ICAO

Doc 10110

Helicopter Code of Performance Development Manual

First Edition, 2020

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

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AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

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FOREWORD

This manual provides guidance material to assist States, their civil aviation authorities and the operators under their jurisdiction in the development of a code of performance for international helicopter commercial air transport.

The technological advances in aviation developed over the last century would not have been possible without parallel achievements in the control and reduction of safety risks. It is only through the disciplined application of the best safety risk management practices that the frequency and severity of aviation occurrences can continue to decline.

Until the advent of this manual, ICAO Annex 6 — *Operation of Aircraft*, Part III — *International Operations — Helicopters* provided only general guidance on helicopter performance. The ability for a State to permit variations from the prescriptive standard within the code of performance was not sufficiently detailed.

This manual assists States to achieve flexibility by implementing a code of performance based on a prescriptive standard and allowing for variations without a safe forced landing while achieving acceptable levels of safety risk.

Comments concerning this manual should be addressed to:

The Secretary General
International Civil Aviation Organization
999 Robert-Bourassa Boulevard
Montréal, Quebec, Canada H3C 5H7
icaohq@icao.int

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GLOSSARY

DEFINITIONS

When the following terms are used in this manual, they have the following meanings:

Acceptable level of safety risk. The level of risk which is considered acceptable in particular circumstances.

Aerial work. An aircraft operation in which an aircraft is used for specialized services such as agriculture, construction, photography, surveying, observation and patrol, search and rescue, aerial advertisement, etc.

Note.— Aerial work is referred to but not addressed in this manual.

Aircraft tracking. A process, established by the operator, that maintains and updates, at standardized intervals, a ground-based record of the four dimensional position of individual aircraft in flight.

Category A. With respect to helicopters, means a multi-engined helicopter designed with engine and system isolation features specified in Annex 8 — *Airworthiness of Aircraft,* Part IVB, and capable of operations using take-off and landing data scheduled under a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight or safe rejected take-off.

Category B. With respect to helicopters, means a single engine or multi-engined helicopter which does not meet Category A standards. Category B helicopters have no guaranteed capability to continue safe flight in the event of an engine failure, and a forced landing is assumed.

Commercial air transport operation. An aircraft operation involving the transport of passengers, cargo or mail for remuneration or hire.

Compliance-based regulatory oversight. The conventional and prescriptive method of ensuring safety used by a State's civil aviation authority that requires strict conformance to pre-established non-variable regulations by the operator.

Congested area. In relation to a city, town or settlement, any area which is substantially used for residential, commercial or recreational purposes.

Congested hostile environment. A hostile environment within a congested area.

Defined point after take-off. The point, within the take-off and initial climb phase, before which the helicopter's ability to continue the flight safely, with one engine inoperative, is not assured and a forced landing may be required.

Note.— Defined points apply to helicopters operating in performance Class 2 only.

Defined point before landing. The point, within the approach and landing phase, after which the helicopter's ability to continue the flight safely, with one engine inoperative, is not assured and a forced landing may be required.

Note.— Defined points apply to helicopters operating in performance Class 2 only.

Distance DR. The horizontal distance that the helicopter has travelled from the end of the take-off distance available***.***

Elevated heliport. A heliport located on a raised structure on land.

En-route phase. That part of the flight from the end of the take-off and initial climb phase to the commencement of the approach and landing phase.

Note.— Where adequate obstacle clearance cannot be guaranteed visually, flights must be planned to ensure that obstacles can be cleared by an appropriate margin. In the event of failure of the critical engine, operators may need to adopt alternative procedures.

Exposure**.** Any part of a flight during which a system or engine failure leading to a forced landing is likely to result in a hazardous or catastrophic outcome.

Exposure time. The period during which the performance of the helicopter with the critical engine inoperative in still air does not guarantee a safe forced landing or the safe continuation of the flight.

Final approach and take-off area. A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by helicopters operating in performance Class 1, the defined area includes the rejected take-off area available.

Note.— This requires an area free of obstacles, except for essential objects which because of their function are located on it, and of sufficient size and shape to ensure containment of every part of the design helicopter in the final phase of approach and commencement of take-off - in accordance with the intended procedures.

Hazard. A condition or an object with the potential to cause or contribute to an aircraft incident or accident.

Helicopter medical transport. A dedicated helicopter air medical operation which transports patients from helicopter medical transport (HMT) operating sites to heliports at health care facilities, and between such facilities.

Note.— An HMT flight includes all legs associated with a patient dispatch request, including the non-patient outbound response and repositioning legs of an HMT flight. It is intended that the following flight legs be regarded as integral parts of the HMT flight:

a) to and from the HMT operating site;

b) to and from a heliport for the delivery or pick-up of medical supplies and/or persons required for the completion of the HMT flight; and

c) to and from a heliport for refuelling which is required for the continuation of the HMT flight or for its return to flight-ready status.

Helicopter medical transport operating site. A site selected by the commander during an HMT flight for helicopter hoist operations, landing and take-off.

Helideck. A heliport located on a floating or fixed offshore structure.

Hostile environment. An environment in which:

a) a safe forced landing cannot be accomplished because the surface and surrounding environment are inadequate; or

b) the helicopter occupants cannot be adequately protected from the elements; or

c) search and rescue response/capability is not provided consistent with anticipated exposure; or

d) there is an unacceptable safety risk of endangering persons or property on the ground.

Landing distance available (helicopter). The length of the final approach and take-off area plus any additional area declared available and suitable for helicopters to complete the landing manoeuvre from a defined height.

Landing distance required (helicopter). The horizontal distance required to land and come to a full stop from a point 15 m (50 ft) above the landing surface.

Landing decision point. The point used in determining landing performance from which, an engine failure occurring at this point, the landing may be safely continued or a balked landing initiated.

Note.— Landing decision point applies only to helicopters operating in performance Class 1.

Non-congested-hostile environment. A hostile environment outside a congested area.

Non-hostile environment. An environment in which:

a) a safe forced landing can be accomplished because the surface and surrounding environment are adequate;

b) the helicopter occupants can be adequately protected from the elements;

c) search and rescue response/capability is provided consistent with anticipated exposure; and

d) the assessed risk of endangering persons or property on the ground is acceptable.

Note.— Those parts of a congested area satisfying the above requirements are considered non-hostile.

Operation. An activity or group of activities which are subject to the same or similar hazards and which require a set of equipment to be specified, or the achievement and maintenance of a set of pilot competencies, to eliminate or mitigate the risk of such hazards.

Note 1.— This term is normally used in qualified form such as: 'on an operation', 'in the operation', 'area of operation', 'intended area of operation', 'type of operation', etc.

Note 2.— Such activities could include, but would not be limited to, offshore operations, heli-hoist operations or HMT operations.

Operations in performance Class 1. 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 cases the helicopter must be able to land within the rejected take-off or landing area**.**

Operations in performance Class 2. 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.

Operations in performance Class 3. Operations with performance such that, in the event of an engine failure at any time during the flight, a forced landing will be required.

Performance-based regulatory oversight. An alternative regulatory oversight method which allows the operator to apply whatever means the operator deems appropriate and that is acceptable to the State, to achieve levels of safety performance acceptable to the State.

Prescriptive Compliance. See compliance-based regulatory oversight.

Rejected take-off distance required (helicopter). The horizontal distance required from the start of the take-off to the point where the helicopter comes to a full stop following an engine failure and rejection of the take-off at the take-off decision point.

Rejected take-off distance available (helicopter). The length of the final approach and take-off area declared available and suitable for helicopters operating in performance Class 1 to complete a rejected take-off.

Safe forced landing. Unavoidable landing or ditching with a reasonable expectancy of no injuries to persons in the aircraft or on the surface.

Safety. The state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level.

Safety performance indicator. A data-based parameter used for monitoring and assessing safety performance.

Safety risk. The predicted probability and severity of the consequences or outcomes of a hazard.

Take-off and initial climb phase. That part of the flight from the start of take-off to 300 m (1 000 ft) above the elevation of the FATO, if the flight is planned to exceed this height, or to the end of the climb in the other cases.

Take-off decision point. The point used in determining take-off performance from which, an engine failure occurring at this point, either a rejected take-off may be made or a take-off safely continued.

Note.— Take-off decision point applies only to helicopters operating in performance Class 1.

Take-off distance available (helicopter). The length of the final approach and take-off area plus the length of any clearway (if provided) declared available and suitable for helicopters to complete the take-off.

Take-off distance required (helicopter). The horizontal distance required from the start of the take-off to the point at which V_{TOSS}, a selected height and a positive climb gradient are achieved, following failure of the critical engine being recognized at TDP, the remaining engines operating within approved operating limits.

Note.— The selected height stated above is to be determined with reference to either:

a) the take-off surface; or

b) a level defined by the highest obstacle in the take-off distance required.

Take-off flight path. The vertical and horizontal path, with the critical engine inoperative, from a specified point in the take-off to 300 m (1 000 ft) above the surface***.***

Touchdown and lift-off area. A load bearing area on which a helicopter may touchdown or lift-off.

Note.— This requires a surface which is free of obstacles and of sufficient size and shape to ensure containment of the undercarriage of the most demanding helicopter the TLOF is intended to serve in accordance with the intended orientation.

ACRONYMS AND ABBREVIATIONS

(used in the manual)

AC	Advisory Circular (FAA)
AEO	All engines operating
AIP	Aeronautical Information Publication
ALSR	Acceptable level of safety risk
AMSL	Above mean sea level
ANC	Air Navigation Commission (ICAO)
ASAP	As soon as possible
ATC	Air Traffic Control
CAR	Canadian Aviation Regulation
CAT	Commercial air transport
CP	Committal point
D	Maximum dimension of helicopter
DPATO	Defined point after take-off
DPBL	Defined point before landing
DR	Distance travelled (helicopter)
EASA	European Aviation Safety Agency
EFS	Emergency Flotation System
FAA	Federal Aviation Administration
FADEC	Full authority digital engine control
FAR	Federal Aviation Regulations (US)
FATO	Final approach and take-off area
ft	Feet
HD	Helideck directory
HIGE	Hover in-ground effect
HMT	Helicopter medical transport
HOGE	Hover out-of-ground effect
HTSG	Helicopter/ Tilt-rotor Study Group (ICAO)
HV	Height velocity
IFR	Instrument flight rules
IFSD	In-flight shut-down
IMC	Instrument meteorological conditions
JAA	Joint Aviation Authorities
JAR-OPS	Joint Aviation Requirements – Operations
kts	Knots
LDAH	Landing distance available (helicopter)
LDP	Landing decision point
LDRH	Landing distance required (helicopter)
LOS	Limited obstacle sector
m	Metres
MR	Main rotor
MRCA	Minimum Rotorcraft Containment Area
nm	Nautical miles
OEI	One engine inoperative
OEM	Original equipment manufacturer
OFS	Obstacle-free sector
PC1	Performance Class 1
PC2	Performance Class 2
PC2e	Performance Class 2 enhanced
PC3	Performance Class 3
R	Rotor radius of helicopter

RFM	Rotorcraft flight manual
ROC	Rate of climb
RPM	Revolutions per minute
RTODAH	Rejected take-off distance available (helicopter)
RTODRH	Rejected take-off distance required (helicopter)
SARPs	Standards and Recommended Practices (ICAO)
SERA	Standardised European Rules of the Air
SFL	Safe forced landing
SMS	Safety management system
TCH	Type certificate holder
TDP	Take-off decision point
TLOF	Touchdown and lift-off area
TODAH	Take-off distance available (helicopter)
TODRH	Take-off distance required (helicopter)
VFR	Visual flight rules
VMC	Visual meteorological conditions
V_{50}	Speed at the 50 ft point in the take-off profile
V_{mini}	Minimum IFR Speed
V_{TOSS}	Take-off safety speed for helicopters certificated in Category A
V_Y	Best rate of climb speed
WAT	Weight/altitude/temperature

Chapter 1

INTRODUCTION

1.1 OVERVIEW

1.1.1 This manual provides guidance for States to establish a code of performance for international commercial air transport (CAT) helicopter operations in accordance with Annex 6 — *Operation of Aircraft*, Part III — *International Operations — Helicopters*, Section II, Chapter 3. States may also use this guidance when establishing the performance requirements for international general aviation helicopters in accordance with Annex 6, Part III, Section III, Chapter 3.

1.1.2 The guidance includes ways to establish a code of performance based on prescriptive compliance, and variations to the need for a safe forced landing (SFL).

1.1.3 Serious accidents and incidents occur in CAT for many reasons; engine failure is not the most prevalent of these. This manual does not attempt to address any of these apart from performance effects due to engine, and to some extent, system, failures. Mitigation, for causes/contributing factors other than engine failure, are addressed by the Standards and Recommended Practices (SARPs) outside those of Annex 6, Part III, Section II, Chapter 3. A systematic approach to addressing all causes can be found in Annex 19 — *Safety Management*, in particular Chapter 3. *State safety management responsibilities*, along with detailed guidance on safety management systems (SMSs) in Doc 9859, *Safety Management Manual*.

1.2 BACKGROUND

1.2.1 In formulating the Annex 6, Part III, performance SARPs in the 1980s, ICAO adopted the principle applicable to aeroplanes in Annex 6, Part I, of engine failure accountability or SFL.

1.2.2 With respect to performance operating limitations, the Foreword of Annex 6, Part I, illustrates the necessary integration of airworthiness and operational standards:

> "An element of the safety of an operation is the intrinsic safety of the aircraft, that is, its level of airworthiness. The level of airworthiness of an aircraft is, however, not fully defined by the application of the airworthiness Standards of Annex 8, but also requires the application of those Standards in the present Annex that are complementary to them."

1.2.3 Annex 6, Part III, was developed some time after the decision to include detailed guidance in Part I, and included the provision of an attachment to Annex 6, Part III, serving the same purpose.

1.2.4 The Joint Aviation Authorities (JAA) in Europe developed Joint Aviation Requirements – Operations (JAR-OPS 3) as the first helicopter requirements in compliance with the new ICAO performance standards in 1990, but quickly determined the need to reflect risk assessment and exposure. Specific variations to the standard were developed and the necessary changes were made to JAR-OPS 3. A proposal was subsequently submitted to the Air Navigation Commission (ANC) to amend Annex 6, Part III, accordingly.

1.2.5 In 2002, the Helicopter/Tilt-rotor Study Group (HTSG) was tasked with developing proposals for the introduction of a revision to Annex 6, Part III. The resulting SARPs provided States with a method of applying the intent of Annex 6 with a degree of flexibility that could be tailored to "acceptable safety risk" but provided little further guidance.

1.2.6 In 2017, the Flight Operations Panel was tasked by the ANC to provide a "Helicopter Code of Performance Development Manual" maintaining the overall aim of continued integration of Annexes 6, 8 and Annex 14 — *Aerodromes*[1].

1.3 SCOPE AND OBJECTIVES

1.3.1 The scope and objectives of this manual are to provide States with guidance on developing a code of performance, including variations without an SFL. It is designed to provide examples that meet the objectives of Annex 6, Part III, Section II, Chapter 3, 3.1.1, 3.1.2 and 3.1.3. The manual includes:

a) a detailed description of:

   1) the environment over which operations are conducted, and how it may be classified into hostile and non-hostile[2] to inform the process of constructing a code of performance;

   2) the helicopter airworthiness certification Categories A and B, their relationship to and application within an operational classification; and

   3) the performance classes, their development and extensions;

b) an example of operational objectives using the elements of the environmental classification, certification categories, and performance classes to inform a code of performance;

c) an example of "helicopter performance and operating limitations" (adapted from an earlier version of Annex 6, Part III, Attachment A);

d) an example of helicopter "performance regulation" (adapted from an earlier version of Annex 6, Part III, Attachment A);

e) an introduction to risk assessments, followed by examples of risk assessments that support the introduction of variations without an SFL in a performance code;

f) examples of variations without an SFL that may be introduced in a code of performance;

g) a discussion on mitigation — how to:

   1) reduce engine abuse and improve reliability of engines with specimen systems for establishing reliability and provide preventative maintenance and trend monitoring;

   2) increase the potential for an SFL with pilot training, route planning and selection;

---

[1] The closely integrated Annexes with respect to "performance operating limitations" include Annex 14; although not mentioned in this introduction, the effect of the "code of performance", set out in accordance with Annex 6, Part III, Section II, Chapter 3, 3.1.2, has a direct effect on the SARPs of Annex 14.

[2] Including the subsets of hostile.

3) better protect occupants during a forced landing; and

4) enhance post forced landing survival.

Chapter 2

HELICOPTER CODE OF PERFORMANCE BASED ON ESTABLISHED PERFORMANCE CLASSES

2.1 THE ENVIRONMENT OVER WHICH OPERATIONS ARE CONDUCTED

2.1.1 General

Environmental classification informs the process of establishing safe carriage of commercial air transport (CAT) passengers over varied surfaces, terrain, features, and in changing conditions. It is also used for over water operations to ensure an adequate standard of safety equipment is fitted, carried and worn, and appropriate procedures used.

2.1.2 Classifying the environment

All areas to/from and over which operations are conducted are either non-hostile or hostile (see Figure 2-1-1). The definitions contained in Annex 6 are as follows:

Non-hostile environment. An environment in which:

a) a safe forced landing can be accomplished because the surface and surrounding environment are adequate;

b) the helicopter occupants can be adequately protected from the elements;

c) search and rescue response/capability is provided consistent with anticipated exposure; and

d) the assessed risk of endangering persons or property on the ground is acceptable.

Note.— Those parts of a congested area satisfying the above requirements are considered non-hostile.

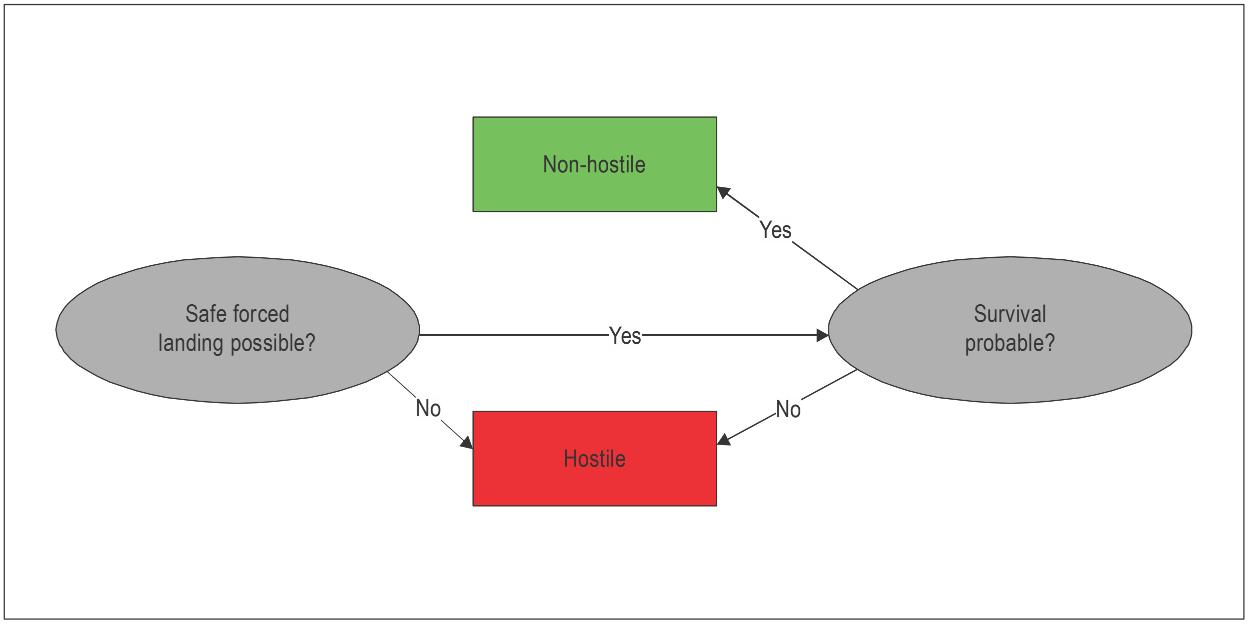

Figure 2-1-1 Hostile/Non-Hostile

***Hostile environment*.** An environment in which:

a) a safe forced landing cannot be accomplished because the surface and surrounding environment are inadequate; or

b) the helicopter occupants cannot be adequately protected from the elements; or

c) search and rescue response/capability is not provided consistent with anticipated exposure; or

d) there is an unacceptable risk of endangering persons or property on the ground.

2.1.2.1 *Safe forced landing (SFL)*[1]

2.1.2.1.1 The term safe forced landing originates from Annex 6, Part I where it applies to the consequence of an engine failure and forced landing on an unprepared surface with a single-engine aeroplane. Because of the unpredictable nature of arrival of the unpowered aeroplane at the surface — the choice of which has been driven by the limiting nature of the glide and required manoeuvring — there is a probability that the landing will result in damage to the aeroplane.

2.1.2.1.2 The same conditions apply to a helicopter, albeit that the area in which the landing can be achieved will be reduced by the steeper angle of glide and slower forward speed. As with the single-engine aeroplane, there is a probability that the unpowered, or not fully powered, landing will result in damage to the helicopter.

2.1.2.1.3 The outcome of an SFL includes known uncertainty — which is expressed as "…reasonable expectancy of

---

[1] For additional information on the derivation and meaning of a safe forced landing, see the description in Sections 3.2.2 and 3.2.3.

no injuries to persons in the aircraft or on the surface" in the definition. This uncertainty can be correlated with the safety risk severity category of "Major" as in the example safety risk severity table in the *Safety Management Manual* (Doc 9859):

> ***MAJOR***.
>
> a) A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency
>
> b) Serious incident
>
> c) Injury to persons

2.1.2.1.4 A key element of the environmental classification is the existence of a surface on which a safe forced landing (SFL) (both on land and water) can be carried out. Some surfaces are generally suited for a safe (forced) landing — these include:

a) runway/helipad

b) prepared reject area

c) open field

d) extensive farms

e) bog/marsh

f) shrubs/bushes of a reasonable height

g) large clearings

Other surfaces do not generally allow for an SFL — these include:

a) forest/trees

b) rough terrain

c) sloping ground

d) buildings

2.1.2.1.5 Most operating areas consist of a mix of features. These could predominantly be farmland or open fields separated by hedgerows, fences or lines of trees/forest bands, where SFL surfaces are in abundance.

2.1.2.1.6 Alternatively, the area might consist of rough terrain or tree-covered terrain with scattered level areas or clearings. Here, available surfaces for making an SFL will be present but more widely dispersed. These are areas which may be overflown employing a suitable height and routing, such that the option of an SFL is always maintained.

2.1.2.1.7 Some environments present challenges because surfaces suitable for an SFL are very sparse, or absent, due to the extent and/or density of the features. These areas present the difficulty that a surface suitable for an SFL cannot be reached from a practical height or from any reasonable flight route through the area — these might be extensive tracts of:

a) forests

b) mountainous areas

c) sea areas

d) congested areas

2.1.2.1.8 The protection of occupants during touchdown and evacuation may also be dependent upon the level of crashworthiness and safety equipment worn and fitted; damage to the helicopter during the landing is accepted but with a reasonable expectation of no injuries.

2.1.2.2 *Safe forced landing (ditching)*

2.1.2.2.1 Over water operations are conducted in the knowledge that emergency situations may arise which may require an immediate or forced landing[2]. Accordingly, Annex 6, Part III, Section II, 2.2.12[3] and 4.5.1, specify those circumstances when certification for ditching is required and adequate flotation and safety equipment must be carried; "sea state"[4] is an integral part of ditching information.

2.1.2.2.2 Experience has shown that ditching/water impact events can lead to avoidable loss of life in otherwise survivable water impacts. There have been avoidable drowning fatalities due to the inability of the occupants to rapidly escape from a capsized and flooded cabin or, after having successfully escaped, their subsequent inability to survive until the rescue services arrived. Even a successful helicopter ditching could still have catastrophic consequences due to the risk of a helicopter capsizing.

2.1.2.2.3 Helicopters flying over water may be certified for ditching or use certified "emergency floatation" systems. Certification for ditching is required for over-water flights in a hostile environment in accordance with Annex 6, Part III, Section II, 2.2.12. In 2018, more stringent design requirements were put into place that required "resistance to capsize in the sea conditions selected by the applicant" for both types of equipment. Both emergency floatation and ditching capability are demonstrated to a certain wave height or sea state. The demonstrated floatation capability should be taken into account to determine tolerance to the expected sea conditions.

2.1.2.2.4 Enhanced design standards were developed to both reduce the likelihood of capsize and further improve the ability of occupants to escape and survive. The amendment to certification improves the probability of survival for occupants in the event of either a helicopter ditching or a survivable water impact. This is achieved by introducing a new flotation stability certification methodology that takes into account the sea conditions for which certification is requested. In addition, the structural ditching provisions have been refined and the physical requirements for emergency exits and seating have been improved to enable occupants to make their escape in the event of either a ditching or a capsize as a result of a survivable water impact. Furthermore, the provisions for emergency flotation systems (EFSs), emergency and survival equipment, and emergency locator transmitters, have been enhanced.

2.1.2.2.5 Following a forced landing in water, the landing (water entry) and subsequent escape by occupants will be conditional upon the efficacy of the equipment — fitted, carried and worn — in the environmental conditions that exist at the time of the event.

---

[2] Aircraft emergency checklist contains failures that require pilots to "land immediately" that are not related to engine failure; there are examples of these having occurred in offshore operations in hostile environments.

[3] Annex 6, Part III, Section 2, 2.2.12, states that "All helicopters on flights over water in a hostile environment… shall be certificated for ditching. Sea state shall be an integral part of ditching information". This recognizes that for flight over a non-hostile environment, the fitting of "emergency flotation equipment" will provide sufficient protection.

[4] The term "sea state" is likely to be replaced in due course by "significant wave height". The significant wave height H_s is the most common and accepted parameter used to define the representative wave height of an irregular sea state.

2.1.3 Application of the classification

2.1.3.1 *Application to forested areas*

2.1.3.1.1 Forests may be classified as hostile due to their lack of SFL areas. When assessing the “hostile classification” of forests, consideration has to be given not only to the size of the forest, but also to its contiguous canopy, clearings or grasslands. A suitable height and route selection can also positively affect reaching the next SFL area.

2.1.3.2 *Application to mountainous areas*

2.1.3.2.1 Mountainous areas may be hostile because of rugged terrain, forestation (the consequential lack of SFL areas), and diminished survival prospects; the effect of density altitude on performance may also have to be considered.

2.1.3.2.2 Hostility due to altitude may have to be carefully assessed; differentiating between the approach and landing, and cruise flight, phases in mountainous areas may be necessary.

2.1.3.3 *Application to sea areas*

Judgement is required when applying the definition of SFL to over water flights as injury to persons in the aircraft extends beyond the touchdown and includes possible capsize, the subsequent evacuation and access to safety equipment (such as life vests and life rafts) under, what might be, difficult conditions.

2.1.3.3.1 *General*

2.1.3.3.1.1 The boundary between hostile and non-hostile for over water flights will depend on the sea state over which the operation is being performed, the certification of the flotation equipment, the additional safety equipment, fitted and worn, and the time to rescue. It is suggested that water surface conditions, equal to or higher than sea state code 4 (see Table 2.1), is one basis for establishing hostility.

2.1.3.3.1.2 When applying a “hostile classification” to sea areas, it may be necessary to decide where the coastline boundary is set. Consideration of estuaries, fjords, and aggregation of offshore islands may be required. The use of the term “open sea areas”[5] should provide sufficient flexibility to enable each State to determine the coastal boundary that reflects its topographical circumstances.

2.1.3.3.1.3 Sea areas are prone to frequent, and sometime rapid, changes of weather. The sea state and the hostility of the sea may vary. The transient nature of these conditions should be addressed.

2.1.3.3.2 *Addressing transient hostility*

2.1.3.3.2.1 A study of wave climates along a representative selection of main helicopter routes in the northern North Sea and west of Shetland indicates that sea state code 4 will be exceeded on 26% — 36% of occasions over the entire year. During the winter period between December and February, this increases to between 51% — 65%. When considering such areas for routine offshore operations they can, and should, be regarded as permanently hostile.

2.1.3.3.2.2 There are open sea areas which are primarily hostile but “transiently” non-hostile — the southern North Sea is an example. Conditions cannot be assured for any length of time — sometimes not even over the extent of a flight. In view of this, it may be necessary for the regulator to declare such an area as hostile. This could be achieved by appending a further element to the State definition of hostile specifying where such boundaries might be placed — an example might be:

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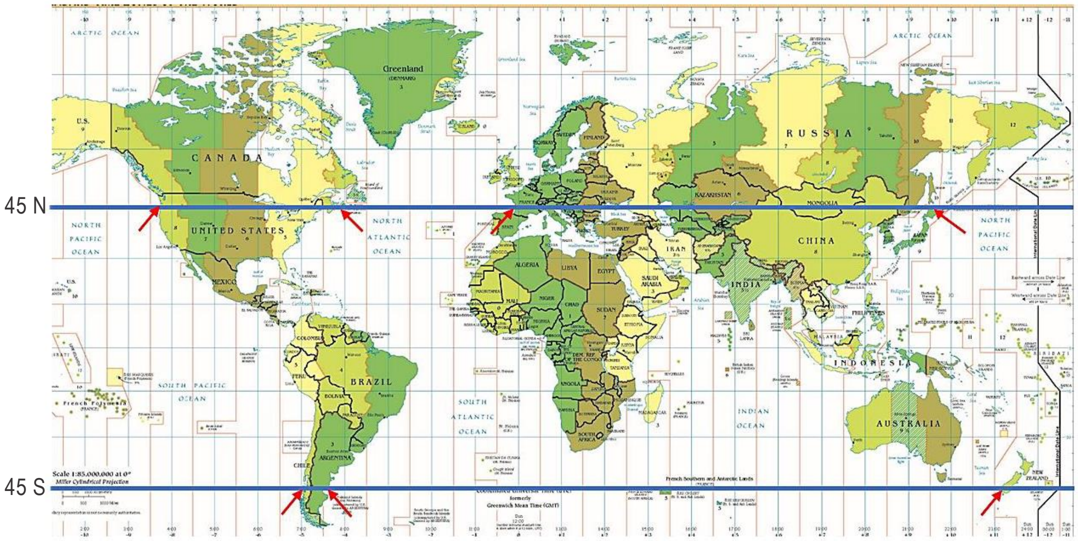
[5] In Europe, “open sea area” is now defined as “to seaward of the coastline” and States should define their coastline in their Aeronautical Information Publication (AIP) or other documentation.

> *"In any case, the following areas shall be considered hostile:*
>
> *(i) For overwater operations, the open sea areas North of 45N*[6] *and South of 45S*[7] *unless any part is designated as non-hostile by the responsible authority of the State in which the operations take place. [Designation would appear in the relevant AIP.]"*



Portland Oregon, Halifax NS, Bordeaux Fr, Hokkaido JN
Puerto Aysén Ch, Camarones Arg, Dunedin NZ

Figure 2-1-2 Boundaries of hostile open-sea areas

2.1.3.3.2.3 There are also open sea areas which are primarily non-hostile but become hostile in some weather patterns — the Gulf of Mexico is an example. Transient hostility should be addressed within the safety management process and should result in an adverse weather policy (this is for operators to provide in their operations manuals as an element of their safety management system). Where operators are in close proximity or serving similar locations, a harmonized adverse weather policy could avoid unnecessary commercial pressure to operate in marginal conditions.

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[6] This northerly line of latitude passes through Portland, Oregon; Halifax, Nova Scotia; Bordeaux, France; and Hokkaido, Japan.

[7] The southerly line of latitude passes through Puerto Aysén, Chile; Camarones, Argentina; and Dunedin, New Zealand.

2.1.3.4 *Application to congested areas*

2.1.3.4.1 The definition of a congested area was produced initially for aeroplanes but applies to all air vehicles and is used in the provision of a “land clear” clause. This definition is too broad for helicopters because it precludes an otherwise safe operation over areas where a helicopter autorotation and SFL could be conducted — for example the heli-lanes established in some cities which are, by definition, in congested areas.

2.1.3.4.2 In order to provide the necessary flexibility and permit (safe) helicopter operations over this “assessed”[8] non-hostile environment, the definition of a congested hostile environment was introduced into Annex 6, Part III.

2.1.3.4.3 This definition was intended to make clear that all parts of a congested area in which an SFL could not be accomplished were hostile; and, conversely, those areas within a congested area where an SFL could be accomplished “without undue hazard to persons and property on the surface” were non-hostile.

2.1.3.4.4 Further clarification of this concept was provided in the ICAO definition of a non-hostile environment — specifically, clause d) and the subsequent *Note*.

2.1.3.4.5 Although the absence of an area for an SFL is the main discriminator for defining a congested hostile environment, third-party risk in open spaces should also be considered.

2.1.3.4.6 This clarification can be used to assist in compliance with Annex 2 — *Rules of the Air*, which contains Standards for flights over a congested area “…without undue hazard to persons or property on the surface”.

Table 2-1.

SEA STATE CODE

(WORLD METEOROLOGICAL ORGANIZATION)

Sea State Code		Significant Wave Height		Wind Speed
	Description of Sea	Metres	Feet	Knots
0	Calm (Glassy)	0	0	0-3
1	Calm (Rippled)	0 to 0.1	0 to 1/3	4-6
2	Smooth (Wavelets)	0.1 to 0.5	1/3 to 1 2/3	7-10
3	Slight	0.5 to 1.25	1 2/3 to 4	11-16
4	Moderate	1.25 to 2.5	4 to 8	17-21
5	Rough	2.5 to 4	8 to 13	22-29
6	Very Rough	4 to 6	13 to 20	28-47
7	High	6 to 9	20 to 30	48-55
8	Very High	9 to 14	30 to 45	56-63
9	Phenomenal	Over 14	Over 45	64-118

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[8] The matter of “assessed by whom” is left moot at this point; there are two possibilities: a static assessment (by the State); or a dynamic assessment (by the pilot — taking into account the transit height). Clearly, a combination of the two would provide maximum flexibility with a safe result.

Notes:

(1) The significant Wave Height is defined as the average value of the height (vertical distance between trough and crest) of the largest one-third of the waves present.

(2) Maximum Wave Height is usually taken to be 1.6 x Significant Wave Height; e.g., Significant Wave Height or 6 metres gives Maximum Wave Height of 9.6 metres.

(3) Winds speeds were obtained from Appendix R of the "American Practical Navigator" by Nathaniel Bowditch, LL.D.: Published by the U.S Naval Oceanographic Office, 1966.

2.2 AIRWORTHINESS CATEGORIES AND THE PERFORMANCE CLASSES

Note.— In this Section, the helicopter certification standards of Parts 27 and 29[9] *are used as examples of Annex 8-compliant airworthiness standards to show the relationship between the airworthiness categories and the performance classes.*

2.2.1 General

2.2.1.1 The certification requirements of Parts 27 and 29 are there to facilitate the provision of a helicopter type that is certificated to "normal/small", "transport/large", and "Category A/Category B" — together with appropriate procedures and limitations in the rotorcraft flight manual (RFM).

2.2.1.2 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 but are not applied retrospectively.

2.2.1.3 How and when the RFM procedures, and in some cases limitations, are required to be applied, should be described in a performance classification that is suited to the conduct of operations.

2.2.2 Certification categories — Category A (ICAO)

2.2.2.1 Category A is a helicopter certification standard based on a set of design requirements including engine and system isolation features. Engine isolation ensures that one engine failure is unlikely to lead to a second, and fire in an engine compartment can be detected, contained and/or extinguished. Category A certified helicopters are capable of continued safe flight or landing following any first failure including engines. For Category A certification, continued safe flight and landing is interpreted as continuing on to the original destination (or a suitable alternate) or returning to the point of departure.

2.2.2.2 Category A also includes the provision of performance data so that one engine inoperative (OEI) flight and obstacle clearance from take-off, through climb, cruise and landing can be achieved. This data includes: mass related take-off and landing procedures; heliport/helideck size limitations; climb gradients (or rates of climb and distances); and, one-engine inoperative climb performance graphs to meet the objective:

> "a multi-engine helicopter…capable of operations using take-off and landing data scheduled under a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight or safe rejected take-off".[10]

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[9] Parts 27 and 29 refer to the harmonized text of US Federal Aviation Regulations Parts 27 and 29 and EASA Certification Specifications CS 27 and 29.

[10] Extract taken from the definition of Category A in Annex 8.

2.2.2.3 It should be noted that certification provides a capability and does not set an operational requirement.

2.2.3 Certification categories — Category B (ICAO)

2.2.3.1 Category B is a certification standard for all single-engine or multi-engine helicopters which do not meet the Category A standard. Category B helicopters have no guaranteed ability to continue safe flight in the event of engine or system failure and a forced landing is assumed.

2.2.3.2 Category B performance requires the provision of all engines operating (AEO) hover, climb, and take-off distance data (under Annex 8: where required by operating rules), along with take-off procedures to ensure that, “a landing can be made safely at any point along the flight path if an engine fails”.[11]

2.2.4 Applicability of Categories A and B in Parts 27 and 29

2.2.4.1 *Part 27 — Normal Category/Small Rotorcraft*

2.2.4.1.1 Certification in Part 27 is to the “Normal Category/Small Rotorcraft”; this standard is considered to be equivalent to Category B.

2.2.4.1.2 A Part 27 helicopter type may be certificated as Category A if it meets the additional design, installation and performance requirements contained in Appendix C[12] of Part 27 — which contains references to Category A paragraphs contained in Part 29.

2.2.4.2 *Part 29 — Transport Category/Large Rotorcraft*

The applicability of the Category A and Category B standards is contained in Part 29.1. The significant clauses are:

2.2.4.2.1 “***(b) Large rotorcraft [Transport category] must be certificated in accordance with either the Category A or Category B requirements. A multiengine rotorcraft may be type certificated as both Category A and Category B with appropriate and different operating limitations for each category.”***

2.2.4.2.1.1 This is transparent to the operator only if the RFM contains a clear statement of the “different operating limitation for each category”. This might be in the form of an entry in the limitation section of the RFM of the number of passenger seats or the height velocity (HV) diagram (the HV diagram could be a limitation or be provided as information) or any other operational limitations.

2.2.4.2.2 “***(c) Rotorcraft with a maximum weight greater than 9 072 kg (20 000 pounds) and 10 or more passenger seats must be type certificated as Category A rotorcraft.***”

2.2.4.2.2.1 All the provisions of Category A must be fulfilled – including those that are contained in Subpart B (which means that the RFM is required to contain the Category A performance procedures and graphs and include the HV diagram as a limitation). However, the range of procedures may be limited and might only include that for runway operations.

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[11] Part 29.63 Take-off: Category B — paragraph (c)

[12] Appendix C to FAR Part 27 outlines “A small multiengine rotorcraft may not be type certificated for Category A operation unless it meets the design installation and performance requirements contained in this appendix in addition to the requirements of this part.” *Note — on the type certificate data sheet (TCDS), these rotorcraft remain certified in the normal/small category with a reference appended to the certification basis for the purposes of Category A.*

2.2.4.2.3 “***(d) Rotorcraft with a maximum weight greater than 9 072 kg (20 000 pounds) and nine or less passenger seats may be type certificated as Category B rotorcraft provided the Category A requirements of Subparts C, D, E, and F are met.”***

2.2.4.2.3.1 The helicopter must meet the “engine and system isolation features” of Category A but does not have to meet the Category A performance criteria.

2.2.4.2.3.2 If the helicopter is dual certificated, the main operational distinctions will be the limit on passenger seat numbers and the HV diagram status.

2.2.4.2.4 “***(e) Rotorcraft with a maximum weight of 9 072 kg (20 000 pounds) or less but with 10 or more passenger seats may be type certificated as Category B rotorcraft provided the Category A requirements of CS 29.67(a)(2), 29.87, 29.1517, and of Subparts C, D, E, and F are met.”***

2.2.4.2.4.1 This is a Category B helicopter with the majority of the features required under Category A: although the helicopter must meet the Category A “engine and system isolation features”, the only Subpart B, Category A elements that have to be provided are the second segment climb and the HV diagram limitation. No Category A take-off and landing procedures have to be included in the RFM.

2.2.4.2.5 “***(f) Rotorcraft with a maximum weight of 9 072 kg (20 000 pounds) or less and nine or less passenger seats may be type certificated as Category B rotorcraft.”***

2.2.4.2.5.1 This is a Category B helicopter.

2.2.4.2.5.2 If the helicopter is dual certificated under 29.1(e) and (f), it will have the “engine and system isolation features” of Category A; the main operational distinctions will be the limit on passenger seats and the HV diagram status.

2.2.5 Direct application of certification categorization to operations

2.2.5.1 *General*

2.2.5.1.1 All performance procedures in the RFM remain optional unless mandated in the RFM or specified by an operational rule. As a result, application to the operations domain depends on the performance code.

2.2.5.1.2 The majority of helicopters in current use are “small” (≤ 3 175 kg (7 000 lbs) with nine or fewer passenger seats) certificated under Part 27[13]; these helicopters are mostly certificated in Category B (or equivalent) but include several sophisticated multi-engine types — some of which are (additionally) certificated in Category A in accordance with Appendix C of Part 27.

2.2.5.1.3 For helicopters certificated under Part 29, the picture is more complex. Multi-engine helicopters may be certificated as Category A, Category B or both with appropriate and different operating limitations for each category.

2.2.5.2 **Application of certification in Category B**

2.2.5.2.1 Certification does not prescribe how a Category B (or equivalent) certificated helicopter is flown. Performance data and procedures that are deemed safe are provided in the RFM. HV curves are provided outside the limitation section of the RFM (except for Category B helicopters certified under 29.1(e)).

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[13] The mass and passenger limitation are the maximum permitted (Part 27.1(a)).

2.2.5.2.2 Certification does not restrict the type of surface over which the take-off (or landing) might be conducted in operations nor consider the obstacle environment. Flight manuals provide a take-off and landing procedure that remains clear of the HV curve.

2.2.5.2.3 It is left to the operational regulations to specify how and when Category B performance data and procedures are applied.

2.2.5.3 **Application of certification in Category A**

2.2.5.3.1 Certification also does not prescribe how a Category A certificated helicopter is flown. Category A performance data and procedures (more than one in most cases) are provided. The HV diagram should be in the limitations section unless the approved Category A procedures are mandated in the RFM.

2.2.5.3.2 In some States, the definition of Category A includes the term "utilizing…" rather than "capable of operations using…" "take-off and landing data". If the term "utilizing" is considered by the State to be prescriptive, it could preclude the use of a Category A helicopter at a site other than one which meets the Annex 14, performance Class 1 standard or be dual certificated and restricted to carriage of nine or fewer passengers.

2.2.5.3.3 It is left to the operational regulations to specify how and when the Category A performance data and procedures are applied. This can be achieved by being very specific in the operational regulations (i.e. requires the use of Category A certified helicopter flown in accordance with the Category A limitations and procedures of the RFM).

2.2.5.3.4 If the helicopter is certificated only under Category A, these procedures and limitations are mandatory independent of any requirements in a performance code.

2.2.6 Three performance classes

2.2.6.1 There is a need for more precise "operational" terms, since the terms "operating in Category A" and "operating in Category B" have:

a) no understanding of the operational environment;

b) no knowledge of the surfaces to, from and over which operations are conducted; and

c) no accepted regulatory meaning in operations.

2.2.6.2 It is necessary to specify, in operational requirements, how and when the certificated procedures, and in some cases limitations, are to be applied. This can be achieved by mapping from certification capability to operations using a three-level classification as follows:

2.2.6.2.1 *Helicopters:*

a) Certificated in Category A, with take-off and landing procedures, can[14] continue to destination (or suitable alternate) or return to the point of departure with engine failure accountability — this requires either:

   1) a runway and the associated profile; or

   2) a specific Category A procedure/profile and, in some cases, the application of a restricted take-off mass;

---

[14] If the RFM contains the specified take-off procedure.

b) certificated in 29.1(e) without take-off and Category A landing procedures, can achieve OEI climb at a defined speed — at a specified take-off mass;

c) certificated in Category B have AEO take-off and landing procedures — at the maximum take-off mass.

2.2.6.2.2 These capabilities, in respect of surface dimensions, space and mass, are reflected in the three performance classes:

a) performance Class 1: reflects the capability specified in a);

b) performance Class 2: reflects the capability specified in b) and c); and

c) performance Class 3: reflects the capability specified in c).

2.2.6.3 There is correlation between the Category A take-off and landing procedures defined in Part 29 and those required for operation in Performance Class 1 — and in some cases Performance Class 2[15] .

2.2.6.4 There is correlation between the take-off and landing procedures defined in Part 27 and Category B in Part 29, and those required for operation in performance Classes 2 and 3. Both require a corridor and surface over which to accelerate to the knee of the HV curve.

2.2.6.5 Under Part 29, the Category B procedures include establishment of:

For the Category B take-off:

a) the take-off weight/altitude/temperature (WAT);

b) the defined surface;

c) the distance required to take-off and climb over a 15 m (50 ft) obstacle; and

d) a profile outside of the HV curve such that a safe landing can be made at any point along the flight path if an engine fails.

For the Category B landing:

a) the landing WAT;

b) a defined surface;

c) the landing distance from 15 m (50 ft); and

d) a profile outside of the HV curve such that a safe landing can be made at any point along the flight path if an engine fails.

2.2.6.6 Sections 2.3, 2.4 and 2.5 further explain how the performance classes may be implemented.

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[15] Where the mass and the profile can be used but the surface would not permit a reject without damage to the undercarriage/helicopter.

2.2.7 Summary

2.2.7.1 Helicopter types certificated in Category A are capable of operations in Performance Class 1, 2 or 3.

2.2.7.2 Helicopter types certificated in Category B in accordance with 29.1(e) are capable of operations in performance Classes 2 or 3.

2.2.7.3 Helicopter types certificated in accordance with the performance provision in Part 27 and in Category B under the provisions of Part 29.1(d) and (f) are capable of operations in performance Class 3.

2.2.7.4 The Category A provisions in Part 29 meet the “engine and system isolation features” such that the malfunction of an engine, failure of a system or the required action of the crew to resolve an abnormal condition will not prevent continued safe flight. These requirements conform to the standard for operations in performance Classes 1 and 2.

2.2.7.5 The terms “Category A Operation” contained in Appendix C to Part 27, and “Category A (B) Operation[16]” in RFMs that are both Categories A and B certified, have no direct application to operations unless referred to in a performance code.

2.2.7.6 The “code of performance” should apply a mapping between the certification codes of Category A and B and the operational classification. Such a classification should be based upon the number of passengers carried and have consideration of the surface conditions to, from, and over which the flight is being conducted.

2.3 PERFORMANCE CLASS 1 (PC1)

2.3.1 Introduction

This Section discusses the fundamentals of operating in performance Class 1 as contained in Annex 6, Part III, Section II, Chapter 3.

2.3.2 What does Category A bring to performance Class 1?

Category A (see Section 2.2.2), is a helicopter certification standard which provides assurance of continued flight with 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 (see Figure 2-3-1).

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[16] Also used are variations such as “Operations in Category A” or “Operations in Category B”.

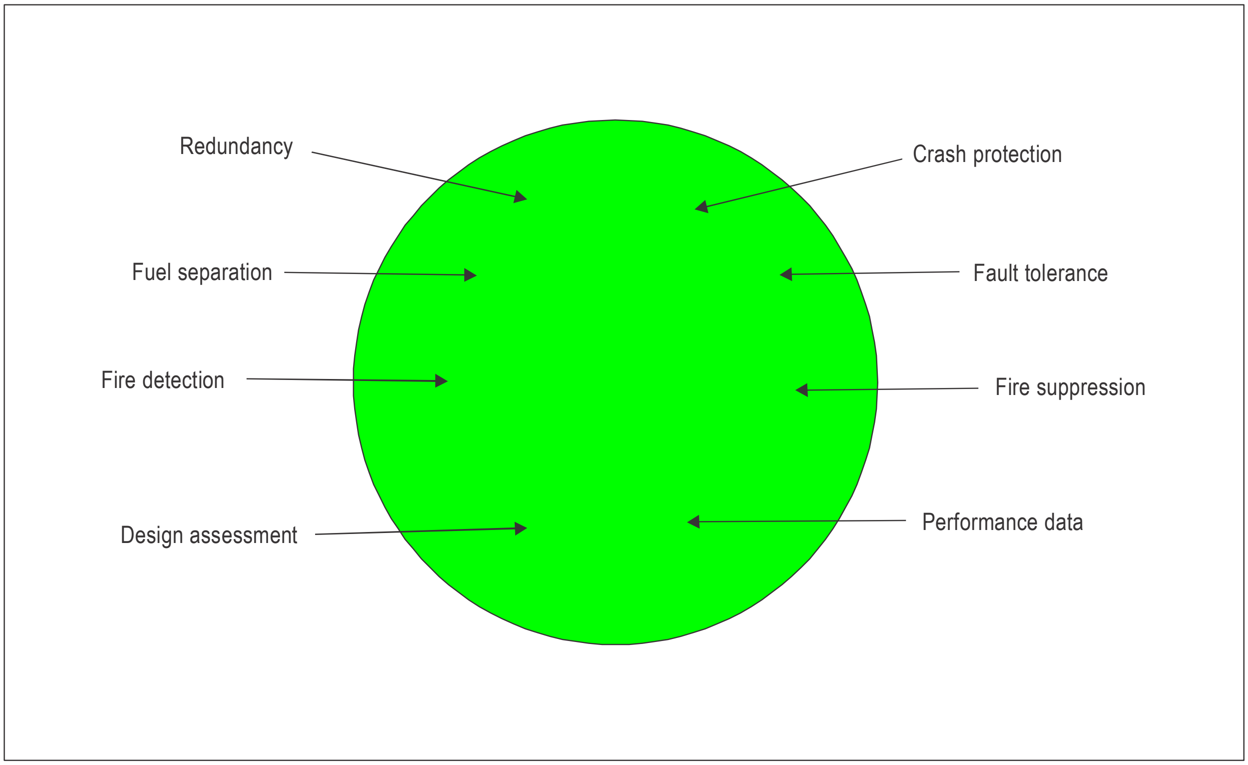

Figure 2-3-1 Category A Certification

2.3.3 Obstacle clearance — PC1 take-off

2.3.3.1 The Category A procedures provide non-adjusted profiles — i.e. they specify only the climb performance required by the rule (not a gradient[17]) and take-off mass is established in a weight/altitude/temperature (WAT) graph. Although a specific Category A procedure takes account of obstacles within the take-off distance required (helicopter) (TODRH), it has no knowledge of those in the take-off flight path.

2.3.3.2 Helicopter procedures derive from aeroplane Category A procedures. At an aerodrome, the approach and take-off climb surface slope profile is standard, or known, and promulgated. This permits the aeroplane manufacturer to provide Category A procedures with take-off climb gradients that can be used universally.

2.3.3.3 Heliports have had a much more informal development path: generally, surface areas are provided and declared, and manufacturers provide basic climb data. PC1 can be employed at aerodromes with standard gradients, or at heliports in obstacle-rich environments — using the unique characteristics of helicopters and coupled with specific and flexible Category A procedures. The downside to this flexibility is that obstacle clearance is put within the ambit of operational requirements and the precise flight path (clearing all obstacles) must be established by the operator.

2.3.3.4 Take-off procedures divide into two distinct groups[18]: runway-type procedures — with or without obstacles in the take-off flight path (shown in Figures 2-3-2, 2-3-3 and 2-3-4); and those with a vertical element — with obstacles in the take-off distance required and, perhaps, in take-off flight path (shown in Figures 2-3-5 to 2-3-7 below).

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[17] Although gradients are provided by some manufacturers.

[18] These groupings are addressed in the two variants of the definition of take-off distance required shown in 2.4.2 — Definitions.

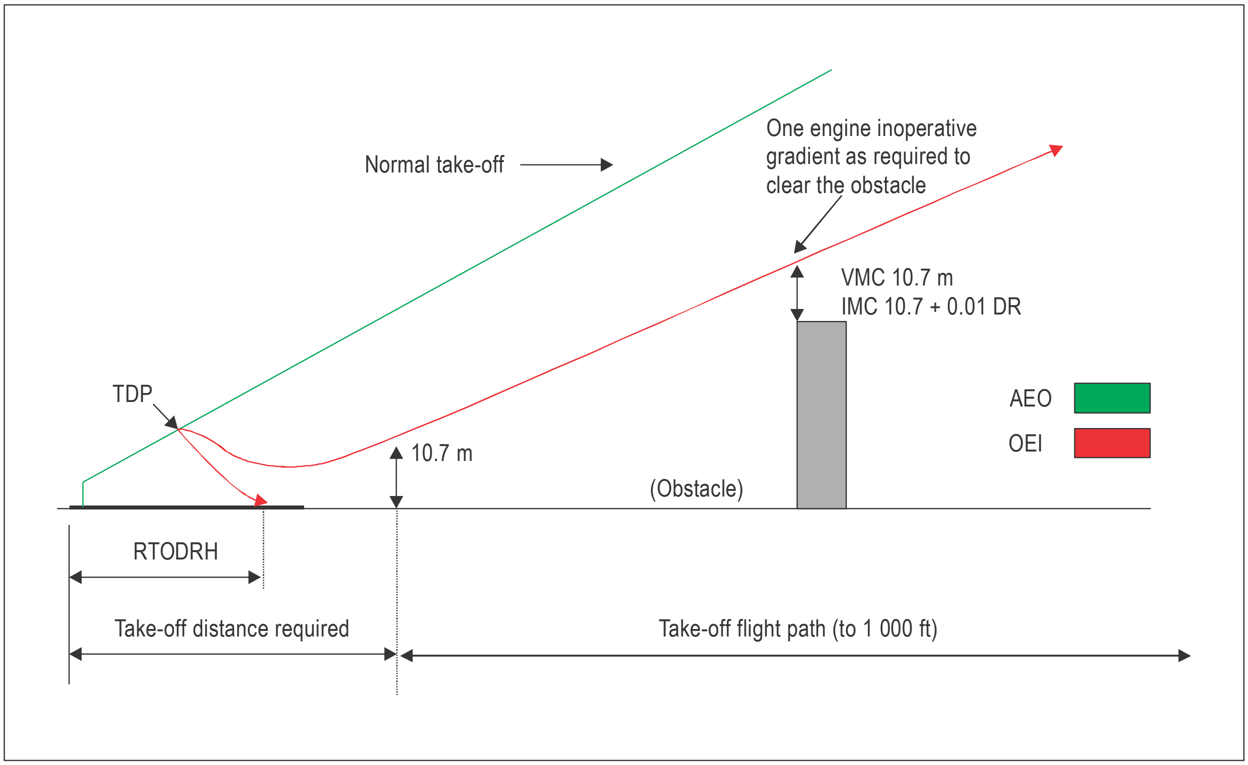

Figure 2-3-2 Performance Class 1 take-off (side view)

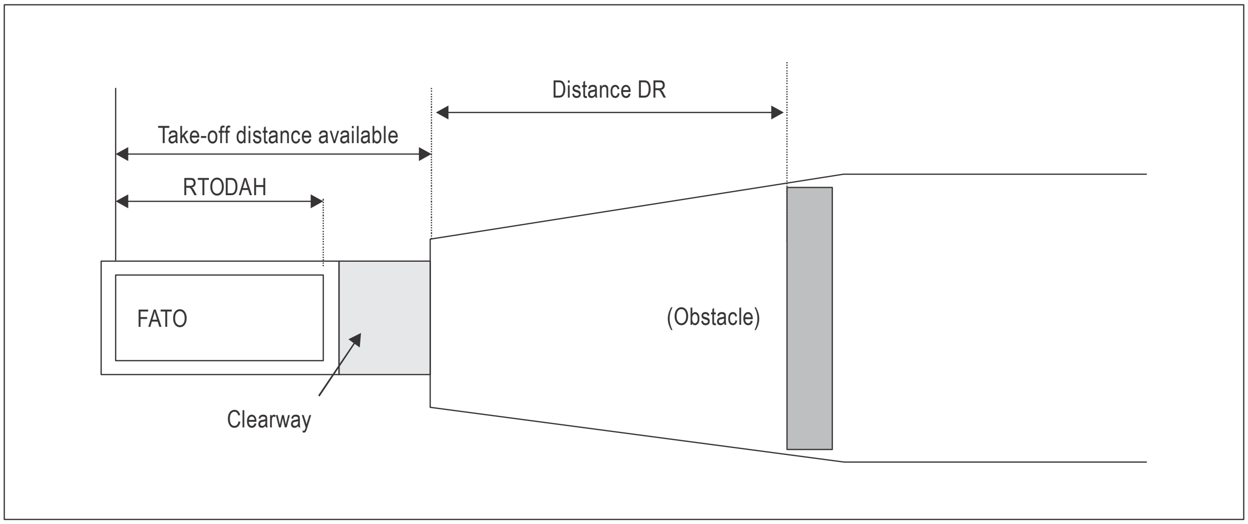

Figure 2-3-3 Performance Class 1 take-off (plan view)

2.3.4 PC1 take-off using Category A procedures

2.3.4.1 There are basically three types of Category A procedures (different names may be used in RFMs): the clear area; the restricted area; and the helipad (ground level and elevated):

2.3.4.1.1 ***The clear area procedure** (*Figure 2.3.4*)*: is a runway-type procedure that is normally provided to fulfil the minimum requirement[19] for the Category A data specified in Parts 27 and 29. Distances will be provided and consist of: the rejected take-off distance required (helicopter) (RTODRH); the take-off distance required (helicopter) (TODRH); the landing distance required (helicopter) (LDRH); the first and second segment climb performance data; and the distance to V_Y at 60 m (200 ft) (the start of the second segment).

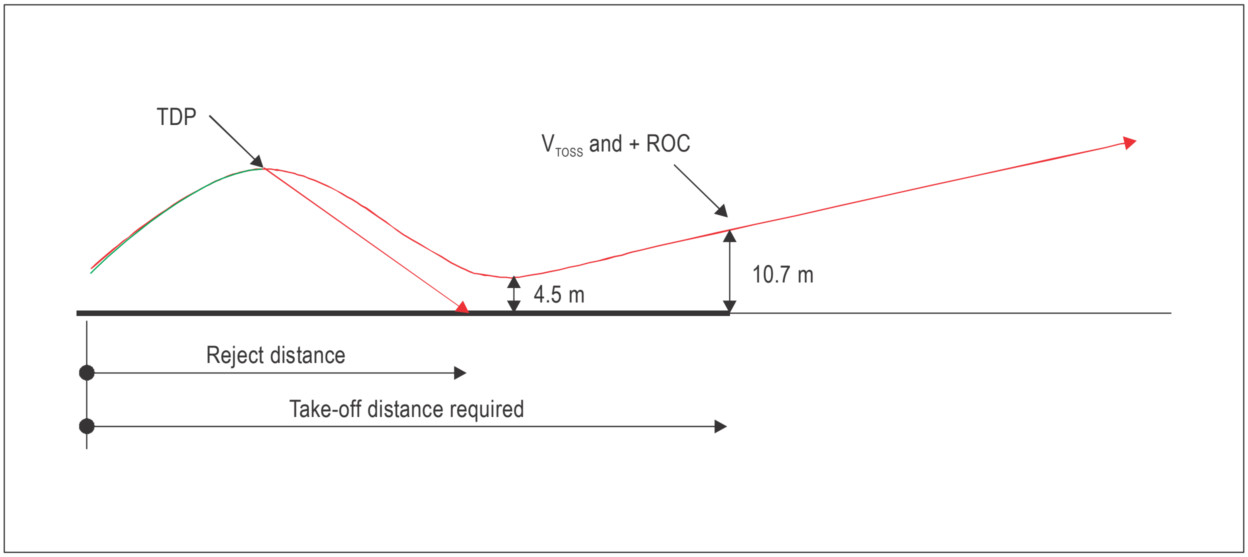

Figure 2-3-4 Clear area procedure

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[19] When this is provided, the helicopter can be designated as a Category A helicopter.

2.3.4.1.2 ***The restricted area (confined space) procedure*** (Figure 2-3-5); can be provided in a number of ways; an oblique steep climb, or vertical climb procedure - both with an oblique rejected take-off - are two common examples. As with the clear area procedure, distances will be provided. Features of this procedure are access to variable V_{TOSS} (which can reduce the take-off distance, against a possible reduction in take-off mass), and a variable take-off decision point (TDP) which, as it is raised, will permit higher-obstacles to be cleared (min-dip[20] must be set to 10.7 m (35 ft) above the highest obstacle in the continued take-off). The main constraint in this procedure is the amount of rejected take-off distance available — i.e. an oblique reject will require more space as the height of the TDP increases. A vertical reject can be used but it introduces visibility issues because of the limited field of vision ahead of the helicopter; this can be partially resolved by adding a sideways element to the vertical climb and providing visibility through the chin window or pilot's door.

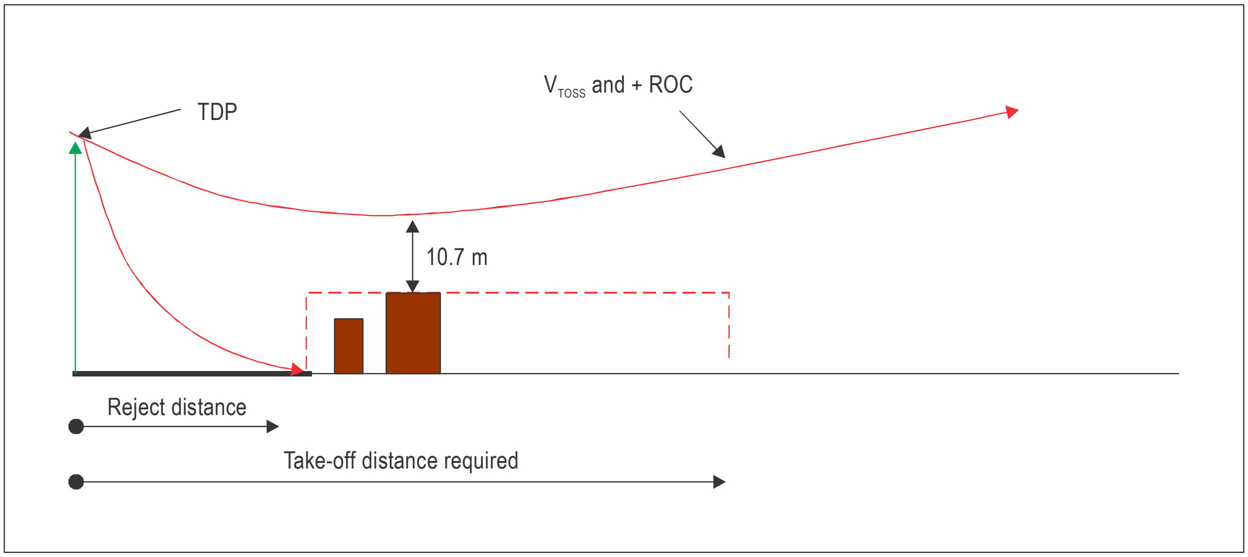

Figure 2-3-5 Restricted area procedure

2.3.4.1.3 ***Helipad procedures*** (Figures 2-3-6 and 2-3-7); have a single common feature in that the rejected take-off is restricted to the helipad (TLOF/FATO) itself. This procedure can be at ground-level or elevated and features a vertical or rearward/sideways climb (which must afford sufficient visibility to provide a return to the take-off surface should an engine fail before TDP).

2.3.4.1.3.1 The vertical climb element can be tailored to the application[21] allowing for higher obstacles in the take-off flight path. For ground-level or elevated heliports where there are no obstacles behind the aircraft, the vertical section can be in a rearward climb area and, if facilitated in the RFM, the TDP can be set to a height which provides the specified clearance over obstacles at min-dip.

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[20] The lowest point in the continued take-off.

[21] For a helideck where there can be obstacles behind the helicopter, the (purely) vertical section is short and the TDP not normally set higher than 30ft (9 m).

2.3.4.1.3.2 Drop-down beyond the helipad, following an engine failure after TDP, can be used to gain speed where the obstacle environment permits.

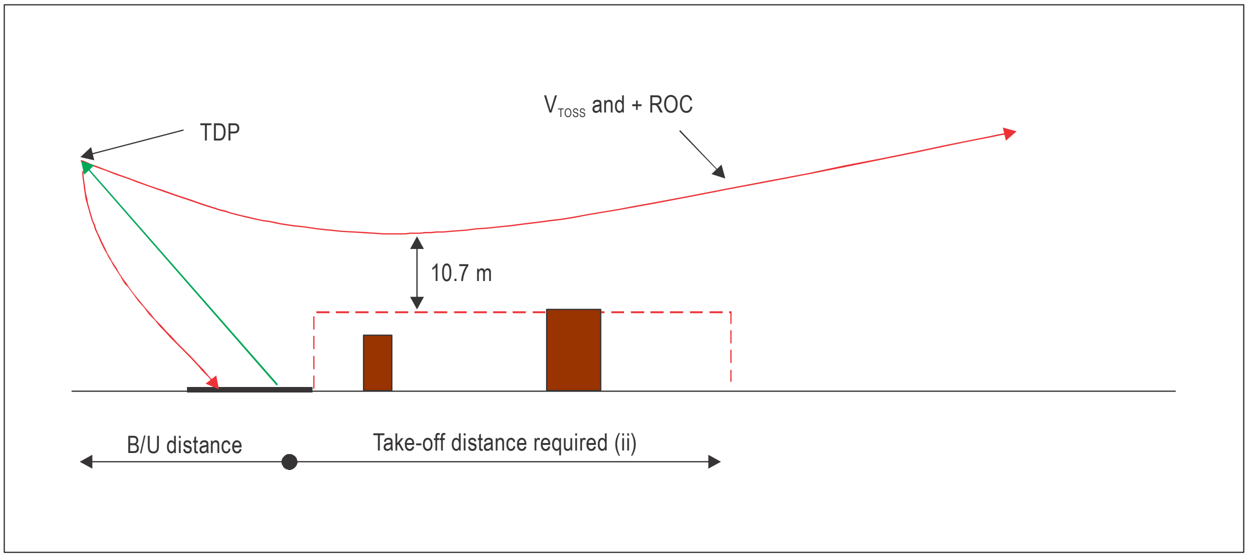

Figure 2-3-6 Helipad procedure

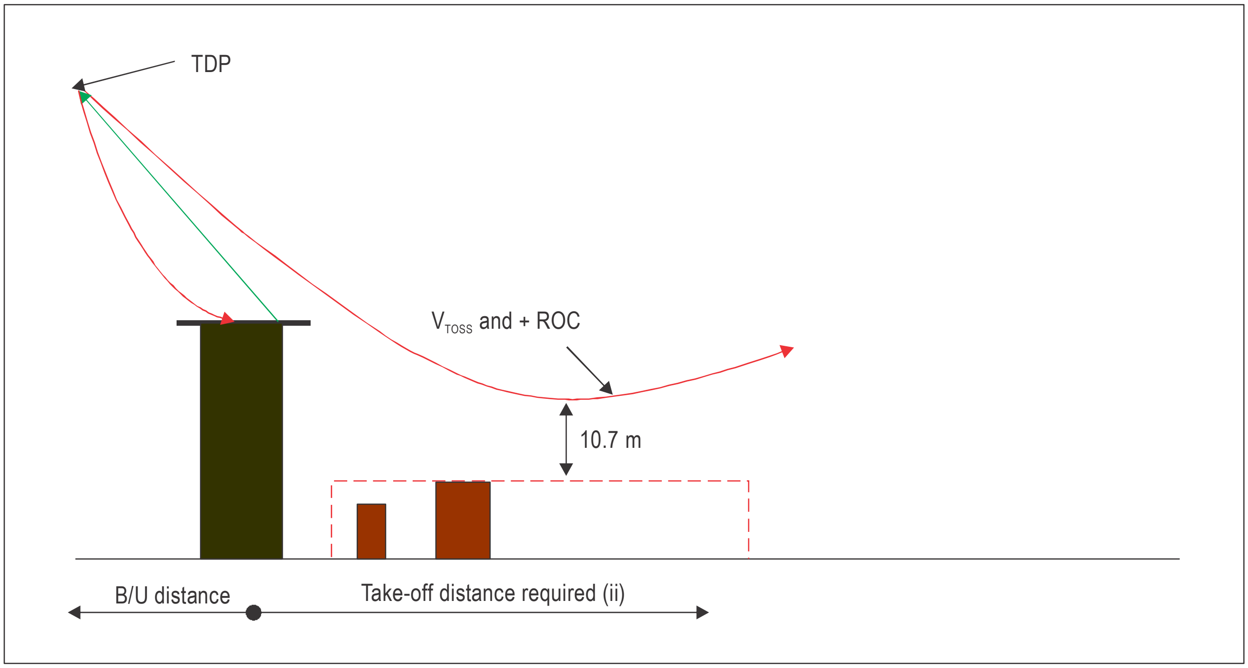

Figure 2-3-7 (Elevated) helipad procedure

2.3.4.1.4 As procedures become more configurable, they provide a toolbox of profiles and graphs that can be tailored to any location. The more power to weight ratio the helicopter has, the more configurable the TDP can be and fewer profiles are required. Helicopters having a higher power to weight ratio also benefit from a slower descent following an engine failure before TDP.

2.3.5 Obstacles in the back-up area of helipad procedures

2.3.5.1 With the advent of back-up procedures for ground-level sites, and the use of elevated heliports located in an obstacle-rich environment, came the need to provide guidance on obstacle clearance in the back-up area. The following text shows how obstacles in the back-up area can be tolerated[22].

2.3.5.2 As can be seen in Figures 2-3-8 and 2-3-9, the obstacle accountability area is an inclined plane — or a combination of planes — sloping upwards and backwards from the end of the safety area, centred on a line passing through the centre of the FATO and contained within a defined area.

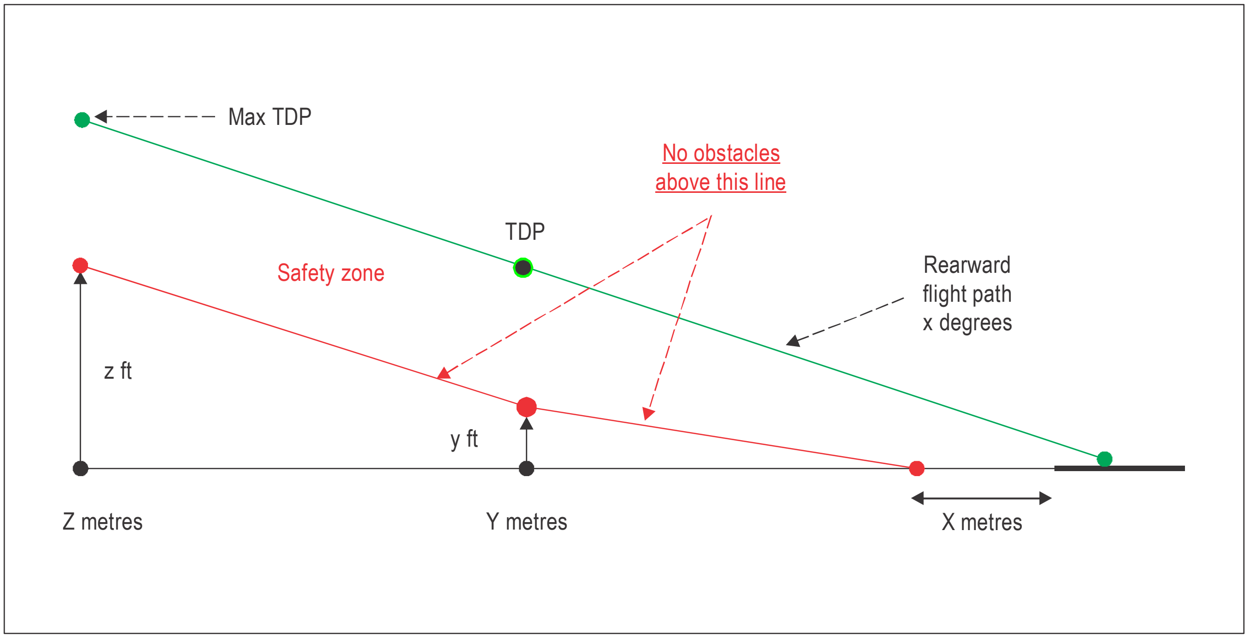

Figure 2-3-8 Obstacle accountability area (side view)

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[22] This discussion on obstacles in the back-up area is not well reflected in Annex 14, Volume II; there is a (logical) assumption within Annex 14 that the slopes in the approach path (the back-up area) will be obstacle free. However, that may not be a true reflection of the conditions that might prevail in some operational heliports utilizing these procedures.

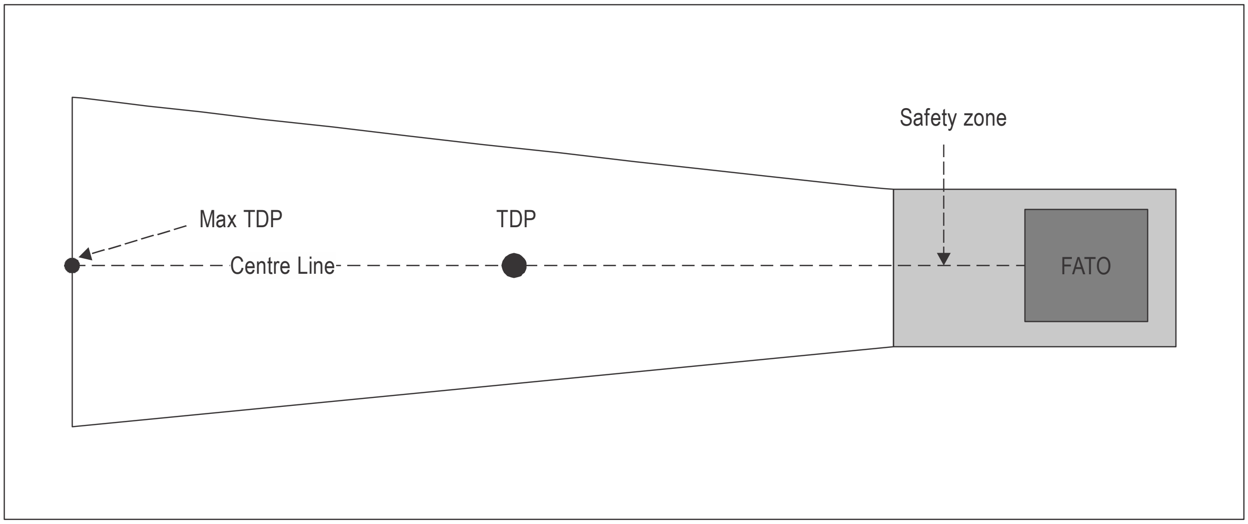

Figure 2-3-9 Obstacle accountability area (plan view)

2.3.5.3 *The back-up area*

2.3.5.3.1 The characteristics of the back-up area are:

a) An inner edge horizontal and equal in length to the specified width of the FATO plus the safety zone, perpendicular to the centre line and located at the edge of the safety zone.

b) Two side edges originating at the ends of the inner edge diverging uniformly at a specified rate from the vertical plane containing the centre line of the FATO (the specified rate might be 10 per cent for day operations and 15 per cent for night).

c) An outer edge horizontal and perpendicular to the centre line at a specified height above the elevation of the FATO (the highest TDP for the procedure).

2.3.5.3.2 The elevation of the inner edge should be the elevation of the safety zone at the point on the inner edge that is intersected by the centre line of the obstacle limitation plane.

2.3.5.3.3 The slope of the plane (or combination of planes) should be measured in the vertical plane containing the centre line.

2.3.5.4 *Establishment of the obstacle clearance plane(s)*

2.3.5.4.1 It should be established that obstacles can be cleared in the three phases of the back-up take-off procedure:

a) the back-up manoeuvre;

b) the rejected take-off; and

c) the continued take-off.

2.3.5.4.2 The profile of each of these manoeuvres should be considered in establishing obstacle clearance:

a) In the back-up; the pilot has few visual cues and should rely upon the altimeter and sight picture through the front, or chin, window (if flight path guidance is not provided) to achieve an accurate rearward flight path.

b) In the rejected take-off; the pilot should be able to manage the descent which permits a landing on the FATO, while ensuring clearance from obstacles.

c) In the continued take-off; the pilot should be able to accelerate to V_{TOSS} while ensuring a 10.7 m (35 ft) clearance from obstacles.

2.3.5.4.3 The manufacturer producing the profile (and procedure) should ensure that the construction (and testing) of the defined area permits obstacle clearance in all three phases when flown by a pilot without using exceptional piloting skills.

2.3.5.4.4 There will be occasions when the arrival and departure segments are not diametrically opposed, or when the back-up procedure has a lateral element; neither of these cases is specifically addressed in the example code in the Attachment to Appendix of Chapter 2[23], and it remains the responsibility of the operator to ensure that obstacle clearance is planned and achieved.

2.3.6 Additional flexibility — PC1 take-off using partial Category A data

2.3.6.1 The definition of Performance Class 1 does not require the operator to apply a Category A procedure. Compliance can be shown with alternative methods which provide engine failure accountability using hover out-of-ground-effect (HOGE) OEI performance[24], and procedures providing obstacle clearance (the distances from the scheduled data of any Category A procedure can be used and is likely to be conservative).

2.3.6.2 The continued take-off clearances/distances (shown in Figure 2.3.10 below) depend upon the operator/pilot either: overlaying the profile on an existing Category A profile; or, when using a vertical climb, ensuring that the vertical section of the profile is flown with enough (vertical) speed that an engine failure (when recognized at the take-off decision point (TDP)) will not cause the helicopter to descend below the horizontal plane of the TDP when rotation is applied.

2.3.6.3 The use of this alternative removes the need for heliport sizes prescribed by Category A rejected take-off and/or landing procedures, provided adequate visual cues are available.

2.3.6.4 The TDP and the landing decision point (LDP) are still defined, but the OEI hover capability allows them to be shifted vertically — as required for obstacle clearance — providing that visual cues are sufficient to permit a re-land from the TDP or continuation of the landing from the LDP.

2.3.6.5 The helicopter at TDP will be at zero (forward) speed and will not have a “calibrated” climb capability until it reaches V_{TOSS}.

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[23] The procedure with a lateral transition is mentioned but only to ensure that responsibility for obstacle clearance is specifically placed with the operator (who alone has access to all of the salient dimensions).

[24] This is mentioned in the guidance of FAA AC 29-2C.

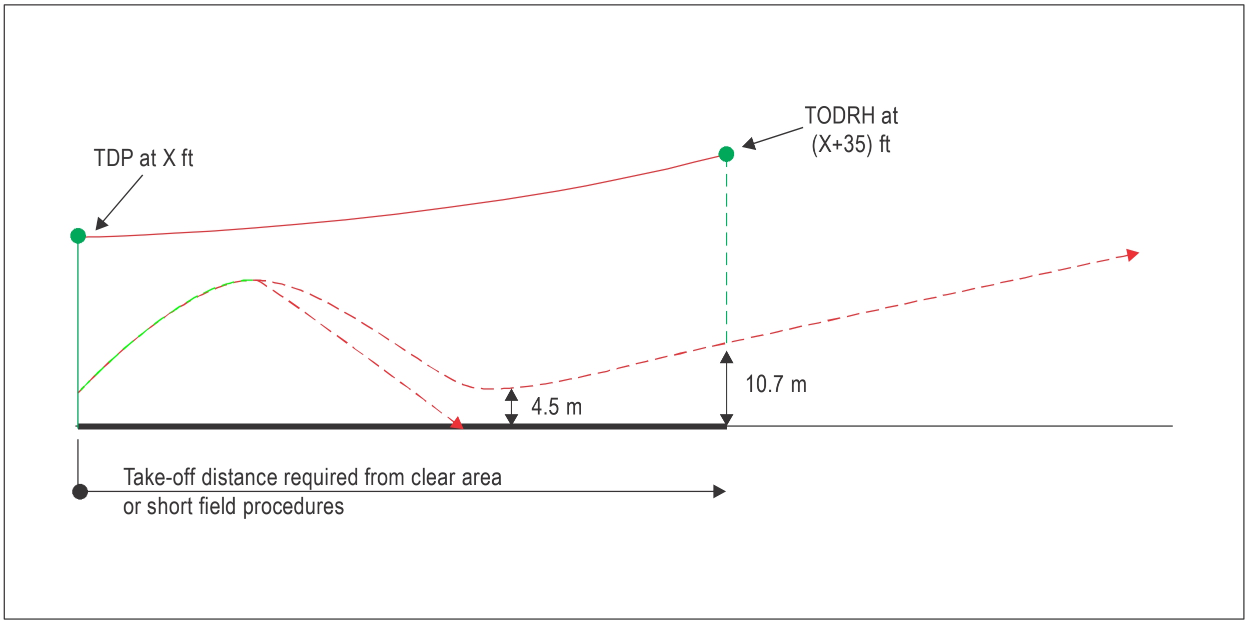

Figure 2-3-10 Estimation of TODRH (from the clear area or short field data)

2.3.6.6 The take-off distance required (to reach V_{TOSS}) can be taken as

a) the “clear area” Category A take-off distance (shifted vertically);

b) the “short-field” Category A take-off distance (shifted vertically); and

c) the “helipad” Category A take-off distance, plus any backup distance (if it is not already included).

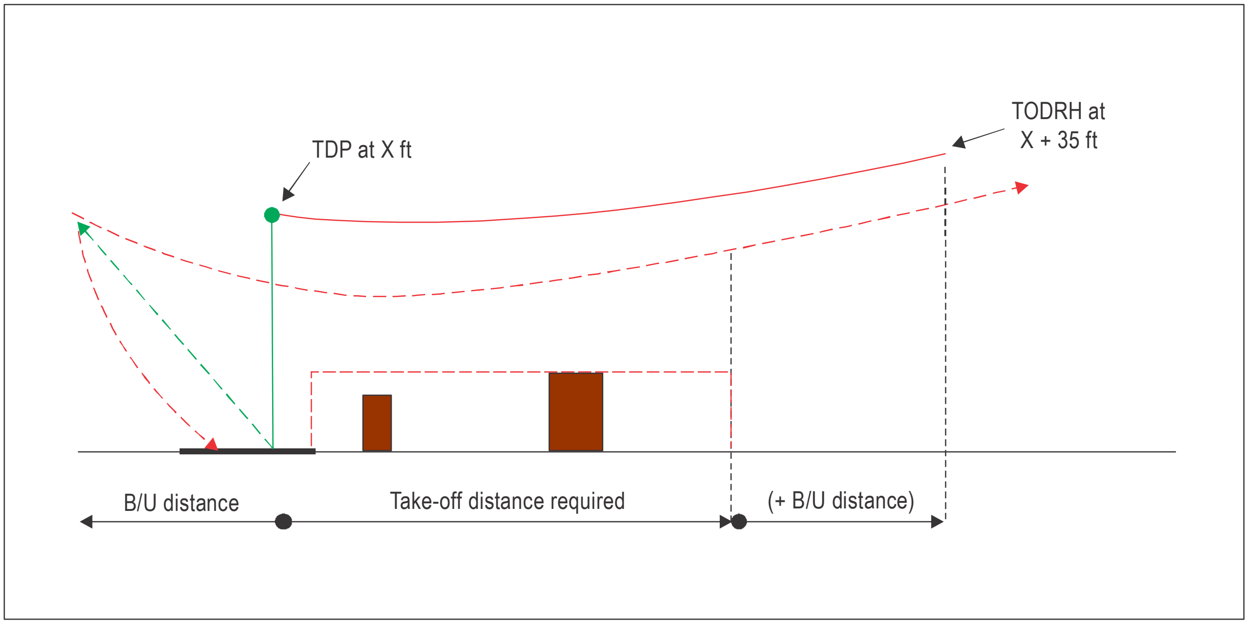

Figure 2-3-11 Estimation of TODRH (from back-up procedure data)

2.3.6.7 Compliance with obstacle clearance would have to be verified from a point at 10.7 m (35 ft) above the TDP height, at the distance from the TDP determined in accordance with the above calculations.

2.3.7 Compliance with performance Class 1 (PC1)

2.3.7.1 Together with any Category A limitation, compliance with PC1 may be assured with:

a) the use of an appropriate Category A take-off and landing procedure scheduled in the rotorcraft flight manual (RFM); or

b) the use of a take-off and landing profile at a mass not exceeding the mass scheduled in the RFM for HOGE with OEI (which will be more restrictive than the mass required by the Category A procedure) ensuring that:

   1) the take-off can be rejected vertically from the TDP (or a rotation point selected by the operator) onto the TLOF with adequate external references (in view of this, the TLOF should be a circle of diameter not less than 0.83D);

   2) the take-off meets the obstacle clearance requirements. For defining the TODRH, the take-off distance required can be derived from the take-off distance provided in the RFM for an appropriate Category A take-off profile;

   3) the landing can be continued from the LDP onto the TLOF with adequate external references (in view of this, the TLOF should be a circle of diameter not less than 0.83D); and

   4) the balked landing meets the obstacle clearance requirements.

2.3.8 PC1 en-route

2.3.8.1 OEI climb performance data is provided in accordance with Part 29.67(a)(3) but it is left to the operational regulation to set the required climb performance at the cruise altitude. Various methods can be used in regulations to implement limitations with respect to required en-route single-engine performance, such as:

a) instrument meteorological conditions (IMC); either an OEI rate of climb of 50 ft/min at a level of 1 000 ft (2 000 ft in mountainous areas) above the highest obstacle within 5 nm (each side) of the intended track; or

b) IMC; the ability to drift down to a point 1 000 ft above the intended landing site avoiding all obstacles by a vertical margin of 1 000 ft (2 000 ft in mountainous areas) and 5 nm laterally; or

c) visual meteorological conditions (VMC); the ability to drift down to a point 1 000 ft above the intended landing site avoiding all obstacles without flying below the appropriate minimum flight altitude (generally accepted to be 500 ft).

2.3.8.2 When calculating drift down obstacle clearance in accordance with item 2) above, wind effect should be taken into account. Fuel dump, if pre-planned, may be used to provide OEI obstacle clearance en-route provided the destination or alternate can be reached with the reduced fuel load.

2.3.8.3 The corridor width should be in accordance with the relevant navigation specification.

2.3.9 PC1 landing considerations

2.3.9.1 Most of the preceding discussion applies to landing as well as take-off. Simply described, landing at a location (where a take-off has been conducted) should satisfy two sets of criteria: for an engine failure at or after LDP, where the helicopter must be able to land and stop on the TLOF; and, for an engine failure at or before the LDP, when the helicopter must be able to perform a balked landing, meeting the same obstacle clearance required for the take-off procedure.

2.3.9.2 In the simplest case, the LDP will be well behind the TDP established for the Category A take-off. Because at the LDP the speed and power application will be more favourable than that for the take-off, the main consideration following an engine failure is that the helicopter is flown positively to the touchdown point.

2.3.9.3 The LDP will be as established in the RFM except when an arrival is at a site where, for obstacle clearance purposes, the procedure calls for a raised TDP; in that case the LDP should be located no lower and no further forward than the equivalent TDP to ensure that obstacle clearance is achieved on any required balked landing.

2.3.9.4 The LDP is typically defined in terms of airspeed, rate of descent, and altitude above the landing surface. The approach path angle can be defined by LDP airspeed and rate of descent values. Definition of the LDP should include an approach angle because both the landing distance and the missed approach path are significantly influenced by the landing approach angle.

2.3.10 Obstacle clearance — PC1 landing

2.3.10.1 The Category A procedures provide non-adjusted profiles — i.e. they specify only the climb performance required by the rule (not a gradient[25]) and landing mass is established in a WAT graph. Although the specific Category A procedure takes account of obstacles within the LDRH, it has no knowledge of those in the balked landing path.

2.3.10.2 As described in 2.3.9 above, the LDP should be as stated in the RFM for the procedure.

2.3.10.3 The OEI landing profile and obstacle clearance in the balked landing phase, required by operational regulations, can be seen in Figures 2-3-12 and 2-3-13 below. The point from which the take-off flight path begins will be established as part of the Category A landing procedure. Obstacle clearance from this point will be as stated for the take-off procedure.

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[25] Although gradients are provided by some manufacturers.

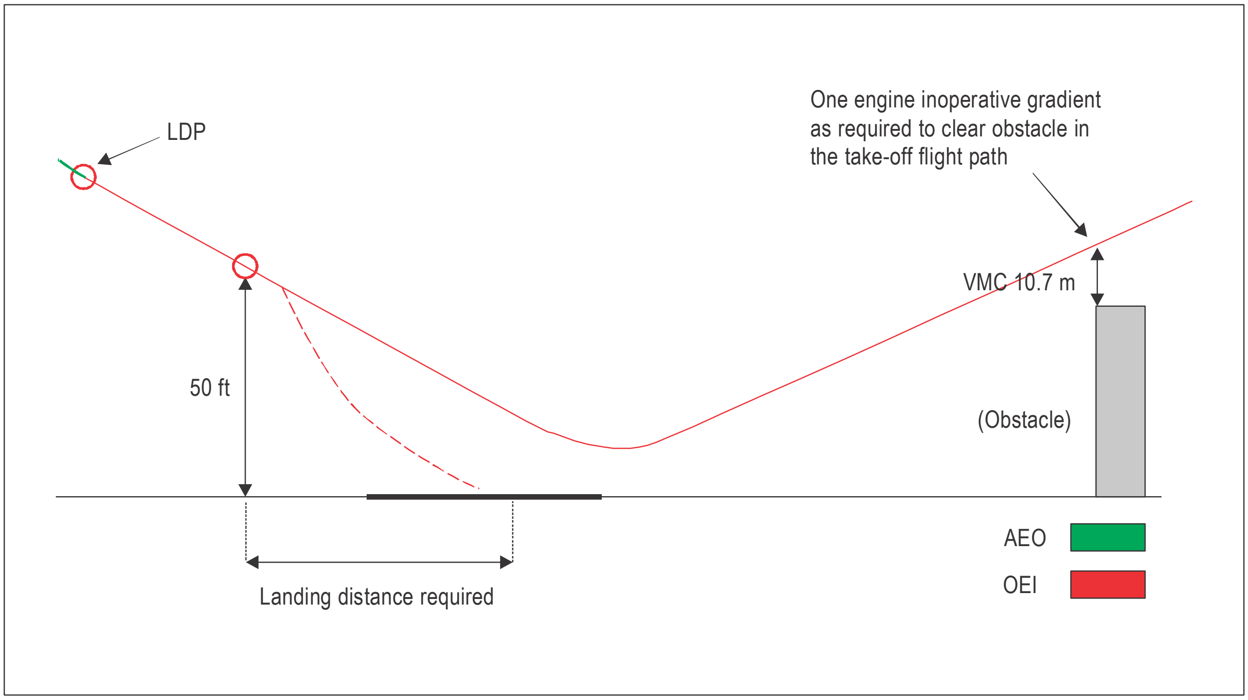

Figure 2-3-12 Performance Class 1 landing (side view)

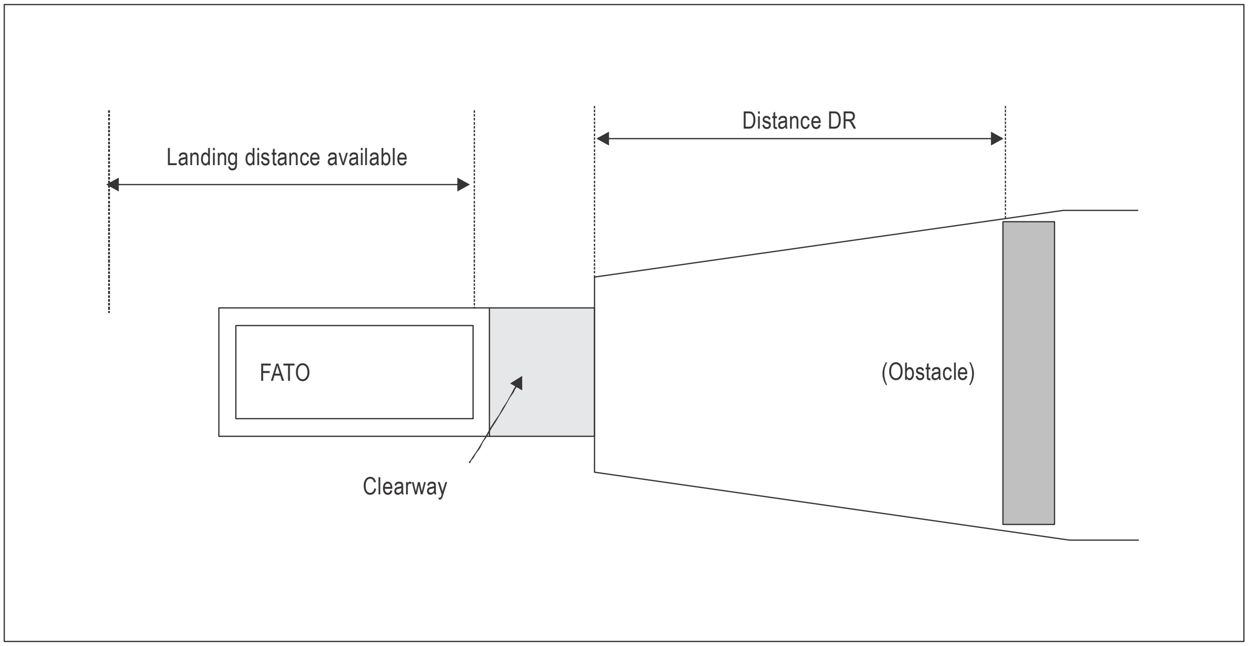

Figure 2-3-13 Performance Class 1 landing (plan view)

2.3.11 Landing procedures associated with the take-off with a vertical component

2.3.11.1 A PC1 departure procedure with a vertical component is normally associated with obstacles in the take-off flight path, within either the take-off distance or the departure surface. Providing landing procedures in these cases is problematic for the manufacturer because, in the provision of the procedure, only the obstacles in the take-off distance can be accounted for (the other obstacles being site-related).

2.3.11.2 This is normally addressed by taking a conservative approach and specifying that the LDP is located at the same position as the TDP, but with slightly modified flight characteristics. This conservative approach ensures that the two elements of the LDP can be met: an OEI approach can be conducted from the LDP; and obstacle clearance can be achieved in a balked landing.

2.3.11.3 Since the procedure addresses obstacles anywhere in the take-off flight path, obstacle clearance is as specified for departure — i.e. a base line[26] clearance of 10.7 m (35 ft).

2.3.12 Manufacturers data in the RFM for PC1 Heliports

2.3.12.1 *Description of the issue*

2.3.12.1.1 There have been few changes to the helicopter certification standard in recent years. Although the last major revision of performance in the Part 29 certification code (Amendment 29-39 — 1996) contained modification of the vertical profiles, the text still referred to the rejected take-off and landing distances and the necessity to include the entire helicopter, including the rotors, in the resulting dimensions.

2.3.12.1.2 For landing, and specifically for Category A procedures with vertical components, additional guidance introducing a surface size was added:

> "The minimum elevated heliport size demonstrated for the OEI approach procedure …
> should also be provided in the Flight Manual."

2.3.12.1.3 For most procedures contained in the Category A Supplement, the "minimum heliport size demonstrated" might be the *only* dimension provided (it therefore serves both for take-off and landing) and, because there is no "objective" set in its provision, it has been used to reduce the minimum dimension for the Category A procedure to that of the "surface area requirement" (undercarriage, not helicopter, containment). The consequence is that there may be no dimension that provides safe containment of the entire helicopter.

2.3.12.2 *Revision to Annex 14 to address the change in certification practices*

2.3.12.2.1 Since a single dimension only may now be provided in RFMs, a revision was made in Annex 14, Volume II — objectives of the TLOF and FATO, to facilitate a solution and ensure continued safety:

a) The objective of the TLOF was amended to contain only the surface area and loading for containment of the undercarriage (this is now correlated with the dimension being provided in the Category A Supplement).

b) The objective of the FATO was amended to strengthen the requirement for containment of the whole helicopter but the necessity for a surface area was removed.

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[26] Obstacles in an IMC departure should have the additional clearance factor added (10.7 m (35 ft) plus 0.01 DR).

2.3.12.2.2 The requirement of the (additional) FATO dimension is necessary to ensure protection of the helicopter from surrounding objects. This dimension can be derived (by the manufacturer) from “scatter plot” data, collected and recorded during the certification flight and acceptance trials.

2.3.12.2.3 In the absence of provision of the helicopter containment dimension, the addition of 1 x Design D to the dimension contained in the RFM Category A Supplement, would ensure a safe FATO. In most cases, this would result in a slight addition to the minimum FATO dimension.

2.3.12.3 *Resolution of inconsistencies in the RFM (TLOF/FATO/RTODRH)*

2.3.12.3.1 The following is a description of the required dimension(s) (see Figure 2-3-14 for a technical diagram).

2.3.12.3.1.1 The “minimum demonstrated heliport size” for the OEI approach procedure should be provided in the RFM. This “minimum demonstrated heliport size” represents the sum of:

a) the size of the surface area (TLOF) required to contain the undercarriage of the rotorcraft;

b) the aircraft performance scatter during OEI landings to a specific reference point; and

c) the distance required to provide the minimum suitable visual cues for a safe OEI landing.

2.3.12.3.1.2 It should be noted that “the minimum demonstrated heliport size” does not necessarily guarantee rotor containment. The minimum rotorcraft containment area is defined as the larger of either:

a) the “minimum demonstrated heliport size”; or

b) the overall length of the helicopter (including main and tail rotor tip paths) plus the performance scatter seen in the heliport size determination.

2.3.12.3.1.3 If the minimum rotorcraft containment area is larger than the “minimum demonstrated heliport size”, the “minimum rotorcraft containment area” (the FATO) should also be provided in the RFM[27].

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[27] The FATO dimension does not include the safety area.

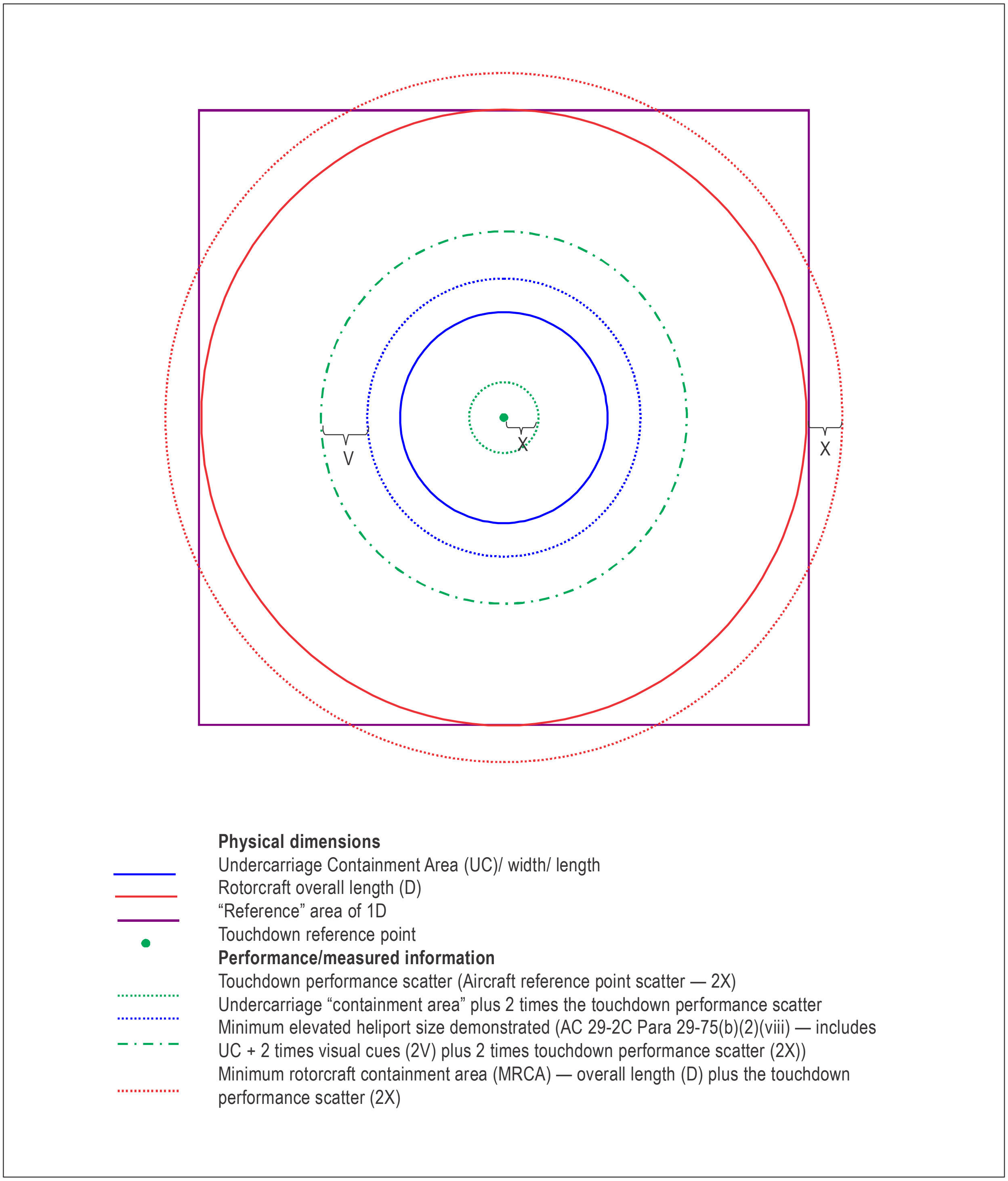

Figure 2-3-14 Performance Class 1 TLOF/FATO (RTODRH) dimensions

2.4 PERFORMANCE CLASS 2 (PC2)

2.4.1 Introduction

2.4.1.1 This Section describes performance Class 2. It has been provided to:

a) establish the underlying philosophy of operations in performance Class 2;

b) show simple methods of compliance; and

c) explain how to determine, with examples and diagrams:

1) the take-off and landing masses;

2) the length of the SFL area;

3) distances to establish obstacle clearance; and

4) entry point(s) into performance Class 1.

2.4.1.2 Basic requirements are described along with the limit of operation and benefits of the use of performance Class 2.

2.4.1.3 Examples of performance Class 2, in specific circumstances, are provided along with explanation of how these examples may be generalized to provide operators with methods of calculating landing distances and obstacle clearance — when required.

2.4.2 Defining performance Class 2

2.4.2.1 Performance Class 2 arises from the fact that not all multi-engine rotorcraft have the engine failure capability for continued safe flight, or safe rejected take-off, following an engine failure within certain low speed flight phases[28].

This prevents, for CAT operations with transport/large category rotorcraft, adoption of a single performance standard[29]. This results in the necessity for a three-part performance classification, rather than the two of aeroplanes, and the ICAO taxonomy, based upon the three engine failure risk profiles discussed in 2.2.6.

2.4.2.2 The SARPs of Annex 6, Part III, Section II, Chapter 3, 3.1.2 for performance Class 2, are based upon the following capabilities:

a) Obstacle clearance before defined point after take-off (DPATO*)*: the helicopter shall be capable, with all engines operating, to clear all obstacles by an adequate margin until it is in a position to comply with b) below.

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[28] An aeroplane needs a runway on which to accelerate to an efficient speed before taking off; the rotorcraft has the ability to take-off and then accelerate — eliminating dependence upon runways; this provides flexibility in the reduced size of operating sites but comes at a cost in required power for PC1 (or ability to sustain flight should an engine fail at a low speed).

[29] For a further discussion of the airworthiness standards associated with this, see Chapter 2, 2.2 of this manual.

b) Obstacle clearance at and after DPATO: the helicopter shall be capable, in the event of the critical engine becoming inoperative at any time after reaching DPATO, of continuing the take-off, clearing all obstacles along the flight path by an adequate margin until it is able to comply with en-route clearances.

c) Engine failure at and before DPATO: before DPATO, failure of the critical engine may cause the helicopter to force land and therefore, an SFL should be possible (this is analogous to the requirement for a reject in performance Class 1 but where some damage to the helicopter can be tolerated).

d) Engine failure after DPBL: after DPBL, failure of the critical engine may cause the helicopter to force land; therefore, an SFL should be possible (this is analogous to the requirement for an OEI in performance Class 1 but where some damage to the helicopter can be tolerated.)

2.4.3 The benefits of performance Class 2

2.4.3.1 Operations in performance Class 2 permit advantage to be taken of an all-engines-operating (AEO) procedure for a short period during take-off and landing — while retaining engine failure accountability in the climb, descent and cruise. The benefits include the ability to:

a) Use (the reduced) distances scheduled for the AEO — thus permitting operations to take place at smaller heliports and allowing airspace requirements to be reduced.

b) Operate when the SFL distance available is located outside the boundary of the heliport.

c) Operate when the take-off-distance available is located outside the boundary of the heliport.

d) Use existing Category A profiles and distances when the surface conditions are not adequate for a reject but are suitable for an SFL (for example when the ground is waterlogged).

e) Increase the number of passengers carried to 19, when the State's definition of Category A permits[30].

2.4.4 Implementation of performance Class 2

The following sections address the principles of the implementation of performance Class 2.

2.4.4.1 *Take-off and obstacle clearance*

2.4.4.1.1 The use of take-off procedures defined in Subpart B of Part 29 is contained in Sections 2.2.6.2, 2.2.6.3 and 2.2.6.4.

2.4.4.1.2 Annex 6 requires that, up to DPATO AEO, and from DPATO OEI, obstacle clearance is established (see Figure 2-4-1).

Note.— Annex 8 — Airworthiness of Aircraft *(Part IV, Chapter 2.2.3.1.4) requires that an AEO distance be scheduled for all helicopters operating in performance Classes 2 and 3. Annex 6 is dependent upon the scheduling of the AEO distances, required in Annex 8, to provide data for the location of DPATO.*

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[30] The Annex 8 definition of Category A, specifies that helicopters must be "…capable of operations using take-off and landing data scheduled under a critical engine failure concept…". In some States, the definition of Category A uses the term "utilizing" rather than "capable of". If a Category A procedure is not being used, this could limit the number of passengers to nine.

2.4.4.1.3 When showing obstacle clearance, the divergent obstacle clearance height required for instrument flight rules (IFR) is — as in Performance Class 1 — achieved by the application of the additional obstacle clearance of 0.01 DR, where DR = the distance from the end of "take-off-distance-available" (see the pictorial representation in Figure 2-4-1 and the definitions in 2.4.2 above).

2.4.4.1.4 As also shown in Figure 2-4-1, flight must be conducted in VMC until DPATO has been achieved (and **deduced** that if an engine failure occurs before DPATO, entry into IMC is not permitted (as the OEI climb gradient will not have been established)).

Note. — V_{mini} must also have been achieved before leaving VMC.

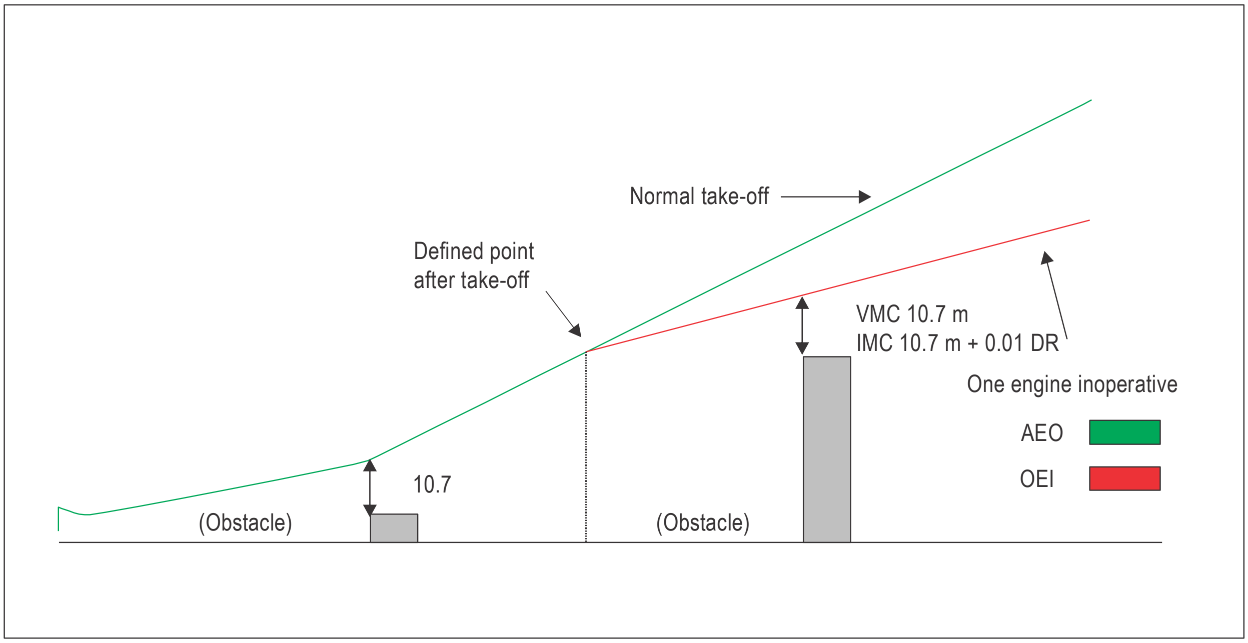

Figure 2-4-1 Performance Class 2 obstacle clearance (side view)

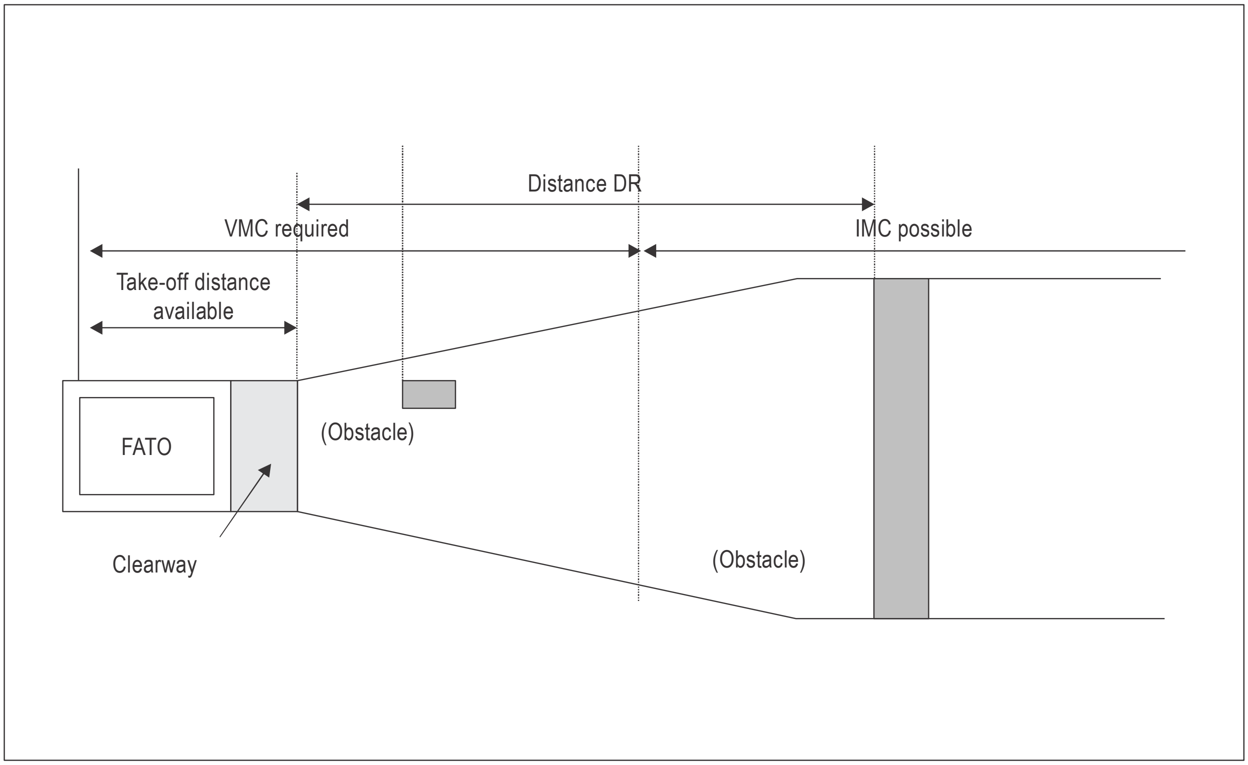

Figure 2-4-2 Performance Class 2 obstacle clearance (plan view)

2.4.4.2 *Function of DPATO*

2.4.4.2.1 DPATO is relevant to PC2 and has, potentially, to satisfy a number of requirements which are not necessarily synchronized (nor need to be).

2.4.4.2.2 It is only possible to establish a single point for DPATO, satisfying the requirement of 2.4.2.2 b) and c) above, when:

a) accepting the TDP of a Category A procedure; or

b) extending the SFL requirement beyond required distances (if data is available to permit the calculation of the distance for an SFL from the DPATO).

2.4.4.2.3 The critical element at DPATO is OEI obstacle clearance. From examination of the flight path in Figure 2-4-1 above, it can be seen that DPATO is the point at which the ability to continue the flight safely with the critical engine inoperative is achieved and adequate climb performance is established. Consideration of Category A procedures indicate that this could be (in terms of mass, speed and height above the take-off surface) the conditions at the start of the first or second segments — or any point between.

2.4.4.2.4 During take-off and before reaching an appropriate climb speed (V_{TOSS} or V_Y), the speed will already have been achieved that will provide the ability to continue the flight and accelerate without descent — shown in some Category A procedures as V_T or target speed — and where, in the event of an engine failure, no landing would be required.

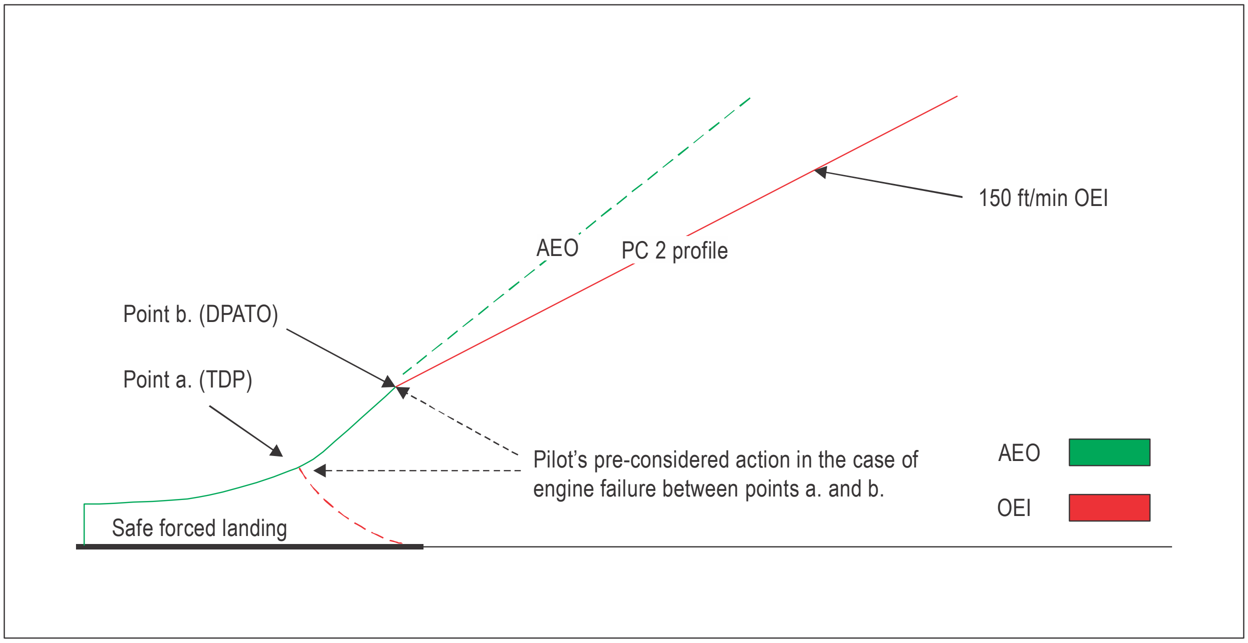

Figure 2-4-3 Three elements in a PC 2 take-off

2.4.4.3 *Take-off from the pilot's perspective*

2.4.4.3.1 When seen from the pilot's perspective (see Figure 2-4-3), there are three elements of the PC 2 take-off — each with associated related actions which need to be considered in the case of an engine failure:

a) action in the event of an engine failure — up to the point where a forced-landing will be required (point a.).

b) action in the event of an engine failure — from the point where OEI obstacle clearance is established (DPATO — point b.).

c) pre-considered action in the event of an engine failure — in the period between points a) and b).

2.4.4.3.2 The actions of the pilot at point a) and point b) are defined, i.e. they remain the same for every occasion. Pre-consideration of the action required for a failure at any point between a) and b) becomes necessary. As it is likely that the planned flight path will have to be abandoned (the point at which obstacle clearance using the OEI climb gradients not yet being reached) the pilot must (before take-off) have considered all options, the associated risks, and consider the course of action that will be pursued in the event of an engine failure during that short period. (As it is likely that any action will involve turning manoeuvres, the effect of turns on performance must also be considered.)

2.4.5 Modifying the take-off mass for obstacle clearance

2.4.5.1 PC2 is an AEO take-off which, from DPATO, must meet the requirement for OEI obstacle clearance[31] in the climb and en-route phases. Take-off mass is therefore the mass that gives at least the minimum climb performance of 150 ft/min (0.76 m/s) at V_Y, at 1 000 ft (300 m) above the take-off point, and obstacle clearance.

2.4.5.2 As indicated in Figure 2-4-4 below, the take-off mass may require modification when it does not provide the required OEI clearance from obstacles in the take-off-flight path (exactly as in performance Class 1). This could occur when taking off from a heliport where the flight path must clear an obstacle such as a ridge line (or line of buildings) which can neither be:

a) flown around using VFR and see and avoid; nor

b) cleared using the minimum climb gradient given by the take-off mass (150 ft/min at 1 000 ft).

2.4.5.3 In this case, the take-off mass must be modified (using data contained in the RFM) to give an appropriate climb gradient.

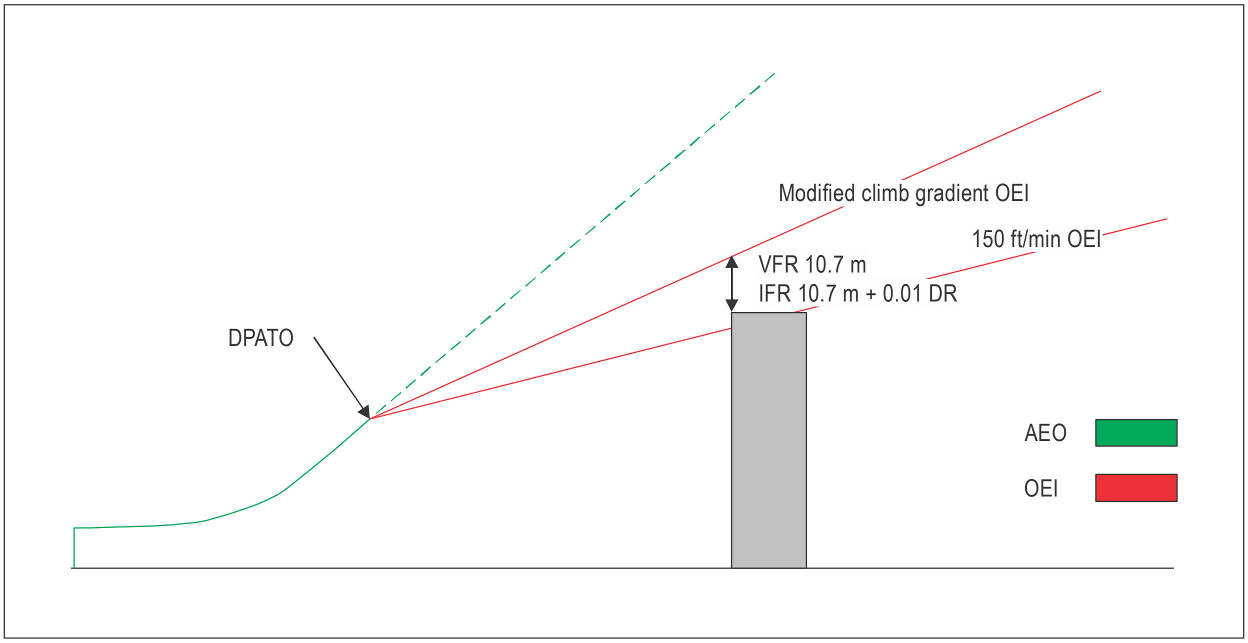

Figure 2-4-4 Performance Class 2 (modified climb gradient)

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[31] As in performance Class 1.

2.4.6 Calculation of Distances

2.4.6.1 Distances do not have to be calculated if, by using pilot judgement or standard practice, it can be established that:

a) an SFL is possible following an engine failure (notwithstanding that there might be obstacles in the take-off flight path); and

b) obstacles can be cleared (or avoided) — AEO in the take-off phase and OEI in the climb.

2.4.6.2 If early entry (in the sense of cloud base) into an IMC departure is required, then calculations should be carried out. However, standard masses and departures can be used when described in the operations manual.

2.4.7 Use of Category A data

2.4.7.1 In Category A procedures, TDP is the point at which either a rejected landing or a safe continuation of the flight, with OEI obstacle clearance, can be performed.

2.4.7.2 For PC2 (when using Category A data), only the SFL (reject) distance depends on the equivalent of the TDP. If an engine fails between TDP and DPATO, the pilot must decide what action is required but it is not necessary for an SFL distance to be established from any point beyond the equivalent of TDP (see Figure 2-4-3 and discussion in 2.4.6 above).

2.4.7.3 Category A procedures based on a fixed V_{TOSS} are usually optimized either for the reduction of the rejected take-off distance, or the take-off distance. Category A procedures based on a variable V_{TOSS} allow either a reduction in required distances (low V_{TOSS}) or an improvement in OEI climb capability (high V_{TOSS}). These optimizations may be beneficial in PC2 to satisfy the dimensions of the take-off site.

2.4.7.4 In view of the different requirements for PC2 (from PC1), it is perfectly acceptable for the two calculations (one to establish the SFL distance and the other to establish DPATO) to be based upon different Category A procedures. However, if this method is used, the mass resulting from the calculation cannot be more than the mass from the more limiting of the procedures.

2.4.8 DPATO and obstacle clearance

If it is necessary for OEI obstacle clearance to be established in the climb, the starting point (DPATO) for the (obstacle clearance) gradient must be established. Once DPATO has been defined, the OEI obstacle clearance is relatively easy to calculate with data from the RFM.

2.4.8.1 *DPATO based on AEO distance*

2.4.8.1.1 In the simplest case, and if provided, the scheduled AEO to 200 ft (60 m) at V_Y can be used (see Figure 2-4-5).

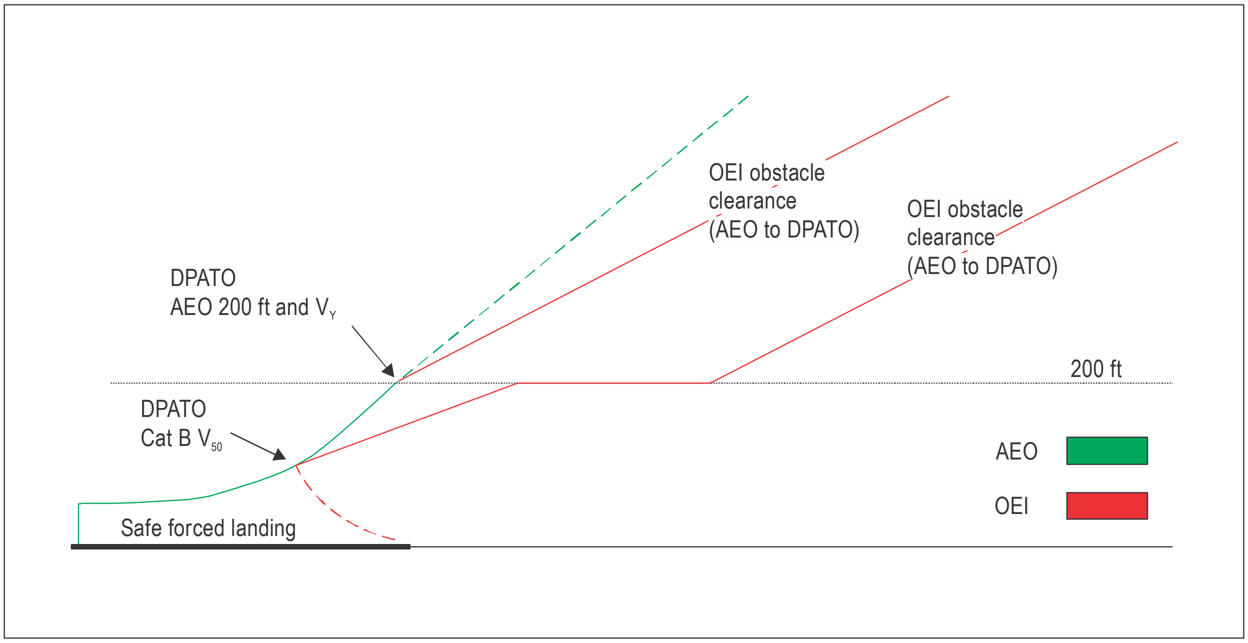

Figure 2-4-5 Suggested AEO locations for DPATO

2.4.8.1.2 If scheduled in the RFM, the Category B AEO distance to 50 ft (V_{50}) — determined in accordance with Part 29.63 — can be used (see Figure 2.4.8). Where this distance is used, it will be necessary to ensure that the V_{50} climb out speed is associated with a speed and mass for which OEI climb data is available so that, from V_{50}, the OEI flight path can be constructed.

2.4.8.2 *DPATO based on Category A distances*

2.4.8.2.1 It is not necessary for specific AEO distances to be used (although for obvious reasons it is preferable); if they are not available, a flight path (with OEI obstacle clearance) can be established using Category A distances (see Figures 2-4-6 and 2-4-7) — which will then be conservative.

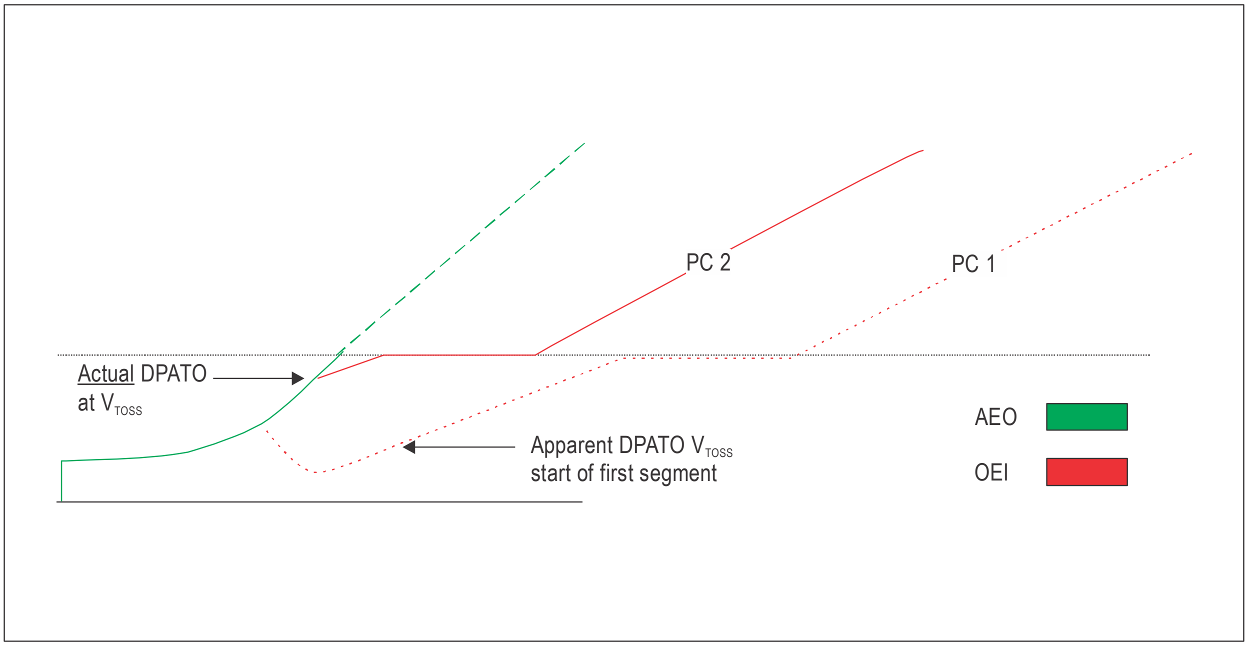

Figure 2-4-6 Using Category A data; actual and apparent position of DPATO (V_{TOSS} and start of first segment)

Note.— The apparent DPATO is for planning purposes only in the case where AEO data is not available to construct the take-off flight path. The actual OEI flight path will provide better obstacle clearance than the apparent one (used to demonstrate the minimum requirement) — as seen from the firm and dashed lines in the above diagram.

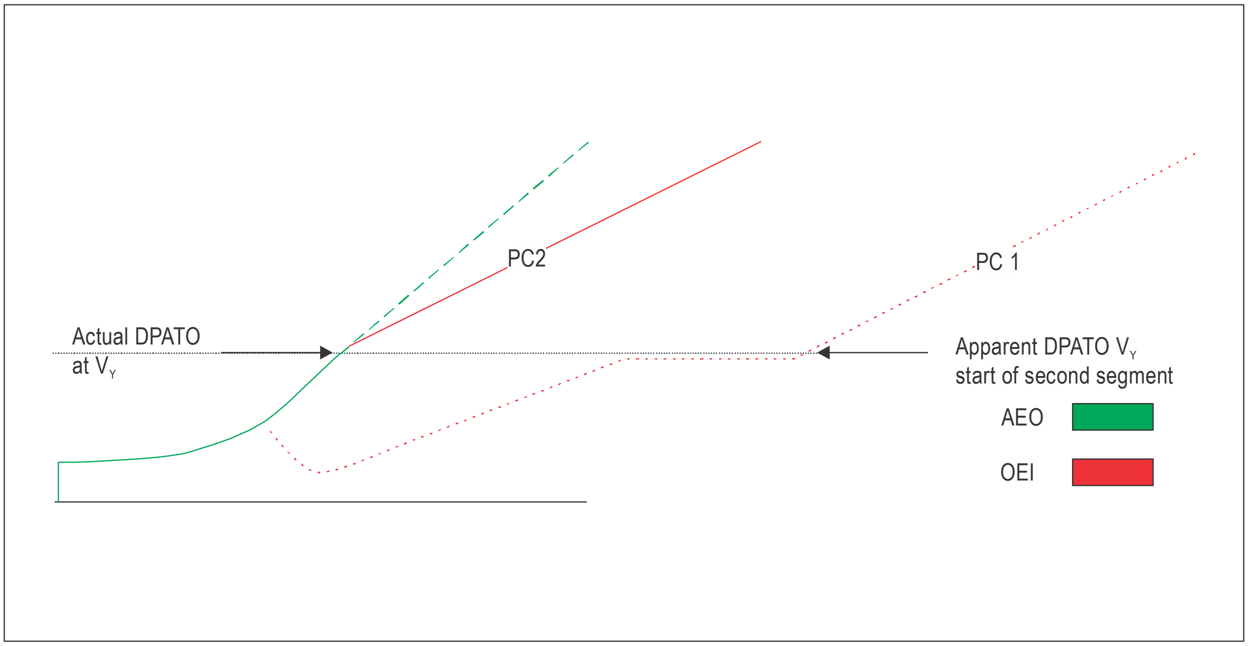

Figure 2-4-7 Using Category A data; actual and apparent position of DPATO (V_Y and start of second segment)

2.4.8.3 *Use of most favourable Category A data*

2.4.8.3.1 The use of AEO data is recommended for calculating DPATO. However, where an AEO distance is not provided in the RFM, distance to V_Y at 200 ft (60 m), from the most favourable of the Category A procedures, can be used to construct a flight path (provided it can be demonstrated that AEO distance to 200 ft (60 m) at V_Y is always closer to the take-off point than the Category A OEI flight path).

2.4.8.3.2 In order to satisfy the requirements of the take-off flight path, the last point from where the start of OEI obstacle clearance can be shown is at 200 ft (60 m).

2.4.8.4 *Calculation of DPATO — a summary*

DPATO should be defined in terms of speed and height above the take-off surface and should be selected such that RFM (or equivalent) data is available to establish the distance from the start of the take-off up to the DPATO (conservatively if necessary).

2.4.8.4.1 *First method*

2.4.8.4.1.1 DPATO is selected as the RFM Category B take-off distance (V_{50} speed or any other take-off distance scheduled in accordance with Part 29.63) provided that within the distance the helicopter can achieve:

a) one of the V_{TOSS} values (or the unique V_{TOSS} value if is not variable) provided in the RFM, selected so as to assure a climb capability according to Category A criteria; or

b) V_Y.

2.4.8.4.1.2 Compliance with the take-off flight path would be shown from V_{50} (or the scheduled Category B take-off distance).

2.4.8.4.2 *Second method*

2.4.8.4.2.1 DPATO is selected as equivalent to the TDP of a Category A clear area take-off procedure conducted in the same conditions.

2.4.8.4.2.2 Compliance with the take-off flight path would be shown from the point at which V_{TOSS}, a height of at least 10.7 m (35 ft) above the take-off surface and a positive climb gradient are achieved (which is the Category A clear area take-off distance).

2.4.8.4.2.3 SFL areas should be available from the start of the take-off. The Category A “clear area” rejected take-off distance is a good indication of the distance required for an SFL.

2.4.8.4.3 *Third method*

2.4.8.4.3.1 As an alternative, DPATO could be selected such that the RFM OEI data is available to establish a flight path initiated with a climb at that speed. This speed should then be:

a) one of the V_{TOSS} values (or the unique V_{TOSS} value if is not variable) provided in the RFM, selected so as to assure a climb capability according to Category A criteria; or

b) V_Y.

2.4.8.4.3.2 The height of the DPATO should be at least 10.7 m (35 ft) and can be selected up to 200 ft. Compliance with the take-off flight path would be shown from the selected height.

2.4.9 Safe forced landing (SFL) distance

2.4.9.1 Except as provided in 2.4.8.4.2 above, the establishment of the SFL distance could be problematic as it is unlikely that PC2 specific data will be available in the RFM.

2.4.9.2 The Category A reject distance may be used as a good indication of the required SFL distance, when the surface is not suitable for a reject but may be satisfactory for a safe force landing (for example where the surface is flooded or is covered with lighter type vegetation).

2.4.9.3 Any Category A (or other accepted) data may be used to establish the distance; however, once established it remains valid only if the Category A mass (or the mass from the accepted data) is used and the Category A (or accepted) AEO profile to the TDP is flown. In view of these constraints, the likeliest Category A procedures are the clear area or the short field (restricted area/site) procedures.

2.4.9.4 It is evident at Figure 2-4-8 that if the Category B V_{50} procedure is used to establish DPATO, the combination of the distance to 50 ft (15 m) and the Category A "clear area" landing distance, required by Part 29.81 (the horizontal distance required to land and come to a complete stop from a point 50 ft (15 m) above the landing surface), will give a good indication of the maximum SFL distance required.

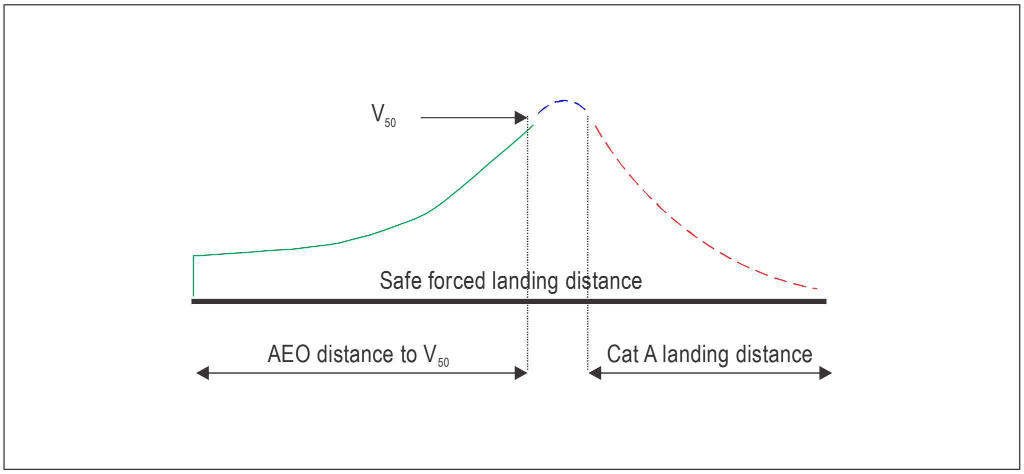

Figure 2-4-8 Category B (V_{50}) safe forced landing (SFL) distance

2.4.10 Performance Class 2 landing

2.4.10.1 For other than PC2 operations to elevated heliport/helidecks, the principles for the landing case is much simpler. As the performance requirement for PC1 and PC2 landings are virtually identical, the condition of the landing surface is the main issue.

2.4.10.2 If the engine fails at any time during the approach, the helicopter must be able to perform a go-around meeting the requirements of the take-off flight path, or an SFL on the surface. In view of this, and if using PC1 data, the LDP should not be lower than the corresponding TDP (particularly in the case of a variable TDP).

2.4.10.3 The landing mass will be identical to the take-off mass for the same site (with consideration for any reduction due to obstacle clearance — as shown in Figure 2-4-4 above).

2.4.10.4 In the case of a balked landing (i.e. the landing site becomes blocked or unavailable during the approach), the full requirement for take-off obstacle clearance must be met.

2.5 PERFORMANCE CLASS 3 (PC3) — WITH NO EXPOSURE

2.5.1 Introduction

2.5.1.1 Performance Class 3 is the most extensively used of the performance classes; it applies to single-engine helicopters, and to twin engine operations that do not meet the criteria for performance Class 1 or 2 (including certification for Category A).

2.5.1.2 To show compliance with Annex 6, Part III, Section II, Chapter 3, 3.1.2, it is necessary to employ procedures, and set conditions of weather and light under which operations in performance Class 3 can be employed (an example is shown in Section 2.3 of the Attachment to Appendix of Chapter 2).

2.5.2 Take-off, landing and en-route procedures

2.5.2.1 The specific procedures for performance Class 3 address take-off, initial climb, en-route, and approach and landing performance. The ability to meet the condition of 2.5.1.2 above requires the establishment of the following:

a) mass for departure, en-route and arrival;

b) AEO obstacle clearance;

c) flight outside of the HV curve; and

d) an appropriate surface over which the operation is performed.

2.5.2.2 A discussion of the use of take-off and landing procedures defined in Subpart B of Parts 27 and 29 is contained in Sections 2.2.6.4 and 2.2.6.5.

2.5.2.3 The performance Class 3 procedures in the code of performance need only address those conditions which are not specifically addressed in the Category B procedures. These are generally associated with: the inability to hover in-ground effect; the surface condition in the take-off flight path; the obstacle environment of the heliport or operating site; and, en-route performance[32].

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[32] An example is shown in section 4, 4.3 of the Attachment to Appendix to Chapter 2.

2.6 EXAMPLE OF OBJECTIVES FOR OPERATIONS CONDUCTED IN ACCORDANCE WITH PERFORMANCE CLASSES WITH NO EXPOSURE

Note.— An example of helicopter performance and operating limitation is shown in the Appendix to Chapter 2, and an example of performance regulation is shown in its Attachment[33].

2.6.1 General

2.6.1.1 The aim of this section is to present an example of the objectives for operations in accordance with performance classes.

2.6.2 Division of responsibilities

2.6.2.1 When the "certification categories" are applied to the "performance classes" it results in the following:

a) A helicopter is certificated in Category A or B[34] but operates in the performance classes.

b) A helicopter that is certificated in Category A can be operated in performance Classes 1, 2 or 3.

c) A helicopter that is certificated in Category B under Part 29.1(e) can be operated in performance Classes 2 or 3.

d) Except under Part 29.1(e), a helicopter that is certificated in Category B (or equivalent) can only be operated in performance Class 3.

2.6.3 Applicability of the standards to the number of passengers carried

2.6.3.1 The number of passenger seats in helicopters certificated in Part 27 is limited to nine. Helicopters certificated in Part 29, Category B with nine passenger seats or less may or may not provide features of Category A.

2.6.3.2 There is no upper limit on the number of seats in a helicopter certificated in Part 29, Category A.

2.6.3.3 A Part 29 helicopter that has a maximum mass of 9 072 kg (20 000 lbs) or less, and 10 passenger seats or more, may be certificated Category B. All features of Category A certification are mandatory except those required to establish take-off and landing performance. This mass is likely to physically constrain the number of seats that could be fitted[35].

2.6.3.4 The correlation between the performance classes and the certification categories may be shown as:

a) Engine failure accountability of performance Class 1 correlates to that of Category A.

b) The engine-failure risk-profile of performance Class 2 correlates with that of Part 29 helicopter with a limiting mass of 9 072 kg and 10 passenger seats or more.

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[33] These are adapted from the original Attachment A of Annex 6, Part III.

[34] For helicopters certificated in Part 27, this is the "Normal Category".

[35] This limitation on mass is likely to result in a configuration of 19, or fewer, seats — correlating with the limit on passengers for performance Class 2.

c) The engine-failure risk-profile of performance Class 3 correlates with that of Category B.

2.6.3.5 In recognition of the three engine-failure risk-profiles, passenger carriage limits within the performance classes should be:

a) Performance Class 1, unlimited.

b) Performance Class 2, 19 or fewer.

c) Performance Class 3, nine or fewer.

2.6.4 Summary of objectives

2.6.4.1 The resulting objectives for operations in accordance with performance classes, taking into consideration the certification categories, environmental classification and the performance classes, should be as follows:

a) Helicopters operated in performance Class 1 should be certificated in Category A.

b) Helicopters operated in performance Class 2 should be certificated in Category A, or Category B under Part 29.1(e).

c) Helicopters operated in performance Class 3 should be certificated in Category A or B (or equivalent).

d) Operations in performance Classes 2 and 3 should be conducted with an SFL capability during take-off or landing.

e) Operations in performance Class 3 should be conducted over a non-hostile environment.

f) Helicopters with more than 19 passengers should be operated in performance Class 1.

g) Helicopters with 19 or fewer but more than nine passengers should be operated in performance Classes 1 or 2.

h) Helicopters with nine or fewer passengers should be operated in performance Classes 1, 2 or 3.

Appendix to Chapter 2

AN EXAMPLE OF HELICOPTER PERFORMANCE AND OPERATING LIMITATIONS

PURPOSE AND SCOPE

This appendix and its attachment provide specimen performance and operating limitations, and regulations. A State may use these, or alternatives, within its code of performance to meet the safety objectives of Annex 6, Part III, Section II, Chapter 3.

1. DEFINITIONS

Category A. With respect to helicopters, means a multi-engined helicopter designed with engine and system isolation features specified in Annex 8, Part IVB, and capable of operations using take-off and landing data scheduled under a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight or safe rejected take-off.

Category B. With respect to helicopters, means a single-engine or multi-engined helicopter which does not meet Category A standards. Category B helicopters have no guaranteed capability to continue safe flight in the event of an engine failure, and a forced landing is assumed.

2. GENERAL

2.1 Helicopters operating in performance Classes 1 and 2 should be certificated in Category A.

2.2 Helicopters operating in performance Class 3 should be certificated in either Category A or Category B (or equivalent).

2.3 Except as permitted by the appropriate authority:

2.3.1 Take-off or landing from/to heliports in a congested hostile environment should be conducted in performance Class 1.

2.3.2 Operations in performance Classes 2 and 3 should be conducted with an SFL capability during take-off and landing.

2.3.3 Operations in performance Class 3 should only be conducted over a non-hostile environment.

Attachment to Appendix to Chapter 2

EXAMPLE PERFORMANCE REGULATION

PURPOSE AND SCOPE

The following example provides quantitative specifications that illustrate a level of performance intended by the provisions of Annex 6, Part III, Section II, Chapter 3.

Note.— This example is provided as a template for States to use in developing their own code, and also as a means of characterizing or illustrating a minimum amount of information and data necessary.

ABBREVIATIONS SPECIFIC TO HELICOPTER OPERATIONS

Abbreviations

D	Maximum dimension of helicopter
DPBL	Defined point before landing
DPATO	Defined point after take-off
DR	Distance travelled (helicopter)
FATO	Final approach and take-off area
LDP	Landing decision point
LDAH	Landing distance available (helicopter)
LDRH	Landing distance required (helicopter)
R	Rotor radius of helicopter
RFM	Rotorcraft flight manual
RTODRH	Rejected take-off distance required (helicopter)
TDP	Take-off decision point
TLOF	Touchdown and lift-off area
TODAH	Take-off distance available (helicopter)
TODRH	Take-off distance required (helicopter)
V_{TOSS}	Take-off safety speed

1. DEFINITIONS

1.1 Only applicable to operations in performance Class 1

Landing distance required (helicopter). The horizontal distance required to land and come to a full stop from a point 15 m (50 ft) above the landing surface.

Rejected take-off distance required. The horizontal distance required from the start of the take-off to the point where the helicopter comes to a full stop following an engine failure and rejection of the take-off at the take-off decision point.

Take-off distance required (helicopter). The horizontal distance required from the start of the take-off to the point at which V_{TOSS}, a selected height and a positive climb gradient are achieved, following failure of the critical engine being recognized at TDP, the remaining engines operating within approved operating limits.

Note.— The selected height stated above is to be determined with reference to either:

a) the take-off surface; or

b) a level defined by the highest obstacle in the take-off distance required.

1.2 Applicable to operations in all performance classes

D. The maximum dimension of the helicopter with the rotors running.

Distance DR. The horizontal distance that the helicopter has travelled from the end of the take-off distance available.

Landing distance available. The length of the final approach and take-off area plus any additional area declared available and suitable for helicopters to complete the landing manoeuvre from a defined height.

R. The rotor radius of the helicopter.

Take-off distance available (helicopter). The length of the final approach and take-off area plus the length of helicopter clearway (if provided) declared available and suitable for helicopters to complete the take-off.

Take-off flight path**.** The vertical and horizontal path, with the critical engine inoperative, from a specified point in the take-off to 300 m (1 000 ft) above the surface.

Touchdown and lift-off area. A load bearing area on which a helicopter may touchdown or lift-off.

V_{TOSS}. Take-off safety speed for helicopters certificated in Category A.

V_Y. Best rate of climb speed.

2. GENERAL

2.1 Applicability

2.1.1 Helicopters with a passenger seating configuration of more than 19, or helicopters operating to or from a heliport in a congested hostile environment should be operating in performance Class 1.

2.1.2 Helicopters with a passenger seating configuration of 19 or less but more than nine should be operating in performance Classes 1 or 2, unless operating to or from a congested hostile environment in which case the helicopters should be operating in performance Class 1.

2.1.3 Helicopters with a passenger seating configuration of nine or less should be operating in performance Classes 1, 2 or 3, unless operating to or from a congested hostile environment in which case the helicopters should be operating in performance Class 1.

2.2 SIGNIFICANT PERFORMANCE FACTORS

To determine the performance of the helicopter, account should be taken of at least the following factors:

a) mass of the helicopter;

b) elevation or pressure-altitude and temperature; and

c) wind; for take-off and landing, accountability for wind should be no more than 50 per cent of any reported steady headwind component of 5 knots or more. Where take-off and landing with a tailwind component is permitted in the RFM, not less than 150 per cent of any reported tailwind component should be allowed. Where precise wind measuring equipment enables accurate measurement of wind velocity over the point of take-off and landing, these values may be varied.

2.3 OPERATING CONDITIONS

2.3.1 For helicopters operating in performance Classes 2 or 3 in any flight phase where an engine failure may cause the helicopter to force-land:

a) a minimum visibility should be defined by the operator, taking into account the characteristics of the helicopter, but should not be less than 800 m for helicopters operating in performance Class 3; and

b) the operator should verify that the surface below the intended flight path permits the pilot to execute an SFL.

2.3.2 Performance Class 3 operations should not be performed:

a) out of the sight of the surface; or

b) at night; or

c) when the cloud ceiling is less than 180 m (600 ft).

2.4 Obstacle accountability area

2.4.1 For the purpose of the obstacle clearance requirements in Section 4 below, an obstacle should be considered if its lateral distance from the nearest point on the surface below the intended flight path is not further than:

a) for VFR operations:

    1) half of the minimum width of the FATO (or the equivalent term used in the RFM) defined in the RFM (or when no width is defined, 0.75 D), plus 0.25 times D (or 3 m, whichever is greater), plus:

        i) 0.10 DR for VFR day operations

        ii) 0.15 DR for VFR night operations

b) for IFR operations:

    1) 1.5 D (or 30 m, whichever is greater), plus:

    i) 0.10 DR for IFR operations with accurate course guidance
    ii) 0.15 DR for IFR operations with standard course guidance
    iii) 0.30 DR for IFR operations without course guidance

c) for operations with initial take-off conducted visually and converted to IFR/IMC at a transition point, the criteria required in 2.4.1 a) apply up to the transition point then the criteria required in 2.4.1 b) apply after the transition point.

2.4.2 For a take-off using a backup take-off procedure (or with lateral transition), for the purpose of the obstacle clearance requirements in 4 below, an obstacle located below the backup flight path (lateral flight path) should be considered if its lateral distance from the nearest point on the surface below the intended flight path is not further than half of the minimum width of the FATO (or the equivalent term used in the RFM) defined in the RFM (when no width is defined, 0.75 D plus 0.25 times D, or 3 m, whichever is greater) plus:

a) 0.10 distance travelled from the back edge of the FATO for VFR day operations;

b) 0.15 distance travelled from the back edge of the FATO for VFR night operations.

2.4.3 Obstacles may be disregarded if they are situated beyond:

a) 7 R for day operations if it is assured that navigational accuracy can be achieved by reference to suitable visual cues during the climb;

b) 10 R for night operations if it is assured that navigational accuracy can be achieved by reference to suitable visual cues during the climb;

c) 300 m if navigational accuracy can be achieved by appropriate navigation aids; and

d) 900 m in the other cases.

Note.— Standard course guidance is associated with a non-precision approach. Accurate course guidance is associated with a precision approach.

2.4.4 The transition point should not be located before the end of TODRH for helicopters operating in performance Class 1 and before the DPATO for helicopters operating in performance Class 2.

2.4.5 When considering the missed approach flight path, the divergence of the obstacle accountability area should apply after the end of the take-off distance available.

2.5 SOURCE OF PERFORMANCE DATA

The operator should ensure that the approved performance data contained in the RFM is used to determine compliance with this example, supplemented as necessary with other data acceptable to the State of the Operator.

3. OPERATING AREA CONSIDERATIONS

3.1 FATO

For operations in performance Class 1, the dimensions of the FATO should be at least equal to the dimensions specified in the RFM.

4. LIMITATIONS RESULTING FROM PERFORMANCE

4.1 Operations in performance Class 1

4.1.1 *Take-off*

4.1.1.1 The take-off mass of the helicopter should not exceed the maximum take-off mass specified in the RFM for the procedure to be used and to achieve a rate of climb of 100 ft/min at 60 m (200 ft) and 150 ft/min at 300 m (1 000 ft) above the level of the heliport with the critical engine inoperative and the remaining engines operating at an appropriate power rating, taking into account the parameters specified in 2.2 (Figure A-1).

4.1.1.2 Rejected take-off

The rejected take-off distance required does not exceed the rejected take-off distance available.

4.1.1.3 Take-off distance

The take-off distance required does not exceed the take-off distance available.

Note 1.— As an alternative, the requirement above may be disregarded provided that the helicopter with the critical engine failure recognized at TDP can, when continuing the take-off, clear all obstacles from the end of the take-off distance available to the end of the take-off distance required by a vertical margin of not less than 10.7 m (35 ft) (Figure A-2).

Note 2.— For elevated heliports, the airworthiness code provides appropriate clearance from the elevated heliport edge (Figure A-3).

4.1.1.4 Backup procedures (or procedures with lateral transition)

The operator should ensure that, with the critical engine inoperative, all obstacles below the backup flight path (the lateral flight path) are cleared by an adequate margin. Only the obstacles specified in 2.4.2 should be considered.

4.1.2 *Take-off flight path*

From the end of the take-off distance required with the critical engine inoperative:

4.1.2.1 The climb path provides a vertical clearance of not less than 10.7 m (35 ft) for VFR operations and 10.7 m (35 ft) plus 0.01 DR for IFR operations above all obstacles located in the climb path. Only obstacles as specified in 2.4 should be considered.

4.1.2.2 Where a change of direction of more than 15 degrees is made, obstacle clearance requirements should be increased by 5 m (15 ft) from the point at which the turn is initiated. This turn should not be initiated before reaching a height of 60 m (200 ft) above the take-off surface, unless permitted as part of an approved procedure in the RFM.

4.1.3 *En-route*

It is possible, in case of the critical engine failure occurring at any point of the flight path, to continue the flight to an appropriate landing site and achieve the minimum flight altitudes for the route to be flown.

4.1.4 *Approach, landing and balked landing* (Figures A-4 and A-5)

At the destination or alternate:

a) the landing mass does not exceed the maximum landing mass specified in the RFM for the procedure to be used and to achieve a rate of climb of 100 ft/min at 60 m (200 ft) and 150 ft/min at 300 m (1 000 ft) above the level of the heliport with the critical engine inoperative and the remaining engines operating at an appropriate power rating, taking into account the parameters specified in 2.2;

b) the landing distance required does not exceed the landing distance available unless the helicopter, with the critical engine failure recognized at LDP, can, when landing, clear all obstacles in the approach path;

c) in case of the critical engine failure occurring at any point after the LDP, it is possible to land and stop within the FATO; and

d) in the event of the critical engine failure being recognized at the LDP or at any point before the LDP, it is possible either to land and stop within the FATO or to overshoot, meeting the conditions of 4.1.2.1 and 4.1.2.2.

Note.— For elevated heliports, the airworthiness code provides appropriate clearance from the elevated heliport edge.

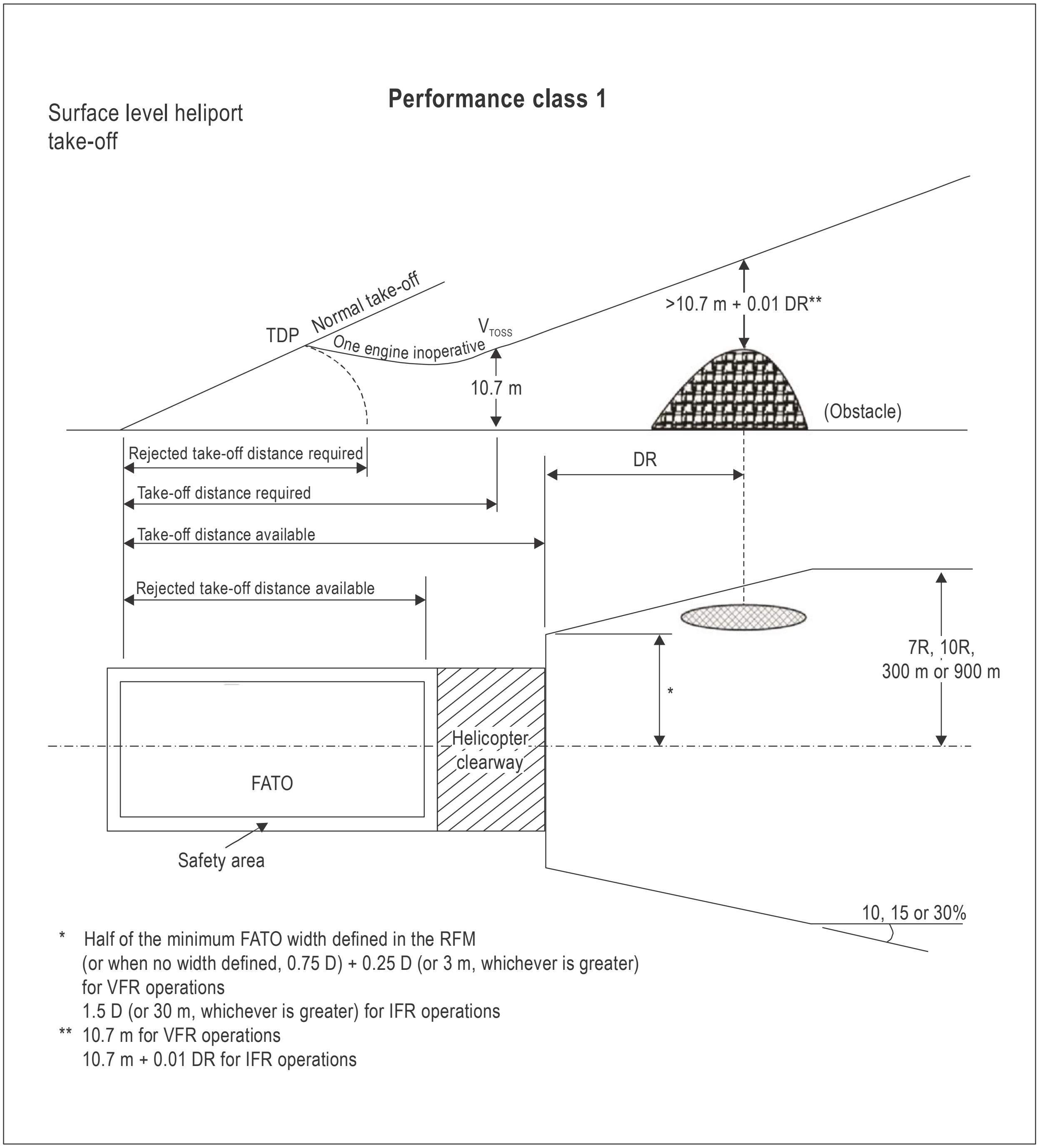
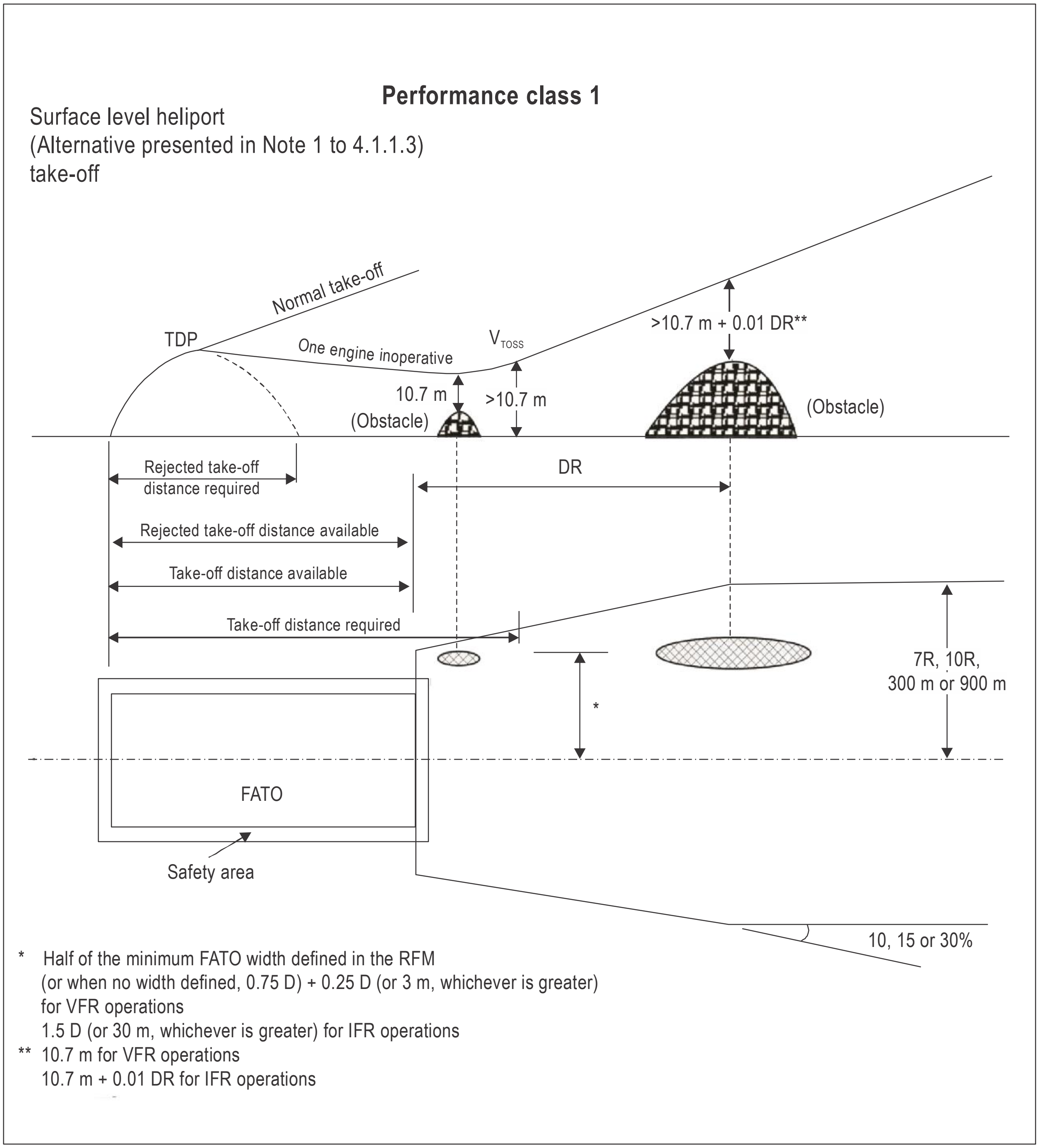

Performance class 1
Surface level heliport take-off
TDP
Normal take-off
One engine inoperative
V_{TOSS}
10.7 m
>10.7 m + 0.01 DR**
(Obstacle)
DR
Rejected take-off distance required
Take-off distance required
Take-off distance available
Rejected take-off distance available
7R, 10R, 300 m or 900 m
*
Helicopter clearway
FATO
Safety area
10, 15 or 30%
* Half of the minimum FATO width defined in the RFM (or when no width defined, 0.75 D) + 0.25 D (or 3 m, whichever is greater) for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations
** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations

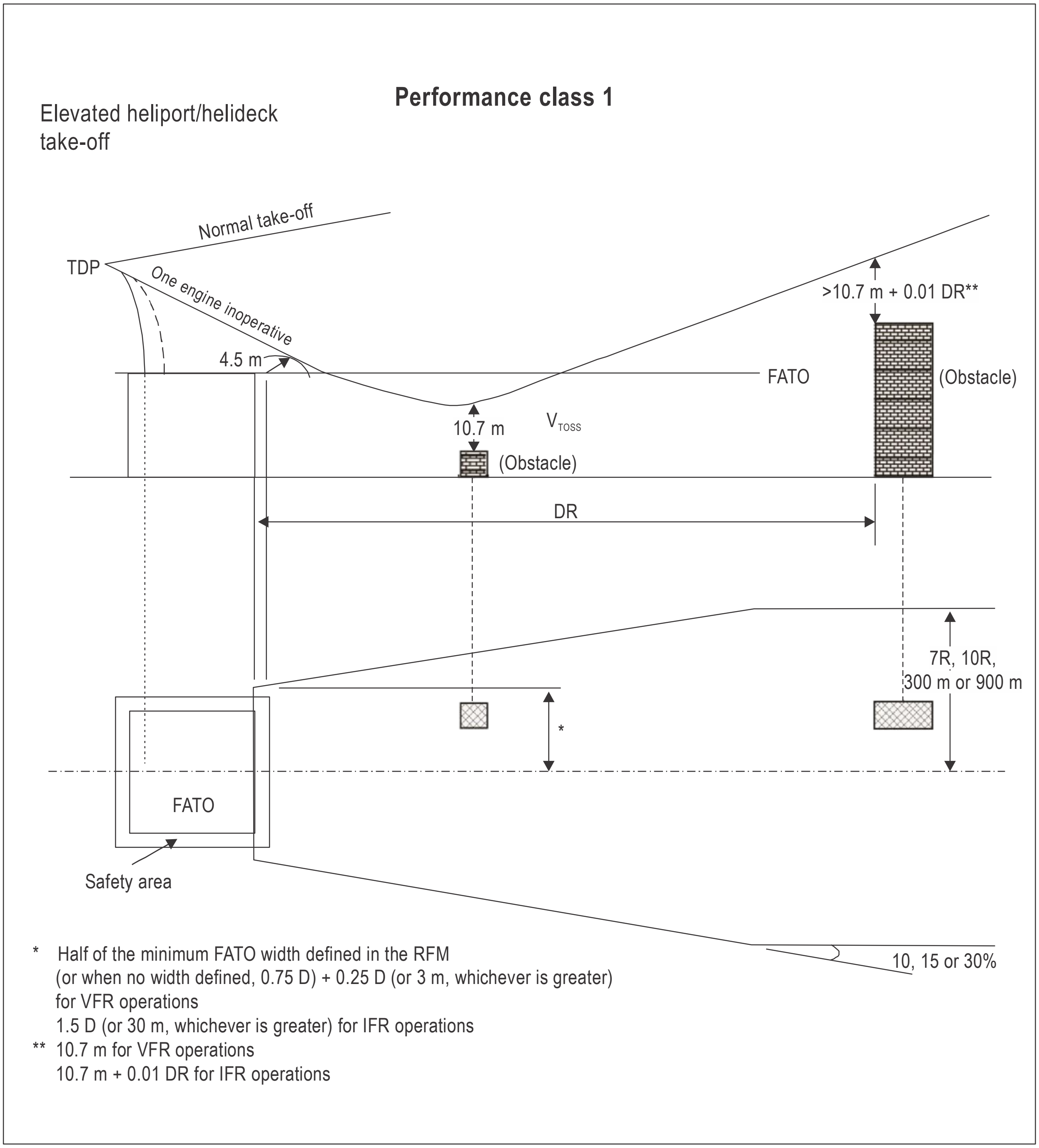
Figure A-1



* Half of the minimum FATO width defined in the RFM
(or when no width defined, 0.75 D) + 0.25 D (or 3 m, whichever is greater)
for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations

** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations

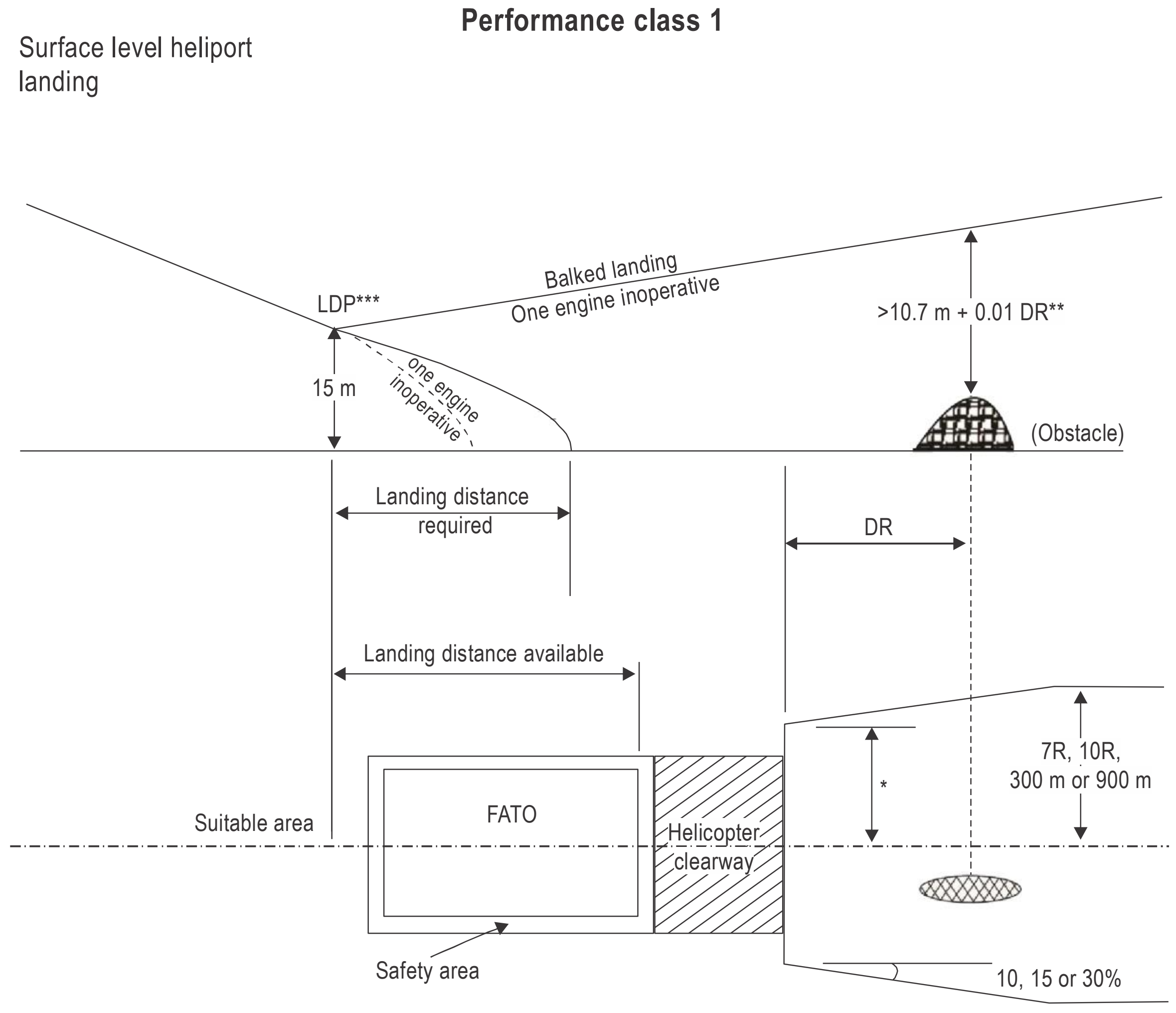
Figure A-2



* Half of the minimum FATO width defined in the RFM
(or when no width defined, 0.75 D) + 0.25 D (or 3 m, whichever is greater) for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations

** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations

Figure A-3



Performance class 1

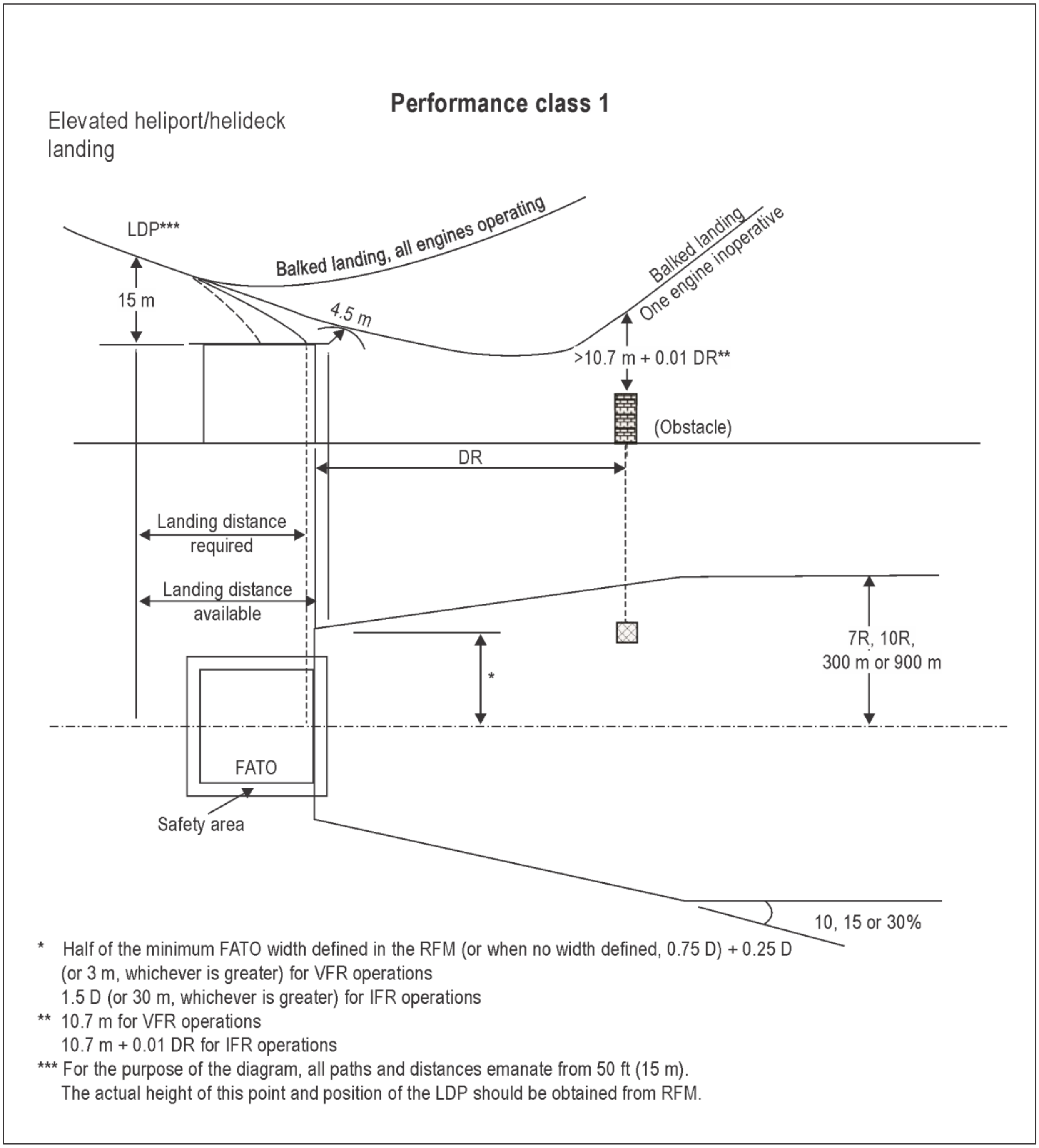
Surface level heliport landing

* Half of the minimum FATO width defined in the RFM (or when no width defined, 0.75 D) + 0.25 D (or 3 m, whichever is greater) or VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations

** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations

*** For the purpose of the diagram, all paths and distances emanate from 50 ft (15 m).
The actual height of this point and position of the LDP should be obtained from RFM.

Figure A-4



* Half of the minimum FATO width defined in the RFM (or when no width defined, 0.75 D) + 0.25 D (or 3 m, whichever is greater) for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations

** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations

*** For the purpose of the diagram, all paths and distances emanate from 50 ft (15 m).
The actual height of this point and position of the LDP should be obtained from RFM.

Figure A-5

4.2 Operations in performance Class 2

4.2.1 *Take-off* (Figures A-6 and A-7)

The mass of the helicopter at take-off should not exceed the maximum take-off mass specified in the RFM for the procedures to be used and to achieve a rate of climb of 150 ft/min at 300 m (1 000 ft) above the level of the heliport with the critical engine inoperative and the remaining engines operating at an appropriate power rating, taking into account the parameters specified in 2.2.

4.2.2 *Take-off flight path*

From DPATO or, as an alternative, no later than 60 m (200 ft) above the take-off surface with the critical engine inoperative, the conditions of 4.1.2.1 and 4.1.2.2 should be met.

4.2.3 *En-route*

The requirements of 4.1.3 should be met.

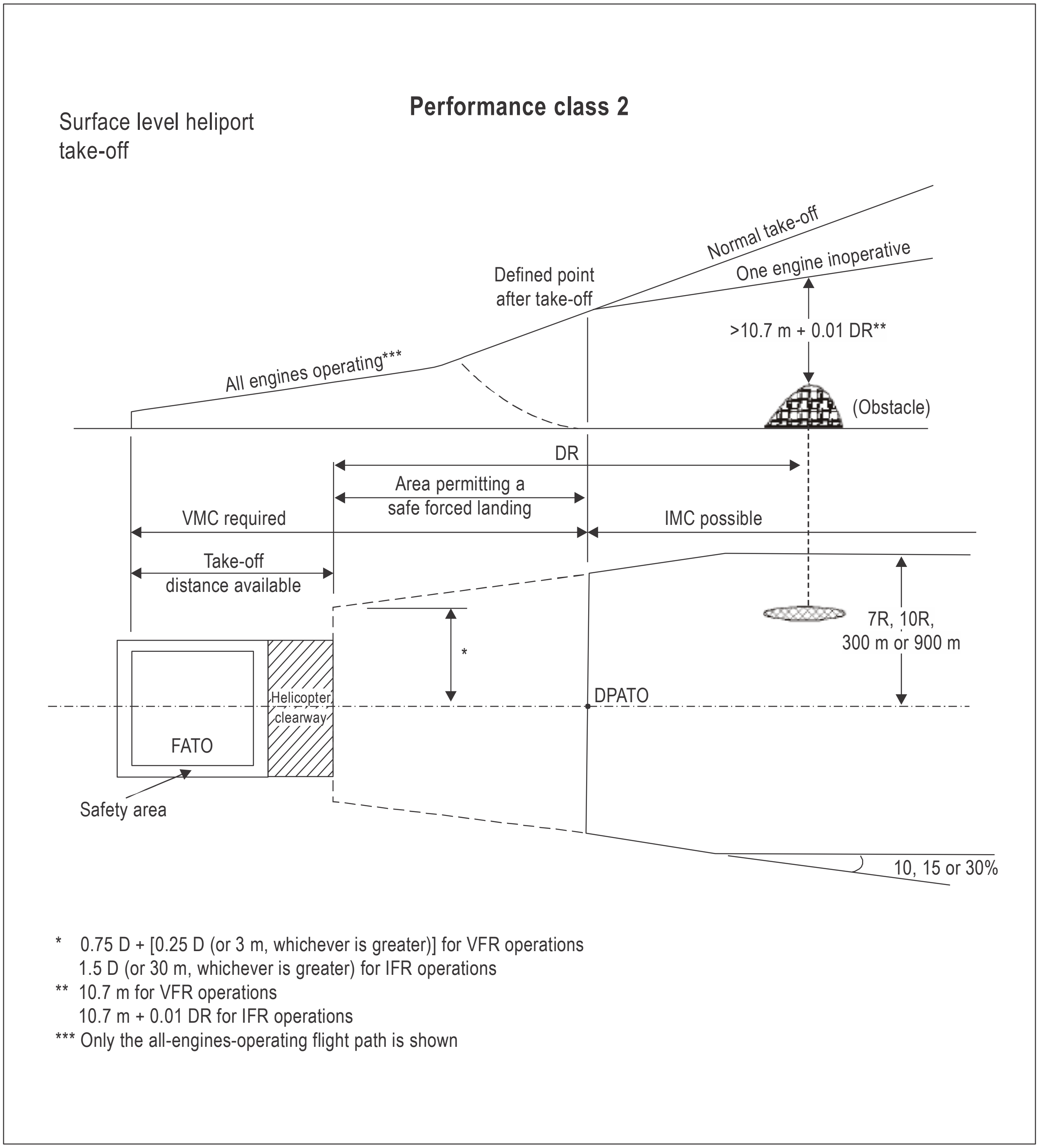
4.2.4 *Approach, landing and balked landing* (Figures A-8 and A-9)

At the destination or alternate:

a) the estimated landing mass does not exceed the maximum landing mass specified in the RFM for a rate of climb of 150 ft/min at 300 m (1 000 ft) above the level of the heliport with the critical engine inoperative and the remaining engines operating at an appropriate power rating, taking into account the parameters specified in 2.2;

b) it is possible, in case of the critical engine failure occurring at or before the DPBL, either to perform an SFL or to overshoot, meeting the requirements of 4.1.2.1 and 4.1.2.2.

Only obstacles as specified in 2.4 should be considered.



* 0.75 D + [0.25 D (or 3 m, whichever is greater)] for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations
** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations
*** Only the all-engines-operating flight path is shown

Figure A-6

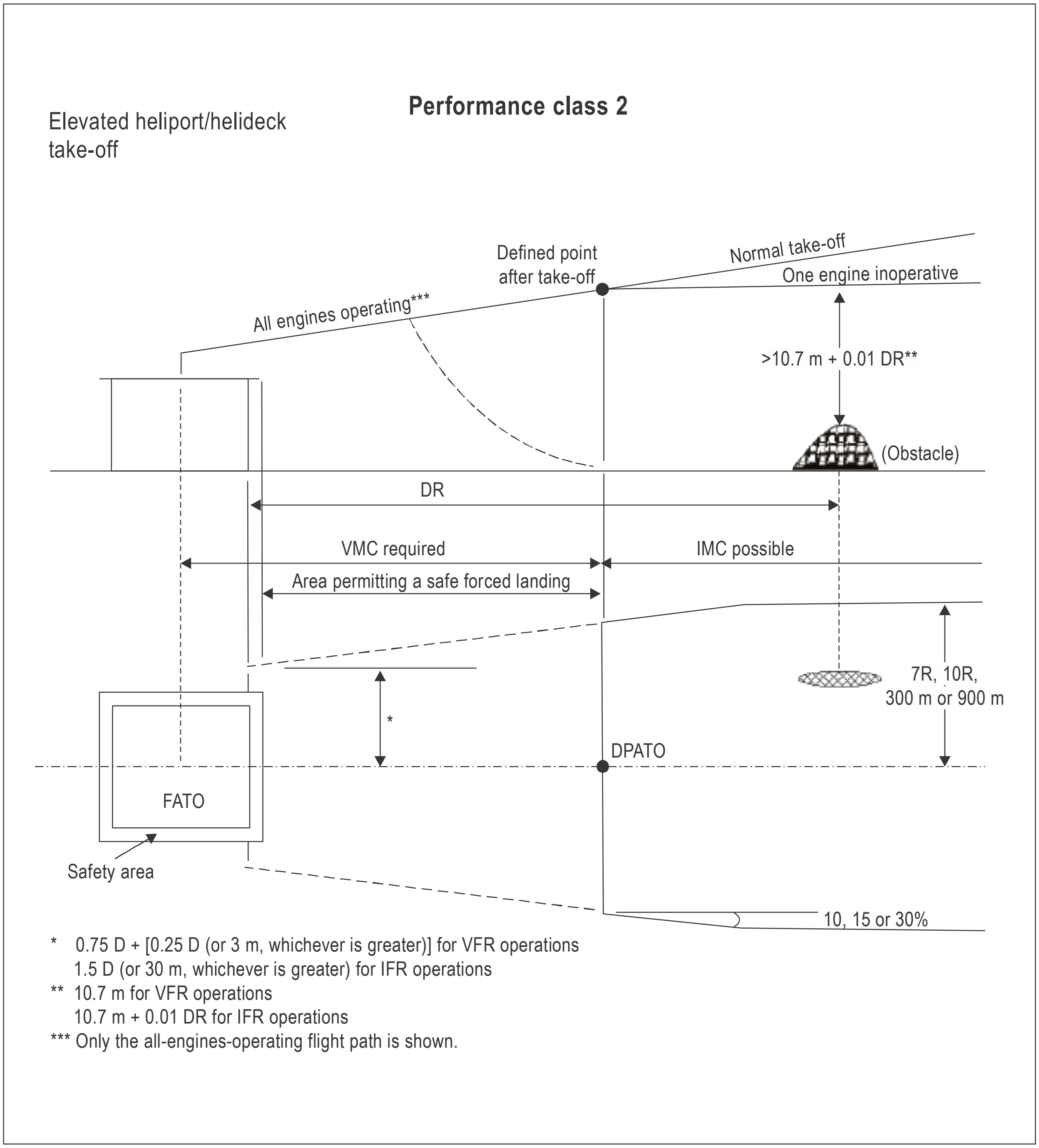
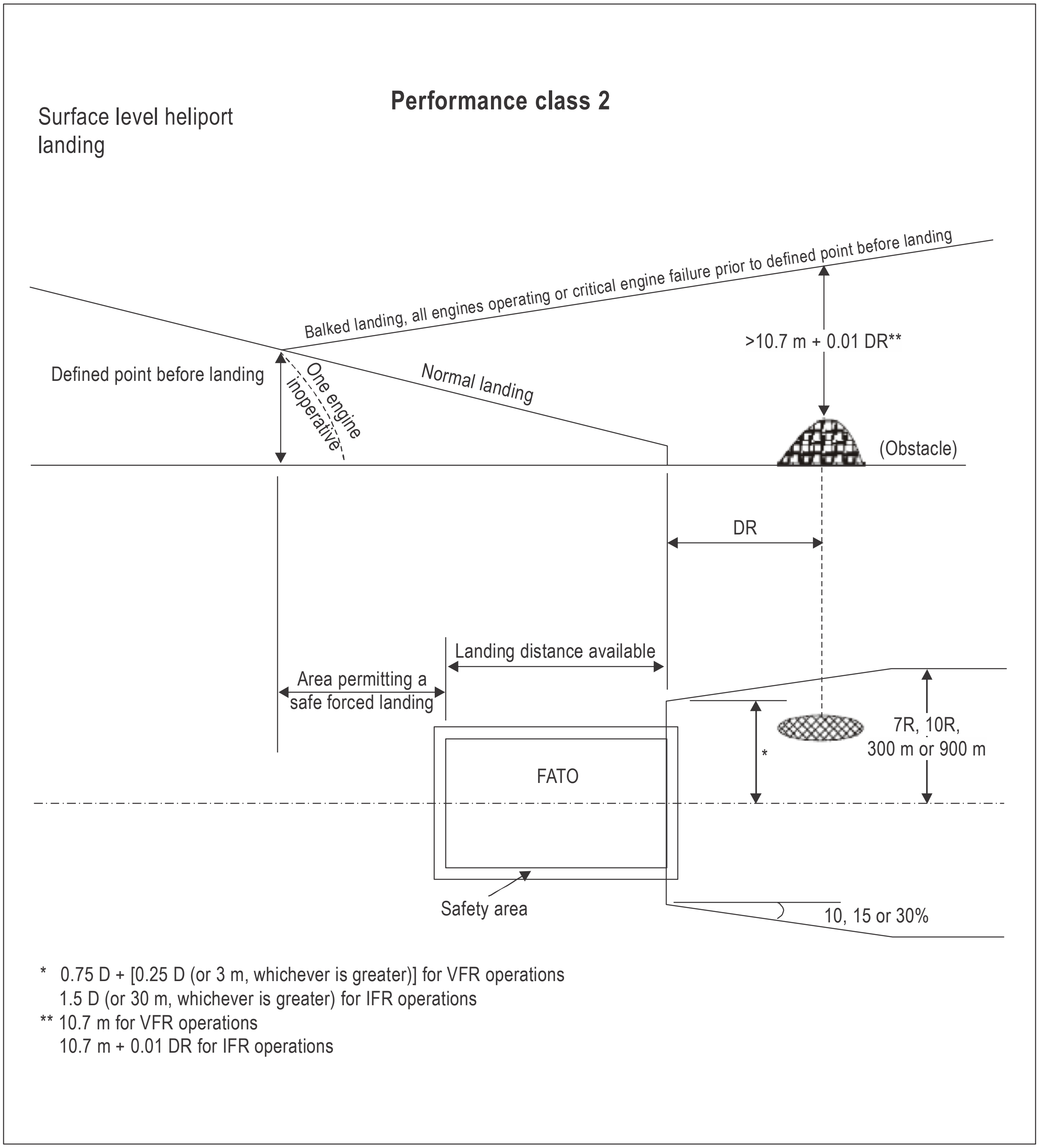
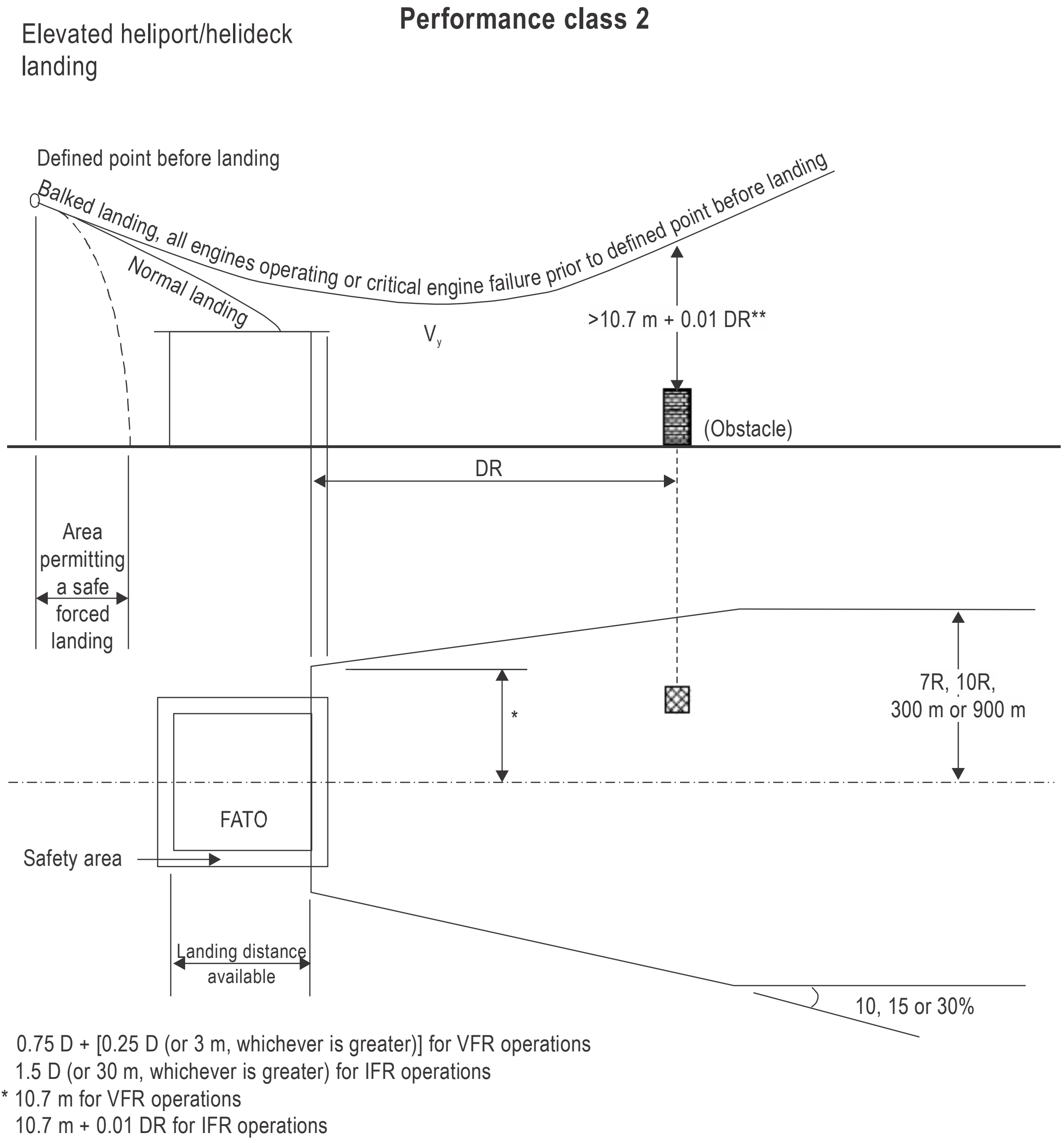

Performance class 2
Elevated heliport/helideck take-off
Defined point after take-off
Normal take-off
One engine inoperative
All engines operating***
>10.7 m + 0.01 DR**
(Obstacle)
DR
VMC required
IMC possible
Area permitting a safe forced landing
*
7R, 10R, 300 m or 900 m
DPATO
FATO
Safety area
10, 15 or 30%
* 0.75 D + [0.25 D (or 3 m, whichever is greater)] for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations
** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations
*** Only the all-engines-operating flight path is shown.

Figure A-7



* 0.75 D + [0.25 D (or 3 m, whichever is greater)] for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations
** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations

Figure A-8



* 0.75 D + [0.25 D (or 3 m, whichever is greater)] for VFR operations
1.5 D (or 30 m, whichever is greater) for IFR operations
** 10.7 m for VFR operations
10.7 m + 0.01 DR for IFR operations

Figure A-9

4.3 Operations in performance Class 3

4.3.1 *Take-off*

The mass of the helicopter at take-off should not exceed the maximum take-off mass specified in the RFM for a hover in-ground effect with all engines operating at take-off power, taking into account the parameters specified in 2.2. If conditions of the take-off surface are such that a hover in-ground effect is not likely to be established, the take-off mass should not exceed the maximum mass specified for a hover out-of-ground effect with all engines operating at take-off power, taking into account the parameters specified in 2.2.

4.3.2 *Initial climb*

The climb path provides adequate vertical clearance above all obstacles located along the climb path, all engines operating.

4.3.3 *En-route*

It is possible to achieve the minimum flight altitudes for the route to be flown, all engines operating.

4.3.4 *Approach and landing*

At the destination or alternate:

a) the estimated landing mass does not exceed the maximum landing mass specified in the RFM for a hover in-ground effect with all engines operating at take-off power, taking into account the parameters specified in 2.2. If conditions are such that a hover in-ground effect is not likely to be established, the take-off mass should not exceed the maximum mass specified for a hover out-of-ground effect with all engines operating at take-off power, taking into account the parameters specified in 2.2; and

b) it is possible to perform a balked landing, all engines operating, at any point of the flight path and clear all obstacles by an adequate vertical interval.

Chapter 3

OPERATIONS WITH EXPOSURE IN A HELICOPTER CODE OF PERFORMANCE

This chapter provides guidance on establishing codes of performance allowing variations without an SFL in the event of a critical engine failure as defined in Annex 6, Part III, Section II, Chapter 3, 3.1.3. It may be used by States as a basis for allowing helicopter operations, conducted without an SFL, to be included in the code of performance.

3.1 INTRODUCTION

3.1.1 General

3.1.1.1 The transport of passengers for remuneration or other valuable consideration is categorized as CAT; such operations should be afforded the highest practical standard of aviation safety.

3.1.1.2 By their very nature, helicopters used in CAT are highly versatile and can be expected to operate in a wide range of environments. Because of this versatility, States should be aware of the safety risk of exposure[1] to engine or system[2] failure on flights over a hostile environment[3].

3.1.1.3 When analysing aspects of any operation, not only should the potential benefits and costs be quantified, acceptable levels of safety risk should also be established by assessing: the likelihood of any event; the possible consequences; and, any mitigating measures that should be applied.

3.1.2 Acceptable Safety Risk

3.1.2.1 Absolute safety is generally an unachievable or prohibitively expensive goal. Therefore, the concept of acceptable safety has been adopted in risk-bearing industries, including aviation. The term "acceptable risk" describes an event with a probability of occurrence and consequences acceptable to the society (i.e. the society is willing to take, or be subjected, to the risk that the event might bring). It is the role of the safety regulatory authorities to translate the society expectations and perceptions into a qualitative or quantitative acceptable level of safety risk (ALSR).

3.1.2.2 The responsibility for defining the risk assessment strategy and setting the ALSR associated with this assessment rests with the individual State. The depth of the risk assessment and acceptable safety risk levels may vary from State to State depending on the socioeconomic needs of the individual State.

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[1] The term “exposure” when used in this chapter means exposure to the consequences of engine or system failure when a safe forced landing or subsequent survival is not assured — see also section 3.3.2.

[2] For multi-engine helicopters, certification in Category A provides assurance that the failure of an engine or system “will not prevent continued safe flight”.

[3] A hostile environment is one where: a safe forced landing cannot be accomplished; or, occupants cannot be protected from the elements; or, rescue is not possible within anticipated survival time.

Note.— In spite of all its complexity and limitations, calculating safety risk is a scientific activity that attempts to achieve a true measurement. Deciding on safety risk acceptability will involve a value judgement because it calls on sociological perceptions, with decisions generally made in the political domain. It will therefore be important to address safety with a clear distinction between facts and values.

3.1.3 Establishing the acceptable level of safety risk

3.1.3.1 Annex 6, Part III, Section II, Chapter 3, 3.1.3 states that:

"The risk assessment shall take into consideration at least the following:

a) the type and circumstances of the operation;

b) the area/terrain over which the operation is being conducted;

c) the probability of, and length of exposure to, a critical engine failure and the tolerability of such event;

d) the procedures and systems for monitoring and maintaining the reliability of the engine(s);

e) the training and operational procedures to mitigate the consequences of the critical engine failure; and

f) helicopter equipment."

3.1.3.2 In defining the assessment strategy and acceptable safety risk, each State should consider the total risk associated with the intended helicopter operation in comparison with other modes of transport that may be available for achieving the operational objective. In addition to the elements contained in 3.1.3.1, more details, or other factors, that could be considered include but are not limited to:

a) the necessity for the types of operation envisaged;

b) the importance to the public interest and its impact on the local population;

c) alternative means of transportation that may be available to fulfil the objective and the level of risk associated with these alternative means;

d) topography and hostility of the surface likely to be traversed;

e) environmental factors — day/night, weather, icing, lightning, seasonal conditions, sea state, etc.;

f) distances to be covered and time to complete the operation; and

g) availability of alerting and search and rescue capabilities.

3.1.3.3 A State's infrastructure will have an impact on the total risk assessment. Operations in hostile environments typically mean isolated areas with difficult terrain, and where search and rescue cannot be assured. In these cases, the helicopter may be the only practical means to transport CAT passengers to rural communities and industries. The time to get to these communities by means other than helicopters may be several days, if it can be done at all.

3.1.3.4 Economic considerations play a role in the overall total risk assessment. States are faced with complex decisions when it comes to the type of helicopters it will permit to conduct CAT operations with exposure. The Category A certificated helicopter reduces the risk of an engine or system failure resulting in a forced landing, but the cost of these helicopters (for both acquisition and operation) are typically (and significantly) more than for a single-engine helicopter. This may have a direct impact on the cost of services provided to some communities.

3.1.3.5 Safety risks are conceptually assessed as acceptable, tolerable or intolerable. Safety risks assessed as initially falling in the intolerable region are unacceptable under any circumstances. The probability and/or severity of the consequences of the hazards are of such a magnitude, and the damaging potential of the hazard poses such a threat to safety, that mitigation action is required or activities are stopped. When safety risk falls into the tolerable level, management approval is generally required to accept the safety risk.

3.1.3.6 The State should verify that the level of safety risk associated with a helicopter operation is reduced to an acceptable or tolerable level while giving due consideration to what it believes is in the public's best interest.

3.1.4 Applicability of the code of performance

3.1.4.1 A State's code of performance (and more specifically, its variations) is applicable to operations conducted within that State and to its operators wherever they conduct operations.

3.1.4.2 When international operations are conducted, the following Standard in Annex 6, Part III, Section II, Chapter 1 applies:

> "1.1.1 The operator shall ensure that all employees when abroad know that they must comply with the laws, regulations and procedures of those States in which their operations are conducted."

3.1.4.3 This Standard requires the more conservative of the codes of performance to be applied; either the code of the State of the Operator, or the code of the State in which operations are being conducted.

3.1.4.4 This ensures that the minimum level of safety intended by the State in which operations are being conducted is achieved (even if the Standard applied by the operator exceeds that minimum).

3.1.4.5 To ensure that the intended Standard is applied, the code of performance should be both transparent and published.

3.1.5 Summary

3.1.5.1 Annex 6, Part III, Section 2, Chapter 3 defines a system of engine failure tolerability[4] on which States should base their codes of performance. However, because of the necessity to operate in hostile environments, flexibility is required within the code to permit operations without an assured SFL capability, when conducted to a level of safety acceptable to the State.

3.1.5.2 Flexibility in allowing variations is facilitated by Annex 6, Part III, Section II, Chapter 3, 3.1.3. The Standard requires the State to conduct a risk assessment when including operations without an SFL in a code of performance. The ALSR is not explicit in the Standard because "acceptable risk" describes an event with a probability of occurrence and consequences acceptable to "the society" and it is for the State to decide what is acceptable.

3.1.5.3 The ALSR provides an objective against which an assessment can be conducted and compliance tested. The lack of an objective (the ALSR) could be problematical because of the consequential necessity for subjective judgment in any assessment.

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[4] Tolerability in this case means the engine-failure accountability of performance Class 1, and safe forced landing provision of performance Classes 2 and 3.

3.1.5.4 Annex 19 — *Safety Management* and the *Safety Management Manual* (Doc 9859), provide the basis for a safety risk assessment. Section 3.3 of this manual contains a mapping of the "effect on occupants" to "qualitative and quantitative probabilities" that can improve the scale or level of solution. They can be used in establishing the ALSR for any proposed alleviation from the consequence of engine or system failure.

3.1.5.5 All solutions will be dependent upon a common assessment of engine reliability. To ensure assessment is based upon up-to-date reliability data, there is a need for the original equipment manufacturers' (OEMs) annual engine reliability reports (currently available only to some States) to be made more widely available.

3.1.5.6 The code of performance, including variations, should be published in order that they may be complied with in the State of Operations.

3.2 OPERATIONS WITH EXPOSURE — INCLUDING EXAMPLES

Annex 6, Part III, Section II, Chapter 3.1.3 provides the State with the opportunity to include operations without an SFL (exposure) in the code of performance. The process used to establish such operations should, however, indicate how exposure in the take-off, landing, or en-route phase will be managed.

3.2.1 What is exposure?

Exposure in this manual is used to describe any part of a flight during which the failure of an engine or system could result in a forced landing with an outcome of "hazardous" or "catastrophic".

3.2.2 Operations without exposure

3.2.2.1 In operations without exposure, the outcome of a failure resulting in an SFL includes the possibility of injuries. As discussed in 2.1.2.1.3, this outcome can be correlated with the failure condition category of "major".

3.2.2.2 Successfully completing the landing phase of a forced landing is only one consideration. It is also essential that occupants are adequately protected from the elements and search and rescue is accomplished within survival time. If the surface conditions, and/or environment, are such that an SFL and recovery could be successfully achieved, the operation is without exposure.

3.2.2.3 That is neither to underestimate the nature of emergencies nor the variability of the conditions; even when operating over an environment that is (considered to be[5]) non-hostile, a failure leading to a forced landing could, if misjudged or mishandled, result in unanticipated consequences.

3.2.3 Operations with exposure

3.2.3.1 A flight where failure of an engine or system does not permit continued safe flight and does not ensure an SFL and subsequent survival, is being conducted with exposure.

3.2.3.2 The consequence of this event will be a safety risk severity category of "hazardous" or "catastrophic":

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[5] An environment is never classified as non-hostile — it is left to the judgement of the operator; the exception is those parts of a "congested area" with adequate safe forced landing areas where a State may give a strong indication, by entering a note into the definition, that they could be considered non-hostile.

HAZARDOUS: Failure which would result in serious or fatal injury to an occupant.

CATASTROPHIC: Failure which would result in multiple fatalities, or loss of rotorcraft.

3.2.3.3 A failure leading to a forced landing in a hostile environment, if handled with exceptional skill or with sufficient luck, could result in an outcome better than hazardous or catastrophic, and occupants have been known to survive and be rescued from the most extreme conditions; however, such an outcome is not assured.

3.2.3.4 The use of the hostile/non-hostile classification is intended to facilitate management of safety, not engender unrealistic expectations or constrain normal operations.

3.2.4 Operations in performance Class 2

3.2.4.1 *General*

Operations in performance Class 2 should have:

3.2.4.1.1 All engines operating (AEO) obstacle clearance to a defined point after take-off (DPATO — limited to 200 ft (60 m) above the take-off surface) and OEI obstacle clearance from there on.

3.2.4.1.2 Mass constrained by the second segment climb and en-route performance (second segment climb performance[6] is defined as a climb rate of 150 ft/min at 1 000 ft above the take-off point). Unless drift down[7] can be conducted maintaining en-route obstacle clearance, a minimum climb rate must be established at the cruise altitude — this is typically 50 ft/min.

3.2.4.2 *Operations in performance Class 2 with exposure*

3.2.4.2.1 Operations with exposure are concerned only with alleviation from the requirement for the provision of an SFL — which includes: the surface conditions of the operating site; obstacles below 200 ft (60 m) in the take-off flight path; and, flight inside the HV curve (for take-off and landing).

3.2.4.2.2 The take-off mass should be obtained from the more limiting of the following:

a) AEO hover out-of-ground effect (HOGE) performance at the appropriate power setting;

b) AEO obstacle clearance (up to 200 ft (60 m));

c) OEI climb performance of 150 ft/min at 1 000 ft above the take-off point;

d) OEI obstacle clearance from 200 ft (60 m); and

e) OEI minimum climb performance at the lowest available cruise altitude.

Note.— AEO HOGE is required to ensure acceleration when (near) vertical dynamic take-off techniques are being used. Additionally, for elevated heliports/helidecks, it ensures a power reserve to offset ground cushion dissipation when leaving the TLOF; and ensures that, during the landing manoeuvre, a stabilized HOGE is available — should it be required.

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[6] This is sometimes called the Category A WAT (weight/altitude/temperature).

[7] Drift down applies when the helicopter cannot maintain the cruise altitude chosen but can safely descend to, and maintain, flight at a lower altitude.

3.2.4.3 *Example — Operations to elevated heliport/helidecks with exposure*

3.2.4.3.1 Operations to elevated heliports and helidecks are a specific case of exposure. In these operations, exposure covers the possibility of:

a) a deck-edge strike if the engine fails early in the take-off or late in the landing; or

b) penetration into the high velocity (HV) curve during take-off and landing; or

c) forced landing with obstacles on the surface (or hostile water conditions) below the elevated heliport (helideck).

The take-off mass should be as stated in 3.2.4.2.2 above.

3.2.4.4 *Example — performance Class 2 “enhanced” (PC2e)*

3.2.4.4.1 For offshore operations only, “performance Class 2 enhanced” (PC2e) is where exposure is present only for a small percentage of flights — i.e. when the helideck environment prevents engine-failure accountability. It requires performance with deck-edge miss and continued flight[8] following an engine failure on take-off or landing without meeting Category A criteria.

3.2.4.4.2 Category A elevated helideck procedures establish profiles and masses (adjusted for wind, temperature and pressure) which assure a 5 m (15 ft) deck edge clearance on take-off and landing; drop-down must be calculated and, once clear of the helideck, a helicopter operating in PC1 would be expected to meet the 10.7 m (35 ft) obstacle clearance (from the sea).

3.2.4.4.3 These procedures and clearances can be assured only when: the helideck is of the required size; the take-off or landing is oriented into the obstacle-free sector (OFS)[9]; and the profile is flown as defined. Because these conditions cannot always be fulfilled in offshore operations, a prescriptive regulation requiring operation in PC1 is not regarded as practical (OEI HOGE could be employed but this would result in a severe and unwarranted restriction on payload/range).

3.2.4.4.4 PC2e take-off and landing masses together with profiles/techniques provide a high confidence of deck-edge avoidance and continued safe flight, or reduction in exposure time. PC2e procedures may be based upon the Category A elevated helideck procedures — without requiring the associated assurances.

3.2.4.4.5 PC2e mass calculation provides notional[10] performance. Actual performance is dependent upon:

a) accuracy of the calculation;

b) how close actual conditions are to those planned;

c) whether the optimum profile can be flown; and

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[8] In the case where flights are being conducted in conditions of low wind and calm seas, operating in “pure performance Class 2” would permit a greater take-off mass than PC2e. This would be subject to “deck-edge clearance” assurance and acceptance by the customer that an SFL (ditching) is an acceptable outcome to an engine failure during take-off.

[9] For offshore helidecks, the obstacle-free sector (OFS) should extend through a minimum of 210º. This consists of a surface clear of obstacles, out to a specified distance, at the helideck level — within which is a 180º arc that is free of obstacles down to sea level (see Annex 14, Volume II, Figures 4-7 and 4-8).

[10] Notional because of the assumption that: the profile is defined and oriented into the OFS; the deck height above sea level is constant; and, the procedure is flown as published.

d) the orientation of the take-off and landing with respect to the OFS.

Planned obstacle clearances should be achieved when the defined profile is flown, and take-off or landing is directly within the OFS; if these conditions cannot be met, exposure might be present[11].

3.2.4.4.5.1 Under conditions of offshore operations, deck-edge clearance and calculation of drop-down is not a trivial matter. The following examples indicate some of the problems that might be encountered:

a) when tide is high and/or with irregular sea state — the level of the obstacle (i.e. the sea) is indefinable, making a true calculation of drop-down nearly impossible;

b) when it is not possible for the approach and departure paths to be oriented into the OFS — this mostly occurs when the wind vector exceeds crosswind limits and is from the limited obstacle sector (LOS) [12], and has the following consequences:

   1) the helicopter cannot “face” into the take-off direction and additional manoeuvring within the take-off profile will be necessary; this ‘upsets’ the projected deck-edge clearance; and

   2) drop-down is adversely affected by additional manoeuvring within the take-off profile;

c) infringements of the OFS, or the 180º clear zone, that are addressed in a helideck directory (HD) [13]; and

d) the influence of turbulence, hot gas emissions and other local environmental effects (also addressed in the HD).

3.2.4.4.5.2 Deck-edge clearance should be an integral part of the calculation; drop-down should be based upon the height of the deck above mean sea level (AMSL) with sea clearance applied; and, take-off and landing into the OFS should be assumed. PC2e mass is determined with these assumptions.

3.2.4.4.5.3 There are other issues which might affect deck-edge clearance and drop-down; examples are:

a) when operating to moving decks on vessels, a recommended landing or take-off profile might not be possible:

b) when the helicopter must be hovered alongside the deck in order that the rise and fall of the ship is mentally mapped; or

c) on take-off, relanding in the case of an engine failure might not be the best option.

3.2.4.4.5.4 Under these and other circumstances, the commander might adjust the profiles to address a hazard more serious, or more likely, than that presented by an engine failure; regardless of these issues, the calculation of mass should still remain as defined in 3.2.4.4.5.2 above.

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[11] Although exposure may only be present for a very small proportion of arrivals/departures, the requirement for PC2e should be contained within a variation that permits exposure.

[12] For offshore helidecks the limited obstacle sector (LOS) should be limited to 150º.

[13] The HD (see ICAO *Heliport Manual* — Doc 9261) is a universally shared document that is constructed and maintained by a local organization — subscribed to and maintained in the interest of all operators. It is kept up-to-date with the aid of a pilot’s reporting system.

3.2.4.4.6 Because of these and other (unforeseen) circumstances, a prescriptive requirement for PC2e obstacle clearance cannot be applied[14]. However, a target of 5 m (15 ft) deck-edge, and 10.7 m (35 ft) obstacle, clearance should, where possible, be considered.

3.2.4.4.7 As accident/incident history indicates that the main hazard is collision with obstacles on the helideck due to human error, the provision of simple and reproducible take-off and landing procedures is important.

3.2.4.4.8 The resulting regulation for PC2e might state that the take-off/landing mass should take into consideration:

a) the procedure;

b) deck-edge miss; and,

c) drop-down appropriate to the height of the helideck.

3.2.4.4.9 This will require manufacturer's information reflecting these elements. It is expected that such information will be produced by utilizing performance modelling/simulation using a model validated through limited flight testing.

3.2.4.5 *Example — Performance Class 2 with defined limited exposure (PC2 DLE)*

3.2.4.5.1 For offshore operations only, "performance Class 2 with defined limited exposure" (PC2 DLE) is a tool box to reduce the risk of an engine failure (and also other risks with all engines operative) with:

a) defined exposure times from 0 seconds to 9 seconds which correspond to an associated safety risk probability from 0 to 5×10^{-8} per event;

b) standardization by using the same simple and robust take-off and landing procedures for PC2 DLE as for PC1.

3.2.4.5.2 Category A elevated helideck procedures establish profiles and masses (adjusted for wind, temperature and pressure) which assure a 5 m (15 ft) deck-edge clearance on take-off and landing; drop-down must be calculated and, once clear of the helideck, a helicopter operating in PC1 would be expected to meet the 10.7m (35 ft) obstacle clearance (from the sea).

3.2.4.5.3 These procedures and clearances can be assured only when: the helideck is of the required size; take-off or landing is oriented into the OFS; and the profile is flown as defined. Because these conditions cannot always be fulfilled in offshore operations, a prescriptive regulation requiring operation in PC1 is not regarded as practical (OEI HOGE could be employed but this would result in a severe and unwarranted restriction on payload/range).

3.2.4.5.4 PC2 DLE take-off and landing masses together with profiles/techniques provide a high confidence of deck-edge avoidance, continued safe flight, or reduction in exposure times for the no fly away risk.

3.2.4.5.5 PC2 DLE mass calculation depends on pressure altitude, outside air temperature, wind, drop-down available and the accepted (defined) exposure time. For each set of calculation, risks to exposure are calculated considering the deck-edge risk (which should be set to 1×10^{-9}) and the water impact risk (which has to be managed).

3.2.4.5.6 The use of the same procedure for PC2 DLE as for PC1 is an important safety factor. It avoids unintended consequences such as increased pilot error which might be the result of non-standardized or complex procedures.

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[14] If the requirement for PC2e is stated as an objective within a code of performance, the method(s) of compliance should specify how the "notional" take-off/landing mass is calculated.

3.2.4.5.7 The resulting regulation for PC2 DLE might state that the take-off/landing mass should take into consideration:

a) the procedure;

b) deck-edge miss; and

c) drop-down appropriate to the height of the helideck.

3.2.4.5.8 PC2 DLE requires manufacturers' information reflecting these elements. Using the Category A elevated helideck procedures, flight profiles and associated performance collected for certification purpose should reduce the need for additional tests to be able to calculate exposure time and safety risk probability for deck-edge risk and no fly away risk. The use of some of the same certification criteria and certification hypotheses should increase data accuracy for performance calculations.

3.2.5 Operations in performance Class 3

Operations in performance Class 3 are defined in 2.5.

3.2.5.1 *General*

Operations in performance Class 3 should have:

a) All engines operating (AEO) obstacle clearance in all phases of flight.

b) Mass constrained by hover in-ground effect (HIGE) performance; if an operation is performed that does not permit an acceleration in-ground effect, or on a surface that does not permit a ground effect, hover out-of-ground effect (HOGE) performance should be assured.

Note.— An example of this is operation from an elevated heliport/helideck with low or zero winds, where the transition over the deck-edge will result in the loss of ground cushion (failure to have HOGE performance might result in a deck-edge strike or an inadvertent pull beyond take-off power — neither of which is acceptable).

3.2.5.2 *Operations in performance Class 3 with exposure*

Operations with exposure are concerned with the alleviation from the requirement for the provision of an SFL. There are a number of phases of flight where exposure might be required — these include flight:

a) from or to a ground-level site where an SFL cannot be accomplished because the surface is inadequate;

b) penetrating the HV curve during take-off or landing;

c) from or to an elevated heliport (possibility exists for a deck-edge strike); and

d) en-route over a hostile environment.

3.2.5.2.1 **Example — Exposure in the take-off and landing phases of flight**

3.2.5.2.1.1 Exposure in the ground-level take-off and landing phases can be a result of:

a) the surface conditions;

b) obstacles in the departure or arrival direction; or

c) penetrating the HV curve, in the case where a steep or vertical AEO climb is performed.

3.2.5.2.1.2 Any of these will prevent an SFL from being carried out in the event of an engine failure.

3.2.5.2.1.3 For the purpose of defining exposure, the take-off and landing phases are bounded by:

a) for the take-off — no later than 200 ft (60 m) above the take-off surface; and

b) for the landing — no earlier than 200 ft (60 m) above the landing surface.

3.2.5.2.2 **Example — Exposure to the HV curve**

3.2.5.2.2.1 Any take-off in performance Class 3 from which an SFL can be undertaken, depends upon a level acceleration segment to the point where a climb is initiated clear of the "knee" of the HV curve (the lower green line in Figure 3-2-1).

3.2.5.2.2.2 There is likely to be exposure to the HV curve if a steep or vertical AEO climb is performed from the operating site (the red line examples in Figure 3-2-1).

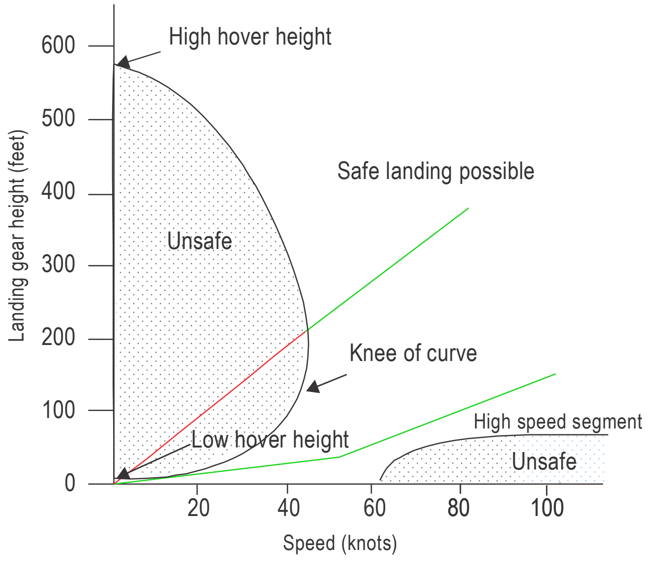

Figure 3-2-1 Example HV diagram showing departure paths

3.2.5.2.3 Example — Operations to elevated heliport/helidecks with exposure

Operations to elevated heliports and helidecks are a specific case of exposure. In these operations, exposure covers the possibility of:

a) a deck-edge strike if the engine fails early in the take-off or late in the landing;

b) penetration into the HV curve during take-off and landing; or

c) forced landing with obstacles on the surface (or hostile water conditions) below the elevated heliport (helideck).

3.2.5.2.4 Example — Exposure in the en-route phase of flight

Exposure in the en-route phase occurs when, following an engine or system failure, there is no adequate surface on which to conduct an SFL, evacuation would be problematical, or survival would not be assured (a hostile environment).

3.2.5.2.5 Operation to/from a site in a congested hostile environment with exposure

Operation to/from a site in a congested hostile environment results in the introduction of exposure to third parties. The extent of the exposure to the occupant of the helicopter will be dependent on the density of obstacle environment. Exposure of third parties will be dependent upon the persons on the surface in the vicinity.

3.2.5.2.6 Operation over a congested hostile environment with exposure

3.2.5.2.6.1 Exposure in the en-route phase over a congested hostile environment[15] differs from 3.2.5.2.4 above *only* in the resultant introduction of exposure to third parties.

3.2.5.2.6.2 Annex 2 — *Rules of the Air*, Chapter 3, 3.1.2 (an ICAO Standard that is implemented by States globally[16]) states that:

> "…except by permission from the appropriate authority, aircraft shall not be flown over the congested areas of cities, towns or settlements...unless at such a height as will permit, in the event of an emergency arising, a landing to be made without undue hazard to persons or property on the surface."

3.2.5.2.6.3 The recipients of the potential benefits that accrue from operations with exposure over a hostile environment outside of a congested area, are the operator and passengers; the consequences of a failure, the operator, crew and passengers. In a general sense, all who are involved are (or should be) "knowing" participants[17].

3.2.5.2.6.4 With exposure over a congested hostile environment the consequence to persons and property on the ground (third parties) must also be taken into consideration. With "knowing" participants, the risk/benefit equation will involve a process of assessing whether the benefit justifies the risk[18]. For the endangered third-party, there is no benefit, only consequence.

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[15] See the discussion of congested hostile environment in 2.1.3.4

[16] Examples include: in Europe, SERA.3105 and CAT.POL.H.400(b); in the United States, FAR 91.119(a); in Canada, CAR 602.14(2)(a), 602.15(1) and 723.36(1)(g).

[17] There is, of course, a necessity to ensure that when passengers are carried on flights where engine or system failure tolerance is not assured, they are advised and understand the issues.

[18] It will, or will not, have met the test of tolerability — as described in 3.3.2.

3.3 USE OF RISK ASSESSMENTS TO SUPPORT VARIATIONS TO THE CODE OF PERFORMANCE

3.3.1 General

3.3.1.1 The number of passengers carried in helicopters may be up to 19 (in current practice/operations), particularly in the case of offshore operations to helidecks. While it may be desirable to require engine failure accountability when such numbers are exposed to engine failure, this is not always possible — for example in the helideck environment. In the case of such operations with Category A certificated multi-engine helicopters, only the landing and take-off phases will be subject to exposure.

3.3.1.2 There are other types of activities that, although regarded as essential, are not conducted using multi-engine helicopters with the inherent safeguards afforded by Category A certification. These activities vary from mountain operations, where required performance is not possible in all existing multi-engine helicopters, to those in which complex issues of social, economic and operational circumstances militate toward single-engine helicopters. Operations with exposure in such circumstances must be carefully evaluated when setting an ALSR.

3.3.1.3 There is also the “general” case of the carriage of passengers over an environment which varies between non-congested-hostile[19] and non-hostile[20] and, where the number of passengers carried, and therefore likely casualties in the case of engine or system failure, are limited. This type of activity could be made acceptable by setting an ALSR which limits exposure without rendering the operation impractical.

3.3.1.4 For operations with exposure over a congested hostile environment, the State should consider their tolerance of risk to third parties. This should then be reflected in the acceptance or non-acceptance of such operations in the code of performance.

3.3.1.5 These activities require a system for assessing engine reliability in order to set an ALSR. Such a system should include a definition of sudden power-loss, smoothing in a five-year statistical window, and annual reporting (see Attachment A to Section 3.4). To ensure up-to-date reliability data, there is a need for original equipment manufacturers (OEMs) to make their annual reliability reports, currently provided on a selective basis, available to all States.

3.3.1.6 For a State to assess tolerability, after establishing the extent of exposure required for an activity, requires a framework from which to evaluate the necessity, benefits, costs and justification.

3.3.2 Introduction to risk assessments

3.3.2.1 The *Safety Management Manual* (Doc 9859) requires that risks of all aviation activities be assessed according to a scale ranging from “acceptable” to “intolerable”. Activities at either limit of this range require no further discussion.

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[19] A non-congested-hostile environment is a hostile environment which is free of third-party risk.

[20] A non-hostile environment is one where: a safe forced landing can be accomplished; and occupants can be protected from the elements; and rescue is possible within anticipated survival time.

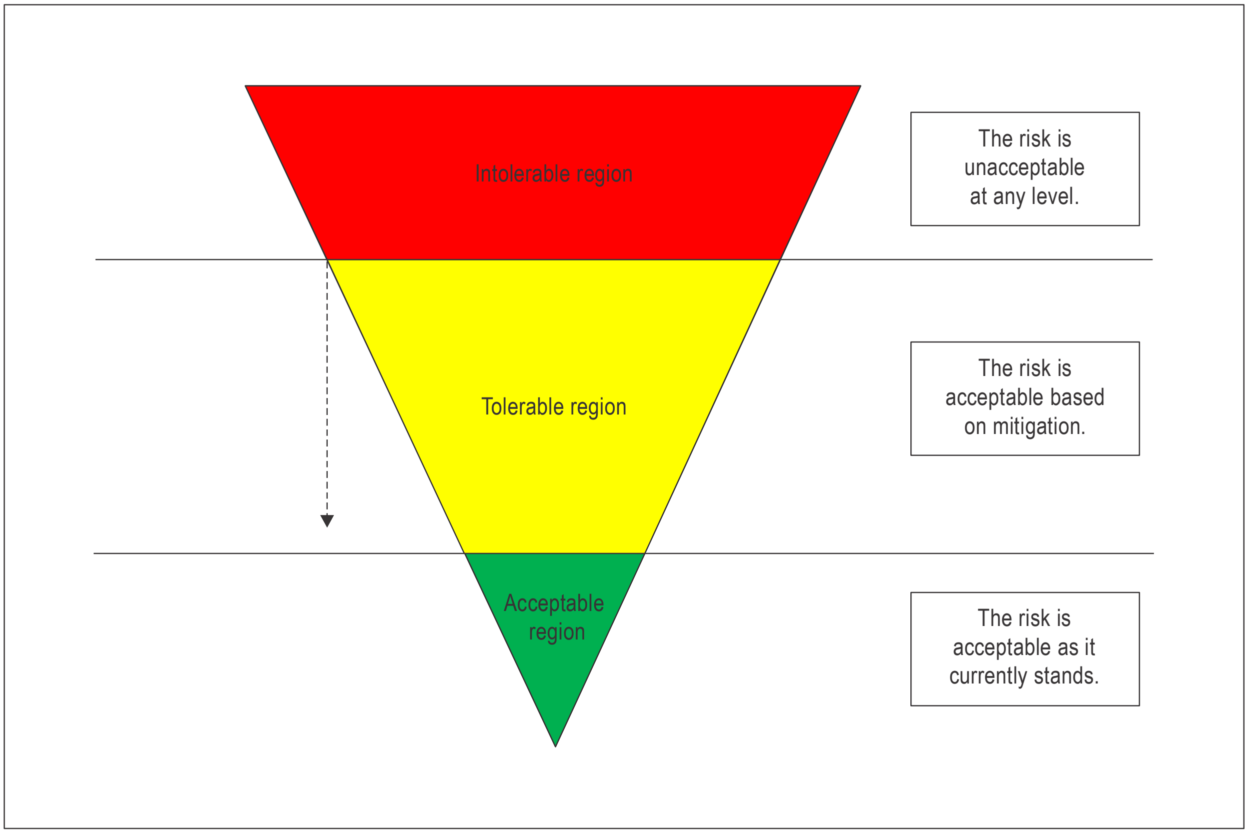

Figure 3-3-1 Tolerability Description

3.3.2.2 Activities between “acceptable” and “intolerable” are deemed “tolerable” or may be deemed “tolerable” if mitigation is applied. Such mitigation, for instance, might include a reduction in the maximum number of passengers carried.

3.3.2.3 Some activities may be in the public interest and regarded as essential by the State, especially where societal benefits are a consideration. For an activity to be viewed as essential, it will be necessary to examine the reason(s) for its initiation, or continuation, to assess whether it is justifiable.

3.3.2.4 While the risk, and mitigation, for one activity may be justifiable and therefore tolerable, for another it may be necessary to reduce the level of risk to make it tolerable. Because in similar activities the consequence of an “event” cannot be significantly altered, risk can only be reduced by lowering the probability of occurrence [21]. In the case of exposure to an engine or system failure over a hostile environment, this can be achieved by limiting the time during which an activity is exposed.

3.3.2.5 The conduct and documentation of the risk assessment should be in accordance with the principles outlined in Doc 9859, using a recognized standard for risk assessment or other systematic methods. This should result in “safety risk assessment” (Figures 3-3-2 and 3-3-7) and “safety risk tolerability” matrices[22] (Figures 3-3-3 and 3-3-8) which will help to establish if additional mitigation is required for an activity to be found tolerable.

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[21] Improvements can be achieved by using the latest safety standards such as improved ditching provisions, crashworthy seats and fuel systems, or with individual safety equipment worn by crew members and passengers — e.g. as presently employed in offshore operations.

[22] See Sections 2.5 and 9.4.6 of Doc 9859.

3.3.2.6 In the absence of numerical values in Doc 9859, the “severity of the failure condition effect”, used in the development of exposure in some States (Figures 3-3-4 and 3-3-6), could be used to establish the quantitative “probability of failure condition” as a starting point for the safety risk assessment. This will permit a finer solution than is possible in a (discrete) five-level qualitative assessment, as intermediate values could be evaluated and used.

Safety Risk		**Severity**				
Probability		**Catastrophic** **A**	**Hazardous** **B**	**Major** **C**	**Minor** **D**	**Negligible** **E**
Frequent	**5**	5A	5B	5C	5D	5E
Occasional	**4**	4A	4B	4C	4D	4E
Remote	**3**	3A	3B	3C	3D	3E
Improbable	**2**	2A	2B	2C	2D	2E
Extremely improbable	**1**	1A	1B	1C	1D	1E

Figure 3-3-2 Example of safety risk matrix

Safety Risk Index Range	**Safety Risk Description**	**Recommended Action**
5A, 5B, 5C, 4A, 4B, 3A	INTOLERABLE	Take immediate actions to mitigate the risk or stop the activity. Perform priority safety risk mitigation to ensure additional or enhanced preventative controls are in place to bring down the safety risk index to tolerable.
5D, 5E, 4C, 4D, 4E, 3B, 3C, 3D, 2A, 2B, 2C, 1A	TOLERABLE	Can be tolerated based on the safety risk mitigation. It may require management decision to accept the risk.
3E, 2D, 2E, 1B, 1C, 1D, 1E	ACCEPTABLE	Acceptable as is. No further safety risk mitigation required.

Figure 3-3-3 Example of safety risk tolerability

3.3.3 Establishing the safety risk probability

3.3.3.1 *General*

3.3.3.1.1 In Doc 9859, "safety risk" is defined as "the predicted probability and severity of the consequences or outcomes of a hazard". In 3.2.3.2, it was established that a failure leading to a forced landing in a hostile environment would result in a "hazardous" or "catastrophic" outcome.

Likelihood	Meaning	Value
Frequent	Likely to occur many times (has occurred frequently)	5
Occasional	Likely to occur sometimes (has occurred infrequently)	4
Remote	Unlikely to occur, but possible (has occurred infrequently)	3
Improbable	Very unlikely to occur (not known to have occurred)	2
Extremely improbable	Almost inconceivable that the event will occur	1

Figure 3-3-4 Example safety risk probability table

Severity	Meaning	Value
Catastrophic	• Aircraft/equipment destroyed • Multiple deaths	A
Hazardous	• A large reduction in safety margins, physical distress or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely • Serious injury • Major equipment damage	B
Major	• A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency • Serious incident • Injury to persons	C
Minor	• Nuisance • Operating limitations • Use of emergency procedures • Minor incident	D
Negligible	• Few consequences	E

Figure 3-3-5 Example safety risk severity table

Aggregation of Safety Risk Severity Category and Safety Risk Probability Definition					
Risk Severity Category	**Negligible**	**Minor**	**Major**	**Hazardous**	**Catastrophic**
Effect on Occupants	Few consequences	Minor incident	Injury to occupants	Serious or fatal injury	Multiple fatalities
Qualitative Probability	Frequent	Occasional/ Reasonably Probable	Remote	Improbable/ Extremely Remote	Extremely Improbable

Figure 3-3-6 Example combined probability and severity table

3.3.3.1.2 When conducting the safety risk assessment, a binary outcome to the forced landing should be assumed — either there will be an SFL with survival or there will not. The calculations should presume the event would result in a hazardous or catastrophic outcome.

3.3.3.1.3 The following sections provide a method of establishing the safety risk probability using common scenarios and known reliability with varied exposure periods. In the full safety risk assessment, it will also be necessary to take account of the reason(s) and justification for an activity as well as any necessary mitigation. It is only after the full process has been completed that the decision on tolerability/acceptability can be made.

3.3.3.2 *Calculating the safety risk probability*

3.3.3.2.1 The safety risk probability is the probability of a "power unit"[23] failure during one exposure event[24]. Its magnitude may be varied by increasing/decreasing the time that the occupants are exposed to a forced landing (the maximum permitted exposure time). Maximum permitted exposure time is established from the following equation:

$$\mathbf{T_{MAX} = (10^5 . 3.6 . 10^3 . R_A) / (n . P_R)}$$

Where:

T_{MAX} = The maximum permitted exposure time (in seconds)

P_R = Power unit failure rate per 100 000 engine hours

R_A = Probability of power unit failure during the exposure time

n = Number of engines

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[23] A "power unit" includes those parts of the system that are designated as part of the airframe (e.g. fuel system elements), as well as the core engine itself.

[24] An event is a failure during one take-off, one landing or en-route flight - when exposed. Each event is considered to be independent for the purpose of calculating the safety risk probability.

3.3.3.2.2 The calculation may be initiated (as above) by inserting the target probability (R_A) for a 'catastrophic' outcome and the engine reliability rate (P_R) from the manufacturer[25] and solving for the maximum permitted exposure time (T_{MAX}); or, where anticipated exposure represents an acceptable level of safety risk, by inserting the maximum permitted exposure time (T_{MAX}) and the engine reliability rate (P_R), and solving for the probability of an engine failure during the exposure time (R_A).

$$\mathbf{R_A = (T_{MAX} . n . P_R) / (10^5 . 3.6 . 10^3)}$$

3.3.3.2.3 In the following subsections this formula is employed in examples of common scenarios to establish either the R_A, or T_{MAX} for each event.

3.3.3.3 *Offshore operations in a hostile environment*

3.3.3.3.1 For take-off and landings during offshore operations with an engine reliability figure of 1×10^{-5} (P_R of 1), the boundary of "Extremely Improbable" (a quantitative probability R_A of 1×10^{-9}) for a "Catastrophic" event with "Multiple Fatalities", results in the following T_{MAX}:

$\mathbf{R_A}$ set to 1×10^{-9} and $\mathbf{P_R}$ set to 1, produces the following $\mathbf{T_{MAX}}$ for a twin-engine helicopter:

$$\mathbf{T_{MAX} = (10^5 . 3.6 . 10^3 . 10^{-9}) / (2 . 1)}$$

$$\mathbf{T_{MAX} = (3.6 . 10^{-1}) / (2) = 0.18\ Seconds}$$

3.3.3.3.2 Such a target is not realistically achievable, and a more pragmatic approach is necessary. By raising the probability to 5×10^{-8}, the following T_{MAX} results:

With the $\mathbf{R_A}$ set to 5×10^{-8} and a $\mathbf{P_R}$ set to 1 with a twin-engine helicopter, the following $\mathbf{T_{MAX}}$ results:

$$\mathbf{T_{MAX} = (10^5 . 3.6 . 10^3 . 5.10^{-8}) / (2 . 1)}$$

$$\mathbf{T_{MAX} = (3.6 . 5) / (2) = 9\ Seconds}$$

3.3.3.3.3 Analysis conducted using manufacturers' models indicate that this value would represent an acceptable level of safety risk limit (see the analysis of exposure — elevated heliports/helidecks in Attachment A to Section 3.3).

3.3.3.3.4 Exposure is not always avoidable but the necessity for its use is limited to those occasions where deck-edge clearance and fly-away cannot be achieved for helideck environmental reasons[26] (see the discussion in 3.2.4.4).

3.3.3.3.5 Based on the above, PC2 with exposure time should be acceptable for offshore operations over hostile seas. Mitigating measures described in Section 3.4 should be adopted.

3.3.3.3.6 This results in the acceptance of nine seconds to three minutes of exposure time per flight hour, depending on the number of take-offs and landings on helidecks per flight hour under the acceptable level of safety risk.

3.3.3.3.7 Under PC3 in the offshore environment over hostile seas, exposure time approaches 100 per cent of the cruise time. Additional risk can be eliminated by the use of Category A certified helicopters operated under PC1 or PC2. Or the risk can be mitigated if operated under PC3 if the sea becomes non-hostile. For example, the helicopter has been certified for ditching for the sea conditions over which the operation is flown, and the search and rescue capabilities are upgraded.

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[25] A simplifying assumption could be a reliability rate (P_R) of 1×10^{-5} — the expected engine reliability rate for Annex 6, Part I, Chapter 5, 5.4 and Part III, Section II, Chapter 3, 3.4.

[26] When the wind vector prevents an unobstructed departure and/or arrival sector.

3.3.3.3.8 If the State does not accept such level of exposure during the cruise, and the main mitigation envisaged by that State for this particular risk is a Category A certified helicopter operated under PC1 or PC2, then the State may, accordingly, introduce such a requirement in their code of performance.

3.3.3.3.9 If the State also does not accept this level of exposure for take-off and landings (e.g. if offshore operations in that State involve heavy shuttling between offshore platforms with high numbers of take-offs and landings per flight hour), then the State may mandate PC2 with defined limited of exposure (PC2 DLE). In order to implement PC2 DLE, the State defines the maximum time of exposure per take-off and landing phase. See 3.2.4.5.

3.3.3.3.10 If the State wishes to reduce the risk even further, it may mandate PC1 or PC2 enhanced (PC2e) or PC2 DLE with no exposure time. See 3.2.4.4. Exposure time is then reduced to the minimum, when severe wind conditions and the obstacle environment at the helideck do not allow Category A procedures to be flown in compliance with Category A limitations.

3.3.3.4 *Onshore non-congested hostile environments*

3.3.3.4.1 **Take-off and landing**

3.3.3.4.1.1 With a probability 5 x 10^{-8} and reliability between 1 x 10^{-5} and 1 x 10^{-6} per flying hour (most turbine engines should be between those two values), T_{MAX} would be:

a) For a twin-engine helicopter, between nine seconds (with an engine reliability of 1 x 10^{-5}) and 90 seconds (with an engine reliability of 1 x 10^{-6}).

b) For a single-engine helicopter, between 18 seconds (with an engine reliability of 1 x 10^{-5}) and three minutes (with an engine reliability of 1 x 10^{-6}).

3.3.3.4.1.2 This could be sufficient for take-off and landing exposure.

3.3.3.4.2 **Reduced Occupancy**

3.3.3.4.2.1 If a lower number of passengers are exposed due to operational limitations or the helicopter type in use, a lower target than 5 x 10^{-8} might be considered.

3.3.3.4.2.2 With a probability of 1 x 10^{-7} and reliability between 1 x 10^{-5} and 1 x 10^{-6} per flying hour, T_{MAX} would be between 36 seconds (with an engine reliability of 1 x 10^{-5}) and six minutes (with an engine reliability of 1 x 10^{-6}) for a single-engine helicopter. This could be sufficient for flight over a mixed environment (non-congested-hostile and non-hostile) but might not be for extended flight over a hostile environment.

3.3.3.4.3 **Extended flight over hostile environment**

3.3.3.4.3.1 Where exposure is likely to exceed six minutes, it will not be possible to meet the target of 1 x 10^{-7} and the essential nature of the activity should be considered. An element of the assessment might be the geographical location and boundaries of the operation. The criteria for acceptance should be clearly established and could include the case where real hardship and comparative risk[27] is substantiated.

3.3.3.4.3.2 With a probability of 1 x 10^{-6}, T_{MAX} would be between six minutes (with an engine reliability of 1 x 10^{-5}) and one hour (with an engine reliability of 1 x 10^{-6}) for a single-engine helicopter. (For one modern single, the failure rate has

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[27] Comparative risk is where the alternative mode of transport is substantially less safe than that of extended flight over a hostile environment when exposed.

been shown to be 0.18 x 10^{-5}; this would permit exposure in excess of 30 minutes and, with a cruise speed of 132 kts, a range of about 65 nm.) This could be adequate for extended flight over a non-congested-hostile environment.).

3.3.3.4.3.3 As in offshore operations over hostile seas, if the State does not accept such a level of exposure during the cruise, and the main mitigation envisaged by that State for this particular risk is the use of a Category A certified helicopter operated under PC1 or PC2, then the State may, accordingly, introduce such a requirement in their code of performance.

3.3.3.4.3.4 If the State wishes to ensure that PC3 operations are conducted to as high a level of safety as possible, the State may introduce restrictions in their code of performance that will reduce the time of exposure per fight hour during the cruise to six minutes or less.

3.3.3.4.3.5 If the State’s acceptance of risk is greater, then it may set higher limits to exposure time under a different risk assessment.

3.3.3.4.3.6 Mitigating measures described in Section 3.4 should be considered. The State should mandate the mitigating measures it considers to be reasonably practicable to implement, provided that the residual risk remains within limits that it is ready to accept.

3.3.3.4.3.7 Mountains and forests are essentially a mixed environment, often made up of both non-hostile and hostile parts. SFL areas near mountain lakes, in the valley below or in forest clearings, may be within auto-rotational reach. Moreover, PC1 or PC2 may not be achievable due to altitude, wind and obstacles.

3.3.3.4.3.8 PC3 with exposure during the cruise and the consequence of the outcome of an engine failure may be acceptable for mountain and forest operations, depending on the outcome of the risk assessment.

3.3.3.5 *Operations within a congested environment*

3.3.3.5.1 A flight into and out of a congested environment may be such that SFL areas are available at any time during the flight. Under PC3, this may happen if the landing site is located near a waterway or a green belt within a town or city, and if the route to or from the landing site is above this waterway or green belt.

3.3.3.5.2 Exposure time within a congested and hostile environment generates risks to third parties on the ground. The acceptance of risk to third parties may vary between States.

3.3.3.5.3 In some cases, the acceptance of risk to third parties may be very low, because of any of the following:

a) reputational damage to the helicopter industry of a single third-party casualty;

b) the local and strict interpretation of ICAO Annex II requirements (to “not create undue hazard to persons or property on ground”); and

c) the possible liability of the authority for accepting such risk in the helicopter performance code, in case of an accident.

If this is the case, exposure time should not be accepted.

3.3.3.5.4 In other cases, the acceptance of risk to third parties may be such that a third-party casualty is assessed as not excessively different from a passenger casualty. If this is the case:

a) PC2 with exposure, and PC3 with exposure during take-off and landing, may be accepted; and

b) PC3 with exposure during a congested and hostile segment of the route may be accepted, if the entire route is a “mixed environment”.

3.3.3.5.5 For congested hostile environments, consideration is given to flights in the public interest[28], for e.g. helicopter medical transport[29] (HMT), to and from operating sites within a congested hostile environment — where third-party risk and societal benefits are considerations.

3.3.3.5.6 **Helicopter medical transport (HMT)**

3.3.3.5.6.1 In some States, rapid delivery of a trauma service to inner city accidents/incidents is undertaken by HMT operators (also referred to as emergency medical services — EMS or air ambulance operations). As with most HMT missions, the potential HMT operating site may be chosen before departure and assessed for use only on arrival[30].

3.3.3.5.6.2 For that reason, it is rarely possible to establish, with any accuracy, the size of the landing surface or the obstacle environment — exposure is the norm but precise determination of the extent of exposure is not possible. However, there is a reasonable expectation that, in most cases, exposure for a twin-engine helicopter can be confined to below 200 ft[31] (60 m).

3.3.3.5.6.3 Any safety risk assessment should weigh the likely benefit of lives saved against the potential risk to third parties. If it is considered that the benefits outweigh the potential risk, it remains only to establish the acceptable level of safety risk for this type of activity. In view of third-party involvement, exposure could be limited by restricting it to the landing and take-off phases only as in 3.3.3.4 above.

3.3.3.5.7 **Operations to/from a hospital in a congested hostile environment**

3.3.3.5.7.1 Globally, there are many hospitals in city centres with heliports that do not meet the ICAO Annex 14 — *Aerodromes*, Volume II — *Heliports*, performance Class 1 Standard.

3.3.3.5.7.2 Such sites allow a much more considered approach to the use of exposure than that for an “HMT operating site” because their dimensions are known and the obstacle environment can be determined. Thus, the extent of exposure can be established and appropriate mitigating strategies put into place.

3.3.3.5.7.3 As with operations to an HMT operating site, any safety risk assessment should weigh the likely benefit of lives saved against the potential consequence to third parties. Where the continuation of operations to such a site is considered as essential, exposure could be limited by restricting it to the landing and take-off phases only as in 3.3.3.4 above.

3.3.4 An example of resultant safety risk and safety risk tolerability matrices for operations with exposure

3.3.4.1 From the examples above, the resulting safety risk matrix (Figure 3-3-7) and safety risk tolerability matrix (Figure 3-3-8 — populated without the defined safety risk mitigation) might appear as follows:

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[28] Although there could be other examples of “flight in the public interest”, in this section only HMT is being considered.

[29] In most countries, HMT is conducted under commercial air transport (CAT) regulations.

[30] Using a defined procedure that enables the pilot to make, from the air, a judgement on the suitability of the site.

[31] This might result in a T_{MAX} slightly in excess of the figures show in 3.3.3.4.

Index	**Safety Risk**	**Severity**				
	Probability (Note)	**Catastrophic A**	**Hazardous B**	**Major C**	**Minor D**	**Negligible E**
4	**≤ 1 x 10^{-6}**	4A	4B	4C	4D	4E
3	**≤ 1 x 10^{-7}**	3A	3B	3C	3D	3E
2	**≤ 5 x 10^{-8}**	2A	2B	2C	2D	2E
1	**≤ 1 x 10^{-9}**	1A	1B	1C	1D	1E

Note. — The probabilities shown are indicative of what might be used.

Figure 3-3-7 Example safety risk matrix for operations with exposure

Safety Risk Index Range	**Safety Risk Probability (Note)**	**Safety Risk Description**	**Recommended Action**
4A, 4B	≤ 1 x 10^{-6}	TOLERABLE	Can be used to allow en-route operations with exposure for reduced occupancy when essential and with safety risk mitigation.
3A, 3B	≤ 1 x 10^{-7}	TOLERABLE	Can be used to allow for en-route operations with exposure with safety risk mitigation.
2A, 2B	≤ 5 x 10^{-8}	TOLERABLE	Can be used to allow for take-off and landing with exposure.

Note. — The probabilities shown are indicative of what might be used.

Figure 3-3-8 Example safety risk tolerability matrix for operations with exposure

3.3.4.2 The probabilities used in the tables are taken from examples in 3.3.3.3, 3.3.3.4, 3.3.3.5 and 3.3.3.6 above. A safety risk probability may be set to a value different to that shown, when considering:

a) comparative risks of other means of transportation;

b) the social benefits of providing a given helicopter service; or

c) the value of acceptance of risk that is specific to the State.

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Attachment to Section 3.3

ANALYSIS OF EXPOSURE — ELEVATED HELIPORTS/HELIDECKS

1. INTRODUCTION

This document illustrates the method used to test the hypothesis that, “a maximum permitted exposure time (T_{MAX}) of nine seconds for a twin, 18 seconds for a single, based on a safety risk probability R_A of 5 x 10^{-8} and engine reliability P_R of 1 x 10^{-5}, represents a pragmatic acceptable level of safety risk for elevated heliport and helideck operations”. A representative range of helicopter types, employed in offshore operations, were used in the assessment.

(Exposure time is the period during which the OEI performance of the helicopter does not guarantee an SFL or the safe continuation of flight. The maximum permitted exposure time is the period, determined on the basis of the engine failure rate recorded for the helicopter’s engine type, during which the probability of an engine failure can be discounted.)

2. ANALYSIS OF EXPOSURE TIME

The maximum take-off and landing exposure times were determined by manufacturers using simulation programmes dedicated to predicting helicopter dynamic performance. These programmes had previously been validated against flight test data related to engine failure simulations (H-V envelope, take-off and landing procedures). Simulation was performed with the following initial conditions: ISA sea level conditions; zero wind; and, maximum take-off mass.

2.1 Take-off

Take-off from an elevated heliport/helideck was modelled using two profiles:

2.1.1 *Deck-edge clearance (see Figure A1)*

This profile is provided for single-engine helicopters. It simulates a Category B (pull-and-go) take-off from an elevated heliport/helideck. The exposure starts when the pilot commands the nose down pitching motion and extends to the point where the entire helicopter is clear of the heliport/helideck edge and an SFL can be carried out.

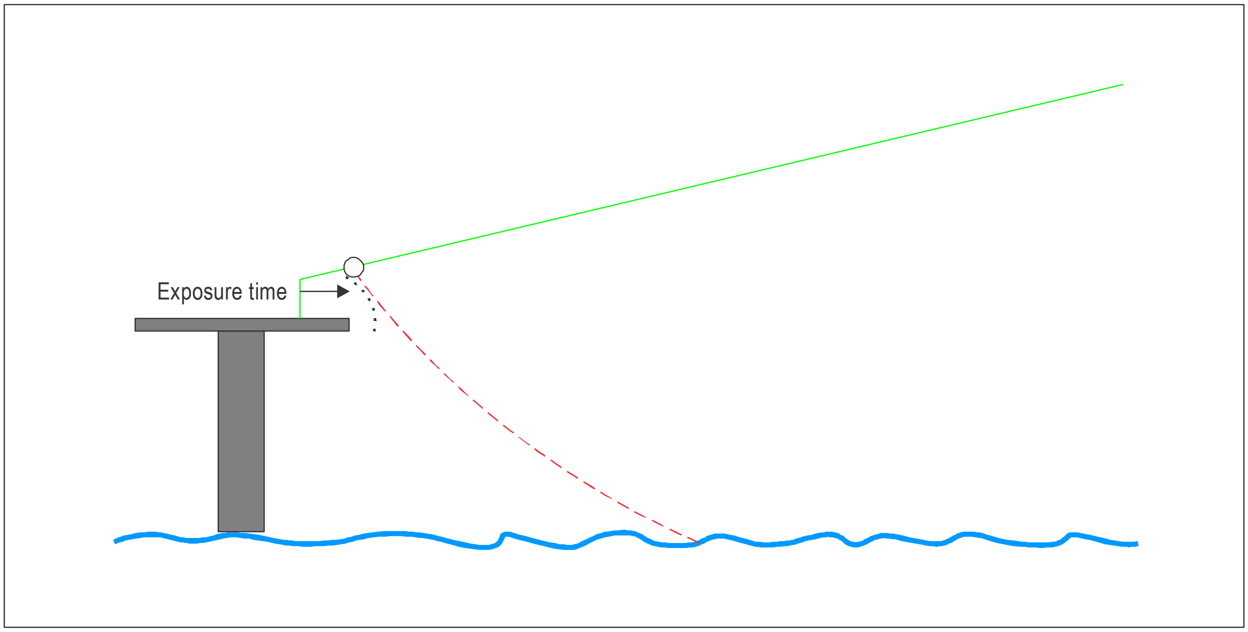

Figure A1 Take-off Method 1 — Deck-Edge Miss

Note .— This method assumes an ability to perform an SFL after clearing the deck-edge.

2.1.2 *Dynamic with zero drop-down (see Figure A2)*

This method simulates a dynamic take-off using the procedures normally used by multi-engine helicopters in offshore operations. Exposure time starts when an SFL on the helideck can no longer be undertaken and stops at the point of the normal take-off flight path where an engine failure would result in a descent not below the helideck level.

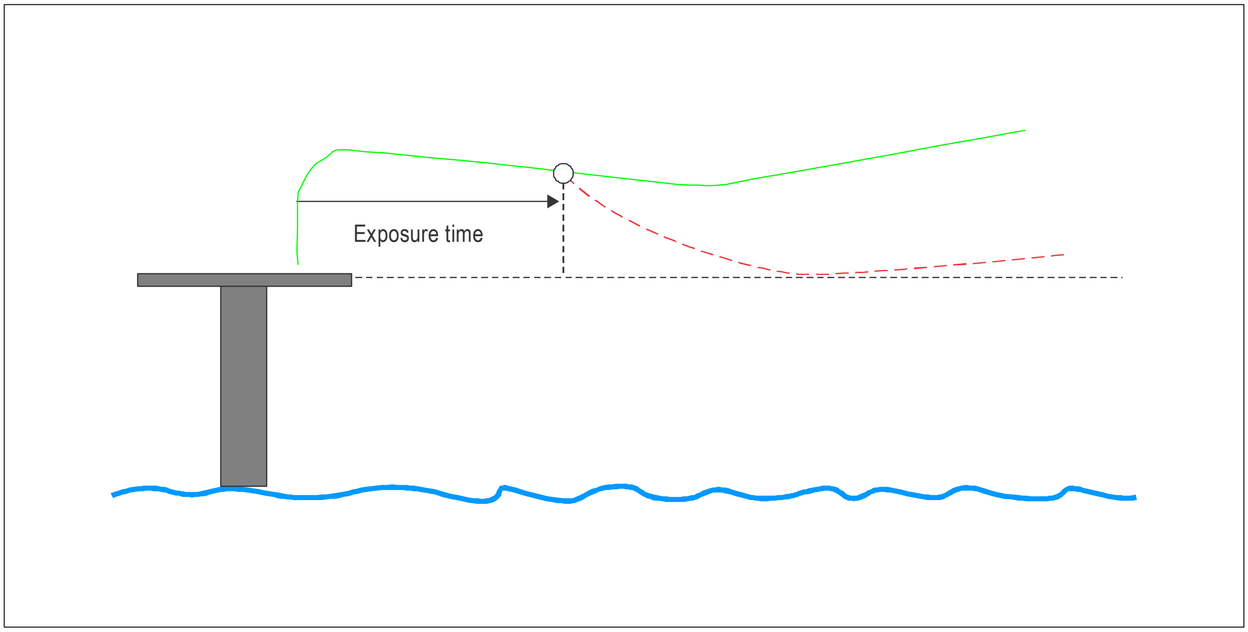

Figure A2 Dynamic — Zero Drop-Down

A slightly modified method of take-off (see Figure A3) has also been modelled. This has a similar flight path to the one shown above but is not optimized for helidecks and thus results in a slightly increased exposure.

Take-off consists of applying the standard pitch attitude while the collective pitch is varied to progressively increase altitude. The available power is adjusted to maintain a constant rotor speed.

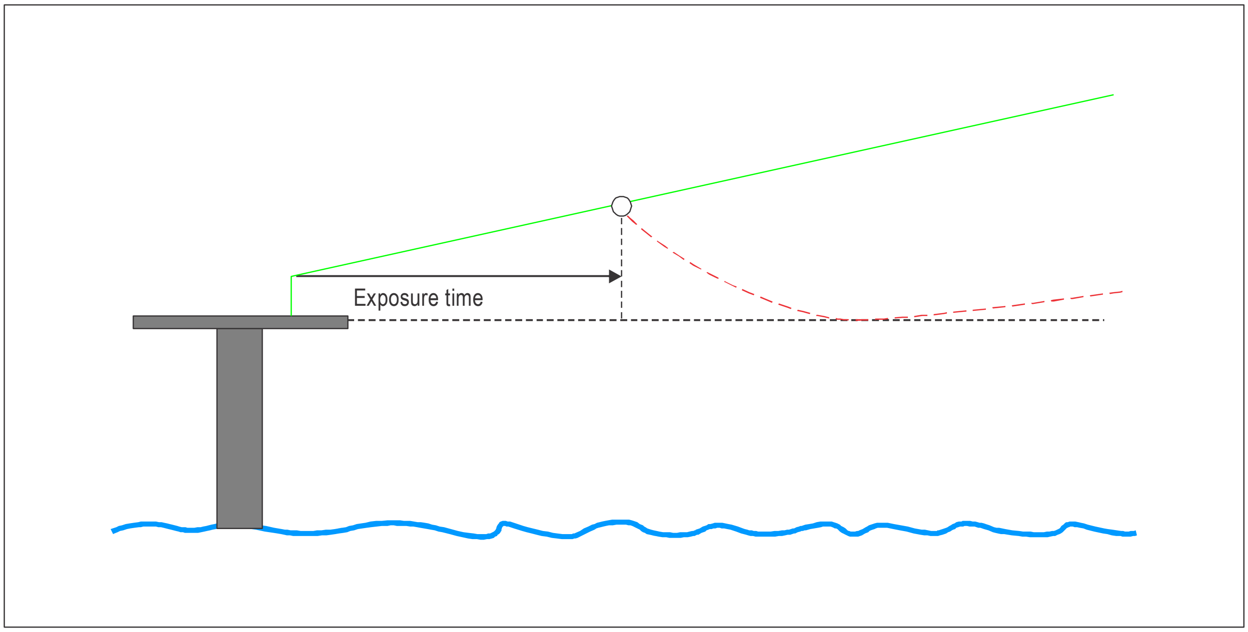

Figure A3 Take-off Method 2 — Zero Drop-Down

Exposure could be reduced by using the potential provided by drop-down although this was not used in the analysis of the exposure time (see Figure A4 below).

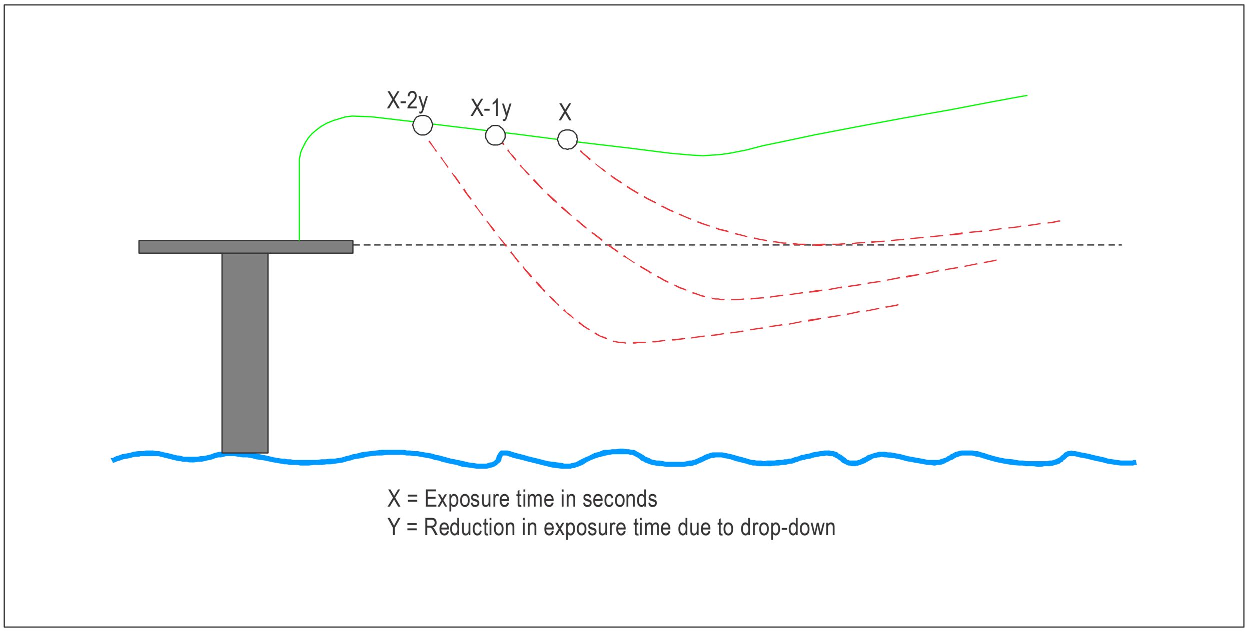

Figure A4 Dynamic — Utilizing Drop-Down

2.2 Landing

The approach-to, and landing-on, an elevated heliport/helideck was modelled using three profiles; for two of these, exposure was calculated; for the third there is a discussion, but, as it is based upon a Category A landing procedure, no exposure is anticipated.

2.2.1 *Deck-edge clearance (see Figure A5)*

This profile is provided for single-engine helicopters. It simulates a Category B arrival at the elevated heliport/helideck. The exposure time starts at the point closest to the heliport deck at which an evasive manoeuvre permits avoidance of the heliport/helideck edge and ends at the landing committal point.

The landing committal point is the first point of the trajectory at which a landing on the heliport/deck is possible in the event of an engine failure.

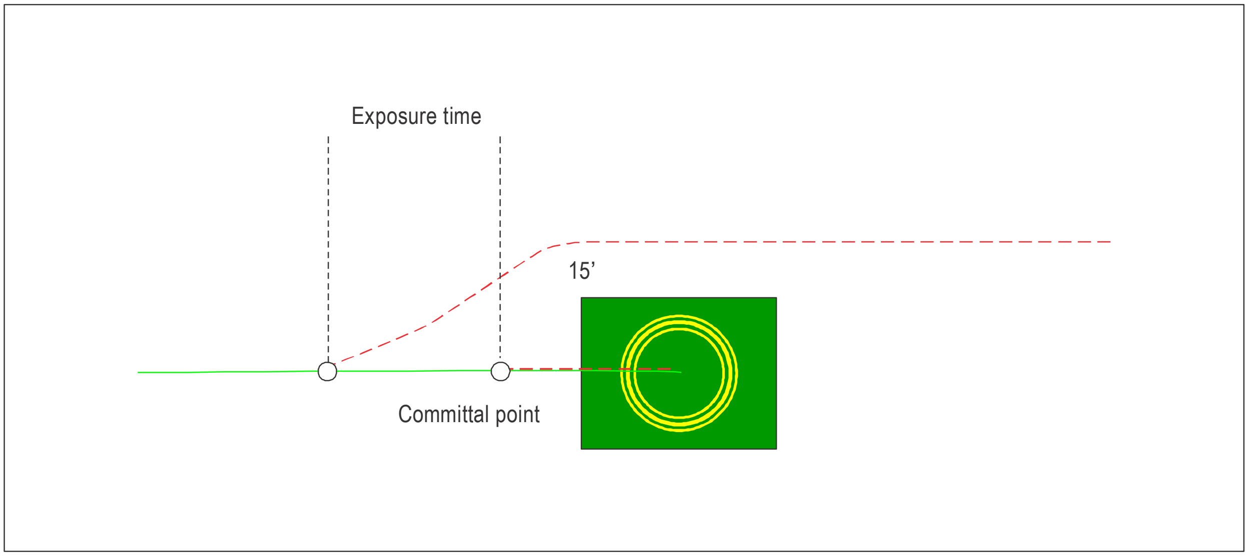

Figure A5 Landing Method 1 — Deck-Edge Miss

Note .— This method assumes an ability to perform an SFL after clearing the deck-edge.

2.2.2 *Zero drop-down — offset procedure (see Figure A6)*

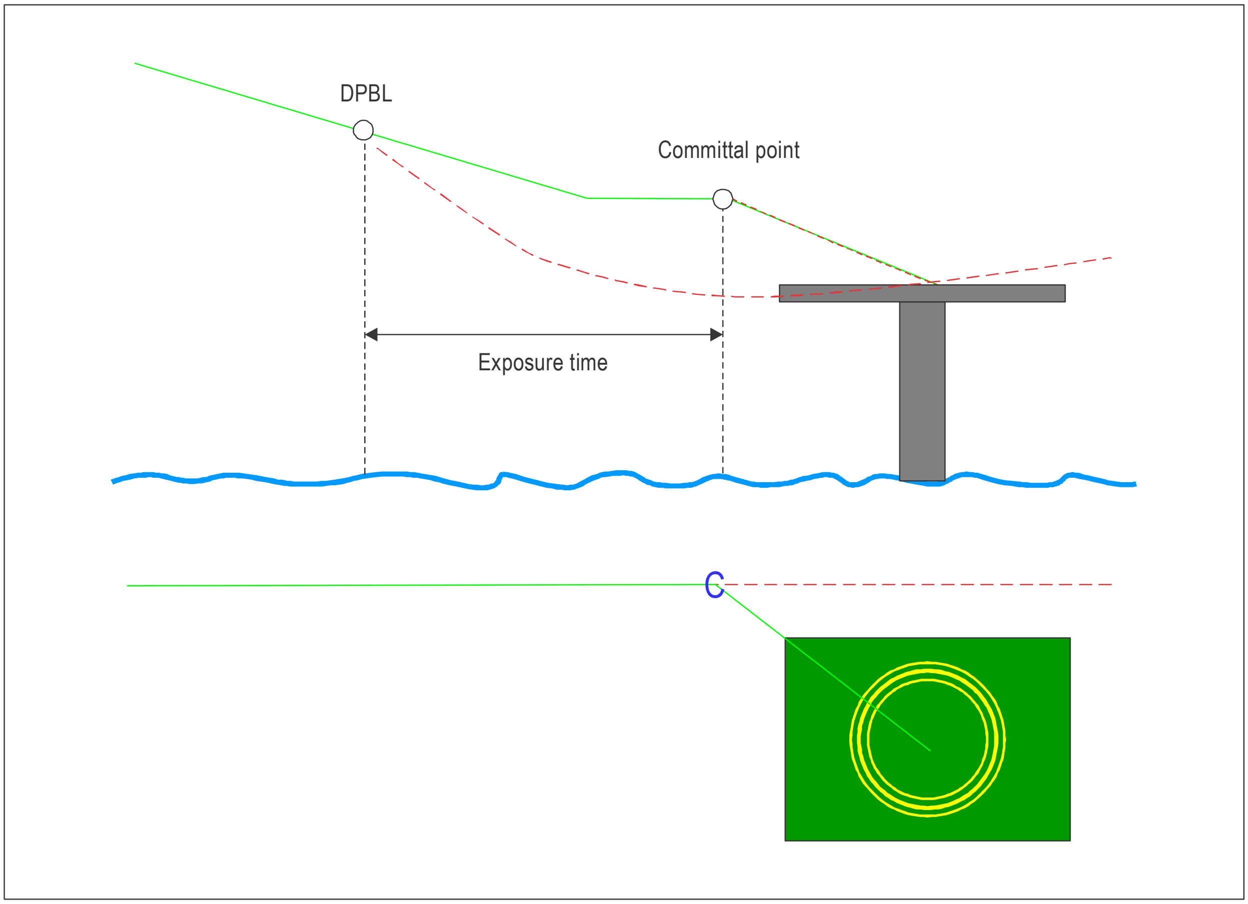

Figure A6 Zero Drop-Down — Offset Procedure

In this profile, normally used by multi-engine helicopters, the landing exposure time is defined as the elapsed time between the defined point before landing (DPBL) and the committal point (CP). For the purpose of the calculation, DPBL was taken to be the closest point to the helideck from which an OEI balked landing can be made without descending below the level of the helideck. The committal point is the farthest point from the helideck from which an OEI landing can be made.

Note.— The committal point could be established from the position shown to a point immediately to the side of the helideck.

There is an ability to reduce exposure by using the potential provided by drop-down although this was not used in the analysis of the exposure time shown in Figure A6. With utilization of drop-down, exposure time tends towards zero as DPBL moves toward CP — eventually becoming located at the same point (see Figure A7).

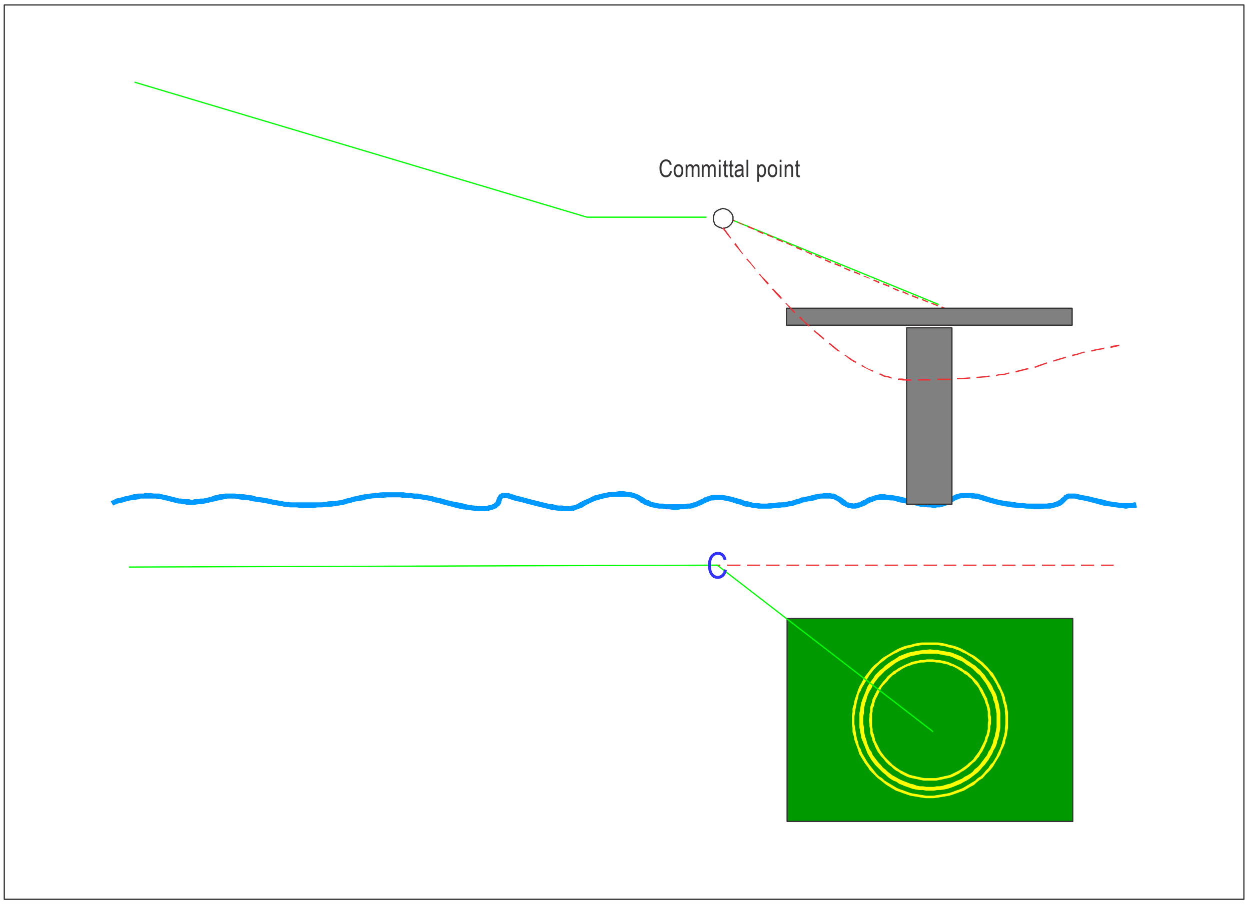

Figure A7 Utilizing Drop-Down

2.2.3 *Zero drop-down — Straight-on procedure (see Figure A8)*

This procedure, which uses the Category A landing profile described in all rotorcraft flight manuals (RFMs), is applicable both for ground level and elevated heliports. Even though for some types, the actual surface dimensions may not permit a Category A procedure, it could be flown at the maximum landing mass. Because of the derivation of the procedure, no balked landing is envisaged after passing (the equivalent of) the landing decision point (LDP).

One manufacturer (using the Category A flight trial data) declared no exposure for a large majority of their range of types. This was because they could demonstrate a single engine transit and landing from LDP. However, the straight-on profile presents problems for offshore landings because it is inappropriate for some directions of approach; and due to the absence of visual cues (both ahead of the helicopter and laterally) in the late stages of the approach.

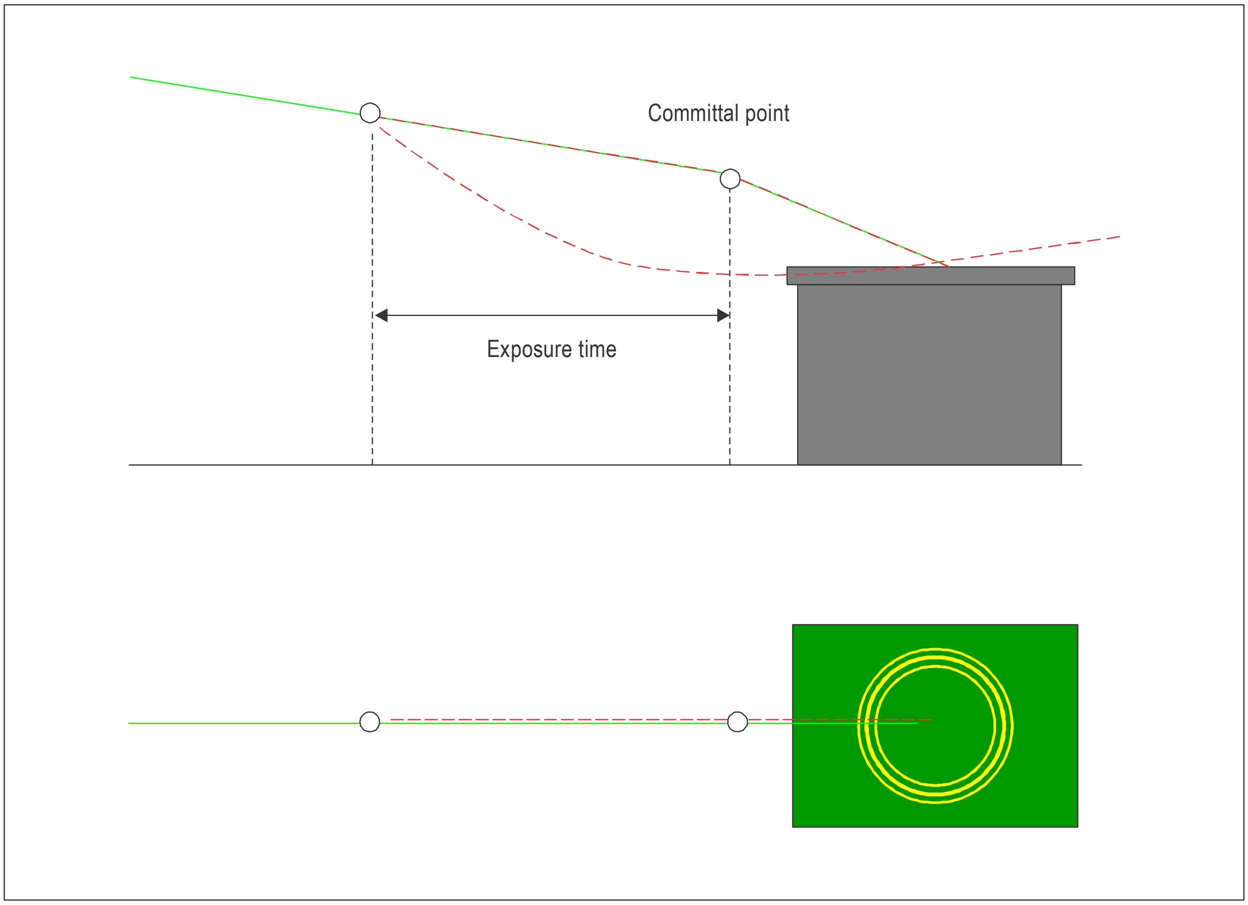

Figure A8 Zero Drop-Down — Straight-on

3. DISCUSSION OF RESULTS

3.1 Take-off and landing — deck-edge clearance

This profile is only appropriate for single-engine helicopters. Using this method, exposure time is always well within T_{MAX} — as is the mean time to reach the knee of the HV curve. There is an assumption of an SFL after (or before in the case of landing) the deck-edge is cleared; when using the knee of the HV curve, there is an assumption of an SFL when outside the HV curve.

3.2 Take-off — dynamic zero drop-down

All values of exposure were within T_{MAX} with the exception of one (10 seconds); however, this could be mitigated with drop down by taking advantage of the fact that helidecks/elevated heliports have a potential for reduction in the exposure time by utilizing their height above the surface.

3.3 Landing — dynamic zero drop-down

The profile used in this calculation is based upon a procedure used by multi-engine helicopters. Deck-edge clearance is achieved at the side of the heliport/helideck, thus permitting a drop-down to deck level (and below if possible). All values of exposure time were within T_{MAX}.

3.4 Landing — straight-in

This mirrors the Category A landing profile which is more aligned with onshore than offshore procedures (for helidecks, the straight in approach introduces exposure to collision with obstacles surrounding the helideck). A large number of helicopters can perform this manoeuvre at their maximum landing mass (with zero exposure).

4. CONCLUSION

With the one exception discussed in 3.2 above, all simulations produced results that were within T_{MAX} of nine seconds for a twin, 18 seconds for a single.

Recent figures on reliability using the power-loss criteria indicate that most turbine engines will meet or exceed a reliability P_R of 1×10^{-5} (one failure in 100 000 flying hours).

The hypothesis that, "T_{MAX} of nine seconds for a twin, 18 seconds for a single, based on a safety risk probability R_A of 5×10^{-8} and engine reliability P_R of 1×10^{-5}, represents an acceptable level of safety risk for elevated heliport and helideck operations", is supported.

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3.4 MITIGATION THAT MIGHT BE APPLIED TO IMPROVE RELIABILITY AND REDUCE THE CONSEQUENCES OF AN EVENT

Note.— The Fourth edition of the Safety Management Manual *(Doc 9859), 2.5.7.1 states, "Safety risk mitigation is often referred to as a safety risk control. Safety risks should be managed to an acceptable level by mitigating the safety risk through the application of appropriate safety risk controls. This should be balanced against the time, cost and difficulty of taking action to reduce or eliminate the safety risk. The level of safety risk can be lowered by reducing the severity of the potential consequences, reducing the likelihood of occurrence or by reducing exposure to that safety risk. It is easier and more common to reduce the likelihood than it is to reduce the severity."*

3.4.1 General

3.4.1.1 A significant part of this manual is associated with establishing and minimizing the risk to commercial air transport (CAT) in the provision of a code of performance.

3.4.1.2 This section is concerned mainly with examining ways of improving reliability and mitigating the consequences where, in the event of a failure, an SFL is not likely — thus facilitating the introduction, or continuation, of operations where the public need is real but the risk level is elevated.

3.4.1.3 It addresses the likelihood of injury to people because of the intended operation. Damage to or loss of the helicopter is not considered, except where it increases the potential for harm to the occupants or to those on the ground.

3.4.1.4 The guidance applies to a "type of operation" or "geographic area". It is not anticipated, nor is it possible, to require approval for individual flights except under the most extreme or unique situations.

3.4.1.5 Having the ability to achieve safe flight to the destination should always be the aim. The following strategies should therefore be a priority for those seeking to reduce the level of safety risk for a proposed operation.

3.4.1.6 This section offers four categories of strategies:

1) reducing failure as a mitigating strategy;

2) increasing the potential for SFLs;

3) protecting occupants during a forced landing; and

4) enhancing post-crash survival and rescue.

3.4.2 Reducing Failure as a Mitigating Strategy

Note.— See Attachments A and B to Section 3.4 for representative guidance.

The premise behind operations in performance Class 1 is that helicopters will continue safe flight despite the loss of an engine, or other system, thus preventing the exposure of occupants to the consequence of failure. Helicopters operating in performance Classes 2 and 3 can reduce exposure to such failure by employing strategies that lower the probability of a failure leading to a forced landing.

3.4.2.1 *Engine reliability/monitoring*

3.4.2.1.1 The reason for monitoring engine reliability is to eliminate "abuse" or to spot a "trend" that will eventually lead to failure if no action is taken; this is particularly important when the helicopter is used in a dual role — i.e. aerial work as well as CAT. A reduction in power revealed through a scheduled "power assurance" check is a useful indicator, providing it is used in accordance with the manufacturer's procedures for rectification or removal. No over-temp or over-torque is likely to result in immediate failure, but they can be precursors to eventual failure.

3.4.2.1.2 It is unlikely that any current system (apart from chip warning) will provide an "immediate" warning of impending failure; in any case, if operating in PC3 over a hostile environment, an indication of failure could not be acted upon without consequence.

3.4.2.1.3 An operational approval system should require the engine/type to be assessed for reliability — and specify a means for achieving that (see Attachment A to Section 3.4). This requires the reliability analysis and reports, produced by manufacturers, to be made available to States on request. The measure of reliability is a principal element of Chapter 3 — P_R (power unit failure rate per 100 000 engine hours). Generally, for turbine engines, reliability for the helicopter/engine combination is established by major manufacturers.

3.4.2.1.4 Flagging exceedances, eliminating abuse and spotting trends, are ways of ensuring that the "reliable" engine/type, used for operations with exposure, stays within its reliability target. Monitoring systems could instil a culture of caring for propulsion units by encouraging pilots to avoid engine abuse, and motivating operators to control trends and report failures.

3.4.2.1.5 With modern control of engines using full authority digital engine control (FADEC), and other systems, there is often built-in control and potential for monitoring. Abuse of engines is prevented by FADEC or shown as an "indelible" flag that must be recorded and investigated.

3.4.2.1.6 Only with legacy helicopters should it be necessary to "bolt-on" an engine usage monitoring system (see Attachment B to Section 3.4). Such systems are now relatively low cost and can pay for themselves just by eliminating hot starts.

3.4.2.1.7 Statistically, most engines can be shown to be within the 1×10^{-5} to 1×10^{-6} reliability range. Abuse control is aimed at ensuring they stay within that range. Further improvement in engine reliability by monitoring is unlikely to change the risk profile to any discernible degree.

3.4.2.1.8 In assessing how much weight to give to engine monitoring systems in the risk assessment, it is necessary to be realistic about the effect of reliability on the risk profile of the exposed operation. It is likely to be less than one order of magnitude. Potential gain may have already been realized by manufacturers installing the latest engine control and monitoring equipment as standard.

3.4.2.1.9 Considering the statistical reliability of engines is one way to assess risk. Not all aircraft engines have the same reliability and it is reasonable to require a higher level of dependability for particular "types of operations" or flight over specific "geographical areas". Certain aircraft/engine types might, appropriately, be deemed unacceptable for some high-risk operations.

3.4.2.1.10 Assessment of reliability is a complex task because it relies upon the reporting of failure, regardless of outcome, and an accepted method of collecting and collating flying hours for the helicopter/engine type. Without these, it is extremely difficult to establish failure rates on which any measure of reliability can be based but neither failure[1] nor flying hours are required to be reported under the existing regulations of some ICAO Member States.

3.4.2.1.11 A comprehensive usage monitoring system as described in Attachment B to Section 3.4, as well as the provision of failure and usage reports to the manufacturer, can provide data for trend monitoring and local analysis of health as well as reports of exceedances. These are likely to have a beneficial effect on local culture and reliability statistics as well as providing evidence of the precursors of failure.

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[1] If the resulting consequences do not reach a specific level of damage.

3.4.2.1.12 Where the aircraft manufacturer specifies maximum permitted power that is substantially less than the maximum potential for the power plant (known as de-rating) then this can be taken into account. This strategy is credited with a significant reduction in engine failures. De-rating may be used by improve the reliability of the engine above the average, to improve it so it meets standards, or simply to increase time between overhauls. It cannot be used by operators as a mitigation without statistical evidence of improved reliability.

3.4.2.2 *Maintenance*

3.4.2.2.1 It is essential that when operating with exposure, the maintenance programme includes the helicopter/engine modification standard using the preventive maintenance actions recommended by the helicopter and/or engine manufacturer (see Attachment B to Section 3.4). This representative guidance has been useful in establishing the categorization of failure — with respect to exposure — and providing a method of establishing and promulgating reliability rates.

3.4.2.2.2 Maintenance is often overlooked as a risk mitigation strategy since it is considered a normal aspect of any air operation. If a quality maintenance programme is in place, an additional preventative maintenance and trend monitoring regime can be considered as risk mitigation for operations with exposure. This must be part of a controlled system to avoid human factors events in unnecessary intervention procedures.

3.4.2.2.3 The modification standard that is applied to any helicopter/engine combination is dependent upon the assessment by the State of the susceptibility to known failure(s) of a component, and the subsequent risk to operations. For example, where a component is an element of a redundant system, rectification might be contained in a ‘bulletin’ rather than a “directive”, or time to rectification might be less stringent.

3.4.2.2.4 In cases where redundancy provides no protection: for PC2, exposure in the take-off and landing phases; or, for PC3, exposure in any phase, the State should ensure that operators are aware of, and apply, the most stringent of modification standards with respect to any known susceptibilities.

3.4.2.2.5 In addition, the State should ensure that a system of preventative maintenance and trend monitoring is used to spot precursors ahead of failure as an element of the maintenance system and the overall operator safety management system.

3.4.2.3 *Engine relight*

For turbine engines, a reignition system that activates automatically or a manually selectable continuous ignition system should be considered unless the engine certification has determined that such a system is not required, taking into consideration the likely environmental conditions in which the engine is to be operated.

3.4.3 Increasing the potential for a safe forced landing

3.4.3.1 *General*

3.4.3.1.1 Day visual flight rules (VFR) are a key safety factor for operations without stay-up capability. When remaining in sight of the surface, day visual meteorological conditions (VMC) and special VFR conditions enable the pilot to immediately identify SFL areas and precautionary landing areas, and to successfully perform SFLs and precautionary landings when necessary.

3.4.3.1.2 It is highly recommended that operations under performance Class 3 and any operations with exposure during the cruise should take place only if the following criteria are met:

a) day VFR; and

b) within sight of the surface.

3.4.3.1.3 There are locations where it should be possible to perform an SFL and areas where the terrain does not allow for it. The extent and density of these two types of terrain determine the likelihood of performing an SFL. It is advantageous to distinguish between different operating areas.

3.4.3.1.4 To a large extent, this has to be left to the operator's policy and the pilot's best judgement, except for those operations in areas of challenging terrain where there are few or no SFL spots available.

3.4.3.1.5 The likelihood of reaching an SFL area in an emergency is directly related to:

a) the height of the helicopter and the glide/drift down range;

b) the distance between the helicopter flight path and the nearest SFL area, taking the wind into account; and

c) the pilot's flying skills and capability to land the helicopter precisely where intended in an emergency scenario.

3.4.3.1.6 The following measures will increase the potential for an SFL:

a) increased flight altitude;

b) increased weather minima, including ceiling or cloud-base minima;

c) identification in advance of SFL areas, when practicable;

d) procedure to adjust the flight path in accordance with the available SFL areas, taking the wind into account;

e) pilot training to implement such procedure;

f) aircraft tracking system, or other recording system, to ensure that the pilot does implement the procedure;

g) pilot experience or pilot training on decision making;

h) for single-engine helicopters, enhanced autorotation training; and

i) for twin-engine helicopters, enhanced engine restart training.

3.4.3.2 *Operating in areas of mixed terrain features (see 2.1.2.1.5)*

3.4.3.2.1 The practical effect on normal operations is usually minimal, as most areas of operation are of a mixed nature. Little or no deviation from the planned route is usually necessary to have an SFL spot within reach, provided the flight is performed at an appropriate height above ground level and using sound pilot skills and judgement.

3.4.3.2.2 There will be operations flown directly above surfaces that do not allow for an SFL, but at normal flight altitudes, sufficiently flat, open areas should be within autorotational gliding distance.

3.4.3.2.3 Flights over such areas normally have an SFL spot within reach and should not require mitigation.

3.4.3.3 *Operating in areas with scattered SFL areas (see 2.1.2.1.6)*

3.4.3.3.1 Where the mix of terrain is such that the SFL spots are less readily available, more consideration is required.

3.4.3.3.2 Adaptation of the flight path may be required, such as climbing before crossing a lake or fjord to have an SFL spot available on land on either side within autorotational distance, or flying around a stretch of forest to have an SFL spot available. In some cases, it may not be feasible to change the routing and shorter stretches of the flight might not have an SFL spot within autorotational distance.

3.4.3.3.3 Flights over such areas could be allowed following a risk assessment, provided the identified controls and mitigations are applied. A prescriptive regulation would list the required mitigations as requirements while a performance-based regulation could list the minimum of hazards, barriers and mitigations that an operator would have to assess and implement as part of their risk assessment and control.

3.4.3.4 *Operating in areas of challenging terrain (see 2.1.2.1.7)*

3.4.3.4.1 Some areas are such that SFL spots are few or non-existent for longer stretches. However, if some SFL spots are available, planning the route to pass near these would reduce the exposure and also address emergencies that require a precautionary landing (land immediately, land as soon as possible (ASAP)).

3.4.3.4.2 When operating over challenging terrain in areas where no, or very few, spots are available to perform an SFL, operations may be 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 3.4.3.3.3 above.

3.4.3.4.3 Predetermined routes with known landing areas that are based on reconnaissance might be entered into the navigation database or marked on a map. This could minimize exposure or make potential landing areas readily identifiable in the case of emergencies that require an autorotation or land ASAP.

3.4.3.5 *Additional hazards*

3.4.3.5.1 A successful touchdown with little or no damage to the helicopter is important in preventing injuries to occupants. Depending on the design of the helicopter, moderate crash forces may cause secondary damage and severe injuries. Experience has shown that even relatively controlled landings have resulted in main rotor blades impacting the cockpit area, or damaged fuel systems causing post-crash fires.

3.4.3.5.2 It should be recalled that this will apply to all classes of terrain discussed above.

3.4.3.5.3 Proper planning will address part of this but will never provide complete assurance. Some aspects are impossible to plan for and will remain as part of known uncertainty. This uncertainty is expressed as “reasonable expectancy” in the definition of SFL:

> *Unavoidable landing or ditching with a reasonable expectancy of no injuries to persons in the aircraft or on the surface.*

3.4.3.5.4 Factors that may affect the degree of success of a touchdown in an otherwise adequate spot are listed in the summary below.

3.4.3.6 *Additional pilot training*

3.4.3.6.1 Additional pilot training is required to avoid early loss of rotor revolutions per minute (RPM) on a single-engine helicopter. In case of engine failure on a single-engine helicopter, the rotor RPM will decay rapidly until the collective is lowered. The expected pilot reaction times depend on the rotor inertia and phase of flight and are typically very short. If rotor RPM is not maintained then an autorotation cannot be achieved and there will be no safe landing regardless of the terrain features.

3.4.3.6.2 Specific training in achieving short reaction times in power management may require simulator training to train the startle effect. Such extended training is not expected to be widely implemented.

3.4.3.6.3 Additional mitigation arises from special training and pilot performance. If enhanced standards for pilot performance in autorotation and precision engine off landing are required, then risk can be significantly reduced. Enhanced training standards are expected to:

a) reduce the minimum size of an SFL area that a pilot is capable of reaching.

b) Increase the number of SFL options a pilot has available.

c) Reduce hostility.

d) Increase the chance of a successful autorotation following a real and unexpected failure.

3.4.3.7 *Summary of hazards to an SFL and possible mitigations*

Table 3-1 presents examples of hazards that threaten the outcome of an attempted SFL and possible associated mitigations, as follows:

Table 3-1. SFL Hazards and possible associated mitigations

Hazards	Mitigation
No SFL spot within autorotational distance/not able to reach an SFL spot.	• Procedures • Pre-flight planning • Route selection • Flight height selection (time to prepare/find the best spot) • Consideration of wind conditions • Survey of operating area, identification of SFL spots • SFL areas readily available in navigation database • Pilot training • Pilot awareness, reconnaissance, scanning • Weather/visibility
Main rotor (MR) RPM decay before established in autorotation, pilot reaction/intervention time.	• Helicopter characteristics, MR inertia • Simulator accurately replicating the helicopter • Pilot training

Hazards	Mitigation
	• Pilot alertness • No other pilot duties/workload during exposure time
Unsuccessful touchdown in a spot suitable for an SFL. Degraded visual environment/few visual references for height judgement/touchdown. White-/brown-out.	• Pilot handling skill • Pilot training • Radio altimeter
Endangering persons or property on the ground (third-party): — random in nature/surroundings; — in open spaces in congested areas (generally considered non-hostile); and — open-air assembly of persons (concerts, sports events, etc.).	• Company policy and procedures in compliance with rules of the air • Policy, procedures and pilot training for selecting SFL areas • Policy for restricting consideration of commonly populated areas (roads, parks, golf courses, populated beaches, etc.) as SFL areas • Policy, procedures and pilot training for assessing SFL areas in congested areas • Survey of routes to be used over congested areas
Elevation (mountain)	• Appropriate helicopter • Pilot training • Performance calculation
Further risks: — wind direction determination from height; — turbulence; — obstacles/wires not visible from height; and — unevenness/rocks/ditches not visible from height.	

3.4.4 Protecting occupants during a forced landing

3.4.4.1 *General*

3.4.4.1.1 Historically, helicopters operating in performance Class 3 were lacking in safety features due to weight constraints and the limited power capabilities of their design. As technology has provided lighter materials and improved engine performance, safety engineers have designed, and regulations have included within certification codes, protection for occupants in the event of a crash.

3.4.4.1.2 While these improvements were not specifically intended as mitigation strategies for elevated-risk operations, their availability should be given significant weight when risk mitigation is being considered for operations performance Class 3 over a hostile environment, and for operations in performance Classes 2 and 3 with exposure during the take-off and landing phases.

3.4.4.2 *Crew training*

3.4.4.2.1 Pilot training for engine failure normally occurs at prepared sites to minimize the potential for training accidents. Such training has only marginal value when compared with the skill and composure required to autorotate into trees or onto rugged terrain.

3.4.4.2.2 Aircrew who are routinely engaged in operations over hostile environments should be provided with recurrent training on how best to minimize the consequences to the occupants during an emergency. Simulator-based scenarios should be the tool of first choice where available because saving the aircraft — the focus of normal autorotation training — should, in these cases, yield to survival of the occupants.

3.4.4.2.3 Simulators should have Nr (rotor rpm) characteristics which are fully representative of the helicopter they simulate in order that such training can be realistically conducted.

3.4.4.2.4 Route selection in such environments also requires a different approach from that of simply looking for clear routes. An example would be an open site in mountainous terrain — normally advantageous — but when located on a steep slope could result in roll-over of the helicopter.

3.4.4.2.5 Discussion of strategies that provide a better chance of survival should be part of such training.

3.4.4.3 *Protecting occupants from crash forces*

3.4.4.3.1 Studies have shown that the best way to protect occupants during the rapid deceleration phase of a crash sequence is with crashworthy seats, restraint systems, and structural requirements that maintain a survival volume and restrain heavy items above and behind the occupants. Such requirements have been included in both Parts 27 and 29 for new type-design since the 1980s and 1990s.

3.4.4.3.2 Yet, several decades after incorporation into certification codes, the clear majority of Part 27 newly-manufactured helicopters do not have such protection. (This is due, in part, to regulations that permit derivative-type, newly-manufactured helicopters to avoid these requirement (*Taneja and Wiegmann, 2003*[2])). Until operational necessity forces a change, helicopters will continue to be manufactured with safety systems equivalent to automobiles built before airbags, seat belts and crumple zones were developed.

3.4.4.3.3 Crash protection regulations were intended to protect passengers in all types of operations, including those where a crash, due to mechanical failure, is unlikely. They have specific relevance to operations with exposure where the consequence of a failure is likely to be a crash.

3.4.4.3.4 Helicopters complying with the latest safety standards are available and States, seeking ways to mitigate risk when approving operations with exposure, should encourage their employment.

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[2] "Analysis of Injuries Among Pilots Killed in Fatal Helicopter Accidents", 2003, Aviation Space and Environmental Medicine, Narinder Taneja and Douglas A. Wiegmann.

3.4.4.3.5 The development of these safety systems was an important advance in the evolution of helicopter design. Their availability for use in operations with exposure may be viewed in the same way as airbags and crumple zones have become the standard in automobiles. Compliance with current Part 27.562 “Emergency landing dynamic conditions” and Part 27.785, “Seats, berths, safety belts, and harnesses” should be considered as essential mitigation by a State approving operation where exposure to the consequence of an engine or system failure is increased.

3.4.4.4 *Protecting occupants from post-crash fire*

3.4.4.4.1 Unlike aeroplanes, helicopters have the unique ability to slow their forward and vertical speed to near zero during a forced landing, minimizing, to some extent, the dynamic load on occupants. A helicopter built with the crash protection standards discussed above provides an opportunity for occupants to survive a crash. Yet many survive the crash only to perish in post-crash fires.

3.4.4.4.2 As with crashworthy seats, harnesses and helicopter design, crash resistant fuel systems have been required in newly-certified helicopter-types since the early 1990s. Also, like crash protection requirements, rules for derivative types have permitted the manufacture of new helicopters lacking these safety features.

3.4.4.4.3 A study by the FAA’s Rotorcraft Directorate and Civil Aerospace Medical Institute found that in 97 fatal Part 27 accidents between 2008 and 2013, post-crash fires occurred in 39 per cent of fatal accidents in helicopters not fitted with Part 27.952 ”fuel system crash resistance” compliant fuel systems. The post-crash fire contributed to a fatality in 20 per cent of these fatal accidents.

3.4.4.4.4 Several manufacturers have made compliant systems a standard on all or a large number of their models. In addition, unlike passenger protection, which often cannot be easily improved in legacy aircraft due to basic design issues, fuel tanks and systems are normally upgradable — even if not achieving full compliance with the certification standard.

3.4.4.4.5 This is an area where States can mitigate some of the risk inherent in operations with exposure over a hostile environment. Protecting occupants from post-crash fires has been the subject of intense research, on both rotary and fixed wing aircraft, for many decades. The technology is mature, and affordable, and the requirement to have the capability should be waived only in the most risk tolerant operations.

3.4.5 Post-Crash Survival and Rescue

Helicopters are often used to access remote locations far removed from rescue resources. When approving the operations with exposure in such environments, States should consider the issues of: flight following and tracking; expeditious warning of forced landing; location of downed helicopter and occupants; and, survival requirements. The term hostile environment pertains not only to the unavailability of a safe forced landing area, but also to the conditions that influence post-landing survival. The requirements for flight over areas designated by a State as areas in which search and rescue would be especially difficult, as detailed in Annex 6 Part III, Section II, 4.6, may be especially pertinent in this regard.

3.4.5.1 *Flight following and tracking*

3.4.5.1.1 Aircraft Tracking has been defined as a process, established by the operator, that maintains and updates, at standardized intervals, a ground-based record of the four-dimensional position of individual aircraft in flight. Although currently only required for large commercial airliners, the principle might be extended by a State to require helicopter operators conducting operations in more remote areas, or areas lacking normal communication or air traffic service coverage, to implement such a tracking system.

3.4.5.1.2 The principal intent of a tracking system is to ensure that operators develop and implement the operational control capability to track their aircraft throughout the designated area of operations.

3.4.5.1.3 Information and guidance on tracking systems and procedures may be found in Circular 347 — *Aircraft Tracking Implementation Guidelines*.

3.4.5.2 *First aid for injuries*

The first post-crash consideration is care of the injured. While all helicopters have a mandatory amount of first aid equipment based on number of occupants, standard equipment assumes the rapid availability of advanced medical care. Flight over remote terrain could mean that survivors might have to provide their own care for an extended period. Operators should provide a degree of first aid capability, including crew training, that is appropriate to the anticipated delay of advanced care and which is acceptable to the State.

3.4.5.3 *Rescue resources*

3.4.5.3.1 When approving operations with exposure in remote areas, the State should consider the availability of rescue resources for the area under consideration. If public rescue resources are not available for practical use, the operator should provide a plan acceptable to the State for the timely recovery of the occupants as a condition for receiving operational approval.

3.4.5.3.2 Such plans could include either ground or air rescue resources based on the environment, expected time to the site, and the availability of survival gear as discussed below.

3.4.5.4 *Communication capabilities for rescue*

3.4.5.4.1 Occupants of a helicopter operating with exposure over a hostile environment should have the ability to access rescue resources in the event of an accident.

3.4.5.4.2 When operating over remote areas, flight tracking could be achieved with systems that include alerting, and voice communications even when on the surface. If this is achieved with equipment fitted in accordance with 3.4.5.1 above, the ability to communicate from outside the helicopter following a crash landing might be an additional consideration.

3.4.5.5 *Climate and protective equipment and clothing*

3.4.5.5.1 Small helicopters have limited capability to carry survival gear. In certain environments, such limitations simply indicate the necessity for a more capable helicopter.

3.4.5.5.2 Operators should provide a plan acceptable to the State that provides for the survival needs of the occupants should they be involved in a forced landing in an extreme climate or environment. Such a plan should factor in the anticipated rescue time — with allowances for potential weather delays based on normal weather patterns for the area.

3.4.5.5.3 Considerations include but are not limited to: access to water, protective clothing, overnight shelter, protection from dangerous animals, and food, if an extended amount of time to rescue is anticipated. In some climates, protective gear might need to be worn during flight, as there is no time during a helicopter forced landing sequence to don such equipment.

3.4.5.5.4 Consideration should also be given to the potential need for specific survival skill training where passengers routinely transit severe environments — such as open sea areas.

3.4.6 Regulation and compliance

3.4.6.1 When regulating operation with exposure, requirements should be proportionate to, and in accordance with, the level and the nature of the risk.

3.4.6.2 For an unprepared pilot in an unsuitable and ill-equipped helicopter, many environments will be hostile but that should not be the case for a well-trained, prepared and equipped pilot and helicopter. Even when an SFL is possible, the prospects of survival have to be considered and addressed. Requirements to reduce exposure are the first part of any required strategy, mitigating the consequences is the second.

3.4.6.3 Operators' risk assessments may vary in standard, scope and quality; it is therefore necessary for the State to set requirements and specify the required controls. A combination of measures may be needed; the greater the risk, the more barriers and mitigation required to make the total risk tolerable.

3.4.6.4 An example of a mitigation strategy to minimize likely consequences when operating over challenging terrain could be as follows:

3.4.6.4.1 *Operator policy and procedures*:

a) implementation of a policy to reduce exposure time to a strict minimum;

b) increase of flight altitudes according to the areas flown over;

c) increase of weather minima (cloud base height and visibility); and

d) preliminary identification and documentation of emergency areas on the usual routes.

3.4.6.4.2 *Establish criteria for flight crew selection and training including*:

a) minimum crew experience;

b) determining the hostility of the overflown environment;

c) strategies to minimize overflying of hostile areas; and

d) enhanced techniques for autorotation into difficult sites.

3.4.6.4.3 *Helicopter equipment, occupant protection*:

a) additional navigation aids, minimum equipment list adaptation;

b) occupant protection systems (energy absorbing seats, harnesses, survival equipment);

c) installation of flight path recording and tracking systems (for supervision purposes);

d) implementation of continuous ground monitoring of the helicopter's position and/or submission of an ATC flight plan; and

e) the carriage of additional emergency locator transmitter or personal locator beacon beacons by passengers or crew.

3.4.7 Summary

3.4.7.1 It is for the State to assess the level of mitigation when determining the ALSR after consideration of the necessity of the operation to the community, the availability of other means of accomplishing the objective, and the tolerance to risk of the society represented.

3.4.7.2 This manual suggests that risk should be reduced to an acceptable level — which will vary from State to State. While such a concept does not provide a uniform level of safety on a global basis, helicopter operations will inevitably be reflective of local sociocultural norms.

3.4.7.3 The goal of this chapter, and indeed this document, is to provide a structured approach toward the process of risk assessment and provision mitigation such that States, when approving specific operations, can make informed decisions on exposure to the residual risk that passengers and third parties might be subject to.

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Attachment A to Section 3.4

OPERATIONS WITH EXPOSURE — ESTABLISHING RELIABILITY

1. Appropriate power plant reliability statistics should be made available for the helicopter type and the engine type. If not already in their database, States should request the current statistics directly from the OEMs, plus an ongoing update service.

2. Except in the case of new engines, such data should show sudden power-loss from the set of in-flight shut-down (IFSD) events not exceeding 1 per 100 000 engine hours in a 5-year moving window. However, a rate more than this value, but not exceeding 3 per 100 000 engine hours, may be accepted by the authority after an assessment showing an improving trend.

3. New engines should be assessed on a case-by-case basis.

Note.— To avoid penalizing new designs, the assumption that the reliability target in 2. above is met should be accepted unless otherwise established.

4. After the initial assessment, updated statistics should be periodically reassessed; any adverse sustained trend will require an immediate evaluation to be accomplished by the operator in consultation with the authority and the manufacturers concerned. The evaluation may result in corrective action or operational restrictions being applied.

5. The purpose here is to provide guidance on how the in-service power plant sudden power loss rate is determined.

5.1 Sharing of roles between the helicopter and engine type certificate holders (TCHs).

a) The provision of documents establishing the in-service sudden power loss rate for the helicopter/engine installation, and the interface with the operational authority of the State of Design should be the engine TCH or the helicopter TCH depending on the way they share the corresponding analysis work.

b) The engine TCH should provide the helicopter TCH with a document including: the list of in-service power loss events, the applicability factor for each event (if used), and the assumptions made on the efficiency of any corrective actions implemented (if used).

c) The helicopter TCH should provide the operational Authority of the State of Design or, where this authority does not take responsibility, the operational authority of the State of the Operator, with a document that details the calculation results — taking into account: the events caused by the engine and the events caused by the engine installation; the applicability factor for each event (if used), the assumptions made on the efficiency of any corrective actions implemented on the engine and on the helicopter (if used); and the calculation of the power plant power loss rate.

5.2 The following documentation should be updated every year:

5.2.1 The document with detailed methodology and calculation as distributed to the authority of the State of Design or, where this authority does not take responsibility, the (operational) authority of the State of the Operator.

5.2.2 A summary document with results of computation as made available on request to any operational authority.

5.2.3 A service letter establishing the eligibility for such operation and defining the corresponding required configuration as provided to the operators.

5.3. The definition of “sudden in-service power loss” is:

A sudden in-service power loss is an engine power loss:

a) larger than 30 per cent of the take-off power;

b) occurring during operation; and

c) without the occurrence of an early intelligible warning to inform and give sufficient time for the pilot to take any appropriate action.

5.4 Database documentation.

Each power loss event should be documented, by the engine and/or helicopter TCHs, as follows:

a) incident report number;

b) engine type;

c) engine serial number;

d) helicopter serial number;

e) date;

f) event type (demanded IFSD, undemanded IFSD);

g) presumed cause;

h) applicability factor when used; and

i) reference and assumed efficiency of the corrective actions that will have to be applied (if any).

5.5 Counting methodology.

Various methodologies for counting engine power loss rate have been accepted by authorities. The following is an example of one of these methodologies:

5.5.1 Events resulting from:

a) unknown causes (wreckage not found or totally destroyed, undocumented or unproven statements); or

b) where the engine or the elements of the engine installation have not been investigated (for example, when the engine has not been returned by the customer); or

c) an unsuitable or non-representative use (operation or maintenance) of the helicopter or the engine are not counted as engine in-service sudden power loss,

the applicability factor is 0 per cent.

5.5.2 Events caused by:

a) the engine or the engine installation; or

b) the engine or helicopter maintenance, when the applied maintenance was compliant with the maintenance manuals, are counted as engine in-service sudden power loss,

the applicability factor is 100 per cent.

5.5.3 Events where the engine or an element of the engine installation has been submitted to investigation which did not allow definition of a presumed cause,

the applicability factor is 50 per cent.

5.6 Efficacy of corrective actions.

5.6.1 The corrective actions made by the engine and helicopter manufacturers on the definition or maintenance of the engine or its installation could be defined as mandatory for operations with exposure. In this case, the associated reliability improvement could be considered as a mitigating factor for the event.

5.6.2 A factor defining the efficiency of the corrective action could be applied to the applicability factor of the concerned event.

5.7. Method of calculation of the power plant power loss rate.

The detailed method of calculation of the power plant power loss rate should be documented by engine or helicopter TCH and accepted by the relevant authority.

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Attachment B to Section 3.4

OPERATIONS WITH EXPOSURE — PREVENTATIVE MAINTENANCE AND TREND MONITORING

An operator conducting operations without an assured safe forced landing capability should implement the following:

1 FOR TURBINE ENGINE HELICOPTERS

1.1 Attain and then maintain the helicopter/engine modification standard defined by the manufacturer that has been designated to enhance reliability during the take-off and landing phases.

1.2 Conduct the preventive maintenance actions recommended by the helicopter, or engine, manufacturer as follows:

a) engine oil spectrometric and debris analysis — as appropriate;

b) engine trend monitoring based on available power assurance checks;

c) engine vibration analysis (plus any other vibration monitoring systems where fitted); and

d) oil consumption monitoring.

1.3 The usage monitoring system should fulfil at least the following:

1.3.1 Recording of the following data:

a) date and time of recording, or a reliable means of establishing these parameters;

b) number of flight hours recorded during the day plus total flight time;

c) N1 (gas producer RPM) cycle count;

d) N2 (power turbine RPM) cycle count (if the engine features a free turbine);

e) turbine temperature exceedance: value, duration;

f) power-shaft torque exceedance: value, duration (if a torque sensor is fitted); and

g) engine shafts speed exceedance: value, duration.

1.3.2 Data storage of the above parameters, if applicable, covering the maximum flight time in a day, and not less than five flight hours, with an appropriate sampling interval for each parameter.

1.3.3 The system should include a comprehensive self-test function with a malfunction indicator and a detection of power-off or sensor input disconnection.

1.3.4 A means should be available for downloading and analysis of the recorded parameters. Frequency of downloading should be sufficient to ensure data is not lost through overwriting.

1.3.5 The analysis of parameters gathered by the usage monitoring system, the frequency of such analysis and subsequent maintenance actions should be described in the maintenance documentation.

1.3.6 The data should be stored in an acceptable form and accessible to the authority, for at least 24 months.

1.4 Include take-off and landing procedures in the operations manual, where they do not already exist in the RFM.

1.5 Establish training for flight crew which should include the discussion, demonstration, use and practice of the techniques necessary to minimize the risks;

1.6 Report to the manufacturer any loss of power control, engine shutdown (precautionary or otherwise) or power unit failure for any cause (excluding simulation of power unit failure during training). The content of each report should provide:

a) date and time;

b) operator (and Maintenance organizations where relevant);

c) type of helicopter and description of operations;

d) registration and serial number of airframe;

e) engine type and serial number;

f) power unit modification standard where relevant to failure;

g) engine position;

h) symptoms leading up to the event;

i) circumstances of power unit failure including phase of flight or ground operation;

j) consequences of the event;

k) weather/environmental conditions;

l) reason for power unit failure — if known;

m) in case of an in-flight shut-down (IFSD), nature of the IFSD (demanded/undemanded);

n) procedure applied and any comment regarding engine restart potential;

o) engine hours and cycles (from new and last overhaul);

p) airframe flight hours;

q) rectification actions applied including, if any, component changes with part number and serial number of the removed equipment; and

r) any other relevant information.

2 FOR RECIPROCATING ENGINE HELICOPTERS

2.1 Attain and then maintain the helicopter/engine modification standard defined by the manufacturer that has been designated to enhance reliability during the take-off and landing phases.

2.2. Conduct the preventive maintenance actions recommended by the helicopter or engine manufacturer as follows:

a) engine oil spectrometric and debris analysis, as appropriate;

b) cylinder and induction/exhaust valve borescope inspections, as appropriate;

c) engine trend monitoring based on cylinder compression checks; and

d) oil consumption monitoring.

2.3. The usage monitoring system should fulfil at least the following:

a) Recording of the following data:

  1) date and time of recording, or a reliable means of establishing these parameters;

  2) amount of flight hours recorded during the day plus total flight time;

  3) cylinder head temperature exceedance: value, duration;

  4) oil temperature exceedance: value, duration;

  5) manifold absolute pressure exceedance (if appropriate to engine configuration): value, duration; and

  6) crankshaft RPM exceedance: value, duration.

b) Data storage of the above parameters, if applicable, covering the maximum flight time in a day, and not less than five flight hours, with an appropriate sampling interval for each parameter.

c) The system should include a comprehensive self-test function with a malfunction indicator and a detection of power-off or sensor input disconnection.

d) A means should be available for downloading and analysis of the recorded parameters. Frequency of downloading should be sufficient to ensure data are not lost through overwriting.

e) The analysis of parameters gathered by the usage monitoring system, the frequency of such analysis and subsequent maintenance actions should be described in the maintenance documentation.

f) The data should be stored in an acceptable form and accessible to the competent authority for at least 24 months.

2.4 The training for flight crew should include the discussion, demonstration, use and practice of the techniques necessary to minimize the risks.

2.5 Report to the manufacturer any loss of power control, engine shutdown (precautionary or otherwise) or engine failure for any cause (excluding simulation of engine failure during training). The content of each report should provide:

a) date and time;

b) operator (and maintenance organizations where relevant);

c) type of helicopter and description of operations;

d) registration and serial number of airframe;

e) engine type and serial number;

f) power unit modification standard where relevant to failure;

g) engine position;

h) symptoms leading up to the event;

i) circumstances of engine failure including phase of flight or ground operation;

j) consequences of the event;

k) weather/environmental conditions;

l) reason for engine failure — if known;

m) in case of an in-flight shut-down (IFSD), nature of the IFSD (demanded/undemanded);

n) procedure applied and any comment regarding engine restart potential;

o) engine hours and cycles (from new and last overhaul);

p) airframe flight hours;

q) rectification actions applied including, if any, component changes with part number and serial number of the removed equipment; and

r) any other relevant information.

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