Relevant Obstacles-distance requirements.*)
Final width is 10R x 2 = 138 m (paragraph 58(5)(c))
Splay parallels at (69 – D)/0.15 = 349 m from end of clearway or FATO

5.2.4 Figure 4 shows the splay area in which relevant obstacles must be identified for two different take-off directions. A take-off to the right assumes the availability of a published helicopter clearway that can be considered as being part of the TODAR. In this case, the splay inner edge is located at the end of the clearway. A take-off to the left assumes no clearway so the splay inner edge is located at the edge of the FATO.

5.2.5 Figure 5 represents the splay area in which relevant obstacles must be identified for a back-up Category A procedure. For lateral take-off techniques, this same splay would need to be re-oriented in the direction of lateral movement. Some RFM procedures require the back-up distance to include an additional safety area from the edge of the FATO, which is level with the FATO, and must be clear of obstacles for a specified distance before any vertical component can be included within the RFM defined obstacle zone. While this is contained within the splay depicted in Figure 5, this area must be clear of obstacles in accordance with the RFM requirements.

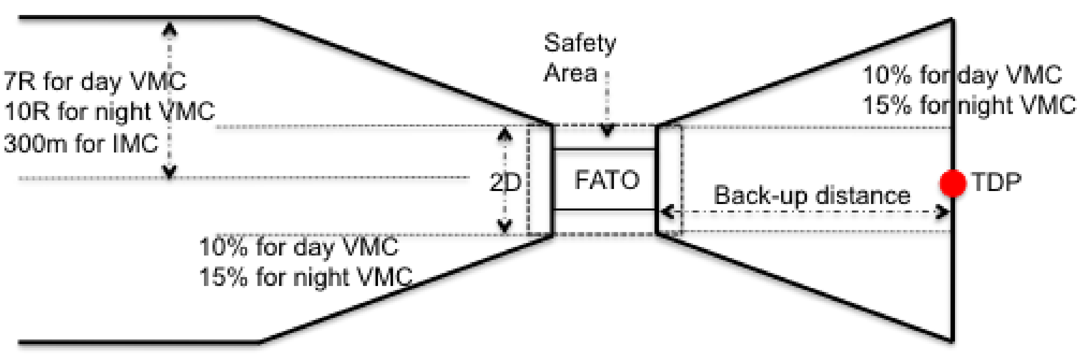

Figure 5. Category A procedure with Back-up

5.2.6 **PC1 operations** – These operations are flown on the assumption that this is the highest standard available and the risks of flying within this class are minimal. To ensure uncertainties are kept at a minimum, where an operator wishes to conduct PC1 operations from an aerodrome or heliport, relevant obstacles within the applicable splay must be identified as a result of formal surveys conducted by persons qualified to carry out such surveys e.g. registered surveyors. If the results of these surveys are not already published by an aerodrome or heliport operator, they must be published in the operator's exposition. Details must include descriptions of splay boundaries plus obstacle heights and locations, or obstacle-free gradients. Annual rotorcraft operator reviews of the obstacle limitation surfaces (OLS) established for the aerodrome or heliport approach and departure paths must be conducted to identify changes to the relevant obstacles.

5.2.7 Rotorcraft operators should include this audit review process and a pilot reporting process for OLS related matters, such as unexpected obstacle intrusions within functionality of their SMS.

5.2.8 **PC2 and PC2WE operations** – In a similar manner to the performance standards for smaller aeroplanes being less stringent than those for larger aeroplanes, rotorcraft flown in PC2 or PC2WE operations are flown on the assumption of a safety standard slightly less than PC1. They are also designed to allow additional operational flexibility within known acceptable risk criteria for air transport operations. For this reason, while it is recognised formal surveys of the aerodrome or heliport obstacle environment will provide much more specific detail and are recommended, where an operator wishes to conduct PC2 or PC2WE operations, relevant obstacles within the applicable splay may alternatively be identified by informal operator or pilot-in-command (PIC) surveys. These surveys must meet the applicable criteria and conditions outlined in the Part 133 MOS. They must also be carried out by the pilot using the 'operator's risk-based obstacle survey process'. Results of operator surveys must be published in the operator's exposition and reviewed annually.

5.2.9 Pilot identification and survey of obstacles at night, without the use of night vision devices, must not be conducted due to the impracticality of identifying distant objects.

5.2.10 Where an operator wishes to conduct day, or night (aided by night vision imaging systems (NVIS)), PC2 or PC2WE operations in visual meteorological conditions (VMC), the operator must detail, in the exposition, the survey methods by which a pilot must determine the splay boundaries and obstacle free gradients. These methods must use a robust and appropriate operator-determined error budget and may include a specific briefing from another qualified company pilot familiar with the heliport provided on the same day as the flight.

5.2.11 PC1, PC2 or PC2WE operations may be conducted based on the application of runway and obstacle data from certified or registered aerodromes or heliports with associated authorised instrument approach obstacle-controlled environments.

5.2.12 The En Route Supplement Australia (ERSA) Introduction details the take-off climb surface survey areas for different runway code numbers (CN). Most runways fall into the CN3 or CN4 category, which provide obstacle-clear take-off gradient data out to 15 km and will encompass most rotorcraft operations. A few smaller runways fall into the lesser CN1 or CN2 categories, and these have a maximum splay length out to 1600 m and 2500 m respectively. Whilst not limited to this requirement, current ICAO guidance requires heliport operators to provided survey data out to just 3386 m. Therefore, quite often surveys for CN1/CN2 runways and heliports will not include all of the obstacles relevant for the performance class, particularly if instrument meteorological conditions (IMC) entry is required (refer to the ERSA - Runway Distance Supplement for runway code numbers and details on the obstacle-free take-off gradients for a given take-off distance available (TODA) or supplementary take-off distance (STODA)).

5.2.13 Figure 6 represents the minimum take-off climb surface survey areas to be provided by operators of NVFR heliports, plus CN2 and CN3 runways. If the splay requirements for a particular performance class are outside of these surveyed areas, the rotorcraft operator must conduct an extended obstacle survey. This may be most relevant where low rates of climb require an extended distance to achieve the minimum flight altitude (1000 ft or lowest safe altitude/minimum sector altitude (LSALT/MSA). For example, a 2 000 ft (600 m) straight climb on departure heading to a NVFR LSALT at a 5.0% climb gradient would require a splay out to 12 km, which is well beyond what a heliport is required to provide.

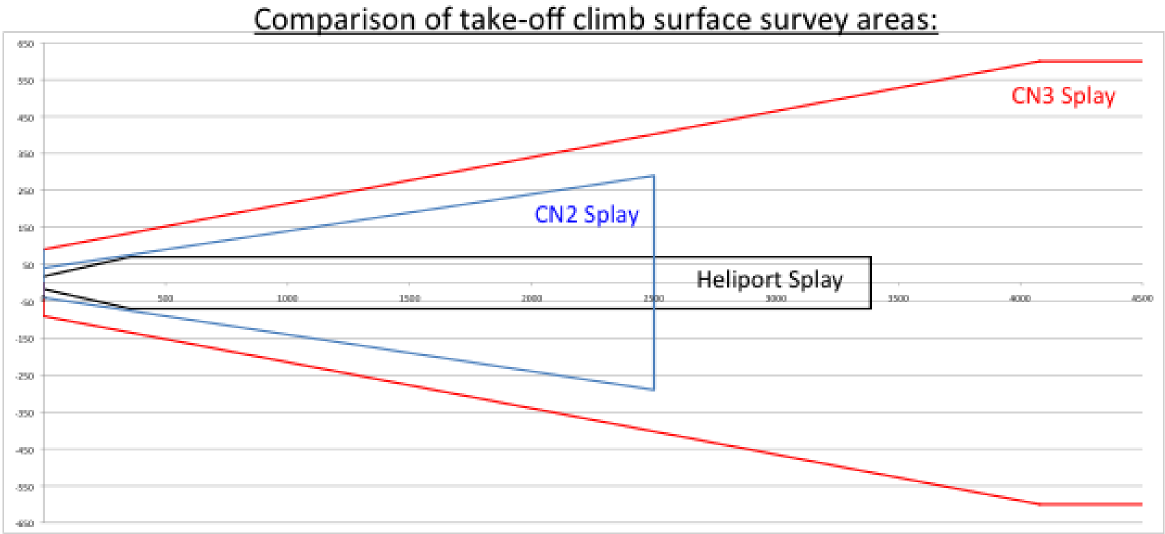

Figure 6. Comparison of take-off surfaces

5.2.14 For PC1 obstacle identification where a formal survey has been provided by a heliport or aerodrome operator and the survey area provided does not fully encompass the area required by the Part 133 MOS, the following can be applied to obtain the length of any extended survey:

- The rotorcraft operator is permitted to extend the survey by using a desktop analysis of appropriate aviation charts
- These may be used to identify the minimum flight altitude (including allowance for unmarked obstacles up to 360 ft above ground level (AGL))
- After obtaining the minimum altitude, it is possible to determine the overall length of the extended survey.

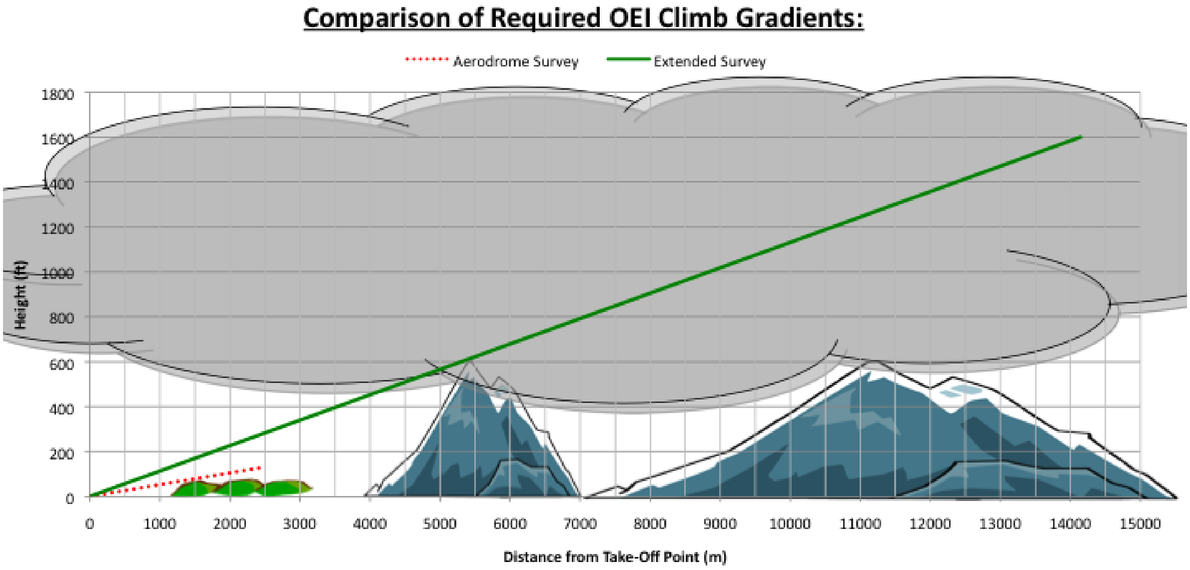

Figure 7. Comparison of survey requirements

5.2.15 Figure 7 above shows two different climb gradient options assuming the only option is the straight-out climb. If the rotorcraft flight manual allows consideration of a turning or curved departure profile, this may also be used by the operator. The OEI climb gradient required by the rotorcraft must be the greater of the following:

- **Gradient to avoid obstacles within the splay published by the aerodrome or heliport operator** – Used where the minimum flight altitude can be reached within the published splay (Figure 7 depicts a CN2 runway surveyed gradient out to 2500 m, which does not achieve the minimum flight altitude, and if flown without turning will result in impacting the mountain beyond)
- **Gradient to avoid obstacles beyond the published splay, as provided by the rotorcraft operator** – Required where the minimum flight altitude cannot be reached within the published splay. In Figure 7, the solid line shows such a gradient up to the minimum flight altitude at 14 km.

5.2.16 The length of the required splay will be driven by a combination of the achieved climb gradient and the minimum flight altitude. A steeper gradient would mean the minimum flight altitude is reached earlier and the splay length can be reduced. In some cases, it may be acceptable to calculate the splay length based on the calculated minimum obstacle free gradients. In other cases, it may be advantageous to plan on steeper (but achievable) climb gradients so a lesser splay length can be used. For the purposes of determining the length of the splay survey required, one of the following methods may be used:

- **For day/night VFR/IFR operations at instrument aerodromes** – Surveyed splay length need only extend to the edge of a nominated circling area for a published instrument approach. For example, 4.2 NM from the runway threshold for a Category D circling area. The intention with this procedure is that, once the rotorcraft reaches the circling minima, it may be turned and climbed to the minimum *flight* altitude while remaining within the circling area. By allowing a published IMC circling area to be used as an obstacle-controlled environment, it means the need for extended surveys from instrument aerodromes can be removed. This allows lower performance IFR helicopters climbing at only 4.5%, to achieve a 400 ft departure surface obstacle clearance within 1.5 NM (whereas a 3000 ft straight climb would require a survey out to 11 NM) . This will greatly reduce the need for additional surveys beyond the robust surveys already provided by aerodrome operators, provided rotorcraft operators address this procedure, as well as flight crew training and checking processes in the exposition.

- **For night unaided by NVIS, or in IMC at non-instrument aerodromes** – In these cases, for PC2 operations, it is permitted for the pilot to determine an advantageous local circling area and circling height that provides at least 500 ft obstacle clearance. Once determined, the surveyed splay need only extend on the take-off path to the point where the circling height is achieved. This is the same principal as described for instrument aerodromes but based on a pilot calculation, hence the need for a higher obstacle clearance than standard. Once at circling height, the aircraft is climbed within the circling area to the published or pilot calculated LSALT/MSA. Note that the pilot calculated LSALT/MSA must include all obstacles within 5 NM of the rotorcraft.
- **For day VMC or night aided by NVIS at non-instrument aerodromes** –Surveyed splay must extend to the point where 1 000 ft above the highest obstacle on the ground or water within 5 NM ahead of, and to either side of, the rotorcraft is achieved.

5.3 Adequate vertical margin

5.3.1 An *adequate vertical margin*[6] obstacle miss criteria may need to be stipulated by an operator in a number of situations when rotorcraft flight manual data is not available. Some examples of these situations are:

- During a PC3 take-off and initial climb stage of a flight, where the rotorcraft flight manual does not stipulate an obstacle miss distance. For example, a PC3 take-off from an area with limiting obstacles in the flight path with no fly around option or a take-off from an elevated heliport or helideck where there is exposure to deck edge strike if an engine fails.
- During a PC3 approach and landing and baulked landing climb stage of a flight, where the rotorcraft flight manual does not stipulate an obstacle miss distance in a situation with limiting obstacles in the flight path for the approach or baulked landing climb if it were to be necessary.
- During PC2WE operations between rotation and DPATO, as obstacle miss distance criteria are not stipulated in this area and all engines operating climb performance is assumed. Where obstacles may still need to be missed in the initial climb out.
- At any other time where the operator considers stipulating a vertical obstacle miss criteria is of safety benefit to their operations.

Note: Vertical obstacle miss criteria do not need to be considered if obstacles can be avoided by an appropriate horizontal distance.

5.3.2 Where an operator’s exposition is required to include the minimum distance to achieve an adequate vertical margin, several factors should be considered:

- **Size of rotorcraft** – The closer a pilot’s seating position is to the main and tail rotor tips, the more accurate their depth perception and judgement of distance from obstacles will be. Therefore, smaller rotorcraft lend themselves to allowing for a lesser distance from obstacles than larger aircraft. Even for small aircraft, vertical margins of less than 3.0 m (10 ft) are unlikely to offer sufficient allowance for errors in a pilot’s depth perception. An adequate vertical margin in large helicopters may need to be as much as 10.7 m (35 ft).
- **Field of view** – For equivalent sized aircraft, the field of view may be more restrictive in one type compared to other types operated by the operator. This may mean the ability to sight and judge potential objects is degraded to different extents in different types with your fleet.

[6] Adequate vertical margin is defined in section 10.02 of the Part 133 MOS, and repeated in the definitions section at the beginning of this AC.

In such cases, larger vertical margins are advisable, based on the most limiting type utilised for your operations.

- **Nature of obstacles** – Distance judgement from large solid obstacles with well-defined edges and good colour contrast will be much easier compared with small, low-contrast obstacles, such as power lines or dead trees. Expositions should explain the need to increase margins in these circumstances.
- **Environmental conditions** – Distance judgement in favourable conditions of light and visibility will be more accurate than in unfavourable conditions. Expositions should explain the need to increase margins where unfavourable conditions of light and visibility exist.

6 Rotorcraft performance – general and PC1

6.1 Take-off and landing weights

6.1.1 The performance class requirements in Chapter 10 of the Part 133 MOS, empowered from regulation 133.315 of CASR and the definition of performance class in the CASR Dictionary, establish offences for the operator and the PIC for operating a rotorcraft at a weight greater than its maximum take-off weight (MTOW), or a lesser weight (performance-based weight limits, noting it is assumed that MTOW and maximum landing weight (MLW) are structural limits) determined in accordance with the relevant requirements outlined in the Part 133 MOS.

6.1.2 The weights determined in accordance with the requirements of the Part 133 MOS are the performance-based weight limits for the flight of a rotorcraft and will often, dependant on the circumstances of the take-off or landing, require the rotorcraft to be operated at a weight less than is structural MTOW or MLW.

6.1.3 The performance requirements for a flight are to be converted to operator-based Standard Operating Procedures (SOP) and described in the operator's exposition as their performance policy and procedures.

6.1.4 Exposition requirements for the different performance classes are contained in Division 5 of Chapter 10 of the Part 133 MOS, which consists of sections 10.27, 10.28, 10.29 and 10.30. Explanations of these requirements are contained in sections 6.9 (for PC1), 7.5 (for PC2) and 8.6 (for PC3) of this AC.

6.1.5 Pre-flight performance determination requirements that are common to all performance classes are explained in section 5.1 of this AC.

6.1.6 Multiple performance class requirements require the determination of which obstacles are relevant obstacles. An explanation of determining relevant obstacles is contained in section 5.2 of this AC.

6.1.7 Once an operator has set up a mature performance policy and SOPs in the exposition, it is assumed the operator's flight crews would use these as their primary reference for day-to-day operations. The Part 133 MOS content simply sets the boundaries within which the rotorcraft code of performance must operate.

6.2 PC1 – take-off

6.2.1 Prior to conducting PC1 operations, the operator and the PIC must satisfy themselves of the suitability of the heliport and surrounding obstacles for PC1 operations (refer to paragraph 5.2.6 above). Aircraft performance must also be determined to ensure that at the most limiting weight factors, relevant to the flight and mentioned in the Part 133 MOS for PC1, are met.

6.2.2 Suitability of the heliport surface for PC1 is determined from the dimensions and load bearing capability and provided by the heliport operator. The main requirements are dimensions of at least 1.5D plus safety area = 2D, and a surface load bearing capability of sufficient capacity to handle your rotorcraft at a descent rate of 720 fpm. In this regard, other elements such as undercarriage configuration must also be considered; however, PC1 purpose-built heliport design will take into consideration such requirements as heliport or helideck surface punching sheer capability.

6.2.3 Therefore, referring to the heliport’s T-value and D-value will assist with this determination. These values, which are derived from the heliport’s ‘Design Helicopter’, ensure the relevant heliport structural factors for a PC1 take-off are considered for compliant heliports designed for PC1 operations. These values are also displayed to ensure that only helicopters with a ‘T’ or ‘D’ less than or equal to the heliport's designed limits use the heliport for such operations.

6.2.4 The limiting weight is driven by the most limiting of:

- weight limit for the procedure
- 100 fpm first segment V_{TOSS} climb
- 150 fpm second segment climb (refer to Figure 2)
- weight limit to allow a reject within the rejected take-off distance required - rotorcraft (RTODAR)
- weight limit to ensure the take-off distance required - rotorcraft (TODRR) does not exceed the take-off distance available - rotorcraft (TODAR) (with some exceptions)
- the weight limit to ensure the OEI climb gradient achieved exceeds the obstacle-free gradient and maintains the required obstacle clearance.

6.2.5 Heliports are classified as 'elevated' once they are more than 2.5 m above the surrounding surface. This then triggers different certification criteria for the Category A procedure on the assumption that visual cues away from the helipad are absent. This results in either a larger elevated heliport to allow for the loss of visual cues, or a similar sized heliport but with a procedure involving a drop-down below the level of the heliport's FATO/ touchdown and lift-off area (TLOF).

6.2.6 However, where substantial public benefit is to be derived in circumstances where a legacy heliport is 'elevated' but remains surrounded by valid and safe usable visual cues. CASA may consider approval (under regulation 133.015 of CASR) of PC1 operations to the elevated HLS based on the Category A procedures and dimensions described for the ground level HLS.

6.2.7 This will only be considered where the operator can provide written evidence of a supporting risk assessment, which has been reviewed by the original equipment manufacturer (OEM), and where the OEM has provided a written no technical objection (NTO) confirming its support for the operation of the rotorcraft from that location.

6.2.8 This is most likely to be applicable in the urban environment where elevated HLS procedures involving drop-downs below the level of the FATO are not practical but are the only Category A option provided in the RFM. This could also be applied where the elevated FATO is not large enough to permit use of an elevated back-up procedure but is large enough to use a ground level back-up procedure. It should be noted that, if any such an operation results in exposure occurring at any point in the take-off, the operation is not PC1 and should be considered under PC2WE requirements[7].

6.2.9 Newer rotorcraft with greater hover out of ground effect (HOGE) performance with one-engine inoperative may negate requirements to reject back onto a FATO, even when below TDP. This may allow a continued take-off at any time. This level of performance is a possible mitigator for approval to conduct heliport PC1 operations from FATOs, even where their dimensions are too small for the described RFM Category A procedure. Once again, this would require an approval under regulation 133.015 of CASR, and operators who intend to apply for such consideration should conduct an analysis of the heliports into which they operate so a detailed safety case can be supplied with their applications.

6.2.10 During a PC1 take-off procedure, the rejected take-off distance required - rotorcraft (RTODRR) must not exceed the RTODAR. This ensures that, following an engine failure at or prior to TDP, there is sufficient distance to reject the take-off back on to the FATO and stop. However, because RFM scheduling of distance for RTODRR only refers to the distance of a fixed point on the rotorcraft (e.g. the tail rotor), to ensure full containment of the rotorcraft within the RTODAR, operators should add an additional distance margin (to the RTODRR) to allow for the length of the rotorcraft extending beyond the RTODRR. This is particularly relevant for Category A procedures, in which a run-on landing is part of a short-field or clear area procedure.

[7] Refer to AC 133-02 - Performance Class 2 with exposure operations.

6.2.11 During a clear area (runway) take-off procedure, the TODRR must not exceed the TODAR. However, many short-field, helipad or helideck Category A procedures result in the TODRR being well in excess of the TODAR (end of the FATO). In these cases, the distance to the end of the FATO (TODAR) could be as little as 20 m, whereas the TODRR might be several hundred metres.

6.2.12 Where the TODRR exceeds the TODAR there must be an assurance, beyond the TODAR, that the rotorcraft can clear all obstacles by 35 ft while OEI and accelerating to V_{TOSS}. If the take-off involves a drop-down below the level of the FATO, the RFM Category A procedure must also provide data to ensure that, following an engine failure, the edge of the helipad/helideck will be cleared by at least 4.5 m.

6.2.13 Prior to conducting a Category A back-up or lateral manoeuvre, relevant obstacles[8] must be identified in the back-up or lateral direction. An adequate vertical margin from these obstacles during the AEO take-off does not necessarily mean an adequate vertical margin is maintained following an engine failure event and rejected take-off. This is due to the possibility of the rotorcraft dipping below the AEO flight path.

6.2.14 Assurance of the adequate vertical margin following an engine failure at or before TDP can be achieved by ensuring there are no obstacles within the take-off safety zone as described within the RFM procedure and an example in Figure 8). Where such data is not available within the RFM, the rotorcraft manufacturer must be asked to define a safety zone, or the operator must demonstrate to CASA how adequate obstacle clearance is achieved during a rejected landing.

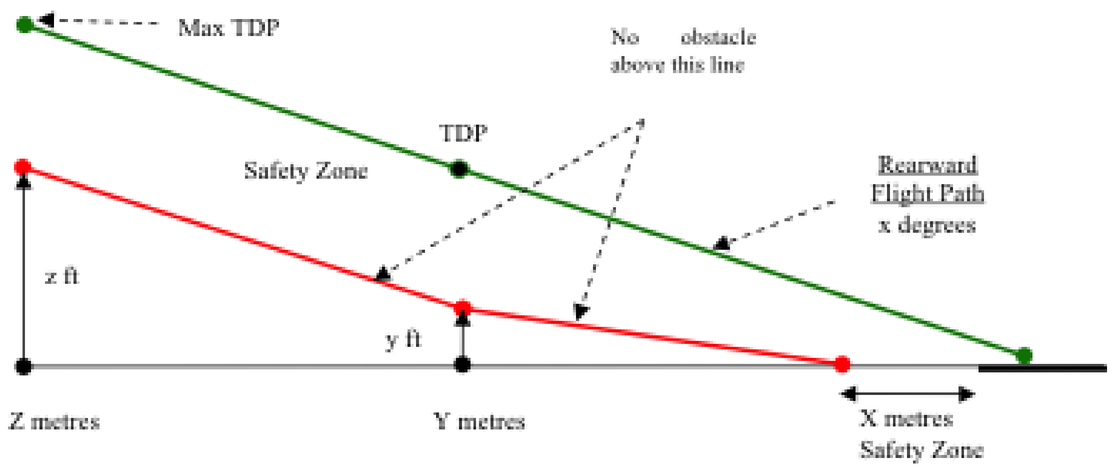

Figure 8. Back-up flight path and obstacle considerations

6.3 PC1 – Take-off and initial climb

6.3.1 There are three basic Category A procedures applicable to PC1 take-offs: clear area (runway), ground level helipad and elevated helipad (helideck). Short field take-offs can be treated similarly to ground level helipads just with a longer FATO. In all cases, if an engine fails at or beyond the TDP, the rotorcraft is accelerated to at least V_{TOSS} prior to commencing a climb. The end of the TODRR is marked by the point where V_{TOSS}, a positive rate of climb, and 35 ft obstacle clearance, are all achieved.

6.3.2 In all cases, once beyond the TODRR, clearance from a relevant obstacle must be at least 35 ft for VFR flight. For IFR flight, additional obstacle clearance height must be added equalling 1.0% of the distance travelled from the end of the FATO (e.g. an additional 33 ft clearance for every

[8] Refer to section 10.32 of the Part 133 MOS.

1 000 m travelled). The simplest method to allow for IFR flights is to add 1.0% onto the measured obstacle-free gradient.

6.3.3 Within a straight take-off climb surface, changes in direction are permitted under day or night (if aided by NVIS) VMC to achieve the shallowest take-off gradient available. Curved take-off climb surfaces, with planned direction changes at specified distances, may be developed for IMC operations, but these will require a more complex survey. Where the change in direction is more than 15°, an additional 15 ft margin from obstacles applies.

6.3.4 Below the minimum flight altitude, direction changes of more than 15° are only permitted if approved by the RFM Category A procedure. When using straight take-off paths, direction changes of more than 15° would not normally be required, but where the overall length of the required splay is excessive (e.g. 20 km), curved or even 180° turning climb paths may be preferable.

6.3.5 **Clear Area (runway) PC1** – Figure 9 shows a clear area scenario where an engine has failed beyond the TDP, and an OEI climb is being conducted. Relevant obstacles along the shallowest flight path have been identified and based on the central mountain. These provide a 4.5% obstacle-free gradient as represented by the dotted line. The minimum flight path to maintain 35 ft obstacle clearance is shown above that. The RTODAR is 400 m, the TODRR is 360 m, and the climb gradient is 8.0% (In many multi-engine rotorcraft, different climb gradients will be achieved at V_{TOSS} prior to 200 ft, compared with those at V_Y above 200 ft, but for simplicity this example shows a constant rate of climb).

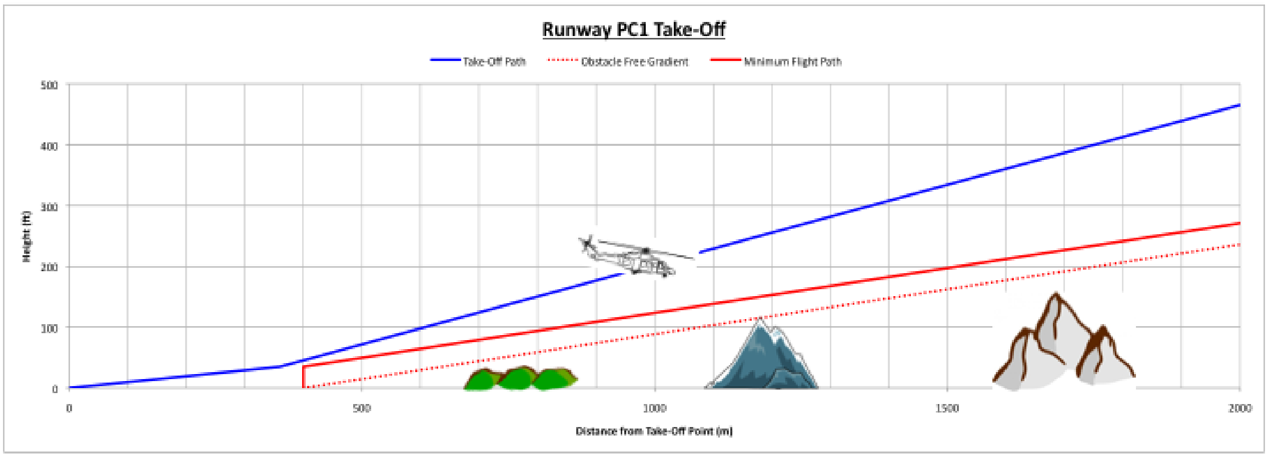

Figure 9. Surface level runway PC1 take-off

6.3.6 In the case above, it would have been possible to measure a lesser obstacle-free gradient initially, then a steeper segment, then a lesser one again once past the central mountain. However, practically achieving this through either formal or informal surveys would be quite complex when compared with measuring a single gradient. Where limitations on rotorcraft performance require the most advantageous obstacle-free gradients to be found, more complex surveys may be required.

6.3.7 **Ground level helipad PC1** – Figure 10 shows the case of an engine failure immediately beyond TDP, and where an obstacle-free gradient of 4.5% is measured from the edge of the FATO, being 30 m from the take-off point. Because it is an IFR flight into IMC, an extra 1.0% for obstacle clearance has been added to the obstacle-free gradient, which now requires the rotorcraft to achieve a minimum OEI climb gradient of 5.5%. To ensure that the drop-down height loss from TDP does not infringe on the obstacle clearance requirements, the TDP has been raised to 160 ft. If the RFM does not permit raising the TDP, this take-off could not achieve PC1, although a lower TDP may have been possible with a lesser obstacle-free gradient. The small line to the left of the back-up flight path represents the obstacle-free safety zone as required by the RFM Category A procedure.

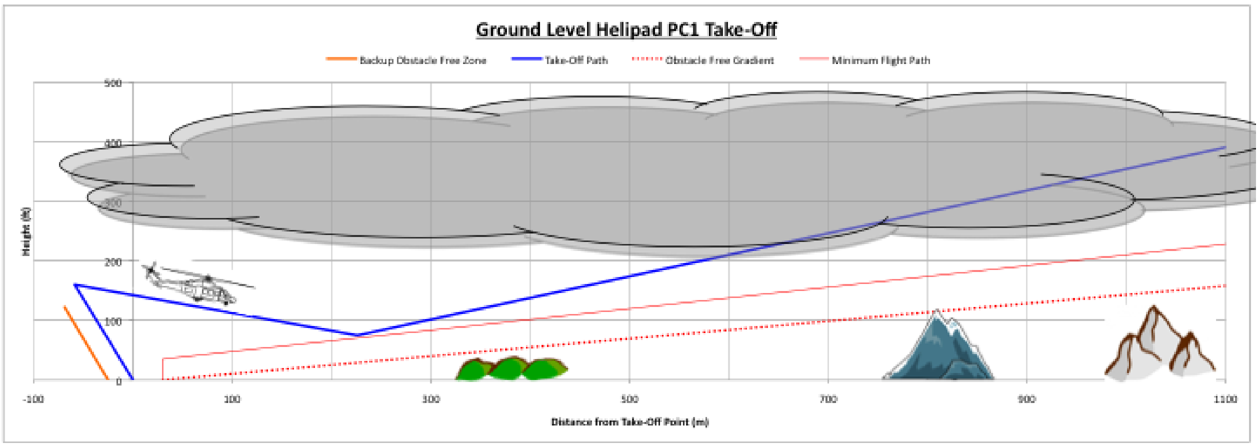

Figure 10. Surface Level heliport PC1 take-off with back-up

6.3.8 RFM helipad or short field Category A procedures often refer to the need to identify the highest obstacle within the take-off distance. With this knowledge, it is simply a matter of adding the 35 ft required obstacle clearance to the drop-down height to come up with a TDP that will clear the obstacles adequately. However, this calculation does not account for avoiding obstacles beyond the end of the TODRR, so a further upward TDP correction may be needed. These latter obstacles may have a more limiting impact on the required TDP height and would require separate obstacle-free gradient surveys from the end of the TODRR. Operators may find it simpler to survey just one obstacle-free gradient from the edge of the FATO, or use the raised incline plane and/or *virtual clearway* method below, rather than attempting multiple surveys of different segments, all of which can vary depending on the TODRR for a particular flight.

6.4 PC1 – Raised incline plane and virtual clearway

6.4.1 The ICAO Heliport Manual (Doc 9261 Onshore) outlines the concept of the elevation of the OLS via a raised incline plane and use of a virtual clearway. These principles allow for the presence of high obstacles immediately in front of, or some distance beyond the helipad, while still allowing PC1 operations. The raised incline plane may be located at the edge of the FATO or, when combined with a virtual clearway, some distance from the FATO at the first point where obstacles are protruding above the FATO elevation. A virtual clearway allows the origin of the take-off climb surface to be extended beyond the boundary of a heliport so that a descent below the OLS in the TODRR can be avoided in the take-off phase of the profile.

6.4.2 **Ground level heliport PC1 (raised incline plane)** – In the example of an OEI fly away after TDP shown in Figure 11, there is a 100 ft tree immediately ahead of the take-off point. From the top of the tree, an obstacle-free gradient of 4.5% has been determined. This scenario still allows PC1, provided the TDP can be raised to 250 ft. In this example, a measured obstacle-free gradient from ground level at the edge of the FATO would produce a required climb gradient well in excess of the helicopter's capabilities. However, the raised incline plane allows climb gradients to be kept at achievable levels by raising the TDP, but without sacrificing PC1 capability. It should be noted that operations in the opposite direction may not allow appropriate obstacle clearance for a back-up procedure, so alternative options may need to be explored in these cases. This example should highlight the importance of close discussion with heliport operators to ensure data appropriate for the desired Category A procedure is provided (the raised incline plane works on the same principle as the STODA for runways, where reductions in obstacle-free gradients are achieved by reducing the take-off distance available. In the rotorcraft case, this is taken even further by raising the origin of the obstacle-free gradient).

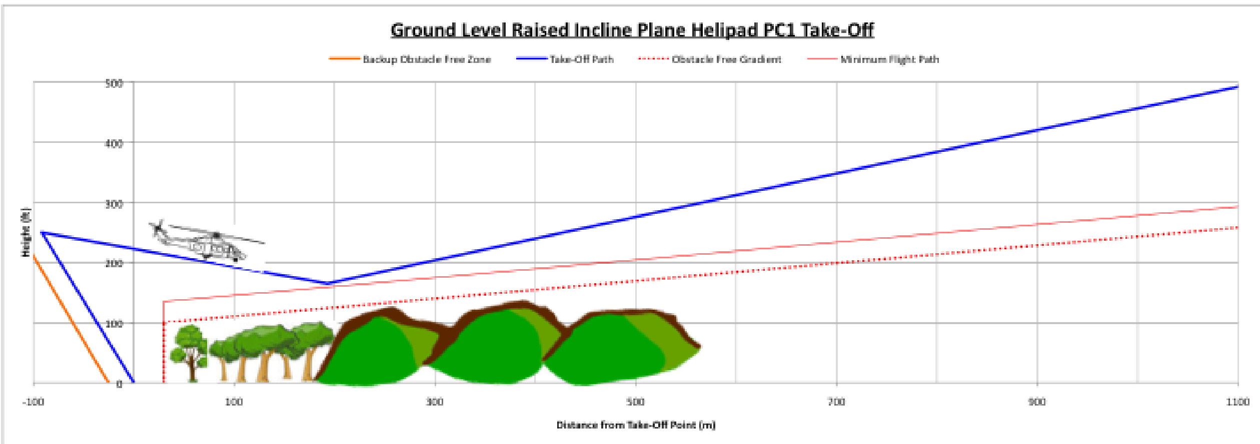

Figure 11. Surface level heliport with raised incline plane

6.4.3 **Elevated Helipad (Helideck) PC1** – Figure 12 shows the case of an elevated HLS 150 ft above the surface with a 'negative' raised incline plane. From surface level, a 4.5% obstacle-free gradient has been measured (this could be close to 0% if totally over water). The rotorcraft is able to use a 30 ft rotate point and, when combined with a 4.5 m deck edge clearance and a 95 ft OEI drop-down, the rotorcraft can avoid obstacles by the required margin. This example also shows the case of a procedure where an acceleration segment from V_{TOSS}, to V_Y at 200 ft is required.

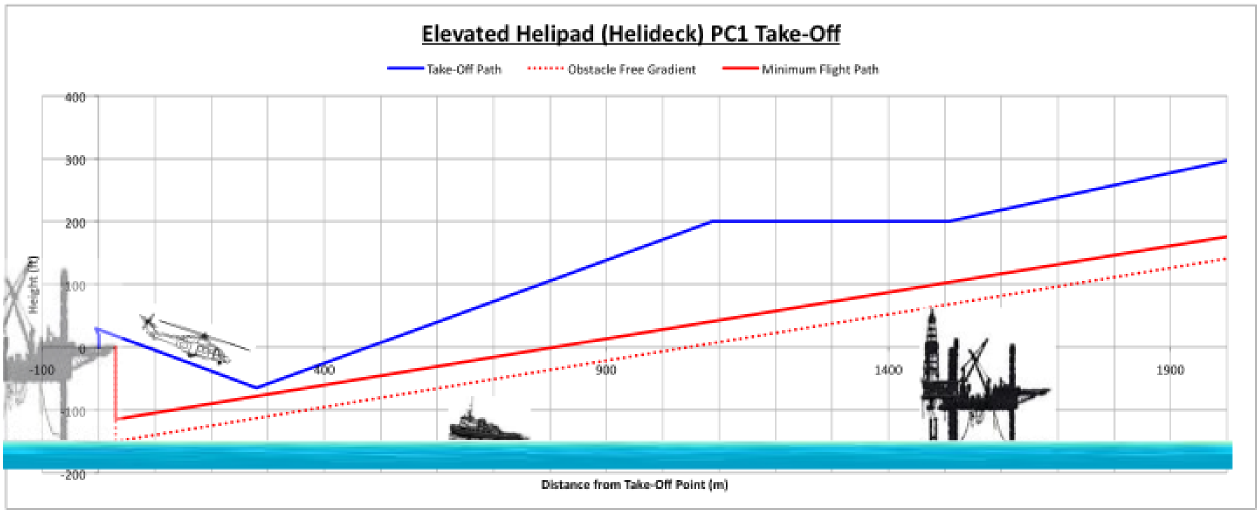

Figure 12. Elevated Heliport (helideck) with drop-down

6.4.4 Prior to conducting elevated HLS operations with drop downs below the height of the FATO, operators should carefully consider their suitability for PC1. Urban elevated helipads, such as hospital landing sites, may have extremely complex obstacle environments often influenced by changing construction infrastructure. In these cases, detailed and regular surveys will be essential. In some cases, the use of a virtual clearway (refer to section 6.5 in this AC) may also assist in maintaining operational flexibility at the heliport.

6.4.5 In the offshore environment, vessels and platforms may also have complex infrastructure limiting the ability of a rotorcraft to consistently follow a helideck Category A procedure. Variations in platform height, due to tides, sea state and buoyancy, can also impact on the helideck height above the surface. For these reasons, it is not normal for PC1 operations to be conducted in offshore environments.

6.4.6 The diagrams above were developed by plotting heights and distances determined from the RFM Category A data. By plotting the positions of TDP, min-dip, take-off distance, OEI climb gradients and surveyed obstacle-free gradients, it is a straightforward process to identify non-compliance and then identify solutions to ensure compliance, such as raising the TDP or increasing the climb gradient by reducing weight.

6.5 PC1 – Establishing a virtual clearway

6.5.1 To safeguard a helicopter during its approach to the FATO and in its climb after take-off, as mentioned in section 5.2, it is necessary to establish an approach surface and a take-off climb surface through which no obstacle is permitted to project, for each approach and take-off climb path designated as serving the FATO. For PC1 operations, this is achieved using formal surveys and by establishing a series of obstacle limitation surfaces that define the limits to which objects may project into the airspace. Rotorcraft operators can then take advantage of this knowledge when designing the safest and most efficient use of the heliport for their PC1 operations.

6.5.2 Establishment of a virtual clearway at some heliports, particularly those surrounded by complex obstacle environments, is another method to achieve safe and efficient use of a heliport in these circumstances.

6.5.3 A 'virtual clearway' means a helicopter clearway that extends outside the boundary of the heliport and which complies with the helicopter clearway standards provided in Appendix D to Chapter 3 of Part II of the Heliport Manual (ICAO Doc 9261)[9].

6.5.4 The objective of a virtual clearway is to allow the origin of the take-off climb surface to be extended horizontally beyond the boundary of a heliport so that a descent below the OLS in the TODRR can be avoided in an OEI continued take-off phase of the profile (refer to Figure 13).

6.5.5 When combined with the raised incline plane, it also allows the use of a variable TDP to raise the elevation of the origin of the OLS above obstacles within a close proximity of the heliport (refer to Figures 14 and 15). This can serve to reduce the gradient of the OLS and make it easier to avoid prominent obstacles in the first or second segment of the climb.

6.5.6 Establishment of a virtual clearway also increases the potential for the use of the drop-down profile on an elevated heliport where the obstacle environment permits it (refer to Figure 16). It should be noted that these elements also apply to clearance above obstacles in the baulked landing climb stage of a flight.

6.5.7 Operators should be aware that not all current transport category certified helicopter types have the appropriate Category A (Variable TDP/LDP) procedures; however, there are sufficient numbers of these more capable rotorcraft now in operation to make facilitation of the virtual clearway worthwhile by heliport operators. All types could take advantage of the ability to extend the origin of the OLS without the use of variable TDP/LDPs, so this option should not be discounted in your operational risk assessment and mitigation processes. Heliport designers should ensure any use of virtual clearways is configured so as to permit use by the widest population of types and users.

6.5.8 A virtual clearway that is established at the elevation of the FATO may be used to extend the origin of the take-off climb surface to the outer edge of the virtual clearway (refer to Figure 13).

[9] Refer to ICAO Doc 9261 (Part II Onshore) for more detail on virtual clearways.

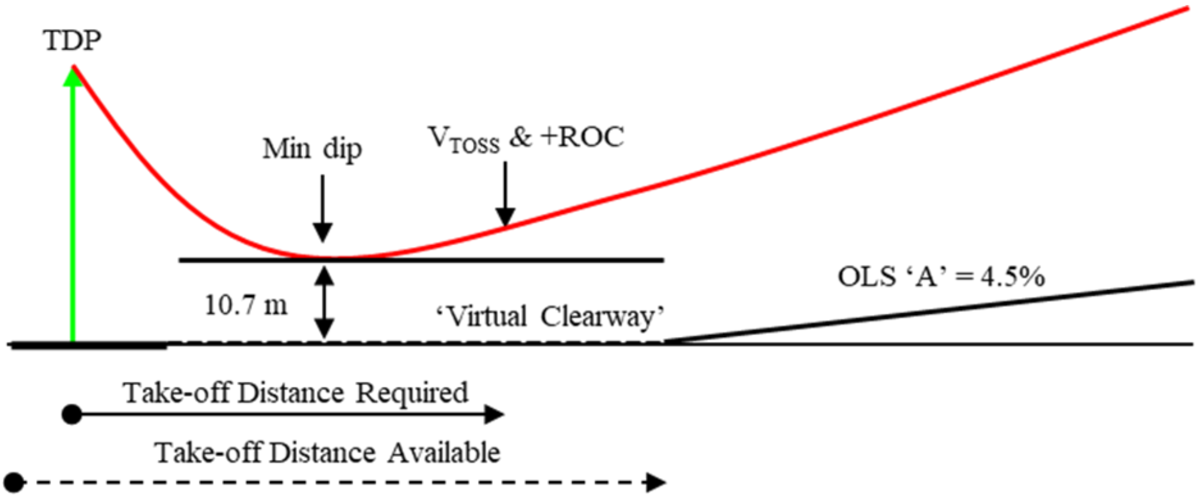

Figure 13. Virtual clearway at the level of the FATO

6.5.9 A virtual clearway can also be established at locations other than at the elevation of the FATO and should be located at the level of the highest obstacle immediately below the virtual clearway. While Figure 14 describes a virtual clearway above the level of the FATO, Figure 15 describes a virtual clearway above the level of an elevated FATO, and Figure 16 describes a virtual clearway below the level of an elevated FATO.

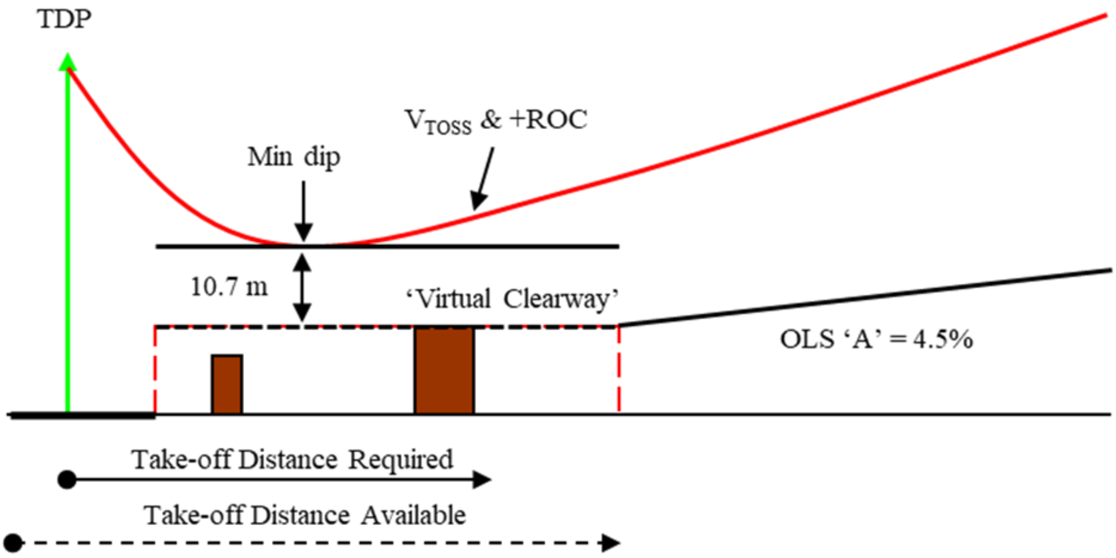

Figure 14. Virtual clearway above the level of the FATO

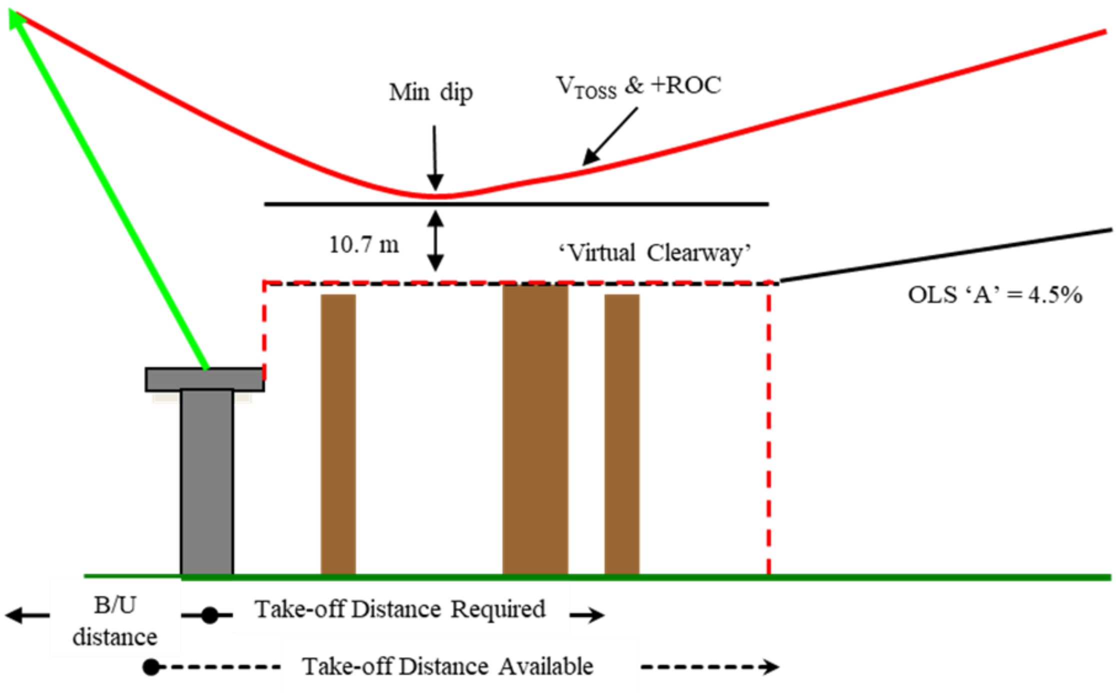

Figure 15. Virtual clearway above the level of an elevated FATO

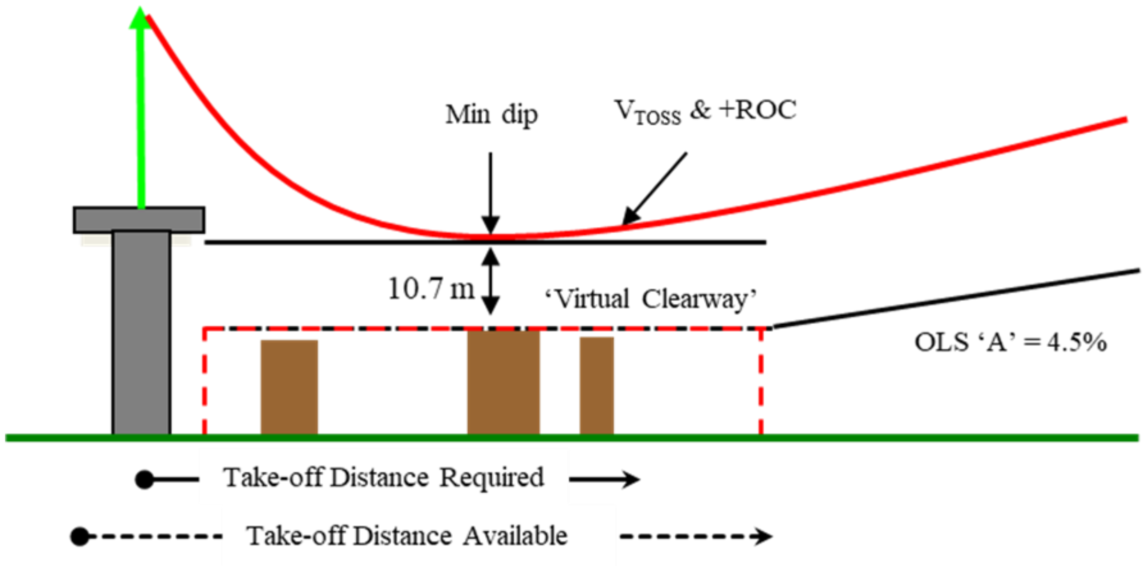

Figure 16. Virtual clearway below the level of an elevated FATO

6.5.10 Figure 17 provides an example where the virtual clearway is raised to allow a standard 4.5% OLS to be achieved, and an upwards correction of the TDP is made to ensure the first segment climb remains 35 ft above the OLS. Figure 17 also shows that both the first and second segment climb gradients exceed the OLS gradient, which would normally be a sign of compliance with the requirements. However, the presence of an acceleration segment in some aircraft performance data can result in an unexpected infringement on the obstacle clearance requirement. In the figure below, this occurs in proximity to the hill. Rotorcraft operators should carefully assess the combination of the expected first segment OEI climb gradient and the acceleration distance to ensure the OLS clearance requirement is not breached.

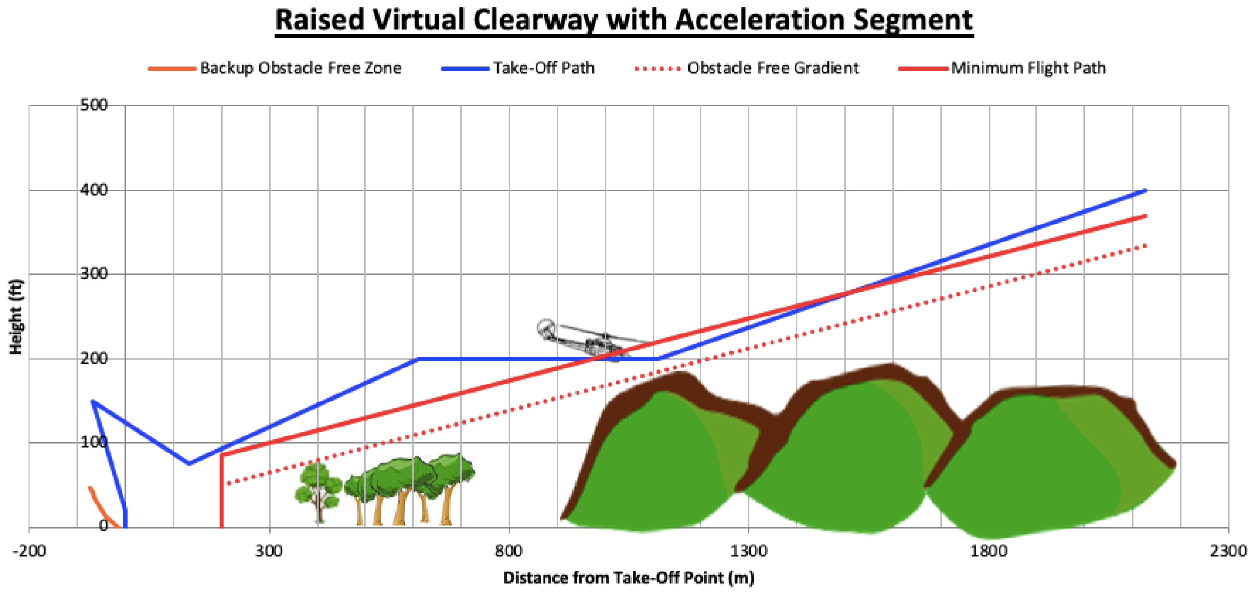

Figure 17. Raise virtual clearway with acceleration segment

6.5.11 Rotorcraft operators should closely consult with their PC1 heliport operators and designers if virtual clearways are to be put in place and used in their operations.

6.5.12 Operational procedures for virtual clearway operations should also be included in the exposition as well as in training and checking system processes. These should ensure that, following an engine failure in the take-off and initial climb or baulked landing climb stages, the min dip is set so that the helicopter is able to clear all obstacles in the virtual clearway by a vertical margin of 10.7 m (35 ft).

6.6 PC1 – Flight profile spreadsheets

6.6.1 Attached to this AC are a series of flight profile spreadsheets designed to assist heliport operators gain a practical understanding of the guidance material provided at sections 6.4 and 6.5.

6.6.2 There are spreadsheets for the following aircraft types and models:

- AW139
- Bell 412EP
- EC135 P2
- BK117 B2
- BK117 850D2 (STC conversion)
- A109E.

6.6.3 These spreadsheets are used to assist heliport operators to determine the parameters for a virtual clearway, as dictated by obstacles associated with the heliport's approach and departure surfaces and the performance capabilities of the heliport's chosen 'design helicopter'. The spreadsheets can also assist the helicopter operator and/or pilot to determine TDP or rotate point (RP) heights to ensure appropriate obstacle clearance is maintained throughout the take-off and initial climb.

6.6.4 The AW139 spreadsheet has five worksheets and each other aircraft type's spreadsheet has four worksheets. While originally derived for PC1 operations, from DPATO as OEI PC2 and PC2WE follow the PC1 climb profile requirements, the spreadsheets are not limited to PC1 with worksheets providing a method for determining obstacle avoidance for the following take-off procedures:

- Category A Heliport back-up take-off in compliance with PC1 or PC2 requirements.
- Heliport vertical take-off when below the applicable Category A weight limit and in compliance with PC2WE. (In this example rotate point represents the end of the exposure period and DPATO).
- Heliport vertical take-off when above the applicable Category A weight limit, and in compliance with PC2WE. (In this example V_{TOSS} represents the end of the exposure period and DPATO).
- Clear Heliport take-off in compliance with PC1.
- For the AW139 only; heliport vertical take-off when above the applicable Category A weight limit, and in compliance with PC2WE. (In this example rotate point represents the end of the exposure period and DPATO).

6.6.5 Applicable RFM data is used within the worksheets to support calculations for the aircraft flight path. However, operators must confirm their specific aircraft RFM data, obstacle information, environmental and operational situations are compatible and that they are safe for use in their operations.

6.6.6 For the aircraft in 6.6.2, the spreadsheets are designed to assist in quantifying and visualising the obstacle avoidance criteria outlined in chapter 10 of the Part 133 MOS and a set of guidance instructions on the use of the spreadsheets has been provided as one of the attachments to this AC.

6.7 PC1 – En-route flight

6.7.1 The Part 133 MOS establishes that an OEI rate of climb of at least 50 fpm at the *minimum flight altitude* for each point in the en-route stage of the flight must be available unless the drift down requirements of the Part 133 MOS can be met. The Part 133 MOS also refers to the alternate compliance elements for the conduct of a drift down manoeuvre.

6.7.2 An example of how this can be applied is while operating day VFR and flying at 3 000 ft above terrain, the rotorcraft may not have the OEI performance to achieve a 50 fpm climb at 1 000 ft above the terrain, but a predicted 100 fpm OEI rate of descent means a descent for [(3000-1000)/100=20] 20 minutes before the 50 fpm rate of climb is required. In 20 minutes, the mountains may have been crossed and 50 fpm rate of climb now becomes possible at a lower altitude.

6.7.3 An IFR rotorcraft only able to maintain 50 fpm rate of climb at a 4 000 ft LSALT or less is still able to cruise at 8 000 ft with a 7 000 ft LSALT provided, by the time the drift down reaches 7 000 ft, the rotorcraft has cleared the 7 000 ft LSALT area and entered an area with a more manageable LSALT.

6.7.4 The use of drift down techniques are only permitted when:

- the effect of wind has been taken into account
- navigational accuracy is assured
- certain minimum heights are adhered to depending on the flight rules being followed.

6.7.5 If operators elect to utilise these techniques in their operations, a set of operational procedures should be designed and inserted in their exposition outlining to their flight crews how, when and where these techniques may be used in their operations.

6.8 PC1 – Approach and landing or baulked landing

6.8.1 As for the PC1 take-off, various factors must be considered to determine the limiting weight for approach and landing. The Part 133 MOS considerations regarding rates of climb or weight limits for the procedure are the same as for the PC1 take-off.

6.8.2 Following initiation of a Category A baulked landing at or before the landing decision point (LDP), the rotorcraft is expected to continue losing height while accelerating to V_{TOSS}. However, it should not descend below the planned AEO flight path, so additional consideration of obstacles short of the FATO is not required. Obstacles beyond the FATO, within the appropriate splay, will need considering in the same way as if it were a take-off. Operators and flight crews should be aware that some baulked landing distances may extend beyond the take-off distance and could then infringe on the 35 ft clearance requirements. In these cases, the baulked landing distance might become the limiting obstacle avoidance factor for a particular approach and take-off direction.

6.8.3 As required by the Part 133 MOS for PC1 operations, relevant obstacles must still be identified for approaches to land. If an engine becomes inoperative at or after the LDP, the rotorcraft must be able to land safely and stop within the FATO. Landing safely in this context means the obstacles must be avoided by an adequate vertical margin until conducting the landing.

6.9 PC1 – Exposition guidance

6.9.1 This section sets out guidance for Part 133 operators on what to include in expositions for PC1 operations. A rotorcraft operator's exposition must include procedures that relate to each stage of flight in which the rotorcraft is flown in PC1.

> **Note**: Although sections of this AC are written as guidance material (GM) for content of company expositions or operations manuals, operators must ensure that the related material is inserted in the relevant sections of their documentation. For example, whilst it is included in a single section for simplicity, some GM is performance policy and administrative information, and other GM is preflight planning, obstacle assessment and standard operating procedures. As such, these will need to be integrated into the appropriate sections of your expositions or operations manuals.

6.9.2 From data provided by the heliport or aerodrome operator, the PIC must determine the characteristics of the FATO and specified obstacle-free gradients. An appropriate take-off and landing procedure shall be selected from the flight manual to conform to the limits of the departure and destination FATO's. A determination from the RFM will be made of the most limiting weight based on:

- weight limit for the procedure
- 100 fpm first segment V_{TOSS} climb
- 150 fpm second segment climb
- weight limit to allow a reject within the RTODAR
- weight limit to ensure the TODRR does not exceed the TODAR (unless 35 ft obstacle clearance can be met beyond the TODAR)
- weight limit to ensure the OEI climb gradient achieved exceeds the obstacle-free gradient and maintains the required obstacle clearance until the minimum flight altitude.

6.9.3 The PIC must identify relevant obstacles and obstacle-free gradients from data supplied by the heliport or aerodrome operator. Where such data does not include all of the relevant obstacles, the PIC will use extended survey data supplied by the rotorcraft operator.

6.9.4 The PIC will use the procedures below to ensure that the flight meets PC1 requirements:

- **Most suitable flight path for take-off** – The flight path for take-off will be along the axis described by the heliport or aerodrome operator. Variations in heading of greater than 15° are permitted in day or night (aided by NVIS) VMC if allowed by the RFM procedure. Crosswind or downwind RFM limits for the Category A procedure selected must not be exceeded.
- **Take-off obstacle clearance requirements** – All obstacles prior to the end of the FATO or clearway must be avoided by an adequate vertical margin. All relevant obstacles beyond the FATO or clearway must be avoided by at least 35 ft. After entry into IMC all relevant obstacles must be avoided by at least 35 ft plus 1.0% of the distance from the end of the FATO or clearway.
- **TDP** – For clear area and helideck drop-down procedures, the TDP must be determined from the RFM Category A procedure corrected, if necessary, to ensure 35 ft obstacle clearance. For other procedures, the TDP must be corrected for obstacles within the TODRR (if any) and for the stated obstacle-free gradient. There are various methods that could be used, but a simple formula to determine this correction is:

  TDP correction = TODRR x Gradient (%)

  E.g. For a 400 m TODRR and 4.5% obstacle free gradient, TDP should be corrected by 400 x 4.5/100 = 18 m (60 ft).

Note: Operators should ensure the method they require to be used is clearly articulated in their exposition.

- **En-route obstacle clearance** – Relevant obstacles in the take-off and climb must be avoided by the appropriate margin until at the minimum flight altitude for VFR flight, or at LSALT/MSA for IFR flight. In the pre-flight planning stage of the flight, the PIC should determine the planned OEI performance at the planned minimum flight altitudes for the route. Once at the minimum altitude, the PIC must determine the performance of the aircraft and confirm that 50 fpm rate of climb can be maintained when OEI. This data must be obtained from the RFM or other approved source. Drift-down procedures may be used in accordance with exposition procedures where 50 fpm rate of climb cannot be maintained.
- **Most suitable flight path for approach** – The flight path for approach will be along the axis described by the heliport or aerodrome operator. Approach angles must be flown in accordance with the applicable Category A procedure, while at all times maintaining an adequate vertical margin from obstacles. Crosswind or downwind RFM limits for the Category A procedure selected must not be exceeded.
- **Baulked landing obstacle clearance requirements** – Following a baulked landing, all obstacles beyond the FATO and/or helicopter clearway must be avoided by at least 35 ft. Until the end of the FATO or clearway, obstacles must be avoided by an adequate vertical margin. Provided the baulked landing flight path follows a surveyed take-off flight path, and rotorcraft performance is no less than that for a PC1 take-off, all obstacles will be avoided.
- **LDP** – For clear area and helideck drop-down procedures, the LDP must be determined from the RFM Category A procedure and corrected, if necessary, to ensure 35 ft obstacle clearance. For other procedures, the LDP height correction may be determined by the same method as mentioned above for TDP.

7 Rotorcraft performance – PC2

7.1 PC2 – Take-off

7.1.1 As a refresher, it is worth reviewing the ICAO definition of PC2: A helicopter with performance such that, in the case of critical power-unit failure, it is able to safely continue the flight, except when the failure occurs prior to a DPATO, or after a DPBL, in which case a forced landing may be required.

7.1.2 Flight prior to the DPATO may be planned on the assumption of all engines operating normally. Obstacles must be avoided by an adequate vertical margin up until the DPATO. However, the rotorcraft must be flown such that a suitable forced landing area is available, and rotorcraft performance allows that area to be used.

7.1.3 PC2 operations allow a number of different take-off procedures, some of which may be outside of Category A procedures and limits. This may mean hover in ground effect (HIGE) is the limiting weight. In all cases, 150 fpm OEI rate of climb must still be achievable 1 000 ft above the aerodrome, which in some rotorcraft may be more limiting than HIGE weight limits.

7.1.4 Prior to DPATO, there is a stage of flight where a suitable forced landing area must be available. Suitable forced landing areas are discussed in section 4.1 above and require both a suitable landing area and appropriate rotorcraft performance and flight paths. The rotorcraft weights must be within the limits for the chosen procedure, and flight paths must be in accordance with Category A procedures or, if outside Category A weight limits, clear of the avoid area of the HV envelope. Operators of transport category certified rotorcraft with Category B RFM supplements should review the procedure and limitations outlined therein if Category B operations are contemplated.

7.1.5 **Elevated helipads or helidecks** – These provide for interesting operational performance scenarios. Quite often these locations are not able to facilitate PC1 due to surrounding infrastructure and variable deck heights (in the offshore case). Helideck Category A weight limits may also be very restrictive for older rotorcraft. Where operations cannot be conducted PC1, but can be conducted within helideck Category A requirements, this may be classified as PC2 based on the principle of there being a reasonable chance of no injuries with an OEI landing onto the deck environment. As an alternative, use of PC2 beyond Category A weight limits (category B operations) would require flight outside of the avoid area of the HV envelope to achieve a suitable forced landing area. Given the low airspeed coming off an elevated helideck, it is unlikely the rotorcraft can remain outside the avoid area of the HV envelope, which could then result in landing injuries, or possibly even a deck-edge strike during the take-off stage of the flight.

7.1.6 To operate PC2 above Category A weights from elevated helipads or helidecks, specific RFM procedures may be required. These procedures would require an assurance of avoiding a deck-edge strike by 4.5 m and known mass-height-velocity performance that allows either the ground or sea surface to be used as a suitable forced landing area, or a safe continued take-off to be performed.

7.1.7 It is important to note that for PC2 operations beyond the (DPATO), or before the DPBL, the requirements are identical to PC1 as discussed in detail within section 6 of this AC. This means climb performance plus obstacle knowledge and avoidance requirements, for the climb, cruise and descent, are identical across PC1, PC2 or PC2WE. However, in the case of PC2 or PC2WE, operator/pilot-based surveys of relevant obstacles may be conducted by the operator or the PIC in lieu of formal surveys.

7.2 PC2 – Take-off and initial climb

7.2.1 There are three basic scenarios for a PC2 take-off and initial climb:

- A take-off within Category A weights and procedures, and meeting all PC1 obstacle clearance requirements, but the surveys of the obstacles are based on the processes of the rotorcraft operator and pilot surveys in accordance with the Part 133 MOS.
- A take-off within Category A weights and procedures, but not meeting PC1 obstacle clearance requirements prior to DPATO.
- A take-off beyond the Category A weight limits.

7.2.2 In cases where there has only been an operator/pilot-based survey of the reject areas or relevant obstacles, PC2 may be achieved via the use of Category A procedures. If the informal survey is judged as satisfying PC1 obstacle avoidance requirements, the DPATO location will coincide with the TDP for the procedure, and the flight paths will be identical to PC1 flight paths. In this case, the length of the FATO plus any suitable forced landing area must be greater than the rejected take-off distance required by the procedure.

7.2.3 In cases where Category A procedures can be used, but obstacles beyond the OEI take-off distance available can be avoided by an adequate margin (but not by the PC1 35 ft margin), this is also classified as PC2. Figure 18 represents a PC2 Clear Area take-off where the rotorcraft is within Category A weight limits, and there are sufficient suitable forced landing areas, but trees prevent the OEI Category A flight path from being followed. At or prior to the TDP, the rotorcraft can reject onto the FATO. An engine failure immediately beyond the TDP would result in a fly-away into the trees, so a reject onto the suitable forced landing area is required, or possible manoeuvring to fly around the trees (the choice is up to the pilot). From the TDP, a PC2 rotorcraft is assumed to, and can plan to be climbed on an AEO profile until the point where an engine failure would allow the obstacles to be cleared according to PC1 requirements. When the rotorcraft's OEI performance meets this PC1 criteria, this point is the DPATO. In any case, this must be achieved by 300 ft above the heliport or HLS level.

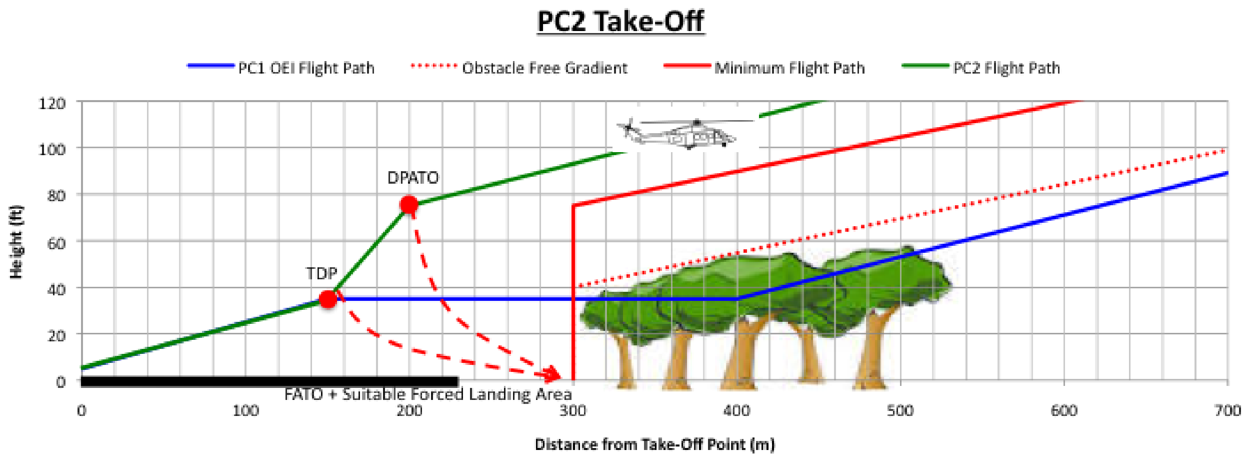

Figure 18. PC2 take-off

7.2.4 The example provided in Figure 18 could also be applicable to a Category A helipad take-off technique where the RFM does not allow the TDP to be increased. In Figure 19, prior to TDP, a safe reject can be conducted. After TDP, an OEI fly-away can be conducted, but with only an adequate vertical margin, so not meeting the PC1 standard of 35 ft. For PC2, after TDP, the rotorcraft is accelerated AEO to the point where a safe OEI climb speed can be achieved, and a climb established, without requiring a descent to within 35 ft of the obstacles. The plan prior to DPATO must include a safe option of landing or flying away.

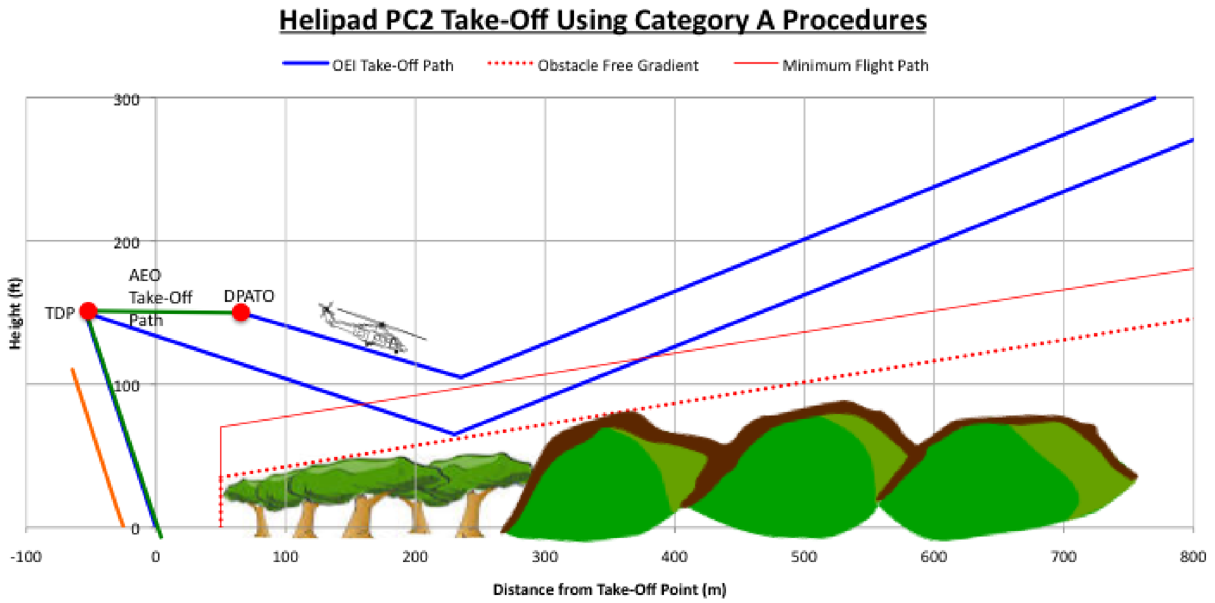

Figure 19. PC2 take-off using Category A procedures

7.2.5 If beyond Category A weight limits (Figure 20), the take-off would need to be conducted outside the avoid area of the HV envelope in accordance with the applicable RFM procedure and, up until DPATO, the reject area must allow for a suitable forced landing. Once the rotorcraft is both at a speed that allows an OEI climb to the minimum flight altitude and is 35 ft above the informally surveyed obstacle-free gradient, it is at the DPATO. From DPATO, the obstacle clearance requirements are the same as that for PC1, so the rotorcraft climb gradient must not be less than the obstacle free gradient.

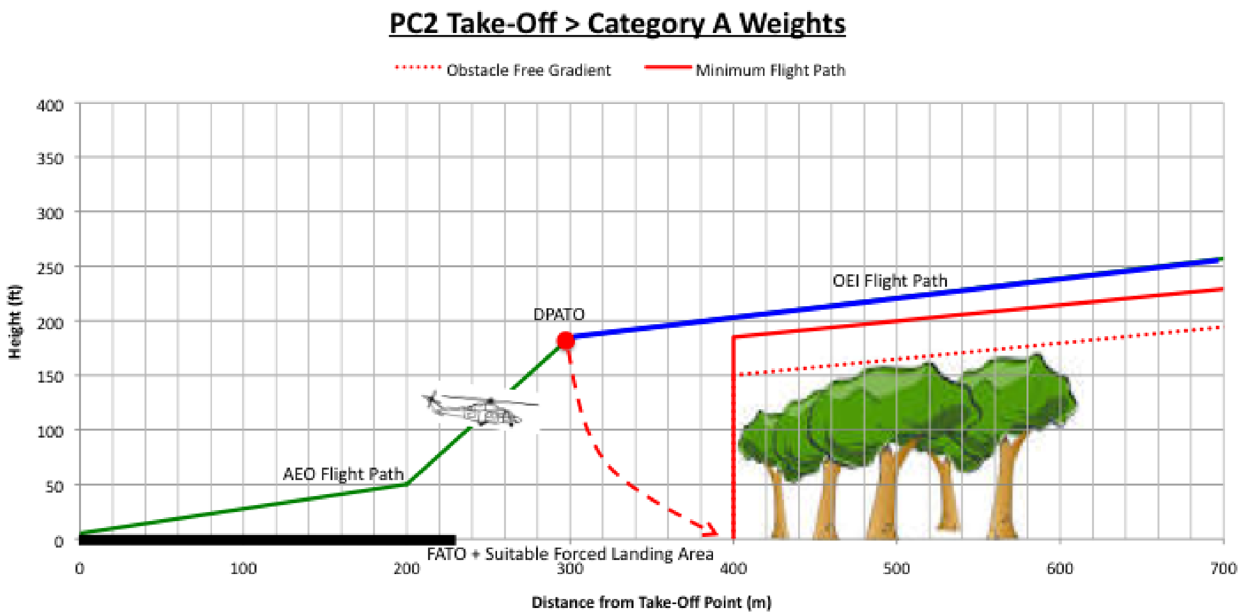

Figure 20. Surface level PC2 take-off category A compliant weights

7.2.6 Here are some examples of take-offs that are not PC2, when operating above the applicable Category A weight limits:

- vertical, steep, or any take-off from helipads that enters the avoid area of the height-velocity envelope
- elevated heliport, HLS/Helideck take-offs with no RFM assurance of avoiding deck-edge strike by 4.5 m
- elevated heliport, HLS/Helideck take-offs with no RFM assurance of a continued take-off being possible, or no assurance of the ground/water surface being a suitable reject area
- helideck take-offs where the sea-state exceeds the limitations on the flotation equipment.

7.2.7 The exact location of the DPATO need not be calculated. The obstacle-free gradient beyond the end of the suitable forced landing area must still be determined from the survey conducted by the operator or pilot, using the operator's procedures in accordance with the requirements of the Part 133 MOS.

7.2.8 Provided the ability to conduct a suitable forced landing is available prior to 300 ft above the departure location during a normal AEO take-off, pilot judgement may be used to determine DPATO as the point where a safe OEI climb speed is obtainable, and 35 ft clearance above the obstacle-free gradient can be maintained. Up until this point, there must be a justifiable plan for either rejecting the take-off or flying away with adequate vertical margin from obstacles.

7.2.9 Guidance for determination of DPATO may come from RFM scheduled data for AEO take-off distance to 50 ft, and AEO climbs above 50 ft, where available. Guidance for the suitable forced landing area being long enough may come from the sum of the take-off distance to 50 ft and the single-engine landing distance from 50 ft (both available within the RFM). The increased length of the reject area will need careful consideration if the DPATO is above 50 ft. This process of using pilot judgement to define abort points (in this case DPATO) is not dissimilar to the process long taught for marginal power single-engine rotorcraft taking off from large confined areas.

7.2.10 Prior to DPATO, the PC2 standard for a rejected landing area is less than the higher standard of PC1 nevertheless it must meet the criteria for a suitable forced landing or higher standard. Also, any fly-away attempt may have a lesser margin of obstacle clearance compared with PC1, provided obstacle avoidance can be carried out visually by the pilot(s). For risk mitigation purposes, the intention is that this acceptance of greater risk for PC2 must have a defined limit, beyond which the higher standard of PC1 obstacle clearance is mandatory. Therefore, the DPATO is not permitted to be located any higher than 200 ft above obstacles directly below the rotorcraft to maximum height of 300 ft above the heliport or aerodrome.

7.2.11 Flight in IMC adds more risk to the assurance of obstacle clearance. For this reason, IMC entry is not permitted until DPATO is achieved, and PC1 obstacle clearance standards can be met.

7.3 PC2 – En-route flight

7.3.1 PC2 requirements for en-route flight are identical to those for PC1. Refer to section 6.7 of this AC.

7.4 PC2 – Approach and landing, or baulked landing

7.4.1 As for the PC2 take-off, several factors must be considered to determine the limiting weight for approach and landing. Part 133 MOS considerations regarding rates of climb or weight limits for the procedure are the same as for the PC2 take-off.

7.4.2 Following an engine failure prior to the DPBL, the requirements are identical to those for PC1 (refer to section 6.6 above). Following initiation of a baulked landing at or before the DPBL, the rotorcraft is expected to continue losing height while accelerating to a safe OEI climb speed. However, this should not take it below the planned AEO approach path, so additional consideration of obstacles short of the FATO is not required. To allow for the baulked landing flight path, obstacles beyond the FATO within the appropriate splay will need considering in the same way as if a take-off were being conducted from that FATO. In some rotorcraft, the baulked landing flight path may achieve entry into an OEI climb later than an OEI continued take-off, so this should be considered in the planning.

7.4.3 In cases where obstacle avoidance is based on operator/pilot surveys of the landing areas and relevant obstacles, PC2 may be achieved via the use of Category A procedures. If the operator/pilot survey is judged as satisfying PC1 requirements, the DPBL location will coincide with the LDP for the procedure, and the flight paths will be identical to PC1 flight paths. In this PC2 case, the length of the FATO plus any suitable forced landing area need not be greater than the landing distance required by the procedure, provided pilot operating technique allows for a landing with the distance available, possibly at zero ground speed. It is accepted that such a landing may be heavier than a normal landing, but that it should still meet the intent of a SFL in a SFLA.

7.4.4 Category A landing procedures provide guidance on the expected baulked landing height loss when operating within the weight limits for the procedure. This makes it simple to confirm that the baulked landing flight path will maintain the required clearance from obstacles. DPBL will be the last point where the obstacles cannot be cleared by the required margin, and this may be above the LDP for the procedure. In this situation, the actions below the DPBL are to either conduct a baulked landing, infringing on the 35 ft obstacle clearance, but still maintaining an adequate vertical margin, or to continue the landing.

7.4.5 For operations beyond clear area Category A weights, where a V_{TOSS} may no longer be provided (noting that a clear area category A V_{TOSS} could still be useful into a helipad), operators can only be sure of minimal baulked landing height loss if the rotorcraft is maintaining close to V_Y. This uncertainty places the DPBL no later than the last point on the approach when a pilot is no longer able to achieve V_Y while maintaining 35 ft above any obstacles in the baulked landing distance.

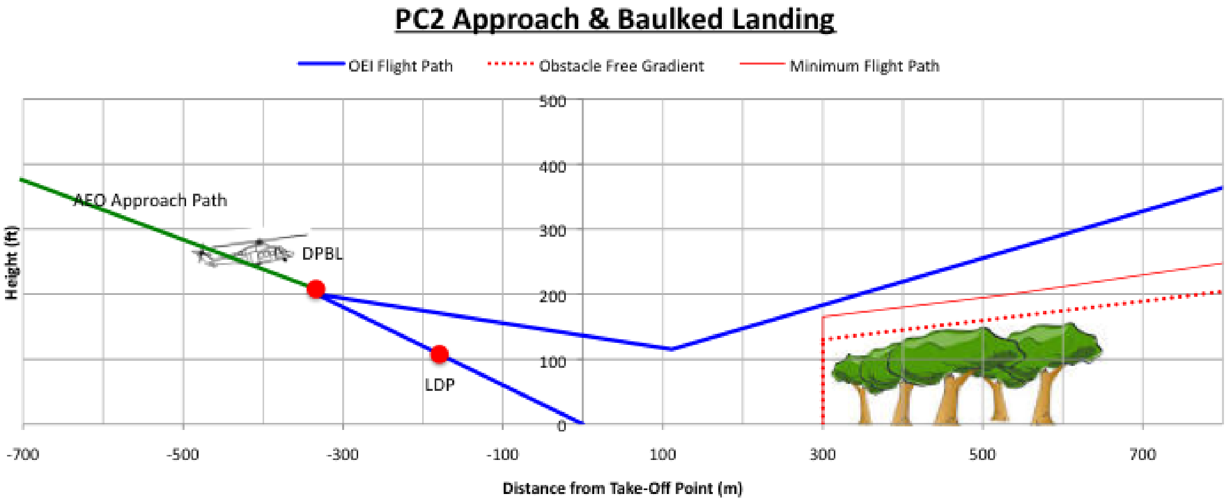

Figure 21. PC2 Approach and baulked landing

7.4.6 Figure 21 shows that, if the DPBL were lowered any further, the required PC1 standard of obstacle clearance would not be achieved following the baulked landing. Therefore, below the DPBL, the option is to accept a lesser obstacle clearance in the baulked landing, while still maintaining an adequate vertical margin, or continue to the suitable forced landing area. Where there is any doubt about the extent of the height loss during a baulked landing, a decision to continue to the suitable forced landing area will be the most prudent.

7.4.7 In line with the principles of PC2, when above clear area Category A weights, the approach flight path should remain outside the avoid area of the HV envelope to ensure a suitable forced landing can be conducted such that there is a reasonable expectation of no injuries. This could require a very shallow flight path, so may only be feasible at large and clear landing sites.

7.4.8 For a PC2 landing below clear area Category A weights, the landing distance required is permitted to exceed the landing distance available. However, this is conditional upon the pilot flying a normal, constant angle approach arriving at an appropriate touch down speed for the landing area and using appropriate power management techniques throughout the approach. This method meets the intent of a landing area being a SFLA.

7.5 PC2 – Exposition guidance

7.5.1 This section sets out guidance for Part 133 operators on what to include in expositions for PC2 operations.

> **Note:** Although sections of this AC are written as guidance material (GM) for the content of company expositions or operations manuals, operators must ensure that the related material is inserted in the relevant sections of their documentation. For example, while it is included in a single section for simplicity, some GM is performance policy and administrative information, and other GM is preflight planning, obstacle and SFLA risk assessment processes and standard operating procedures. As such, these will need to be integrated into the appropriate sections of your expositions or operations manuals.

7.5.2 From data provided by the heliport or aerodrome operator, the rotorcraft operator, or pilot assessment, the PIC must determine the characteristics of the FATO, surrounding suitable forced landing areas and specified obstacle-free gradients. An appropriate take-off procedure must be selected to conform to the limits of the FATO and availability of suitable forced landing areas. A determination will be made of the most limiting weight based on:

- weight limit for the procedure
- 150 fpm second segment climb
- weight limit to ensure the OEI climb gradient achieved exceeds the surveyed obstacle free gradient and maintains the required obstacle clearance until the minimum flight altitude.

7.5.3 The PIC must identify relevant obstacles and obstacle-free gradients from data supplied by the heliport or aerodrome operator, the rotorcraft operator, or from pilot assessment. Where pilot assessment is required, the procedures mentioned in section 7.6, must be applied.

7.5.4 The PIC will use the procedures below to ensure that the flight meets PC2 requirements:

- **Most suitable flight path and track for take-off** – The flight path for take-off will be in accordance with the relevant RFM procedure, and along the take-off track identified by survey. Variations in the flight path are permitted under visual conditions. Crosswind or downwind RFM limits for the procedure selected must not be exceeded.
- **Take-off obstacle clearance requirements** – All obstacles prior to the DPATO must be avoided by an adequate vertical margin. Beyond the DPATO, all obstacles must be avoided as per PC1 requirements.
- **DPATO** – When PC1 obstacle clearance requirements can be met by using a Category A procedure, the DPATO will coincide with the TDP for the procedure. If PC1 obstacle clearance requirements cannot be met, the DPATO will be located at the earliest point in the take-off where a safe single-engine climb speed is obtainable and from which a minimum of 35 ft obstacle clearance can be continuously maintained. The ability to achieve an OEI rate of climb that maintains 35 ft above obstacles must be determined from a comparison with the surveyed obstacle free gradient from the FATO.
- **En-route obstacle clearance** – En-route obstacle clearance requirements are the same as for PC1.

- **Most suitable flight path for approach** – The flight path for approach will be on a track, that is, within 15° of a surveyed take-off track for the heliport or HLS. This will ensure that any baulked landing flight path coincides with the surveyed take-off path and so achieves the required PC1 obstacle clearance. Approach angles must be flown in accordance with an RFM procedure, including category B flight manual supplement procedures if applicable to the operation, while at all times maintaining an adequate vertical margin from obstacles. Crosswind or downwind RFM limits for any selected Category A procedure selected must not be exceeded.
- **Baulked landing obstacle clearance requirements** – Following a baulked landing and until the end of the FATO, obstacles must be avoided by an adequate vertical margin. Beyond the FATO, all obstacles must be avoided by at least 35 ft. If the baulked landing flight path follows a surveyed take-off flight path, and rotorcraft performance is no less than that for take-off, all obstacles will be avoided by PC1 margins.
- **DPBL** – The DPBL is located at the latest point in an approach where the PIC determines that a safe OEI climb speed is no longer obtainable and a minimum of 35 ft obstacle clearance can no longer be continuously maintained along the baulked landing flight path. The ability to achieve an OEI rate of climb that maintains 35 ft above obstacles must be determined by a comparison with the surveyed obstacle free gradient from the FATO.

7.6 PC2 – Pilot assessment of FATO and surrounds

7.6.1 In cases where operators permit pilot surveys for PC2 operations, detailed instructions are required to assist pilots in achieving an adequate level of survey accuracy. Detailed below is an example of a ground survey instruction for a day VFR pilot conducting PC2 or PC2WE operations:

- For PC2 operations, pace out the FATO plus safety area to ensure a minimum 2D dimension in all directions (for any shape) is available, or an area of dimensions required by the RFM Category A procedure selected, whichever is greater. Ensure suitable forced landing areas are available beyond the FATO up until the anticipated DPATO.
- Assess the mean slope of the FATO as not exceeding 5° (7%) for PC2 operations, or within RFM sloping ground limits for PC2WE. PC2 suitable forced landing areas beyond the FATO must be within RFM slope limits.
- For PC2, assess the surface strength of the FATO and suitable forced landing areas beyond the FATO as being capable of bearing a 720 fpm rate of descent impact. This can be assumed for any ground level heliport, or elevated heliports with a T value rated for the rotorcraft.
- From the left then right departure corners of the FATO/clearway, look 6°(10%) left and right of the departure track out to a distance of (7R - D)/0.10, then parallel the departure track out to the distance the rotorcraft requires to reach 1 000 ft above all obstacles within 5 NM. (If the rotorcraft can climb OEI at 10%, this distance equals 3 km).
- From the end of the FATO and within the splay, identify the shallowest obstacle-free gradient achievable, with visual manoeuvres if necessary, out to 1 000 ft above obstacles (gradient = 100 x obstacle height / distance). Shallower gradients may be achieved by elevating above the FATO edge to a point from which the gradient could originate (raised incline plane), but this may not normally be feasible for a pilot to do while standing on the ground. There are smartphone and tablet applications that can measure and record gradients from the FATO edge; these may be useful in assisting with the assessment task.
- Use the same method above for identifying obstacles to the rear or side of the helipad if required for back-up or lateral Category A take-off manoeuvres.

7.6.2 Detailed below is an example of an airborne survey instruction for day VFR pilots conducting PC2 or PC2WE operations:

- For PC2 operations, assess the FATO plus safety area to ensure a minimum 2D dimension in all directions (for any shape) is available. Ideally, this information should be able to be provided by the heliport or landing site owner, or an operator prior to departure. Ensure the FATO can be used as a SFLA for a possible slow or zero ground speed landing. Use common measures, such as football fields or house sizes, to assist with distance judgement.
- For PC2, from the information provided before departure, assess the mean slope of the FATO as not exceeding 5° (7%), or within RFM limits for PC2WE. PC2 suitable forced landing areas beyond the FATO should be within RFM slope limits. Use surrounding features of watercourses and terrain to assist with judgement of slope.
- For PC2, assess the surface strength of the FATO and suitable forced landing areas as being capable of bearing a 720 fpm rate of descent impact. Natural surfaces without water influences will usually meet this requirement. Be wary of manufactured surfaces with questionable strength ratings.
- For the chosen approach angle(s), assess the obstacles on the approach path to ensure that adequate vertical margin can be maintained until the DPBL, then beyond the DPBL to the landing area. If this is achieved, any baulked landing flight path should continue to clear all obstacles by an adequate vertical margin until over the FATO. Approach paths must either remain clear of the avoid area of the height-velocity diagram or, if within Category A weight limits, follow an RFM Category A profile.
- Identify the DPBL in terms of the lowest height above the FATO from which the known OEI climb capability can exceed the baulked landing path obstacle free gradient from the FATO, while maintaining 35 ft obstacle clearance. Due to potential errors in pilot judgement, this determination of DPBL should be conservative unless more accurate ground surveys of gradients have been conducted and are available for assessment.

8 Rotorcraft Performance – PC3

8.1 PC3 – Take-off

8.1.1 In addition to meeting the RFM weight limits for the type of take-off selected, and meeting HIGE or HOGE performance, the PIC must ensure there is sufficient additional power available for the type of take-off procedure used[10]. A common method to achieve this could be the application of a percentage margin of power available above that required for the HIGE or HOGE. This margin will vary between rotorcraft types and with different take-off techniques.

8.1.2 There is an expectation that a PC3 take-off, followed by an engine failure, retains the capability to conduct a forced landing with a reasonable expectation of no injuries to persons in the rotorcraft or on the ground. This is only considered achievable by operating outside any published avoid area of HV envelope and to a SFLA. However, the Part 133 MOS permits conditional operations without a suitable forced landing area. In these cases, the obstacles that make the forced landing area unsuitable may also drive a need to temporarily enter the avoid area of the HV envelope to avoid those obstacles during take-off. For this reason, the Part 133 MOS permits momentary and limited entry into this area for rotorcraft that do not have this as a mandatory limitation with the RFM, where this is necessary for obstacle, incident or accident avoidance.

8.2 PC3 – Take-off and initial climb

8.2.1 For PC3 operations, there is no requirement for avoidance of relevant obstacles as defined by the Part 133 MOS or as identified through a survey. However, obstacles must still be cleared by at least an *adequate vertical margin*[11] with all engines operating.

8.2.2 If operating over a populous area and unable to meet the additional requirements of the Part 133 MOS, a PC3 rotorcraft must be able to reach a SFLA while avoiding obstacles by an *adequate vertical margin*. This must remain the case until the rotorcraft is at the minimum safe height for flight as defined in Part 91 of CASR.

8.2.3 Where the Part 133 MOS allows operations without a SFLA, the safest take-off and climb path may require entry into the avoid area of the HV envelope to avoid obstacles. Where this is the case, entry into the avoid area must be for the minimum time necessary to avoid the obstacle, incident or accident.

8.3 PC3 – En-route flight

8.3.1 For information regarding the specific requirements for flights in PC3 over populous areas – see section 8.5 of this AC.

8.3.2 Enroute SFLA availability (any PC3 operation)

8.3.2.1 For PC3 enroute, the rotorcraft must be flown in a way that minimises the time the flight is without the availability of a suitable forced landing area.

8.3.2.2 Operators should develop a policy in their exposition that instructs pilots on the operator's expectations regarding minimising the time the rotorcraft is operating without availability of a SFLA. This policy should include judicious use of pre-departure flight planning tools, as well as exposition guidance and instructions to enhance flight crew knowledge of the availability of SFLAs over the planned tracks of the flight.

[10] See paragraph 10.41(2)(a) of the Part 133 MOS.

[11] See section 5.3 of this AC for information about *adequate vertical margin*.

8.3.2.3 An operator may choose to utilise a scalable approach to this policy, such as describing situations where the flight is operating in:

- areas of mixed terrain with regular SFLA availability
- areas with scattered SFLA's; and
- areas of challenging terrain with limited SFLA availability

and applying different operational requirements in each situation.

8.3.3 Operating in areas of mixed terrain features

8.3.3.1 In these areas the practical effect on normal operations is usually minimal, as most areas of operation are of a mixed nature in regard to SFLA availability.

8.3.3.2 Therefore, the operator may accept little or no deviation from the planned route is usually necessary to have an SFLA within reach, provided the flight is performed at an appropriate height above ground level and using sound pilot skills and judgement.

8.3.3.3 In such circumstances it is an acceptable means of compliance that there will be operations flown directly above surfaces that do not allow for a SFL, but at normal flight altitudes, sufficiently flat, open areas should be within autorotational gliding distance, or quickly come into autorotational glide distance as the flight progresses.

8.3.3.4 Flights over such areas normally have an SFLA within reach or quickly within reach and should not require further mitigation.

8.3.4 Operating in areas with scattered SFLA

8.3.4.1 Where the mix of terrain is such that SFLA's are less readily available, additional considerations should be applied by the operator when designing their exposition procedures.

8.3.4.2 In these areas the operator should outline an adaptation of the flight path that may be required, such as climbing before crossing a lake or other water feature to have an SFLA available on land on either side within autorotational distance, or flying around a stretch of heavily treed country provided it does not cause a significant deviation of the flight plan track, to have an SFLA more readily available.

8.3.4.3 Operators should outline what they consider to be an insignificant deviation of the flight plan track, so flight crew members are not in doubt as to these criteria. For example, a deviation or series of deviations that create no more than 5 minutes additional flight time to the flight plan would be an acceptable means of compliance.

8.3.4.4 In some cases, it may not be feasible to change the routing and shorter stretches of the flight might not have an SFLA within autorotational distance.

8.3.4.5 Flights over such areas are permitted however it is recommended that a risk assessment be conducted and identified controls and mitigations are applied. Operator's may apply similar risk mitigations to operations over populous areas to reduce the hazard for operations in these situations.

Note: A risk assessment outlined in this section can be for a flight or a series of flights in an area, provided the hazards reviewed and mitigations introduced can be satisfactorily applied to the series of flights being undertaken.

8.3.5 Operating in areas of challenging terrain

8.3.5.1 Some flights are over areas where SFLA's are few or non-existent for longer stretches. However, if some SFLA are available, an operator's policy could specify planning the route to pass near these areas. This would reduce the exposure and address the risk of encountering emergencies that require a precautionary landing (such as land immediately, or land as soon as possible (ASAP) non-normal checklist items).

8.3.5.2 When operating over challenging terrain in areas where no, or very few, SFLA's are available to perform an SFL, the operator's policy should outline operations are permitted, if the result of the risk assessment shows that the risk level is acceptable, and the identified controls and mitigations are properly applied as in areas with scattered SFLAs above.

8.3.5.3 The operator may consider including a procedural requirement for predetermined routes with known landing areas or SFLAs that are based on previous reconnaissance or desk top review of the flight route, which can be entered into the navigation database or marked on a map for quick reference if needed.

8.3.5.4 These processes, included in the operator's exposition, should be aimed at establishing in their flight crew members a generalised flight planning and operational concept which minimizes to the greatest extent practical, exposure to the consequences of an engine failure, and which makes potential landing areas more readily identifiable in the case of emergencies that require an autorotation or a land ASAP response.

Note: A risk assessment outlined in this section can be for a flight or a series of flights in an area, provided the hazards reviewed and mitigations introduced can be satisfactorily applied to the series of flights being undertaken.

8.4 PC3 – Approach and landing or baulked landing

8.4.1 The PIC must meet the RFM weight limits for the type of approach selected and have HIGE or HOGE performance, as applicable, for the type of approach procedure used. There is no necessity for additional power available as required for the take-off.

8.4.2 With all engine operating, obstacles must be cleared by at least the adequate vertical margin for approach, landing or baulked landing.

8.4.3 Suitable forced landing areas and/or flight outside the avoid area of the HV envelope are not mandatory for PC3 approach and landing or baulked landing operations, unless over populous areas and unable to comply with the additional requirements in the Part 133 MOS.

8.5 PC3 – Additional requirements for operations over populous areas

8.5.1 During any stage of a flight of a rotorcraft operated in PC3 over a populous area, regulation 133.340 of CASR requires a SFLA to be available unless certain Part 133 MOS[12] requirements are met.

8.5.2 These requirements are:

- the rotorcraft must not be flown in a way that may create a hazard to a person, or property, on the ground or water under the rotorcraft's flight path
- the rotorcraft must be flown so that, for the route for the flight, the time during the flight over the populous area in which a suitable forced landing area, is not available is minimised

[12] See section 10.26 of the Part 133 MOS for the requirements that must be met if any stage of a PC3 flight is conducted without an available SFLA.

- the rotorcraft must be equipped with a particle detection system that monitors the main and tail rotor transmission gearboxes and that, from 2 December 2023, includes a flight deck caution indicator for each gearbox mentioned.

Notes:

1. It is recommended that the rotorcraft be fitted with a flight deck caution indicator for each gearbox before 2 December 2023 where this is feasible.
2. The requirement to fit a flight deck caution indicator is deferred through the effect of the end of the Part 133 performance class deferral contained in the exemption instrument CASA EX70/24.

8.5.3 The purpose of regulation 133.340 and section 10.26 of the Part 133 MOS is to permit air transport operations over populous areas using PC3 to occur without the availability of suitable forced landing areas, where the requirements of section 10.26 of the Part 133 MOS are met.

8.5.4 An aircraft is not considered to be creating a hazard simply by flying over populous areas in the normal course of navigation, provided the aircraft adheres to the prescribed distances and altitudes outlined in regulation 91.265 of the CASR, (which also applies to Part 133 operations) and the distances and general requirements mentioned in sections 10.26, 10.42 and 10.43 of the Part 133 MOS.

Note: The distances described in sections 10.42 and 10.43 are the 'adequate vertical margin', the 'minimum safe height for the flight under Part 91 of CASR or the Part 91 MOS' and 'the minimum flight altitude for each point in the en-route stage of the flight'.

8.5.5 The term *adequate vertical margin* is explained in the definitions section and section 5.3 of this AC.

8.5.6 The term *minimum flight altitude* is defined in chapter 1 section 4 of the Part 133 MOS and the relevant minimum flight altitude for a flight is dependent on its category of operation and are described as follows:

> ***minimum flight altitude***, for a point on the route, or a route segment, of a flight of a rotorcraft, means:
>
> (a) for an IFR flight, or VFR flight at night:
>
> (i) the published LSALT for the route or route segment; or
>
> (ii) if subparagraph (i) does not apply — the LSALT for the route or route segment; or
>
> (b) for a VFR flight at night, when not using the LSALT determined under paragraph (a) — 1 000 ft above the highest feature or obstacle on the ground or water within 10 nautical miles ahead, and to either side, of the rotorcraft at that point; or
>
> (c) for a VFR flight by day over a populous area — 1 000 ft above the highest feature or obstacle within a horizontal radius of 300 m of that point on the ground or water immediately below the rotorcraft; or
>
> (d) for a VFR flight by day, other than over a populous area — 500 ft above the highest feature or obstacle within a horizontal radius of 300 m of that point on the ground or water immediately below the rotorcraft.

8.5.7 The 'minimum safe height for the flight under Part 91 of CASR or the Part 91 MOS' simply means the minimum height that Part 91 describes as suitable for your flight. In the case of PC3 day VFR operations over populous areas this is 1 000 ft above the highest feature or obstacle within a horizontal radius of 300 m of the point on the ground or water immediately below the rotorcraft.

8.5.8 In summary for operations over populous areas, if an operator ensures their rotorcraft are operated in compliance with paragraphs 10.26(a) and (c) of the Part 133 MOS and regulation 91.265 of CASR, they will be compliant with regulation 91.055 of CASR.

8.5.9 Subsection 10.29(4) of the Part 133 MOS outlines that the operator’s exposition must include risk assessment, and risk management, procedures for flights over populous areas, and details of training for the operator’s pilots in conducting autorotative descents to locations with limited access to suitable forced landing areas for a flight of the rotorcraft.

8.5.10 In Part 133 operations, the management of the potential consequences of increased risk can be achieved by means of:

- pilot procedures and training
- robust risk assessment processes
- improved transmission monitoring systems.

8.5.11 The guidance material detailed below will assist with understanding what needs to be achieved to meet the PC3 requirements for the lack of availability of a suitable forced landing area, in situations where, otherwise, it would have been required.

8.5.12 The pilot should select a flight path that avoids all persons by an adequate vertical margin, or a greater margin if the flight path is likely to cause those persons to take evasive action due to their perception that they are in danger from the aircraft or its rotor-wash. Pilots must consider the impact of rotor wash on dirt, dust, sand, water and other debris in terms of the hazard it may cause to persons or property on the ground or water.

8.5.13 The rotorcraft should be flown in a way that minimises the time during the flight over the area in which a suitable forced landing area is not available (see section 8.3). This does not mean that, if there is a flight path allowing for a suitable forced landing area, a pilot must choose that flight path to the complete disregard of other important factors such as power available or controllability requirements. Approach and departure paths should be chosen on the basis of all considerations, including the availability of suitable forced landing areas.

8.5.14 In keeping with the operator's risk assessment procedures and requirements of their Safety Management System (SMS), the operator's regular use of heliports in populous areas should have specific risk assessments conducted on them and standard operating procedures added to the operator's exposition. This is to ensure all pilots are aware of the preferred flight paths and appropriate other risk mitigation considerations.

Note: A risk assessment outlined in this section can be for a flight or a series of flights in an area, provided the hazards reviewed and mitigations introduced can be satisfactorily applied to the series of flights being undertaken.

8.5.15 For non-regular use landing sites, the exposition should detail the processes a pilot is expected to use to assess a site for approach and departure manoeuvres where a suitable forced landing area is absent.

8.5.16 The exposition should include descriptions of the expected pilot actions following in-flight emergencies in cases where a suitable forced landing area is absent.

8.5.17 The pilot training program in the operator's exposition should include risk-based processes for practice in autorotative descents that ensure pilot competency in conducting such manoeuvres to locations with limited access to suitable forced landing areas (precision auto-rotations).

> **Note:** Refer to Annex B to this AC for expanded information to allow operators and pilots to work through the practical application of these CASR requirements and an operational example of a rotorcraft conducting VFR by day passenger transport scenic flight operations over a populous area in accordance with PC3 requirements.

8.6 PC3 – Exposition guidance

8.6.1 This section sets out guidance for Part 133 operators on what to include in an exposition for PC3 operations. Refer to Annex C for specific sample exposition text that is an acceptable means of compliance (AMC) for operators, contingent on an operator ensuring the sample text is modified to suit the specific operational circumstances and rotorcraft of the operator.

> **Notes:**
>
> 1. Although sections of this AC are written as guidance material (GM) for content of company expositions or operations manuals, operators must ensure that the related material is inserted in the relevant sections of their documentation.
>
>   For example, whilst it is included in a single section for simplicity, some GM is performance policy and administrative information, and other GM is preflight planning, obstacle and SFLA risk assessment processes and standard operating procedures. As such, these will need to be integrated into the appropriate sections of your expositions or operations manuals.
>
> 2. A risk assessment outlined in this section can be for a flight or a series of flights in an area, provided the hazards reviewed and mitigations introduced can be satisfactorily applied to the series of flights being undertaken.

8.6.2 The requirements for PC3 exposition content are contained in sections 10.29 and 10.30 of the Part 133 MOS.

8.6.3 In compliance with these MOS rules, the PIC will use the procedures below to ensure that the flight meets PC3 requirements:

- **Most suitable flight path and track for take-off** – The flight path for take-off will be in accordance with the relevant RFM procedure, and along the take-off track most likely to provide the best combination of:
  - a suitable forced landing area
  - into wind
  - minimum power required
  - avoidance of hazards to persons or property.
- **Take-off obstacle clearance requirements** – All obstacles must be avoided by an adequate vertical margin.
- **Suitable forced landing areas** – SFLA, once identified by utilising maps, charts and digital mapping programs, should be reviewed via a ground or flight reconnaissance, or from other qualified rotorcraft pilots familiar with the area. Remembering that Part 133 of CASR requires all passenger transport operations at night to be PC2WE or above, reconnaissance of areas at night should be treated with caution due to the risk of missing vital information regarding obstacles and the landing surface.
- **En-route obstacle clearance** – En-route obstacles must be cleared in accordance with the requirements of Part 91 of for minimum height for flight. Tracks will be selected to maintain the greatest extent practical availability of SFLA's, unless doing so requires significant and

extensive deviations from the otherwise preferred track. The following general process and guidance is provided to pilots in command (PIC) when planning a flight.

- **PC3 operations in areas of mixed terrain features:**
  - In these areas PICs may consider the practical effect on normal operations is usually minimal, as most areas of operation are of a mixed nature in regard to SFLA availability.
  - Therefore, little or no deviation from the planned route is usually necessary to have an SFLA within reach, provided the flight is planned and performed at an appropriate height above ground level and using sound pilot skills and judgement.
  - In such circumstances the company recognises there will be short periods where the rotorcraft is flown directly above surfaces that do not allow for a SFL, but at normal flight altitudes, sufficiently flat, open areas should be within autorotational gliding distance, or quickly come into autorotational glide distance as the flight progresses.
  - Flights over such areas normally have an SFLA within reach or quickly within reach and should not require further mitigation.
- **Operating in areas with scattered SFL areas:**
  - Where the mix of terrain is such that SFLA's are less readily available, additional PIC flight planning consideration is required.
  - In these areas PICs are to consider if adaptation of the flight path is required, such as climbing before crossing a lake or other water feature to have an SFLA available on land on either side within autorotational distance, or flying around a stretch of heavily treed country provided it does not cause a significant deviation of the flight plan track, to have an SFLA more readily available.
  - Track deviation or series of deviations that creates no more than 5 minutes additional flight time to the flight plan are acceptable criterion if these are considered necessary by the PIC.
  - Where it is not be feasible to change the routing and shorter stretches of the flight might not have an SFLA within autorotational distance.
  - Company flights over such areas are permitted, however, a risk assessment must be conducted using company form (insert form reference) and identified controls and mitigations are applied. PICs may apply similar risk mitigations to operations over populous areas to reduce the hazard for operations in these situations.
- **Operating in areas of challenging terrain:**
  - Some company operations are over flight areas where SFLA's are few or non-existent for longer stretches. However, if some SFLA are available, PICs are to plan the route to pass near these. This will reduce exposure and also address the risk of encountering emergencies that require a precautionary landing (such as land immediately, or land as soon as possible (ASAP) non-normal checklist items).
  - Company flights over such areas are permitted, however, a risk assessment must be conducted using company form (insert form reference) and identified controls and mitigations are applied.
  - PICs are to include in the prefight planning and risk assessment:
- any predetermined routes (insert exposition reference for route guide) with known landing areas or SFLAs that are based on previous operational pilot reconnaissance
- a desk top review of the flight route
- the entering of locations of SFLA’s into the rotorcraft’s navigation database, or marking identified SFLA’s on their maps for quick reference if needed.

If the result of the PIC's initial risk assessment shows that the risk level is acceptable, the risk assessment is to be reviewed with the Head of Flight Operations, or their delegated senior pilot and a final decision on the acceptability of the planned route made.

- **PC3 Enroute operations over populous areas:**
  - All company PC3 operations over populous areas are to remain compliant with the minimum height requirements of regulation 91.265 of CASR.
  - The enroute obstacle clearance and SFLA availability requirements outlined above are also applicable to flight planning and operations over populous areas.
  - The PIC will select a flight path that avoids all persons by an adequate vertical margin, or a greater margin if the flight path is likely to cause those persons to take evasive action due to their perception that they are in danger from the aircraft or its rotor-wash.
  - All company pilots must consider the impact of rotor wash on dirt, dust, sand, water and other debris in terms of the hazard it may cause to persons or property on the ground or water.
  - Additionally, PICs are to plan and conduct operations over populous areas only in rotorcraft equipped with particle detection systems which monitor the main and tail rotor transmission gearboxes, and which have a flight deck caution indicator for each gearbox are to be used for these operations.
- **Most suitable flight path for approach** – The flight path for the approach will be in accordance with the relevant RFM procedure, and along the track most likely to provide the best combination of:
  - a suitable forced landing area
  - into wind
  - minimum power required
  - avoidance of hazards to persons or property.
- **Baulked landing obstacle clearance requirements** – Following a baulked landing with all engines operating, obstacles must be avoided by an adequate vertical margin.

Note: If the RFM does not outline a distance for adequate vertical margin, the exposition should outline the operator's policy for this distance for their rotorcraft operations.