ICAO Doc 10064 - Aeroplane Performance Manual

Notation:

- [Text in square brackets indicates original references from which the paragraph was taken.]
  - A61D = Annex 6 Chapter 1 Definitions
  - A6C = Annex 6 Attachment C
  - A8I = Annex 8 Part I
  - A14PA = Annex 14 Proposed Amendments
  - D9051I = Doc 9051 Part I
  - D9051III = Doc 9051 Part III
  - CS25 = EASA CS 25
  - AC12091 = FAA AC120-91

1. Foreword

1.1 Motivation

This manual was developed to combine guidelines on certification and operational requirements regarding aeroplane performance. It was developed in the context of the Friction Task Force of the Aerodrome Operations and Services Working Group on the basis of existing and proposed national regulations, Annex 6 Attachment C and the proposals of the FAA Take-off and Landing Performance Aviation Rulemaking Committee (TALPA ARC).

The motivation for a single manual to support Standards and Recommended Practices both for Airworthiness of Aircraft (Annex 8) and Aeroplane Operations (Annex 6) was a holistic approach to operations on contaminated runways in line with the condition reporting and with the Standards and Recommended Practices of Annexes 14 and 15 and associated procedures and guidance.

In places, this Manual provides guidance beyond the operations on contaminated runways, to ensure continuity with Annex 6 Attachment C which it replaces at Amendment 40C, and addresses current regulatory shortcomings regarding obstacle clearance. The guidance provided in this manual describes a possible means of achieving the intended level of safety. However, the described means may not be the only, or even the most adapted, way of meeting this intent by individual aeroplane manufacturers and operators.

1.2 Purpose and scope

[A6C 1.]The purpose of this Manual is to provide guidance as to the level of performance intended by the provisions of Annex 6 Chapter 5 and Annex 8 Part IIIB as applicable to turbine-powered subsonic transport type aeroplanes over 5 700 kg maximum certificated take-off mass having two or more engines. However, where relevant, it can be applied to all subsonic turbine-powered or piston-engine aeroplanes having two, three or four engines. Piston-engine aeroplanes having two, three or four engines which cannot comply with this Manual may continue to be operated in accordance with Appendix 13 and Appendix 14 of this Manual.

[A6C 3.1]Operators should comply with the provisions of chapter 3, unless deviations therefrom are specifically authorized by the State of the Operator on the grounds that the special circumstances of a particular case make a literal observance of these provisions unnecessary for safety.

[A6C 3.2]Compliance with chapter 3 should be established using performance data in the flight manual and in accordance with other applicable operating requirements. In no case should the limitations in the flight manual be exceeded. However, additional limitations may be applied when operational conditions not included in the flight manual are encountered. The performance data contained in the flight manual may be supplemented with other data acceptable to the State of the Operator if necessary to show compliance with chapter 3. When applying the factors prescribed in this Manual, account may be taken of any operational factors already incorporated in the flight manual data to avoid double application of factors.

[A6C 3.3]Operators should follow the procedures scheduled in the flight manual except where operational circumstances require the use of modified procedures in order to maintain the intended level of safety.

Contents

Definitions

[A6C 2.]***Accelerate-stop distance available (ASDA)*****.** The length of the take-off run available plus the length of the stopway, if provided. *Note.— Where the minimum recommended length of Runway End Safety Areas is achieved by application of Annex 14 ATT A 9.2, the ASDA may be shorter than the take-off run available.*

[A61D]***Aerodrome.*** A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

[A8I] ***Aeroplane.*** A power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight.

[A8I] ***Aircraft.*** Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

[A61D]***Aircraft operating manual.*** A manual, acceptable to the State of the Operator, containing normal, abnormal and emergency procedures, checklists, limitations, performance information, details of the aircraft systems and other material relevant to the operation of the aircraft.

Note.— The aircraft operating manual is part of the operations manual.

[D9760] ***Airworthiness Standards.*** Detailed and comprehensive design and safety criteria applicable to the category of the aeronautical product (aircraft, engine and propeller) that satisfy, at a minimum, the applicable standards of Annex 8.

Airworthy. The status of an aircraft, engine, propeller or part when it conforms to its approved design and is in a condition for safe operation.

[A61D]***Alternate aerodrome.*** An aerodrome to which an aircraft may proceed when it becomes either impossible or inadvisable to proceed to or to land at the aerodrome of intended landing where the necessary services and facilities are available, where aircraft performance requirements can be met and which is operational at the expected time of use. Alternate aerodromes include the following:

Take-off alternate. An alternate aerodrome at which an aircraft would be able to land should this become necessary shortly after take-off and it is not possible to use the aerodrome of departure.

En-route alternate. An alternate aerodrome at which an aircraft would be able to land in the event that a diversion becomes necessary while en route.

Destination alternate. An alternate aerodrome at which an aircraft would be able to land should it become either impossible or inadvisable to land at the aerodrome of intended landing.

Note.— The aerodrome from which a flight departs may also be an en-route or a destination alternate aerodrome for that flight.

[D9051I 1.]***Anticipated operating conditions.*** Those conditions which are known from experience or which can be reasonably envisaged to occur during the operational life of the aircraft taking into account the operations for which the aircraft is made eligible, the conditions so considered being relative to the meteorological state of the atmosphere, to the configuration of terrain, to the functioning of the aircraft, to the efficiency of personnel and to all the factors affecting safety in flight. Anticipated operating conditions do not include:
a) those extremes which can be effectively avoided by means of operating procedures; and
b) those extremes which occur so infrequently that to require the Standards to be met in such extremes would give a higher level of airworthiness than experience has shown to be necessary and practical.

[D9051I 1.]***Approved.*** Accepted by a Contracting State as suitable for a particular purpose.

[A6C 2.]***CAS (calibrated airspeed).*** The calibrated airspeed is equal to the airspeed indicator reading corrected for position and instrument error. (As a result of the sea level adiabatic compressible flow correction to the airspeed instrument dial, CAS is equal to the true airspeed (TAS) in Standard Atmosphere at sea level.)

[D9051I 1.]***Configuration (as applied to the aeroplane).*** A particular combination of the positions of the movable elements such as wing flaps, landing gear, etc., which affect the aerodynamic characteristics of the aeroplane.

[D9051I 1.]***Critical engine(s).*** Any engines(s) whose failure gives the most adverse effect on the aircraft characteristics relative to the case under consideration.

[D9051I 1.]***Design landing mass.*** The maximum mass of the aircraft at which, for structural design purposes, it is assumed that it will be planned to land.

[D9051I 1.]***Design take-off mass.*** The maximum mass at which the aircraft, for structural design purposes, is assumed to be planned to be at the start of the take-off run.

[A61D]***Commercial air transport operation.*** An aircraft operation involving the transport of passengers, cargo or mail for remuneration or hire.

[A61D]***Configuration deviation list (CDL).*** A list established by the organization responsible for the type design with the approval of the State of Design which identifies any external parts of an aircraft type which may be missing at the commencement of a flight, and which contains, where necessary, any information on associated operating limitations and performance correction.

[A61D]***Crew member.*** A person assigned by an operator to duty on an aircraft during a flight duty period.

[A6C 2.]***Declared temperature.*** A temperature selected in such a way that when used for performance purposes, over a series of operations, the average level of safety is not less than would be obtained by using official forecast temperatures.

Factored Distance At Time of Landing. A factored landing distance derived from the distance at time of Landing used for the check at Time of Landing.

[D9051I 1.]***Elevation.*** The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Engine. A unit used or intended to be used for aircraft propulsion. It consists of at least those components and equipment necessary for functioning and control, but excludes the propeller/rotors (if applicable).

[A6C 2.]***Expected.*** Used in relation to various aspects of performance (e.g. rate or gradient of climb), this term means the standard performance for the type, in the relevant conditions (e.g. mass, altitude and temperature).

[A61D]***Flight crew member.*** A licensed crew member charged with duties essential to the operation of an aircraft during a flight duty period.

[A61D]***Flight manual.*** A manual, associated with the certificate of airworthiness, containing limitations within which the aircraft is to be considered airworthy, and instructions and information necessary to the flight crew members for the safe operation of the aircraft.

[A61D]***Flight operations officer/flight dispatcher.*** A person designated by the operator to engage in the control and supervision of flight operations, whether licensed or not, suitably qualified in accordance with Annex 1, who supports, briefs and/or assists the pilot-in-command in the safe conduct of the flight.

[A6C 2.]***Grooved or porous friction course runway.*** A paved runway that has been constructed and maintained with lateral grooving or a porous friction course (PFC) surface to improve braking characteristics when wet in compliance with ICAO Doc 9157 Aerodrome Design Manual or equivalent.

[A6C 2.]***Height.*** The vertical distance of a level, a point, or an object considered as a point, measured from a specified datum.

Note.— For the purposes of this example, the point referred to above is the lowest part of the aeroplane and the specified datum is the take-off or landing surface, whichever is applicable.

[A61D]***Human Factors principles.*** Principles which apply to aeronautical design, certification, training, operations and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance.

[A61D]***Human performance*****.** Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

[A6C 2.]***Landing Distance Available (LDA).*** The length of runway which is declared available and suitable for the ground run of an aeroplane landing.

[D9051I 1.]*Note. - The landing distance available commences at the threshold and extends for the length of the runway after the threshold. In most cases, this corresponds to the physical length of the runway pavement. However, the threshold may be displaced from the extremity of the runway when it is considered necessary to make a corresponding displacement of the approach surface by reason of obstructions in the approach path to the runway. Where the minimum recommended length of Runway End Safety Areas is achieved by application of Annex 14 ATT A 9.2, the end of the LDA may also not coincide with the physical end of the runway.*

[A6C 2.]***Landing surface.*** That part of the surface of an aerodrome which the aerodrome authority has declared available for the normal ground or water run of aircraft landing in a particular direction.

Manufacturer. The organization responsible for the type design that holds the type certificate, or equivalent document, for an aircraft issued by a Contracting State.

[A61D]***Maximum mass.*** Maximum certificated take-off mass.

[A6C 2.]***Net gradient.*** The net gradient of climb throughout these requirements is the expected gradient of climb diminished by the maneuver performance (i.e. that gradient of climb necessary to provide power to maneuver) and by the margin (i.e. that gradient of climb necessary to provide for those variations in performance which are not expected to be taken explicit account of operationally).

[A61D]***Obstacle clearance altitude (OCA)*** or ***obstacle clearance height (OCH).*** The lowest altitude or the lowest height above the elevation of the relevant runway threshold or the aerodrome elevation as applicable, used in establishing compliance with appropriate obstacle clearance criteria.

Note 1.— Obstacle clearance altitude is referenced to mean sea level and obstacle clearance height is referenced to the threshold elevation or in the case of non-precision approaches to the aerodrome elevation or the threshold elevation if that is more than 2 m (7 ft) below the aerodrome elevation. An obstacle clearance height for a circling approach is referenced to the aerodrome elevation.

Note 2.— For convenience when both expressions are used they may be written in the form "obstacle clearance altitude/ height" and abbreviated "OCA/H".

Distance at Time of Landing*.* Landing distance achievable in normal line operations following recommended procedures furnished for the prevailing conditions.

[A61D]***Operations manual.*** A manual containing procedures, instructions and guidance for use by operational personnel in the execution of their duties.

[A61D]***Operations specifications.*** The authorizations, conditions and limitations associated with the air operator certificate and subject to the conditions in the operations manual.

[A61D]***Operator.*** A person, organization or enterprise engaged in or offering to engage in an aircraft operation.

[D9051I 1.]***Pressure-altitude.*** An atmospheric pressure expressed in terms of altitude which corresponds to that pressure in the Standard Atmosphere*.

[A6C 2.]***Reference humidity.*** The relationship between temperature and reference humidity is defined as follows:

— at temperatures at and below ISA, 80 per cent relative humidity,
— at temperatures at and above ISA + 28° C, 34 per cent relative humidity,
— at temperatures between ISA and ISA + 28° C, the relative humidity varies linearly between the humidity specified for those temperatures.

Runway Condition Assessment Matrix (RCAM). A matrix allowing the assessment of the Runway Condition Code, using associated procedures, from a set of observed runway surface condition(s) and pilot report of braking action.

Runway Condition Code (RWYCC). A number that describes the effect of the runway surface condition(s) on aeroplane braking performance and lateral control for each third of the runway.

Note.- The purpose of the RWYCC is to permit an operational aircraft landing performance calculation by the flight crew. Procedures for the determination of the RWYCC are described in PANS-Aerodromes (Doc 9981).

* As defined in Annex 8.

Runway surface condition(s). A description of the condition(s) of the runway surface used in the runway condition report which establishes the basis for the determination of the RWYCC for aeroplane performance purposes.

Note 1.— The runway surface conditions used in the runway condition report establish the performance requirements between the aerodrome operator, aeroplane manufacturer and aeroplane operator.

Note 2.— Aircraft de-icing chemicals and other contaminants are also reported but are not included in the list of runway surface condition descriptors because their effect on runway surface friction characteristics and the runway condition code cannot be evaluated in a standardized manner.

Note 3.— Procedures on determining runway surface conditions are available in the PANS-Aerodromes (Doc 9981).

Dry runway. A runway is considered dry if its surface is free of visible moisture within the area intended to be used.

Wet runway. The runway surface is covered by any visible dampness or water up to and including 3 mm deep within the intended area of use.

Slippery wet runway. A wet runway where the surface friction characteristics of a significant portion of the runway has been determined to be degraded.

Contaminated runway. A runway is contaminated when a significant portion of the runway surface area (whether in isolated areas or not) within the length and width being used is covered by one or more of the substances listed in the runway surface condition descriptors.

Runway surface condition descriptors. One of the following elements on the surface of the runway:

Note.— Procedures on determination of contaminant coverage on runway is available in the PANS-Aerodromes (Doc 9981).

Compacted snow .Snow that has been compacted into a solid mass such that aeroplane tires, at operating pressures and loadings, will run on the surface without significant further compaction or rutting of the surface.

Dry snow. Snow from which a snowball cannot readily be made.

Frost. Frost consists of ice crystals formed from airborne moisture on a surface whose temperature is below freezing. Frost differs from ice in that the frost crystals grow independently and therefore have a more granular texture.

Note 1.-Below freezing refers to air temperature equal to or less than the freezing point of water (0 degree Celsius).

Note 2.-Under certain conditions frost can cause the surface to become very slippery, it should then be reported appropriately as reduced braking action.

Ice*.* Water that has frozen or compacted snow that has transitioned into ice, in cold and dry conditions.

Slush*.* Snow that is so water saturated that water will drain from it when a handful is picked up or will splatter if stepped on forcefully.

Standing water. Water of depth greater than 3 mm.

Note.- Running water of depth greater than 3 mm is reported as standing water by convention.

Wet ice*.* Ice with a layer of water on top of it or ice that is melting.

Note.- Freezing precipitation can lead to runway conditions that can be associated with wet ice from an aeroplane performance point of view. Wet ice can cause the surface to become very slippery. It is then reported appropriately as reduced braking action in line with procedures in the PANS-Aerodromes (Doc 9981).

Wet snow*.* Snow that contains enough water content to be able to make a well-compacted, solid snowball, but water will not squeeze out.

[A8I] ***State of Design.*** The State having jurisdiction over the organization responsible for the type design.

[A6] ***State of Registry.*** The State on whose register the aircraft is entered.

Note.— In the case of the registration of aircraft of an international operating agency on other than a national basis, the States constituting the agency are jointly and severally bound to assume the obligations which, under the Chicago Convention, attach to a State of Registry. See, in this regard, the Council Resolution of 14 December 1967 on Nationality and Registration of Aircraft Operated by International Operating Agencies which can be found in Policy and Guidance Material on the Economic Regulation of International Air Transport *(Doc 9587)*.

[A6] ***State of the Operator.*** The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

[A6C 2.]***Take-off distance available (TODA).*** The length of the take-off run available plus the length of the clearway, if provided.

[A6C 2.]***Take-off run available (TORA).*** The length of runway declared available and suitable for the ground run of an aeroplane taking off.

[A6C 2.]***Take-off surface.*** That part of the surface of an aerodrome which the aerodrome authority has declared available for the normal ground or water run of aeroplane taking off in a particular direction.

[A6C 2.]***TAS (True airspeed).***The speed of the aeroplane relative to undisturbed air.

.V_{S_0}. A stalling speed or minimum steady flight speed in the landing configuration. (*Note.— See Appendix 13.)*

V_{S_t}. A stalling speed or minimum steady flight speed. (*Note.— See Appendix 13)*

[A6C 2.] *Note 1.— See Chapter 1 and Annexes 8 and 14, Volume I, for other definitions.*

[A6C 2.]*Note 2.— The terms "accelerate-stop distance", "take-off distance", "V_1", "take-off run", "net take-off flight path", "one engine inoperative en-route net flight path", and "two engines inoperative en-route net flight path", as relating to the aeroplane, have their meanings defined in the airworthiness requirements under which the aeroplane was certificated. If any of these definitions are found inadequate, then a definition specified by the State of the Operator should be used.*

2. Introduction

Performance information should be presented to the intended user in a format that can be easily understood and applied. This principle should be followed when the information is presented as tables, charts and figures, and when it is determined interactively with computation tools, such as Electronic Flight Bags (EFB). Aeroplane performance can be divided into two general categories. The first is airworthiness standards, for which compliance demonstration is under the responsibility of the aeroplane manufacturer or type certificate holder. The other is operating standards which must be complied with by the aeroplane operator.

2.1 Aeroplane Airworthiness Performance Standards

Current airworthiness standards as applied to turbojet aeroplane performance have evolved such that they are harmonized to a very large extent, and fulfil the broad Standards promulgated in Annex 8.

Some countries maintain subtle differences in their airworthiness standards, but for most part the take-off and landing airworthiness performance requirements are the same worldwide.

Aeroplane manufacturers agree with their States of Design on the way of demonstrating compliance with the applicable airworthiness standards for certification of their aeroplane. Airworthiness standards evolve over time, albeit slowly, and therefore there would be no benefit in replicating the specific requirements in this document.

The information provided in this manual with regards to certification standards is applicable to large aeroplanes that have been certificated under Part III of Annex 8.

2.2 Aeroplane Operating Performance Standards

Each Contracting State is responsible for the operating standards of the aircraft on its registry and those for which the transfer of functions and duties has been agreed with the State of Registry under Article 83 bis of the Convention.

As with airworthiness, these standards address the majority of the operating issues and in general aeroplane manufacturers offer operational performance data for their aeroplane that allow operators to meet the applicable standards. Also as with airworthiness standards it may be necessary or desired for an individual Contracting State to have specific operating standards that address specific issues that affect their jurisdiction.

Operators must comply with the regulations of their State of Registry, which must fulfil the broad standards laid out in Annex 6 Chapter 5 regarding performance limitation. Only in very rare and specific cases is compliance with differing local regulations of the countries they fly to required.

2.3 Supplemental Aeroplane Performance

It is recognized that airworthiness and operating standards may not cover all the information necessary to operate the aeroplane in regards to take-off and landing performance. Therefore this document will discuss in Chapter 4 some specific aeroplane performance issues that operators may need to consider to ensure safe operation.

One of these supplemental areas that has been identified and that is the main impetus for this Manual is the operation of aeroplanes on runways that are not dry, that is runways that are wet or contaminated. This specific issue crosses multiple boundaries in the regulatory framework such as airworthiness standards, aircraft operating standards, aerodrome runway construction and maintenance standards and the determination and dissemination of the description of the runway surface condition.

To address these issues the FAA chartered the Take-off and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC). This group made proposals that created a common language on runway surface conditions for all stakeholders that have since been integrated into local regulations of several Contracting States and becomes applicable under ICAO on 5 November 2020. For more historical background, please refer to Appendix 1.

2.4 Implementation of TALPA ARC in ICAO Standards and Guidance

The implementation of TALPA ARC proposals touches many ICAO Annexes, PANS and associated documents, such as:

- Annex 14 Vol 1 Aerodromes defines the reporting needs in terms of runway surface conditions, while Doc 9981 PANS-Aerodromes describes the content and format of the Runway Condition Report (RCR). Additional guidance for aerodrome operators is provided in Circular 329,

- Annex 8 Airworthiness of Aircraft requires the publication of landing distances to be used for the performance assessment at time of landing for all aeroplanes for which the application for the type certificate is made on or after 2 March 2019,

- Annex 6 Part I Operation of Aircraft mandates the check of performance at time of landing and the reporting of worse than expected runway surfaces conditions by flight crew (AIREPs),

- Annex 15 Aeronautical Information Services describes the new SNOWTAM format and Doc 4444 PANS ATM defines the phraseology to be used in Runway Surface Reports and AIREPs.

It is essential that Contracting States introduce all the aspects of the Standards and Recommended Practices summarized in this section into their local regulation for all stakeholders simultaneously and in line with the applicability date set for the 5 November 2020 by ICAO to ensure safe conduct of operations throughout the system and across borders.

Distance At Time of Landing

It is required for new type designs that manufacturers publish landing distances that can be achieved without exceptional skill or alertness for a set of runway surface conditions that spans the range of reportable and operable runway surface conditions, and that take into account all the main factors that influence the length of landing distance. The intent is that the Distances At Time of Landing are established in accordance with the following general principles. Appendix 4 provides a full set of detailed recommendation that allow complying with these principles.

Air Distance

The length of the airborne distance from a point above the threshold to the point of main gear touchdown should be representative of a distance achievable in line operations following normal procedures and in line with the approach guidance provided. It should account for the planned approach ground speed, conservatively consider the wind effect and may take credit for an achievable bleed-off of speed during the flare.

Activation of Deceleration Means

Deceleration means should be taken into consideration in line with their intended use as prescribed in the Standard Operating Procedures (SOP). Delays for manual ground spoiler deployment, braking initiation and reverser thrust activation, if their use is intended, should be assessed conservatively. No allowance for delays needs to be considered for devices for which activation is automatic.

Ground Roll

The ground roll distance should be determined from the moment of full activation of all deceleration devices to full stop of the aeroplane, for the prevailing conditions, in particular regarding the runway surface. In line with the Runway Condition Assessment Matrix (RCAM), published aeroplane performance levels should match the 6 Runway Condition Codes (RWYCC), which are equally valid whatever the origin of the runway surface condition classification: contaminant type, pilot reports of braking action, or any other relevant observations by qualified ground personnel.

Each of the 6 levels is associated with a Runway Condition Code between 6 (for Dry runway) and 1 (for the most slippery conditions) as described in the Table 3 – Assigning a runway condition code (also known as the RCAM when associated with the relevant procedures), provided in Doc 9981 PANS-Aerodromes. For a version of the RCAM tailored to aeroplane operations, refer to Appendix 3.

While it is recommended that only limited credit is taken for the drag generated by fluid contaminants, it is considered allowable to consider the benefit of up to half of the reported depth, in particular for aeroplanes whose configuration (e.g. low wing) exposes them to significant drag effects. However drag generated by fluid contaminants should only be accounted for in time of landing performance data created for specific runway contaminants and not in performance data created for RWYCCs.

No performance should be provided for RWYCC 0 (zero), since operations in these conditions should not intentionally be conducted.

Manufacturers may publish improved performance for Wet Grooved or Porous Friction Course (PFC) runways. However no specific runway code is assigned to such runways, and operations predicated on the improved performance are subject to approval by the State of the Aircraft Operator, since:

- A grooved or PFC runway is basically an enhancement to safety, that would be dissipated if performance credit was attributed systematically,
- Maintenance and minimum friction thresholds are not differentiated between a smooth runway, and one that has been prepared to maintain improved grip in wet conditions. There are thus no provisions in place to ensure that performance credit is maintained over time.

It is recognized that fully compliant distances at time of landing may not be available for all aeroplane types and that it might not be possible to develop them for out-of-production aeroplanes. For non-supported aeroplanes a set of fixed and conservative factors to be applied to the dispatch data furnished in the flight manual may be used. Examples of such factors are included in Appendix 5 of this Manual.

Operational Rules

It is mandated that a systematic check of landing performance is made at the time of landing. The intent is that this check is made on the basis of the Distances At Time of Landing described in the previous paragraph. This check should take into account reasonable margin, as explained in Appendix 9.

While the in-flight procedures in Annex 6 Part I 4.4.11 specify a gate at 300 m (1000 ft) above the landing surface, the intent is not for an actual computation to take place at this gate, where it would distract attention from essential flying tasks. Rather, the intent is that the flight crew monitors throughout the approach that the actual conditions do not degrade below a worst acceptable one determined previously with regards to the available landing distance, reported outside conditions and likely changes to the latter. The recommended time for this determination is during approach preparation before start of descent.

An exemption regarding the application of the operational margin may be applied when using autobrake on a dry or wet grooved/PFC runway:

- If the Factored Distance At Time of Landing for maximum braking is less than the Landing Distance Available (LDA), and
- If the Distance At Time of Landing for automatic braking is less than the LDA, then
- The Factored Distance At Time of Landing for automatic braking may be longer than the LDA.

Restricting the selection of autobrake by mandating the full margin on the autobrake distance may lead to operations with unnecessarily high deceleration settings or even without arming of autobrake before landing with the intent to use pedal braking. The use of autobrake minimizes brake wear and ensures timely use of deceleration means. Flight crew can override autobrake whenever required.

It is considered that it is reasonable to omit the in-flight assessment for landing on the runway planned at dispatch only if:

- Dispatch was performed for dry runway (or worse), and if at time of approach preparation a dry runway and no worse conditions than the standard ones considered for dispatch are reported (e.g. no tailwind when zero wind considered for dispatch, no higher VAPP than usual), or
- Dispatch was performed for wet runway, and if at time of approach preparation a wet runway and no worse conditions than the ones considered for dispatch are reported and the runway is built and maintained to the standards defining grooved or PFC runways, (refer to ICAO Doc 9157 Aerodrome Design Manual part 3 Pavements Appendix 6.B.3), and reverse thrust is available.

It is also mandated that pilots report if they experience runway surface conditions worse than those that had been reported to them before landing, in accordance with the terminology defined in Annex 15. Refer to Appendix 10 for further information.

Runway Surface Condition Reporting

Annex 14 mandates the publication of a Runway Condition Report (RCR) whenever at least one runway third is contaminated by ice, slush or snow. The centrepiece of the reporting of runway surface condition is the Runway Condition Assessment Matrix (RCAM) provided in Doc 9981 PANS-Aerodromes. Its structure was developed from the Estimated Surface Codes in the old SNOWTAM format and includes seven runway surface condition levels associated to codes from 0 (for surface conditions too slippery to operate on) to 6 (for dry conditions), where each Runway Condition Code (except 0) is matched with a corresponding aeroplane deceleration performance level.

Criteria of runway surface condition reporting to be used as input for the determination of the applicable Runway Condition Code are:

- Primary observations of contaminant coverage, type and depth, temperature,
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- Secondary observations, e.g.: Runway friction measurements, and
- Pilot Advisory Report of Braking Action (AIREP).

The latter two types of information are used for downgrading of a Runway Condition Code from a category basically identified via contaminant type and depth. Runway Condition Codes are to be reported for each third of the runway when more than 25 Per cent of the surface of at least one third is contaminated. If observations by the aerodrome personnel or reports from pilots of preceding aeroplanes pilots (AIREPs) indicate that the friction levels have dropped below those expected for the type of contaminant on the runway, the airport considers this information in reporting the relevant condition code in line with all other information available.

Measured coefficients of friction should no longer be transmitted to pilots, but restricted to use by the airport in consolidating the runway surface condition assessment made from observed surface contamination characteristics like type, depth and temperature. Friction measurements can be used as one of the indicators for downgrading or limited upgrading a

Runway Condition Code in line with the procedures provided in Doc 9981 PANS Aerodromes and acceptable to the State.

It is notable that the RCAM provides a performance-wise classification of runways that are reported as Slippery Wet in accordance with Annex 14 2.9.9 due to rubber contamination or otherwise degraded runway friction. ICAO SARPs and PANS promulgate a concept of reporting runways as Slippery Wet when the when the runway is in a condition which fails to provide surface friction characteristics at or above the minimum friction level specified by the State of the Aerodrome. However, no associated aeroplane performance was previously available to allow operators and flight crew to take this information into account in their performance assessment. When such a runway is wet, a RWYCC 3 will now be reported in the Runway Condition Report, and an appropriate computation can be made.

It should be noted that Runway Condition Reports continue to include information on contaminant types and depth for use in determining performance limitations at time of take-off. Please refer to Appendix 2.

3. Airworthiness Aeroplane Performance

[A6C 3.1] The provisions of this section should be complied with, unless deviations therefrom are specifically authorized by the State of Design or by the State of the Operator on the grounds that the special circumstances of a particular case make a literal observance of these provisions unnecessary for safety.

[A6C 3.2] Compliance with the guidance in this section should be established using performance data in the flight manual and in accordance with other applicable operating requirements. In no case should the limitations in the flight manual be exceeded. However, additional limitations may be applied when operational conditions not included in the flight manual are encountered. The performance data contained in the flight manual may be supplemented with other data acceptable to the State of the Aircraft Operator if necessary to show compliance with the guidance of this section. When applying the factors prescribed in this section, account may be taken of any operational factors already incorporated in the flight manual data to avoid double application of factors.

[A6C 3.3] The procedures scheduled in the flight manual should be followed except where operational circumstances require the use of modified procedures in order to maintain the intended level of safety.

3.1 Aeroplane take-off performance limitations

Aeroplane manufacturers, or type certificate holders, furnish take-off performance limitations (runway limitations, climb capability and flight path) in the flight manual in compliance with the regulation of the State of Design. These are harmonized to a great extent and no guidance on how to establish compliance is included in this Manual.

[A6C 4.1] No aeroplane should commence a take-off at a mass which exceeds the take-off mass specified in the flight manual for the altitude of the aerodrome and for the ambient temperature existing at the time of the take-off.

[A6C 4.3] No aeroplane should commence a take-off at a mass which exceeds the mass at which, in accordance with the minimum distances for take-off scheduled in the flight manual, it is shown that:

[A6C 4.3.1] - The take-off run required does not exceed the take-off run available.

[A6C 4.3.2] - The accelerate-stop distance required does not exceed the accelerate-stop distance available.

[A6C 4.3.3] - The take-off distance required does not exceed the take-off distance available.

[A6C 4.3.4] The same value of V1 for the continued and discontinued take-off phases should be used.

[A6C 4.4] The following parameters should be taken into account for the determination of the take-off distances:

a) the pressure altitude at the aerodrome;

b) the ambient temperature at the aerodrome;

c) the runway surface conditions as listed in the definition of the Runway Surface Descriptors, and the type of the runway surface;

d) the runway slope in the direction of the take-off;

e) not more than 50 per cent of the reported headwind component or not less than 150 per cent of the reported tailwind component; and

f) the loss, if any, of runway length due to alignment of the aeroplane prior to take-off.

Note:- The length required for alignment of the aeroplane with the runway axis should be determined in compliance with the minimum clearance distances between the outer main wheel of the aeroplane the and the edge of the taxiway/runway given in Annex 14 paragraph 3.9.3.

[A6C 4.5] Credit is not taken for the length of the stopway or the length of the clearway unless they comply with the relevant specifications in Annex 14, Volume I. Credit is not taken for the length of the clearway on wet or contaminated runways for the one engine inoperative calculation.

3.2 Take-off obstacle clearance limitations

[A6C 5.1] No aeroplane should commence a take-off at a mass in excess of that furnished in the flight manual to correspond with a net take-off flight path which clears all obstacles either by at least a height of 10.7 m (35 ft) vertically or at least 90 m (300 ft) plus 0.125D laterally, where D is the horizontal distance the aeroplane has travelled from the end of take-off distance available (or the end of the take-off distance if a turn is scheduled before the end of the TODA), except:

[A6C 5.1.1] - Where the intended track does not include any change of heading greater than 15°,

a) for operations conducted in VMC by day, or

b) for operations conducted with navigation aids such that the pilot can maintain the aeroplane on the intended track with the same precision as for operations conducted in VMC by day, obstacles at a distance greater than 300 m (1 000 ft) and 600 m (2 000ft) on either side of the intended track need not be cleared if the navigation system under OEI conditions provides a two standard deviation accuracy of 150 m and 300 m respectively.

Note.- For Obstacle Clearance in case of Required Navigation Performance Authorization Required (RNP AR) terminal area procedures, please refer to Doc 9905 RNP AR Procedure Design Manual.

[A6C 5.1.2] - Where the intended track does not include any change of heading greater than 15° for operations conducted in IMC, or in VMC by night, except as provided in b) in the preceding paragraph; and where the intended track includes changes of heading greater than 15° for operations conducted in VMC by day, obstacles at a distance greater than 600 m (2 000 ft) on either side of the intended track need not be cleared.

[A6C 5.1.3] - Where the intended track includes changes of heading greater than 15° for operations conducted in IMC, or in VMC by night, obstacles at a distance greater than 900 m (3 000 ft) on either side of the intended track need not be cleared.

[A6C 5.1] - For aeroplanes with a wingspan of less than 60 m (200 ft) a horizontal obstacle clearance of half the aeroplane wingspan plus 60 m (200 ft), plus 0.125D may be used.

[A6C 5.1] - In determining the allowable deviation of the net take-off flight path in order to avoid obstacles by at least the distances specified, it is assumed that the aeroplane is not banked before the clearance of the net take-off flight path above the end of the TORA is at least one half of the wingspan but not less than 15.2 m (50 ft) height and that the bank thereafter does not exceed 15°, except as provided in the next paragraph. The net take-off flight path considered is for the altitude of the aerodrome and for the ambient temperature and not more than 50 per cent of the reported headwind component or not less than 150 per cent of the reported tailwind component existing at the time of take-off. The take-off obstacle accountability area defined above is considered to include the effect of crosswinds.

[A6C 5.1.4] An aeroplane may be operated with bank angles of more than 15° below 120 m (400 ft) above the elevation of the end of the take-off run available, provided special procedures are used that allow the pilot to fly the desired bank angles safely under all circumstances. Bank angles should be limited to not more than 20° between 30 m (100 ft) and 120 m (400 ft), and not more than 25° above 120 m (400 ft). Methods approved by the State of the Operator should be used to account for the effect of bank angle on operating speeds and flight path including the distance increments resulting from increased operating speeds.

The flight manual generally provides a climb gradient decrement for a 15° bank turn. For bank angles of less than 15°, a proportionate amount should be applied unless the manufacturer or flight manual has provided other data.

Unless otherwise specified in the flight manual or other performance or operating manuals from the manufacturer, acceptable adjustments to assure adequate stall margins and gradient corrections are provided by the following table:

Bank	Speed	Gradient correction
15°	V_2	1 x 15° gradient loss
20°	V_2 + 5 kt	2 x 15° gradient loss
25°	V_2 + 10 kt	3 x 15° gradient loss

The net take-off flight path in which the aeroplane is banked by more than 15° should clear all obstacles by a vertical distance of at least 15.2 m (50 ft) within the horizontal distance specified at the beginning of this chapter. The use of bank angles greater than those mentioned above should be subject to the approval from the State of the Operator.

[EASA CAT.POL.A.240]–Conditions for obtaining approval may include the following:

- the flight manual contains approved data for the required increase of operating speed and data to allow the construction of the flight path considering the increased bank angles and speeds;
- visual guidance is available for navigation accuracy;
- weather minima and wind limitations are specified for each runway; and
- the flight crew has obtained adequate knowledge of the route to be flown and of the procedures to be used.

[AMC1 EASA CAT.POL.A.210] In accordance with the definitions used in preparing the take-off distance and take-off flight path data provided in the flight manual:

- The net take-off flight path is considered to begin at a height of 35 ft above the runway or clearway at the end of the take-off distance determined for the aeroplane, as described below.
- The take-off distance is the longest of the following distances:
  - 115 per cent of the distance with all engines operating from the start of the take-off to the point at which the aeroplane is 35 ft above the runway or clearway;
  - the distance from the start of the take-off to the point at which the aeroplane is 35 ft above the runway or clearway assuming failure of the critical engine occurs at the point corresponding to the decision speed (V_1) for a dry runway; or
  - if the runway is wet or contaminated, the distance from the start of the take-off to the point at which the aeroplane is 15 ft above the runway assuming failure of the critical engine occurs at the point corresponding to the decision speed (V_1) for a wet or contaminated runway.

[AMC1 EASA CAT.POL.A.210] The net take-off flight path, determined from the data provided in the flight manual in accordance with the previous paragraph, should clear all relevant obstacles by a vertical distance of 35 ft. When taking off on a wet or contaminated runway and an engine failure occurs at the point corresponding to the decision speed (V_1) for a wet or contaminated runway, this implies that the aeroplane can initially be as much as 20 ft below the net take-off flight path in accordance with (a) and, therefore, may clear close-in obstacles by only 15 ft. When taking off on wet or contaminated runways, the operator should exercise special care with respect to obstacle assessment, especially if a take-off is obstacle-limited and the obstacle density is high.

[AC12091 9.a.] - For the purpose of the take-off obstacle clearance analysis, the end of the take-off flightpath is considered to occur when:

- The aeroplane has reached the minimum crossing altitude (MCA) at a fix or the minimum en-route altitude (MEA) for a route to the intended destination; or
- The aeroplane is able to comply with en-route obstacle clearance requirements (Chapter 3.3); or
- The aeroplane has reached the altitude at which it may be safely guided, or
- The aeroplane has reached a fix and altitude from which an approach may be initiated, if the operator's emergency procedure calls for an immediate return to the departure airport or a diversion to the departure alternate in the event of an engine failure during take-off.

[AC12091 9.b.] - When determining the limiting take-off mass, the obstacle analysis should be carried out to the end of the take-off segment as defined in the previous paragraph. Operators should note that the end of the take-off segment is determined by the aeroplane's gross flightpath, but the obstacle analyses must use the net flightpath data. However, once the aeroplane has transitioned to en-route configuration, and V_{FTO} is reached, and the height difference between the net and the gross flightpath exceeds the Minimum Obstacle Clearance (MOC) specified in Doc 8168 PANS-OPS Volume 1 Chapter 1 1.4.1, whichever point is higher, obstacles may be considered cleared when the gross flight path clears them by the MOC.

[AC12091 9.c.] - In the event that the aeroplane cannot return to and land at the departure airport, the take-off flightpath should join a suitable en-route path to the planned destination or to another suitable airport. It may be necessary to address extended times and alternate fuel requirements when climbing in a holding pattern with reduced climb gradients associated with one-engine-inoperative turns.

3.3 En-route limitations

[A6C 6.1] **General**

En-route limitations may be complied with allowing for consumption of fuel and oil.

[A6C 6.2] **One engine inoperative**

[A6C 6.2.1] No aeroplane should commence a take-off at a mass in excess of that which, in accordance with the one-engine-inoperative en-route net flight path data furnished in the flight manual, permits compliance with either of the two following paragraphs at all points along the route. The net flight path has a positive slope at 450 m (1 500 ft) above the aerodrome where the landing is assumed to be made after engine failure. The net flight path used is for the ambient temperatures anticipated along the route. In meteorological conditions where icing protection systems are to be operable, the effect of their use on the net flight path data is taken into account.

[A6C 6.2.1.1] The slope of the net flight path is positive at an altitude of at least 300 m (1 000 ft) above all terrain and obstructions along the route within

- 9.3 km (5 NM) when navigation accuracy meets at least required navigation performance 5 (RNP5), or
- 18.5km (10NM) otherwise

on either side of the intended track.

[A6C 6.2.1.2] The net flight path is such as to permit the aeroplane to continue flight from the cruising altitude to an aerodrome where a landing can be made, the net flight path clearing vertically, by at least 600 m (2 000 ft), all terrain and obstructions along the route within

- 9.3 km (5 NM) when navigation accuracy meets at least required navigation performance 5 (RNP5), or
- 18.5km (10NM) otherwise

on either side of the intended track. The following provisions are applied.

[A6C 6.2.1.2.1] - The engine is assumed to fail at the most critical point along the route.

[A6C 6.2.1.2.2] - Account is taken of the effects of winds on the flight path.

[A6C 6.2.1.2.3] - Fuel jettisoning is permitted to an extent consistent with reaching the aerodrome with satisfactory fuel reserves, if a safe procedure is used.

[A6C 6.2.1.2.4] - The aerodrome, where the aeroplane is assumed to land after engine failure meets the appropriate aerodrome operating minima at the expected time of use.

[A6C 6.3] **Two engines inoperative — aeroplanes with three or more engines**

[A6C 6.3.1] At no point along the intended track is an aeroplane having three or more engines to be more than 90 minutes at all engines normal cruising power or thrust, as applicable, away from an aerodrome at which the distance specifications for alternate aerodromes are complied with and where it is expected that a safe landing can be made, unless it complies with the specific two engine inoperative provisions below.

[A6C 6.3.1.1] No aeroplane should commence a take-off at a mass in excess of that which, according to the two-engine inoperative en-route net flight path data shown in the flight manual, permits the aeroplane to continue the flight from the point where two engines are assumed to fail simultaneously, to an aerodrome at which the landing distance specification for alternate aerodromes is complied with and where it is expected that a safe landing can be made. The net flight path clears vertically, by at least 600 m (2 000 ft) all terrain and obstructions along the route within

- 9.3 km (5 NM) when navigation accuracy meets at least required navigation performance 5 (RNP5), or
- 18.5km (10NM) otherwise

on either side of the intended track. The net flight path considered is for the ambient temperatures anticipated along the route. In altitudes and meteorological conditions where icing protection systems are to be operable, the effect of their use on the net flight path data is taken into account. The following provisions apply.

[A6C 6.3.1.1.1] - The two engines are assumed to fail at the most critical point of that portion of the route where the aeroplane is at more than 90 minutes at normal cruising power or thrust, as applicable, at standard temperature in still air away from an aerodrome at which the landing distance specification for alternate aerodromes is complied with and where it is expected that a safe landing can be made.

[A6C 6.3.1.1.2] - The net flight path has a positive slope at 450 m (1 500 ft) above the aerodrome where the landing is assumed to be made after the failure of two engines.

[A6C 6.3.1.1.3] Fuel jettisoning is permitted to an extent consistent with the next paragraph, if a safe procedure is used.

[A6C 6.3.1.1.4] The aeroplane mass at the point where the two engines are assumed to fail is considered to be not less than that which would include sufficient fuel to proceed to the aerodrome and to arrive there at an altitude of at least 450 m (1 500 ft) directly over the landing area and thereafter to fly for 15 minutes at cruise power and/or thrust.

3.4 Landing Limitations At Time of Take-off

[A6C 4.2] No aeroplane should commence a take-off at a mass such that, allowing for normal consumption of fuel and oil in flight to the aerodrome of destination and to the destination alternate aerodromes, the mass on arrival will exceed the landing mass specified in the flight manual for the altitude of each of the aerodromes involved and for the ambient temperatures anticipated at the time of landing.

[A6C 7.1] **Aerodrome of destination — dry runways**

[A6C 7.1.1] No aeroplane should commence a take-off at a mass in excess of that which permits the aeroplane to be brought to a full stop landing at the aerodrome of intended destination from the threshold:

a) for turbo jet powered aeroplanes, within 60 per cent of the Landing Distance Available (LDA); and

b) for turbo-propeller aeroplanes, within 70 per cent of the Landing Distance Available (LDA).

The mass of the aeroplane is assumed to be reduced by the mass of the fuel and oil expected to be consumed in flight to the aerodrome of intended destination. This should be shown, assuming:

[A6C 7.1.1.1] - the aeroplane is landed on the most favourable runway and in the most favourable direction in still air, and

[A6C 7.1.1.2] - the aeroplane is landed on the runway which is the most suitable for the wind conditions anticipated at the aerodrome at the time of landing, taking due account of the probable wind speed and direction, of the ground handling characteristics of the aeroplane, and of other conditions (i.e. landing aids, terrain). If this provision cannot be shown compliance with, the aeroplane may be taken off if a destination alternate aerodrome is designated which permits compliance with requirements for destination and alternate aerodromes.

[EASA CAT.POL.A.230 (g)] - If the forecast meteorological conditions for the destination aerodrome do not allow complying with all of the above, the aeroplane shall be only dispatched if an alternate aerodrome is designated that allows full compliance.

[A6C 7.1.1.4] For this compliance demonstration, at least the following factors should be taken into account:

a) the altitude of the aerodrome;

b) the runway slope in the direction of the landing if greater than ±2.0 per cent; and

c) not more than 50 per cent of the headwind component or not less than 150 per cent of the tailwind component.

[A6C 7.2] **Aerodrome of destination — wet or contaminated runways**

[A6C 7.2.1] When the appropriate weather reports or forecasts or a combination thereof indicate that the runway at the estimated time of arrival may be wet, the Landing Distance Available (LDA) should be at least 115 per cent of the required landing distance determined for dry runways.

[A6C 7.2.2] A landing distance on a wet runway shorter than that required in the preceding paragraph but not less than that required for dry runways may be used if the flight manual includes specific additional information about landing distance on wet runways.

[A6C 7.2.3] When the appropriate weather reports or forecasts or a combination thereof indicate that the runway at the estimated time of arrival may be contaminated, the landing distance available should be the greater of:

a) the required landing distance for wet runways; and

b) the landing distance determined in accordance with contaminated landing distance data with a safety margin acceptable to the State of the Operator [A6C 7.2.4] unless a destination alternate aerodrome is designated for which full compliance is shown with Landing Performance At Time of Take-off requirements for destination and alternate aerodromes.

[A6C 7.2.4] When showing compliance with required landing performance on wet and contaminated runways, the criteria for dry runways above should be applied accordingly, except that specific safety margins acceptable to the State of the Operator may be applied.

[EASA CAT.POL.A.230 (f)] - For a destination aerodrome where a landing depends upon a specified wind component, the aeroplane may be dispatched if two alternate aerodromes are designated that permit full compliance with all of the above. Before commencing an approach to land at the destination aerodrome, the commander shall check that a landing can be made in compliance with the performance criteria at time of landing.

[AMC1 CAT.POL.A.230] **Automatic Landing Distance Performance Data**

In those cases where the landing requires the use of an automatic landing system, the landing mass of the aeroplane should be determined in accordance with the automatic landing distance for the appropriate surface condition, as given in the AFM or equivalent document, but should not be higher than that determined in accordance with the previous two sections, as applicable. Increments due to system features such as beam location or elevations, or procedures such as use of overspeed, should also be included.

[A6C 7.3] **Destination alternate aerodrome**

No aerodrome should be designated as a destination alternate aerodrome unless the aeroplane, at the mass anticipated at the time of arrival at such aerodrome, can comply with Landing Performance At Time of Take-off requirements for dry runways and wet runways, in accordance with the landing distance required for the altitude of the alternate aerodrome and in accordance with other applicable operating requirements for the alternate aerodrome.

4. Supplementary Aeroplane Performance

It is recognized that airworthiness standards do not contain all the information necessary to operate the aeroplane with regards to take-off and landing performance. The following sections will discuss supplementary aeroplane performance information that operators should consider and that manufacturers should provide. This data could be provided as advisory data in the Operations Manual or in a separate document or computer program as appropriate.

Note:- The data is of an advisory nature as the aeroplane operator may replace this manufacturer supplied data for operations where an equivalent level of safety can be maintained using less conservative performance assumptions in conjunction with operators specific procedures and training.

4.1 Take-off Operations

Two areas of operational take-off performance not specifically addressed by regulation are obstacle clearance on Standard Instrument Departures (SID) with an engine failure following a turn away from the normal engine operative take-off flight path, and operations on runways contaminated with water, snow, slush, or ice.

Engine inoperative SID capability

[EASA CAT.POL.A.210 c)] - The operator should consider establishing contingency procedures to satisfy the net take-off flight path requirements in 3.2 and to provide a safe route, avoiding obstacles, to enable the aeroplane to either comply with the en-route requirements, or land at either the aerodrome of departure or at a take-off alternate aerodrome.

[AC12091 7.b.]In order for an operator to determine that a departure maintains the safe obstacle clearance with an engine failure, the operator should consider that an engine failure may occur at any point on the departure flightpath.

[AC12091 7.b.(2)] Consideration should be given to the possibility of an engine failure occurring after passing the point at which the one-engine-inoperative track diverges from the normal departure track. Judicious selection of this point would simplify the procedure and minimize the difficulty of this analysis. This is generally achieved by keeping the two tracks identical for as far as is practical.

[AC12091 7.b.(3)] In some cases, two or more special one-engine-inoperative tracks may be required to accommodate all the potential engine failure scenarios.

[AC12091 7.b.(4)] Analysis of an engine failure after take-off may require the use of performance data in addition to that provided in the flight manual.

For the purpose of the supplemental flight path analysis manufacturers should supply operators with appropriate means of computing a combination of all engine flight path followed by an assumed engine inoperative flight path be it either in a document or a computer program.

To support this analysis, obstacle and terrain information for the terminal area should be provided by the State of the Aerodrome, ideally in electronic format in compliance with Annex 15 Chapter 10.

Take-off from a wet or contaminated runway

Depending on the certification date and/or certification agency of the aeroplane the flight manual may or may not include take-off performance applicable to a wet or contaminated runway surface condition.

The physical effects of water, snow, slush or ice covering the runway on the take-off performance of an aeroplane are sufficiently well understood to allow manufacturers to make available performance data that will permit a reasonable determination of the performance to be expected, taking into account

- Reduced wheel to ground friction, including aquaplaning considerations, and
- Displacement and impingement drag.

However, this determination can only be accurate for the prevailing conditions if the relevant parameters have been accurately observed, assessed and reported in line with the assumptions on which the performance data is based.

Take-off computations must consider the effect of the contaminant on both the acceleration and the deceleration segments. This is the reason why take-off performance must be produced specifically for each type of winter contaminant, and the operable range of depths of loose contaminants. The Runway Condition Code (RWYCC) alone does not permit a conservative description of the effect of the runway surface condition on aeroplane take-off performance, in particular during the acceleration portion.

For the purpose of this supplementary take-off performance, manufacturers should provide aeroplane performance data consistent with the runway surface condition reporting terms as defined in ICAO Annex 14, Vol I, Definitions. For the purposes of take-off performance, the primary description used is the type and depth of contaminant, as they can significantly affect the aeroplanes ability to accelerate (slush, standing water, snow) and the ability to decelerate and therefore stop (wet runway and all contaminants). Specific runway surface conditions for which take-off performance should be provided are:

- Wet (or associated equivalent conditions)
- Frost
- Slippery Wet
- Compacted Snow ≤-15°C
- Compacted Snow >-15°
- Dry Snow
- Wet Snow
- Dry Snow on top of Compacted Snow
- Wet Snow on top of Compacted Snow
- Standing Water
- Slush
- Ice (Cold and Dry)

Note 1.- Runway surface conditions listed in the previous paragraph are consistent with the reporting procedures of PANS-Aerodromes (Doc 9981).

Note 2.-Slippery Wet is not reported as such in the RCR. The fact that a runway surface or portions thereof are failing the minimum friction level set or agreed by the State of the Aerodrome is promulgated by a Slippery Wet NOTAM. Whenever such a runway is wet, the report will show a RWYCC of 3.

Operations are prohibited beyond the maximum depth of the prevailing contaminant for which data has been provided.

To address take-off performance assessment for layered contaminants, or in case of different contaminants in different runway thirds, operators should provide a policy to their flight crew. Considerations for establishing such a policy are provided in Appendix 2.

For wet and contaminated take-off performance the following modifications to the standard methods of computing dry runway take-off performance calculation method are considered acceptable:

- Reduction of the screen height from 35 ft to 15 ft when computing the engine inoperative take-off distance.
- Credit for reverse thrust when calculating the required accelerate-stop distance, when available, reliable and controllable (effect of engine failure on available reverse thrust must be considered).
- For the purpose of obstacle clearance, the take-off flight path shall be considered to begin 35 ft above the take-off surface at the end of the take-off distance even though the wet and contaminated runway take-off distance is defined to end at a height of 15 ft.

  Note.- The take-off flight path terminology allowing for this 20 foot vertical disconnect between the ends of the engine inoperative take-off distance and the start of the obstacle clearance accountability flight path allows for 15 foot net flight path clearance of the obstacle by using the same data set that is originally based on a net flight path clearance of the obstacle by 35 ft.

For runways covered with slush, snow, or standing water, the effect of the contaminant from the start of the take-off roll until the aeroplane has lifted off or come to a stop in case of rejected take-off should be taken into account. Determination of the physical effects of the contaminants may be by computation or by demonstration. The computation should be based on a uniform contaminant depth. For the purposes of take-off performance calculations, 3mm or less of snow, slush or standing water on the runway surface can be considered a wet runway.

The following should be assumed when computing the take-off performance based on a contaminant that affects acceleration or deceleration capability:

a) The assumed contaminant specific gravity should be as defined in the following table:

Runway Description	Specific Gravity
Dry Snow	0.2
Wet Snow	0.5
Slush	0.85
Standing Water	1.0

b) Reported Depths for which wheel braking effect and contaminant drag should be considered:

Runway Description	Reported Depths (mm)
Dry Snow	>3– 130
Wet Snow	>3– 30
Slush	>3 – 15
Standing Water	>3 – 15

In the absence of appropriate test data or specific analysis the effect of contaminant on drag and wheel braking should be based on parameters for the specific aeroplane to the greatest degree possible using assessment methods found acceptable by the competent authority of State of the Operator.

4.2 Landing Performance

Areas of operational landing performance not specifically addressed by regulation are missed approach, rejected landing, and balked landing obstacle clearance requirements, and Landing Distance verification at time of landing.

Missed approach, rejected landing and balked landing obstacle clearance

[AC12091 17.a.(1)]Instrument approaches require a minimum missed approach gradient of 2.5 per cent, published missed approach gradients may exceed this value. If published gradients can be achieved without penalty, no further analysis is required. To avoid undue penalty, an obstacle clearance analysis for one-engine-inoperative missed approaches or rejected landings may need to be conducted. While it is not necessary to perform such an analysis for each flight, dispatch, or landing mass limitation assessment, it is appropriate to provide information to the flight crews on the safest way to perform such a manoeuver should it be required. The intent is to identify the best option or options for a safe lateral ground track and flight path to follow in the event that a missed approach, balked landing, rejected landing, or go-around is necessary. To accomplish this, the operator may develop the methods and criteria for the analysis of one-engine-inoperative procedures which best reflect that operator's operational procedures.

[AC12091 17.a.(2)]Generally, published missed approach procedures provide adequate terrain clearance. However, further analysis may be required in the following circumstances:

a) Published missed approach has a climb gradient requirement;
b) Departure procedure for the runway has a published minimum climb gradient;
c) A special one-engine-inoperative take-off procedure is required; or
d) There are runways that are used for landing but not for take-off.

To support this analysis, obstacle and terrain information for the terminal area should be provided by the State of the Aerodrome.

Note.-Operators should incorporate procedures for converting required climb gradients to required climb rates in pilot and dispatcher aeroplane performance sections of their approved training programs.

[AC12091 17.a.(3)]A distinction needs to be made between a missed approach and a rejected landing. A one-engine-inoperative missed approach from the minimum descent altitude (height) (MDA (H)), decision altitude (height) (DA (H)), or above can frequently be flown following the published missed approach procedure. A rejected landing from a lower altitude may require some other procedure (e.g., following the same one-engine-inoperative procedure as used for take-off). In any case, the pilot should be advised of the appropriate course of action when the published missed approach procedure cannot be safely executed.

[AC12091 17.b.]**Assessment Considerations**

[AC12091 17.b.(1)]Operators may accomplish such assessments generically for a particular runway, procedure, aircraft type, and expected performance, and need not perform this assessment for each specific flight. Operators may use simplifying assumptions to account for the transition, reconfiguration, and acceleration distances following go-around (e.g., use expected landing mass, anticipated landing flap settings).

[AC12091 17.b.(2)]The operator should use the best available information or methods from applicable flight manuals or supplementary information from aeroplane or engine manufacturers. If performance or flightpath data are not otherwise available to support the necessary analysis from the above sources, the operator may develop, compute, demonstrate, or determine such information to the extent necessary to provide for safe obstacle clearance.

[AC12091 17.b.(3)]The operational considerations should include:

a) Go-around configuration transitions from approach to missed approach configuration, including expected flap settings and flap retraction procedures;
b) Expected speed changes and effect on vertical flight profile;
c) Appropriate engine failure and shutdown (feathering if applicable) provisions, if the approach was assumed to be initiated with all engines operative.
d) Any lateral differences of the missed approach flight path from the corresponding take-off flight path.

e) Suitable balked landing obstacle clearance until reaching instrument approach, missed approach, or en-route procedurally protected airspace.
f) Any performance or gradient loss during turning flight;

Methods used for take-off analysis (such as improved climb), one-engine-inoperative maximum angle climb, or other such techniques may be used.
Operators may make obstacle clearance assumptions similar to those applied to corresponding take-off flight paths in the determination of net vertical flight path clearance or lateral track obstacle clearance.

Refer to Appendix 11 for methods of establishing procedures for adequate obstacle clearance during go-around.

[AC12091 17.c.]**Assessment Conditions for Balked Landing**

While obstacle clearance capability should be considered before operating to a new runway, it rarely becomes a constraint on maximum landing mass, making it necessary only in exceptional cases to provide procedures for balked landing to the flight crew.

[AC12091 17.c.(1)]A "balked landing" starts at the end of the touchdown zone (TDZ). A TDZ typically is considered to be the first one-third of the available landing distance or 900 m, whichever is less. When appropriate for the purposes of this provision, operators may propose to use a different designation for a TDZ. For example, alternate consideration of a TDZ may be appropriate for runways:

a) Which do not have standard TDZ markings (refer to Annex 14 5.2.6);
b) That are short and require special aeroplane performance information or procedures for landing;
c) Where markings or lighting dictate that a different TDZ designation would be more appropriate.

[AC12091 17.c.(2)]An engine failure occurs at the initiation of the balked landing from an all-engines-operating configuration.

[AC12091 17.c.(3)]Balked landing initiation speed > VREF or VGA (as applicable).

[AC12091 17.c.(4)]Balked landing initiation height is equal to the specified elevation of the TDZ.

[AC12091 17.c.(5)]Balked landing initiation configuration is normal landing flaps and gear down.

[AC12091 17.c.(6)]At the initiation of the manoeuver, all engines are at least in a spooled configuration.

[AC12091 17.d.]**"One-Way" Airports or Other Special Situations**

[AC12091 17.d.(1)]Where obstacle clearance is determined by the operator to be critical, such as for:

a) Airports in mountainous terrain that have runways that are used predominantly for landing in one direction and take-off in the opposite direction ("one way in" and "opposite way out"); or

b) Runways at which the planned landing mass is greater than the allowed take-off mass.

[AC12091 17.d.(2)]The operator should provide the following guidance to the flight crew:

a) The flightpath that provides the best ground track for obstacle clearance, and
b) The maximum mass at which a missed approach or rejected landing can safely be accomplished under various conditions of temperature, wind, and aeroplane landing configuration.

Distance at time of landing

It is important that operators have a systematic method of determining that the distance at the time of landing is adequate based on the conditions that exist at the time of arrival.

[AC25.32 7] Landing distance data should cover all normal operations with all engines operating within the normal landing operating envelope. The effect of each of the parameters affecting landing distance should be provided, and should take into account the following:

- Approved landing configurations, including Category III landing guidance where approved;
- Approved deceleration devices (for example, wheel brakes, speedbrakes/spoilers, and thrust reversers);
- Pressure altitudes within the approved landing operating envelope;
- Mass up to the maximum take-off mass;
- Expected airspeeds at the runway threshold, including speeds up to the maximum recommended final approach speed considering possible speed additives for winds and icing conditions;
- Temperatures within the approved landing operating envelope;
- Winds within the approved landing operating envelope (1) not more than 50 percent of the nominal wind components along the landing path opposite to the direction of landing; and (2) not less than 150 percent of the nominal wind components along the landing path in the direction of landing;
- runway slopes within the approved landing operating envelope; and
- Icing conditions, if the aeroplane is certified for flight in icing conditions.

Appropriate information should be provided for minimum equipment list and configuration deviation list items that affect landing distance.
It is encouraged to include landing distances for non-normal configurations. When making a landing distance assessment, it should be based on data that is consistent with the recommended method of operating the aeroplane. These distances are made up of the following 3 segments:

1) The landing distance shall include an air distance allowance that extends from the threshold to the point of main gear touchdown. This air distance should be a distance that reflects the expected in-service air distance and a commensurate speed bleed-off in the flare consistent with the recommended method of operating the aeroplane. Items that may be considered are the approach guidance being used, recommended flare technique and whether the landing is based on manual flight or an automatic landing. See Appendix 4.
2) The landing distance shall include a transition from main gear touchdown to full braking configuration. This transition should be computed considering representative time delays for

each manual action performed by the flight crew and/or demonstrated times for automatic devices. Items to be considered are application of wheel brakes, speed brake deployment and deployment of thrust reversers or reversing of the propeller. See Appendix 4.

3) The landing distance shall include a full braking segment from the end of transition to full stop assuming the planned method of decelerating the aeroplane either through maximum manual wheel braking or with an automatic wheel braking system. It is permissible to take credit for the decelerating effect of the thrust reverser system. See Appendix 4.

For the purpose of this supplemental landing performance manufacturers should provide aeroplane performance data consistent with the runway surface condition reporting terms as published in PANS-Aerodromes (Doc9981), except for conditions associated with a RWYCC 0 (zero).

Runway condition code (RWYCC)	**Runway surface condition description**	**AIREP**
6	**DRY**	
5	**FROST** **WET** (The runway surface is covered by any visible dampness or water up to and including 3 mm deep.) **SLUSH** (up to and including 3 mm depth) **DRY SNOW** ((up to and including 3 mm depth) **WET SNOW** ((up to and including 3 mm depth)	**Good**
4	**COMPACTED SNOW** (Outside air temperature minus 15 degrees Celsius and below)	**Good to Medium**
3	**WET** ("Slippery wet") runway **DRY SNOW**(more than 3 mm depth) **WET SNOW**(more than 3 mm depth) **DRY SNOW ON TOP OF COMPACTED SNOW** (Any depth) **WET SNOW ON TOP OF COMPACTED SNOW** (Any depth) **COMPACTED SNOW** (Outside air temperature above minus 15 degrees Celsius)	**Medium**
2	**STANDING WATER** (more than 3 mm depth) **SLUSH** (more than 3 mm depth)	**Medium to Poor**
1	**ICE**	**Poor**
0	**WET ICE** **WATER ON TOP OF COMPACTED SNOW** **DRY SNOW ON TOP OF ICE** **WET SNOW ON TOP OF ICE**	**Less than Poor**

Note.-The previous table, consistent with the reporting procedures of PANS-Aerodromes (Doc9981), correlates runway surface condition description with aeroplane performance parameters.

In general the manufacturer should provide supplemental landing data based on Runway Condition Code which can be cross referenced to a runway description and AIREP. In this method the operational landing performance data will not take credit for the decelerating drag effect of slush, standing water or snow.

The manufacturer may choose to provide a second dataset based on runway description of contaminant type and depth. If the manufacturer does choose to provide data based on contaminant type and depth, the calculation of the decelerating effect of contaminant drag may only be based on ½ of the reported depth. If the manufacturer does choose to take credit for this decelerating effect of slush, standing water or snow then the computation methods of determining the drag force should be consistent with the methods used in creating the data needed for take-off.

Aquaplaning should be accounted for where appropriate.

5. Operational Aeroplane Performance

[A6C 7.4] **Performance considerations At Time of Landing**

The flight crew should perform a performance check at time of landing on every flight. This check may require a computation of landing distances based on the latest available information on weather and runway surface condition, but not necessarily so. In many cases it can be sufficient to confirm the validity of a previous assessment, or verify the current conditions against pre-determined worst acceptable conditions for the airport.

In the great majority of the cases it is expected that the landing distance verification can simply be confirming that the assumptions used at the time of dispatch are adequate and no further calculations are required.

Note1.- The dispatch landing field length calculations could be the same as what is in the aeroplane's flight manual based on the appropriate operating regulations or it could be an operational performance check (see Appendix 4) that reflects the actual conditions expected at the time of arrival and includes appropriate margins (see Appendix 9), however if this operational check is used for the dispatch landing field length calculation it must result in a planned dispatch landing mass that is no higher than that complying with the flight manual and operating regulation requirements.

Note 2.-A dispatch landing performance check is considered valid if established for the same runway, wind and normal approach speed

- *On a dry runway if the runway is dry on arrival,*
- *On a wet runway if the runway is no worse than wet grooved/PFC and all reversers are available.*

However there will be cases where the assumptions used at dispatch will be inadequate and the flight crew will need to evaluate the performance at the destination airport. Examples of conditions that would require a calculation at time of arrival of landing distance required include but are not limited to:

a) Runway Surface Condition as reported by RCR, consistent with the procedures described in PANS-Aerodromes (Doc9981) are worse than assumed at dispatch,

b) Winds are worse than assumed at dispatch,
c) Runway changed from the runway(s) used in the dispatch calculations,
d) Excessive operational approach speed additives,
e) Wet runway with “slippery wet” NOTAM or braking action reported as less than “Good”.

Note.-On item e) judgment may be required based on location and extent of the section of runway declared “slippery wet”.

Before commencing an approach it should be confirmed that in accordance with the performance provided for that purpose, the aeroplane can be stopped with appropriate margins within the Landing Distance Available (LDA).

A minimum margin of 15 per cent versus the operational landing distance is considered to be appropriate (see Appendix 9).

For the purpose of the performance assessment at time of landing, weather conditions and runway surface condition should be accounted for as reported for intended time of landing. This implies that performance data is presented against the terminology defined in ICAO Annex 14, Vol I, Definitions and used in the Runway Condition Assessment Matrix (RCAM) in PANS-Aerodromes (Doc 9981).

For the purpose of performance assessment at time of landing, the planned aeroplane configuration, approach guidance, automation and deceleration means intended to be used should be considered.

The computation should reflect any MEL/CDL items or in-flight failures affecting landing performance, and operational choices such as autoland, autothrust and autobrakes.

Note.- For landing on dry or wet grooved/PFC runway with autobrake in sufficient visibility, less than the full 15 per cent margin may exist to the LDA if the full 15 per cent margin exists for the operational landing distance calculated for maximum manual braking. Restricting the selection of autobrake by mandating the full margin on the autobrake distance may lead to operations with unnecessarily high deceleration settings or even without arming of autobrake before landing with the intent to use pedal braking. The use of autobrake minimizes brake wear and ensures timely use of deceleration means. Flight crew can override autobrake whenever required

Appendices

Appendix 1. Historical Background

Introduction

Dissemination of Pavement Surface State Information has historically made a distinction between

a) Wet surface state information
b) Snow-, slush- or ice-covered surface state information.

This information has been presented for at least two forms of use: one by local air traffic service units and local pre-flight briefing (AIS) and the other for pre-flight briefing (and en-route updating where possible) of inbound aeroplanes.

ICAO made applicable in 1968 the specification for snowplans, the definition and *pro forma* for SNOWTAM and the content of the AIP, which outlined the dissemination of snow-, slush- or ice-covered surface state information. This also included water associated with snow, slush or ice.

ICAO made applicable in 1983 a revised SNOWTAM format and publication in the AIP of wet runway surface friction. A link to the operational aspect was sought through an aeroplane stopping distance ratio of two and the term "slippery when wet".

In 1987 a revised SNOWTAM format and the guidance for its completion became applicable.

In 2013 a revised SNOWTAM format became applicable as a consequence of the work of the Friction Task Force in phase 1. Measured friction coefficients were no longer reported.

Amendment 13 of Annex 14 Vol I, Amendment 39 to Annex 15 and associated procedures introduce fundamental changes to the philosophy and format of these reports.

The previous format allowed reporting of information on the runways at an aerodrome, including observation time, cleared length and width, and for each third: a list of runway surface conditions, including combinations thereof, mean depth and estimated friction coefficients or braking action based on friction measurements with ground equipment. Information on snowbanks, and the condition of aprons and taxiways could also be included.

The format contained a mix of information that could be relevant to airplane performance computation and items that were transmitted for situational awareness only. The basic philosophy was to report observations as made without filter or interpretation as to their implications for airplane performance. In addition, the information reported was not matched with the performance information typically provided by airplane manufacturers in compliance with the only standard available at the time (JAR 25X1591 or EASA CS25.1591).

Application of guidance for aerodrome operators on the use of SNOWTAMs was minimal, leading to disparate adoption and use in different Contracting States, or even by individual aerodromes. Regional or national reporting protocols and practices developed over time created an inhomogeneous operational environment for international air operations that presented flight crews with information of varying quality and usability, depending on how accustomed they were with the local practices.

This unsatisfactory situation was evidenced by ICAO and addressed in 2004. In 2006 an informal Friction Task Force was established and formalised in 2008. In the meantime a runway excursion accident occurred in Chicago-Midway in 2005. The FAA realized that a multi-disciplinary approach was necessary to address the issues of winter runway surface condition reporting and performance assessment by flight crews. The Takeoff And Landing Performance Assessment Aviation Rulemaking Committee (TALPA ARC) was tasked with making proposals for the required regulatory changes required. The ICAO Friction

Task Force and the TALPA ARC shared some of the same members. The ICAO FTF developed a circular on *Assessment, Measurement and Reporting of Runway Surface Conditions* (Cir 329) which provides an overarching conceptual understanding of the surface friction characteristics that contribute to controlling an aircraft via the critical tire-to-ground contact area. The ICAO FTF also recommended the suspension of reporting measured friction coefficient in the SNOWTAM.

The TALPA ARC was composed of a large membership from a wide range of stakeholders of the industry, like regulation authorities from several states, airline operators, aerodrome operators, aeroplane manufacturers, and various associations representing stakeholders in the industry (pilots, aerodromes, airlines and manufacturers). It was tasked with an exhaustive review of safety issues of operations on contaminated runways and recommending modified FAA regulations, which would become retroactively applicable to all aeroplanes in operation.

The proposals for regulatory changes concerning transport category aeroplanes put forward to the FAA by the ARC were oriented along three main axes:

- Standards for runway surface condition reporting by Aerodromes (FAR139),
- Definition of operational landing performance computation (FAR25),
- Operational Rules for Transport Category Aeroplanes (FAR121).

The committee also covered FAR23 (Airworthiness of smaller aeroplanes) /91 (General Operating and Flight Rules) /91K (Fractional Ownership) /135 (Commuter and On-Demand) operations, which are not addressed further here.

The following aspects were outside of the scope of the FAA TALPA ARC mandate:

- Assessment of landing with in-flight failures,
- Overweight landing without failures,
- Automatic landing distances,
- Dispatch landing distances.

Dispatch was excluded to minimize the economic impact of the proposed changes. The validity of a landing performance assessment at time of dispatch for a runway surface condition as observed prior to departure was considered to be questionable at best. Consequently, the use of a more operationally representative assessment of landing distances for dispatch was not considered to have the potential for a significant improvement in safety levels, while accurate in-flight landing distance assessments were generally accepted as being a significant contributor to mitigating exposure to runway excursions at landing.

The TALPA ARC recommended technical concepts for the construction of realistic landing distances to be used for in-flight performance computation at time of arrival, and that landing distances in line with the spirit of the proposal be published for all existing aeroplanes still supported by the manufacturer, albeit with less stringent requirements and with an increased grace period.

The TALPA ARC submitted its final recommendations to the FAA in July 2009. The ARC Charter expired October 2009. In the following winters, field trials were conducted with volunteering airports and operators to validate a crucial element of the proposals, the Runway Condition Assessment Matrix (RCAM). The rulemaking project was suspended in September 2010 for 8 + years. Instead, the FAA has taken the approach of implementing the proposals of the TALPA ARC in a series of Advisory Circulars and other guidance and policy documents that permit the various stakeholders to apply them on a voluntary basis. The relevant guidance material came into effect in the US on October 1, 2016, together with runway surface condition reporting as recommended by the ARC.

In 2011, the ICAO Aerodrome Panel mandated the Friction Task Force (FTF) in Phase 2 to conduct a review of the existing SNOWTAM format and required improvements to achieve airplane performance relevant reporting of winter runway surface conditions. The FTF considered existing regional initiatives with this purpose and eventually decided to implement the TALPA ARC proposals within the ICAO framework. A multi-Annex review permitted to make comprehensive proposals for the required changes, which were adopted by the Air Navigation Commission in 2015 and by the Council in 2016, for applicability in November 2020.

The following summary gives an overview of the philosophy, principles and methodology adopted and endorsed by ICAO, including terminology and references to Standards and Recommended Practices (SARPs) and procedures for Air Navigation Services (PANS).

Rules for Aeroplane Operators

Issues Addressed

Most operational regulations made a very generic statement regarding the need to assess landing performance in flight, which did not detail the criteria and factors to be taken into account for the determination of a safe landing distance.

This lack of clear direction had led to airline operations departments filling the gap with a variety of policies of their own initiative (or sometimes under requirement from the State of the Operator).

Changes Introduced

Operators should put into place flight crew procedures to perform in-flight landing performance assessments as part of the approach preparation. These should be based on , Distances At Time of Landing derived in accordance with Appendix 4 of this Manual and include an operational margin of 15% as described in Appendix 9 (resulting in the Factored Distance At Time of Landing). This distance should systematically be less than the Landing Distance Available (LDA), except in emergency situations.

Annex 6 Part I paragraph 4.4.11 mandates a systematic in-flight landing performance assessment based on a Factored Distance At Time of Landing, furnished for the prevailing conditions.

The recommended margin to covers variations in parameters entering in the calculation, like for example:

- The variability of braking action due to precision and timeliness of evaluation and reporting of surface contamination, changing runway surface condition due to weather and in the case of wet runway surface issues such as texture loss and precipitation rate,
- The variability in the flare execution or deceleration means application by the pilot,
- The variability in touchdown speed due to turbulence or the impact of cross-wind.

It is considered s reasonable to omit the in-flight computation for landing on the runway planned at dispatch only if:

- Dispatch was performed for DRY (or worse), and if at time of approach preparation a DRY runway and no worse conditions than the standard ones considered for dispatch are reported (e.g. no tailwind when zero wind considered for dispatch, no higher VAPP than usual)
- Dispatch performed for WET, and if at time of approach preparation a WET runway and no worse conditions than the ones considered for dispatch are reported and the runway is built and maintained to the standards defining grooved or PFC runways (refer to ICAO Doc 9157 Aerodrome Design Manual part 3 Pavements Appendix 6.B.3), and reverse thrust is available.

Finally, Annex 6 Part I paragraph 4.4.2.1 mandates that flight crew make special air reports (AIREPs) whenever they observe worse runway braking action than previously reported.

Runway Surface Condition Reporting

Issues Addressed

Practices for runway surface condition reporting varied between States and were not systematically in line with ICAO Standards and Recommended Practices.

Most frequently, the type of contaminant (and its depth when available) was reported, although the means for measurement, the threshold for reporting in terms of runway coverage, as well as the format, terminology and resolution of the reported information varied with local practices.

Where runway friction measurements by dedicated vehicles were available, such friction values were sometimes reported to flight crew, although no direct correlation existed between runway friction measured with a vehicle or a trailer and aeroplane performance capabilities on the same surface. Some operators and local regulators had developed their own guidance.

In some states pilots reported after landing their assessment of braking action on a scale from GOOD to POOR to ATC, and thus to following aeroplanes. This occurred spontaneously when braking action was found to be different from what had been expected for the reported runway surface condition, or on request by the tower.

Changes Introduced

The centrepiece of the reporting system is the Runway Condition Assessment Matrix (RCAM) and the associated procedures, which are described in detail in Doc 9981 PANS Aerodromes. It combines elements of the ICAO Estimated Surface Friction codes used in the old SNOWTAM format with expected aeroplane wheel to ground friction from EASA AMC 25.1591 to classify runway surface conditions into seven levels associated with codes from 0 (for LESS THAN POOR braking action) to 6 (for DRY), where each runway surface condition code (except 0) is matched with a corresponding aeroplane deceleration performance level.

Observations of runway surface condition reporting are used as in the process of assessment of the applicable Runway Condition Codes (RWYCC), which are reported for each third of the runway. The types of criteria considered are:

- Primary criteria: contaminant coverage, type and depth, outside temperature,
- Secondary criteria such as
  - Vehicle braking action and controllability
    Pilot Advisory Report of Braking Action (AIREP), and
  - Any other observations by a trained person, including runway friction measurements.

The secondary criteria are to be used for downgrading or upgrading of a RWYCC basically identified via contaminant type and depth. Runway Condition Codes are reported for each third of the runway whenever a significant portion of the surface of one third is contaminated. If a friction measurement or reports from preceding aeroplane's pilots (AIREPs) indicated that the friction levels has dropped below those expected for the type of contaminant on the runway, the airport considers this information in reporting the relevant RWYCC.

The upgrading mechanism applies to a runway primarily categorized as having a RWYCC of 1 or 0 can be applied, essentially as a means to reopen a runway that had previously been closed due to reports of insufficient braking action in conditions where it was not possible to restore a bare and dry surface. This mechanism requires all observations to indicate at least GOOD braking action, but does not permit reporting better than RWYCC 3.

Friction values should no longer be transmitted to pilots, since they may be misleading as to the braking action capability of the runway.

It is notable that the RCAM provides a performance-wise classification of runways that are reported as Slippery Wet (RWYCC 3) due to rubber contamination or otherwise degraded runway friction. The concept of reporting runways as Slippery Wet when the measured friction has dropped below the minimum threshold had previously been recommended for enforcement by the States in ICAO Annex 14, but no associated aeroplane performance had so far been available to allow the flight crew to take this information into account in their performance assessments for take-off and At Time of Landing.

Distance At Time of Landing

A new performance model is introduced for in-flight landing distance determination to reflect actual maximum performance as it can be expected to be achieved by a line pilot, realistic but without margin. This distance is referred to as Performance Data At Time of Landing in Annex 8 Part III paragraph 2.2.7.1 (f), built from the components described here below.

Air Distance

The length of a realistic airborne distance from threshold to touchdown is considered to be appropriately represented by the distance covered in 7 seconds at 98 per cent of the ground speed corresponding to the approach speed (including temperature effect and 150 per cent of the tailwind or 50 per cent of the headwind). A touchdown speed of 96 per cent of the approach speed is considered to appropriately represent modern jet aeroplane characteristics regarding speed bleed off capability during the flare.

Activation of Deceleration Means

Deceleration means are to be taken into consideration in line with their intended use as prescribed in the Standard Operating Procedures (SOP) by the aeroplane manufacturer: ground spoiler deployment and maximum pedal braking at or near main gear touchdown, maximum reversers if their use is intended, at or near main gear touchdown. No further allowance for delayed pilot actions is considered to be necessary.

Ground Roll

In line with the RCAM, six aeroplane performance levels matching the six Runway Condition Codes (RWYCC) should be published, which were equally valid whatever the origin of the runway surface condition classification. Indeed, in the RCAM method, one of the observations will always be most constraining one defining the reported RWYCC. But, whatever the type of observation leading to the final braking action classification, the RWYCC equally qualifies the expected braking action. It does not matter whether the criterion itself that leads to the classification is reported or not. The appropriate performance calculation does not depend on the type of observation made.

Each of the 6 levels is associated to a runway code between 6 – DRY and 1 - POOR, and is approximately consistent with the friction coefficients described for the appropriate runway contaminant in the applicable issue of EASA AMC 25.1591 at the time:

- 6 – Dry
- 5 – Good Wet
- 4 – Good to Medium Compact Snow
- 3 –Medium Loose Snow
- 2 – Medium to Poor Standing Water, Slush
- 1 – Poor Ice

The changes made to the models of the EASA AMC were made to ensure a logical progression of landing distances from one RWYCC to the next. The EASA models had originally been set up to be appropriate, albeit conservative, for the braking action to be expected for various “discrete” contaminants, but the RCAM introduced a hierarchy, and thus a continuum, in terms of slipperiness. It was thus important that when the RWYCC dropped by one level, stopping distances would increase. The tyre-to-ground friction value for RWYCC 3 was thus set a little below the value defined in AMC 25.1591 for loose snow (0.16 vs. 0.17) and the ground-speed dependent tyre-to-ground of RWYCC 2 was defined as half of the wet value, capped at 0.16 at low speed. While these choices were more conservative than the EASA values, the friction for RWYCC 1 was increased above the EASA value for icy runway. The latter had historically been chosen to cover melting or wet ice and set at the same value of 0.05 also assumed for aquaplaning. This was justified by the intent not to maintain runways open for operations at such low levels of braking action and lateral control.

In line with this intent, it was proposed that no performance level should be provided for braking action Less Than Poor, since operations in these conditions were not to be conducted intentionally.

Provisions of performance credit for Wet Grooved or Porous Friction Course (PFC) runways have been made. However no specific runway code was assigned to such runways:

- A grooved or PFC runway is considered as an enhancement to safety, that would be dissipated if performance credit was given systematically,
- Minimum friction thresholds are not differentiated in applicable standards between a smooth runway, and one that has been prepared to maintain improved grip in wet conditions. There are thus no provisions in place to ensure that performance credit is maintained over time.

Appendix 2. Performance Considerations at Dispatch

Take-off Performance

Data for computation of take-off performance for contaminated runways have been widely available and applied in line with ICAO Standards and usually derived in line with JAA and EASA guidance. No changes have been made to these Standards, in particular that performance should be computed for reported contaminants, and depth if applicable, rather than an associated RWYCC. This is due to the fact that the overall impact of contaminant drag on take-off performance can be beneficial or detrimental depending on whether the effect on the acceleration or the deceleration part of the take-off distances prevails.

However, the list of reportable contaminants has been incremented by some conditions listed under paragraph 4.1. It can be expected that specific manufacturer data for the new contaminants may not be immediately, or at all, available. The following provides a suggestion on how to calculate for the new contaminants based on the typical set of contaminants for which data has usually been generated by manufacturers. This method should be confirmed with the original data provider.

- Frost: Take-off Data for wet runway should be appropriate. Under some conditions, frost may become very slippery, in which case the assumption of wet runway would not be appropriate or conservative.
- Slippery Wet: If the slippery portions of the runway are known the manufacturer or operator may recommend an appropriate method to account for the performance penalty, such as to reduce the ASDA by the cumulative length of slippery portions, or to consider reduced or partial braking capability. The method should not unduly penalize operational procedures (such as prohibiting assumed temperature).
- Compacted Snow >-15°C: Data provided in accordance with EASA AMC 25.1591 or JAA AMJ25X1591 will be appropriate for Compacted Snow at or below -15°C and should not be used when more slippery conditions are reported (i.e. below RWYCC 4). When data for low depths of dry snow, wet snow or slush is used, drag effects may lead to an optimistic assessment.
- Dry Snow or Wet Snow: Guidance on how to establish performance models for these contaminants has become available relatively recently and specific performance may not be available except for the most recent type designs. Because specific friction of the order of RWYCC 3 is applied in conjunction with specific drag effects, and because it has been determined that equivalences based on contaminant density may not be relevant, use of performance data for another loose contaminant may not be entirely conservative.
- Dry Snow or Wet Snow on top of Compacted Snow: For these layered contaminants, the assumption is that the underlying compacted snow has no impact on take-off performance. When the airports report a depth of dry or wet snow on top of compacted snow, this depth relates only to the top layer of loose snow, as that is the performance-relevant information. For a report of dry snow on compacted snow or wet snow on compacted snow, performance can be assessed as if there was the loose snow layer only.
- Ice (Cold and Dry): JAA and EASA means of compliance define a very low wheel to ground friction coefficient for computations of performance on icy runways. This low value was originally considered to be representative of wet ice. In accordance with Annex 14 standards, operations on a runway affected by wet ice should be discontinued until the situation can be remedied. Wheel to ground friction coefficients for ice in cold and dry conditions may exceed these assumptions considerably, as reflected by the table in Appendix 3. Use of data established in accordance EASA AMC 25.1591 or JAA AMJ25X1591 is thus conservative and may be used for reported icy conditions associated with a RWYCC 1.

The suggested equivalences above assume that the RWYCC reported along with the contaminant and depth is consistent with the classification shown in the RCAM in Doc 9981 PANS Aerodromes Part II Chapter 1 Table 3. However, in accordance with the procedures of that chapter, the aerodrome personnel may use all other observations to down- or upgrade the RWYCC to a different one than that usually associated with a contaminant. Operators should provide recommendations in their operations manual on how to determine performance in such situations, considering that contaminant drag effects may not allow to identify simply a contaminant representative of the reported condition. In case of doubt the prudent approach is to delay take-off. However, due to the low exposure to rejected take-off, it may be sufficient to determine performance in nominal conditions and to adopt appropriate operational procedures such as considering reduced crosswind limits, using the full length of available runway and avoiding rolling take-off.

In some cases, in particular for winter runways when chemicals, wet sand or gravel has been applied, the airport may report better than nominal braking action for compacted snow or icy runways. Improved performance for such conditions may be used subject to prior approval from the State of the Operator.

Aerodrome operators may report that runways have been cleared only on a limited width around the centreline. Operators should have clear policies regarding the minimum cleared width acceptable and the height of snow banks beyond this width. More constraining crosswind limits may apply. Some manufacturers recommend determining take-off performance with penalties for narrow runways (increased minimum control speed on ground (VMCG)).

Landing Performance at Destination and Alternates

The runway length assessment for the destination and destination alternate aerodromes should be based on the flight manual landing performance information provided by the manufacturer and defined in accordance with Section 2.2.7 (e) of Annex 8 Part IIIB (Scheduling of performance – Landing). The required runway length at the expected landing mass should be based on the performance considerations appropriate to the expected surface conditions outlined in Section 3.4 of this manual.

For take-off alternates and en-route alternates, distances at time of landing as per Section 3.4 that can realistically be achieved in line operations as described in Appendix 4 may be used if accepted by the State of the Operator.

Note.- Overweight landing procedures may need to be considered for take-off and en-route diversion planning. For aeroplanes equipped with fuel jettison systems, expected landing mass may be reduced to allow for fuel jettisoning provided the operator can demonstrate that flight crews are properly trained and that diversion fuel requirements are not compromised.

The alternate aerodromes selected for a particular flight should be further evaluated to ensure sufficient runway length for the conditions at the expected time of arrival as part of the dispatch planning assessment. This assessment should take into account probable wind speed and direction as well as expected runway surface condition.

Note.- For aerodromes with limiting local terrain, an evaluation of go-around climb gradient capability in the event of a missed approach following an engine inoperative diversion may also need to be considered in the landing performance assessment.

While for the destination and destination alternates the performance reference is Annex 8 Part IIIB 2.2.7.1 e), once in flight the crew will refer to the distance determined in accordance with paragraph f) of that section. This distance, when including the operational factor recommended in Appendix 9, may in some cases, and in particular on contaminated runways, exceed the landing distance considered at dispatch.
The requirements for dispatch remain unchanged and are based on the requirements laid out in Section 3.4 of this manual. However, when arrival conditions are expected to be marginal it is recommended to

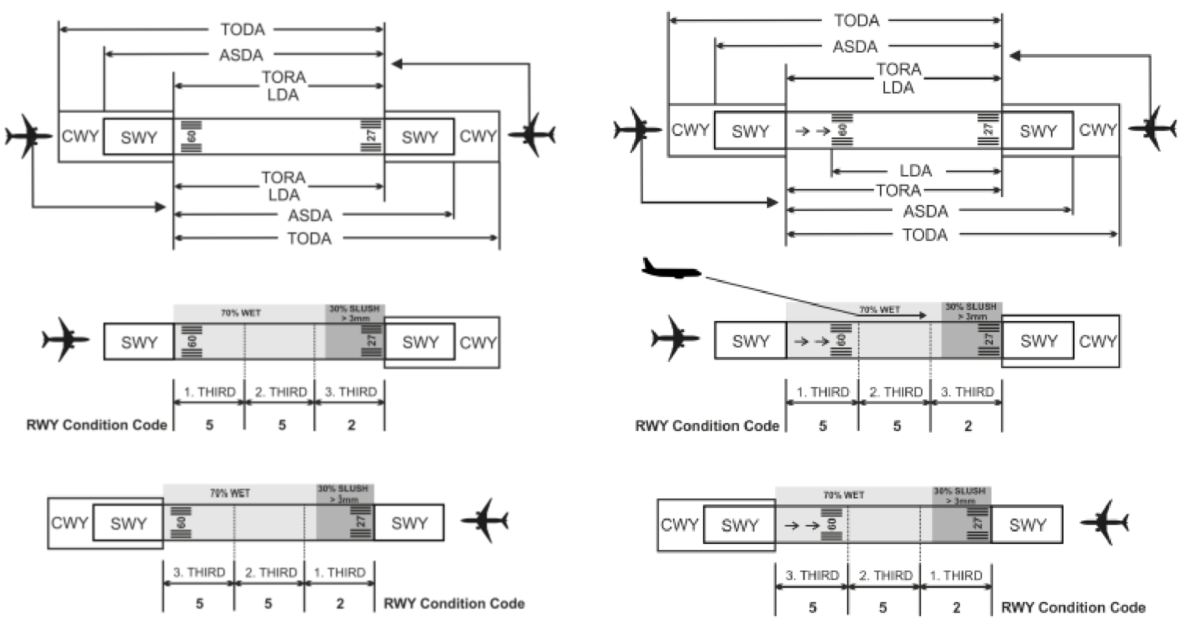
make a preliminary calculation of the Distance at Time of Landing of Section 4.2 at dispatch in order to anticipate operational limitations at destination and nominate suitable destination alternates.

Appendix 3. RCAM and RWYCC

Runway Condition Codes (RWYCC) describe runway surface conditions for each runway third. They represent a three number group within the Runway Condition Report (RCR) for determining the effect of the runway surface condition on aeroplane deceleration performance and lateral control.

It is the task of the aerodrome personnel assessing and reporting runway surface conditions to determine the RWYCCs that appropriately reflect the conditions on the runway and are to be used for the Performance Check at Time of Landing. It is important for the flight crew to understand the process used by the aerodrome personnel in order to be able to assess what the worst likely braking action is that may occur under given conditions.

To establish the conditions to report in a manner relevant to aeroplane performance, the inspector first assesses the coverage. Runway contamination is relevant for aeroplane performance when it exceeds 25 per cent of the length and width intended to be used in at least one runway third. The reference full runway length will typically be the length of asphalt or concrete available for take-off or landing. This is illustrated as follows for runways without and with a displaced threshold in Doc 9981 PANS Aerodromes:



It is notable that when a stopway exists at the airport, the graph indicates that it is excluded from the scope of the Runway Condition Report (i.e. outside any of the thirds). The flight crew should be aware that the stopways will see less traffic than the rest and may be subject to more accumulation of contamination. If the condition of the stopway is significantly different from the rest of the runway, this should be reported in the free text comments of the RCR.

As conditions are always reported in the direction of the lower runway designator in the RCR, pilots should take care to attribute the information from each third correctly for their intended operation.

The RCAM provides a combination of available information (Runway Surface Conditions: State or / and Contaminant or Pilot Report of Braking Action (AIREP)) in order to assess the RWYCC.

The table below permits to perform the primary assessment based on reported contaminant type and depth and OAT (Runway surface temperature should preferably be used where available.

Runway Surface Condition	**Prevailing Surface Condition**	**Depth**	**Notes**	**RWYCC**
Dry		n/a	Includes wet or contaminated below 25 per cent coverage in each runway third	6
Wet	Wet		Includes Damp (any visible moisture)	5
	Wet	3mm or less		5
Slippery Wet	Wet			3
Contaminated	Compacted Snow	Any	At or below OAT-15°C[3]	4
			Above OAT -15°C[3]	3
	Dry Snow	3mm or less		5
		More than 3mm Up to 100mm	Including when any depth occurs on top of Compacted Snow	3
		Any	On top of Ice	0[2]
	Frost[1]	Any		5
	Ice	Any	In cold and dry conditions	1
	Slush	3mm or less		5
		More than 3mm Up to 15mm		2
	Standing Water	3mm or less		5
		More than 3mm Up to 15mm		2
		Any	On top of Ice	0[2]
	Wet Ice	Any		0[2]
	Wet Snow	3mm or less		5
		More than 3mm Up to 30mm	Including when any depth occurs on top of Compacted Snow	3
		Any	On top of Ice	0[2]

Notes.-

1) *Under certain conditions frost can cause the surface to become very slippery.*

2) *Operations in conditions where Less Than Poor Braking Action prevails are prohibited.*
3) *Runway surface temperature should preferably be used where available.*

A primary assessment may have to be downgraded based on an AIREP of lower braking action than typically associated with the type and depth of contaminant on the runway. The following table shows the correlation between AIREP terminology and RWYCC.

AIREP	Description	RWYCC
N/A		6
GOOD	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal	5
GOOD TO MEDIUM	Braking deceleration OR directional control is between good and medium	4
MEDIUM	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	3
MEDIUM TO POOR	Braking deceleration OR directional control is between medium and poor	2
POOR	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced	1
LESS THAN POOR	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	0

Note.- Based on all information available to them, including measurements of the coefficient of friction, the aerodrome operational personnel may in some cases upgrade the primary RWYCC determined from observed contaminant type and depth. Such a decision cannot be taken by a flight crew on the approach, as it must be supported by all other observations. Measured friction values poorly correlate with actual aeroplane braking capability / landing performance. For background information on the reporting process, refer to Circular 329. For information on accounting for AIREPs, refer to Appendix 10.

Appendix 4. Distance At Time of Landing

[AC25-32]

Outside Conditions

Landing performance data for use at time of arrival should be provided for the Runway Condition Codes (RWYCC) 6 through 1 for the approved operational envelope for landing.

Note.- *Landing performance data is not presented for RWYCC 0 (zero) because this is not a performance category. When a runway condition corresponding to RWYCC 0 is observed* *either by the aerodrome personnel or reported by a flight crew, flight operations should cease on this runway until the aerodrome has taken an action to improve the braking action.*

Landing distance data should cover all normal operations with all engines operating within the normal landing operating envelope. The effect of each of the parameters affecting landing distance should be provided, and should take into account the following:

- Approved landing configurations, including Category III landing guidance where approved;
- Approved deceleration devices (for example, wheel brakes, speedbrakes/spoilers, and thrust reversers);
- Pressure altitudes within the approved landing operating envelope;
- Mass up to the maximum take-off mass (to cover overweight landing);
- Expected airspeeds at the runway threshold, including speeds up to the maximum recommended final approach speed considering possible speed additives for winds and icing conditions;
- Temperatures within the approved landing operating envelope;
- Winds within the approved landing operating envelope
    - not more than 50 percent of the nominal wind components along the landing path opposite to the direction of landing; and
    - not less than 150 percent of the nominal wind components along the landing path in the direction of landing;
- Runway slopes within the approved landing operating envelope; and
- Icing conditions, as applicable.

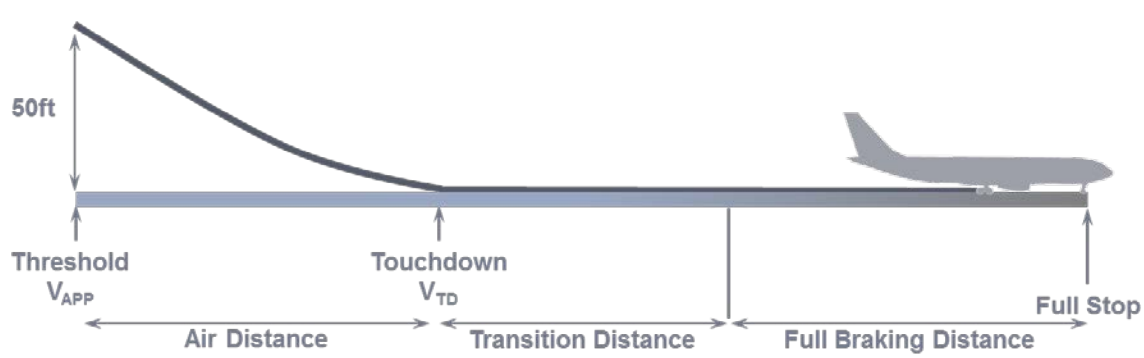
Appropriate information for minimum equipment list and configuration deviation list items that affect landing distance should be provided.

It is also encouraged to include landing distances for non-normal configurations.

Performance Model

The landing distance consists of three segments

- An airborne segment;
- A transition segment; and
- A final stopping configuration (full braking) segment.



The landing distance for a time-of-arrival landing performance assessment may be determined analytically from the landing performance model developed for dry runway dispatch. For the purposes of determining landing distance for time-of-arrival assessments, the model should be modified as described in the following paragraphs.

Changes in the aeroplane's configuration, speed, power, and thrust used to determine the landing distance for time-of-arrival landing performance assessments should be made using procedures established for operation in service. These procedures should

- Be able to be consistently executed in service by crews of average skill;
- Use methods or devices that are safe and reliable; and
- Include allowance for any time delays that may reasonably be expected in service.

Air Distance

The air distance is the distance from a height of 50 feet above the landing surface to the point of main gear touchdown. This definition of the air distance is not different from that customarily used for compliance with Annex 8 Part IIB 2.2.7 e). However, the air distance determined for dispatch may not be appropriate for use in making time-of-arrival landing performance assessments. Depending on the method of determining the air distance agreed with the certifying authority, those air distances may be shorter than the distance that the average pilot is likely to achieve in normal operations.

Reasons why this air distance may not be achievable in line operations are:

- Methods used by some manufacturers to provide landing distance in their flight manuals allows the air distance to be based on a steeper-than-normal approach angle of -3.5°, followed by a flare in which the touchdown rate of descent can be as high as 8 feet per second.
- This air distance is based on beginning at a speed of VREF, whereas the operating procedures may recommend a higher speed, particularly when headwinds are present.
- The philosophy followed by some manufacturers during the certification process is to determine the maximum capability of the aeroplane.

The air distance achieved during any individual landing at any specific runway is a function of the runway approach guidance, runway slope, use of any aeroplane features or equipment (for example, heads-up guidance, autoflight systems, etc.), pilot technique, and the inherent flare characteristics of the specific aeroplane.

The air distance used for time-of-arrival landing performance assessments should be determined analytically as the distance traversed over a time period of 7 seconds at a speed of 98 percent of the recommended speed over the landing threshold, also referred to as the final approach speed (VAPP). This represents a flare time of 7 seconds and a touchdown speed (VTD) of 96 percent of VAPP. VAPP should be consistent with the TC holder's recommended procedures and training material, including any speed additives, such as may be used for winds or icing. The effect of higher speeds, to account for variations that occur in operations or through the operating procedures of individual operators, should also be provided.

If the air distance is determined directly from flight test data instead of the analytical method provided in the preceding paragraph, the flight test data should meet the following criteria:

- Procedures should be used that are consistent with the TC holder's recommended procedures and training for operations in service. These procedures should address the recommended final approach airspeed, flare initiation height, thrust/power reduction height and technique, and target pitch attitudes.
- At a height of 50 feet above the runway surface, the aeroplane should be at an airspeed no slower than the recommended final approach airspeed.
- The touchdown rate of descent should be in the range of 1 to 4 feet per second.
  Note.- This criterion should not be construed to mean that all of the landing data used to determine the air distance may have a touchdown rate of descent of 4 feet per second. The flight test data should contain a range of touchdown rates ranging from 1 to 4 feet per second.

The air distance for the Distances at Time of Landing may also apply to autoland or similar low visibility guidance systems as long as the demonstrated flare time and VTD/VAPP from the autoland testing do not exceed the values of those parameters used in determining the manual landing distance. If they do exceed the values used in determining the manual landing distance, then the demonstrated flare time and VTD/VAPP from the autoland and/or low visibility guidance system demonstrations should be used for computing the air distance when determining the autoland and/or low visibility guidance system landing distance. The autoland/low visibility guidance system test data used for this determination should be from a representative set of airports and not include extreme glide path intercept points or runway slopes.

For landing performance data developed specifically for special operational concepts, examples steep approach or short field landing, the air distance and transition time should reflect the demonstrated performance in line with the applicable procedures, such as prescribed configurations, approach speed increments and flare heights. Considerations could be given to specific training requirements.

If the air distance is based on a time of 7 seconds at a speed of 98 percent of the recommended speed over the runway threshold, this air distance is considered valid for downhill runway slopes up to 1 percent in magnitude. (No credit should be taken for an uphill runway slope.)

An air distance as short as 300 m (1000 ft) may be approved by the State of the Operator. Approval of air distances shorter than that based on a time of 7 seconds at a speed of 98 percent of the recommended speed over the runway threshold should be subject to the development of specific training, procedures and associated measures to minimize the risk of overruns or undershoots, such as:

- Training in touchdown control and short field landing techniques,

- Identification of required touchdown point and training to assure go-around procedures are initiated, if unable to achieve a suitable touchdown point,

- Approach guidance and runway markings on the specific runway are consistent with a shorter air distance,

- Operational data provided to the crew for the specific runway, conditions, and aircraft landing configuration without the need for interpolation,

- The flight techniques assumed in the creation of the performance data used for a shorter air distance are based on flight techniques to be used in the shorter air distance operation. For example, the assumed speed bleed off used in the performance data needs to be consistent with the trained flight techniques for flaring the aircraft.

Transition Distance

The transition distance is the distance travelled from the point of main gear touchdown to the point where all deceleration devices used in determining the landing distance are operating. The speed at the start of the transition segment is at least 96 percent of the final approach speed.

The transition distance should be based on the recommended procedures for use of the approved means of deceleration, both in terms of sequencing and any cues for initiation. Reasonably expected time delays should also be taken into account.

For procedures that call for initiation of deceleration devices beginning at nose gear touchdown, the minimum time for each pilot action taken to deploy or activate a deceleration means should be the demonstrated time, but no less than one second.

For procedures that call for initiation of deceleration devices beginning prior to nose gear touchdown, the minimum time for each pilot action taken to deploy or activate a deceleration means should be the demonstrated time plus one second.

For deceleration means that are automatically deployed or activated (for example, auto-speedbrakes or autobrakes), the demonstrated time may be used with no added delay time.

The distance for the transition segment, and the speed at the start of the final stopping configuration segment should include the expected evolution of the braking force achieved over the transition distance. The evolution of the braking force should take into account any differences that may occur for different runway surface conditions or pilot-reported braking actions as the airplane transitions to the full braking configuration.

Runway Surface Condition–Pilot Reported Braking Action—Wheel Braking Coefficient Correlation Matrix

Note.- The tyre-to-ground braking coefficients in the following table were set by the TALPA ARC part 25 working group, based on their experience and accepted performance levels on different surfaces as defined by aeroplane certification agencies (EASA). They were verified to the greatest degree possible by the latest industry flight testing as embodied by the Joint Winter Runway Friction Program, which was *active from 1995 to 2004. These coefficients may need to be revised if future industry-level acceptance of new information becomes available.*

RWYCC	Runway Surface Condition Description	Pilot-Reported Braking Action	Wheel Braking Coefficient
6	**DRY**	—	90 per cent of certified value used to comply with Annex 8 Part IIB 2.2.7 e)[1].
5	**FROST** **WET** (The runway surface is covered by any visible dampness or water up to and including 3mm deep.) **SLUSH** (up to and including 3mm depth) **DRY SNOW**(up to and including 3mm depth) **WET SNOW**(up to and including 3mm depth)	Good	Per method defined in Note 2 below.
4	**COMPACTED SNOW** (Outside air temperature minus 15 degrees Celsius or below)	Good to Medium	0.20[3]
3	**WET** ("Slippery Wet" runway) **DRY SNOW** (more than 3mm depth) **WET SNOW** (more than 3mm depth) **DRY SNOW ON TOP OF COMPACTED SNOW** (Any depth) **WET SNOW ON TOP OF COMPACTED SNOW** (Any depth) **COMPACTED SNOW** (Outside air temperature above minus 15 degrees Celsius)	Medium	0.16[3]
2	**STANDING WATER** (more than 3mm depth) **SLUSH** (more than 3mm depth)	Medium to Poor	(1) For speeds below 85 per cent of the aquaplaning speed[3]: 50 per cent of the wheel braking coefficient determined for RWYCC=5, but no greater than 0.16; and (2) For speeds at 85 per cent of the aquaplaning speed[4] and above: 0.05[3].
1	**ICE**	Poor	0.07[3]

0	**WET ICE** **WATER ON TOP OF COMPACTED SNOW** **DRY SNOW OR WET SNOW ON TOP OF ICE**	Less than Poor	Not applicable. (No operations in less than poor conditions.)

[1] 100 per cent of the wheel braking coefficient used to comply with § 25.125 may be used if the testing from which that braking coefficient was derived was conducted on portions of runways containing operationally representative amounts of rubber contamination and paint stripes.

[2]From the Annex to ED Decision 2007/020/R (EASA Certification Specification Amendment 4) dated 27 December 2007: the wet runway braking coefficient of friction for a smooth wet runway is defined as a curve of friction coefficient versus ground speed and must be computed as follows:

- The maximum tyre-to-ground wet runway braking coefficient of friction is defined as

Tyre Pressure (psi)	Maximum Braking Coefficient (tyre-to-ground)
50	$\mu_{t/gMAX} = -0\cdot0350\left(\frac{V}{100}\right)^3 + 0\cdot306\left(\frac{V}{100}\right)^2 - 0\cdot851\left(\frac{V}{100}\right) + 0\cdot883$
100	$\mu_{t/gMAX} = -0\cdot0437\left(\frac{V}{100}\right)^3 + 0\cdot320\left(\frac{V}{100}\right)^2 - 0\cdot805\left(\frac{V}{100}\right) + 0\cdot804$
200	$\mu_{t/gMAX} = -0\cdot0331\left(\frac{V}{100}\right)^3 + 0\cdot252\left(\frac{V}{100}\right)^2 - 0\cdot658\left(\frac{V}{100}\right) + 0\cdot692$
300	$\mu_{t/gMAX} = -0\cdot0401\left(\frac{V}{100}\right)^3 + 0\cdot263\left(\frac{V}{100}\right)^2 - 0\cdot611\left(\frac{V}{100}\right) + 0\cdot614$

Where:
  - Tyre Pressure = maximum aeroplane operating tyre pressure (psi),
  - μ_t/gMAX = maximum tyre-to-ground braking coefficient
  - V = aeroplane true ground speed (knots); and

Linear interpolation may be used for tyre pressures other than those listed.

- The maximum tyre-to-ground wet runway braking coefficient of friction must be adjusted to take into account the efficiency of the anti-skid system on a wet runway. Anti-skid system operation must be demonstrated by flight testing on a smooth wet runway and its efficiency must be determined. Unless a specific anti-skid system efficiency is determined from a quantitative analysis of the flight testing on a smooth wet runway, the maximum tyre-to-ground wet runway braking coefficient of friction must be multiplied by the efficiency value associated with the type of anti-skid system installed on the aeroplane:
  Type of anti-skid system Efficiency value
  - On-off 0·30
  - Quasi-modulating 0·50
  - Fully modulating 0·80

[3] These Tyre to ground braking coefficients assume a fully modulating anti-skid system. For quasi-modulating systems, multiply the listed braking coefficient by 0.625. For on-off systems, multiply the listed braking coefficient by 0.375. (See AC 25-7D to determine the classification of an anti-skid system.) Airplanes without anti-skid systems will need to be addressed separately on a case-by-case basis.

[3] The aquaplaning speed, V_P, is given by the equation $V_P = 9\sqrt{P}$, where V_P is the ground speed in knots and P is the tire pressure in lb/in^2.

Final Stopping Configuration Distance (Full Braking Distance)

The final stopping configuration (full braking) segment begins at the end of the transition segment, which is the point where all deceleration devices used in determining the landing distance are operating. It ends at the nose gear position when the airplane comes to a stop.

The calculation of the final stopping configuration distance should be based on the braking coefficient associated with the Runway Condition Code, including the effect of aquaplaning, if applicable.

It is generally allowable to account for the benefit of reverse thrust for the landing performance computation if installed, reliable, available and safe to use. The following aspects should be considered:

- The computation should assume use of the reversers in accordance with the published procedures, including pilot and system delays for its selection and activation, as well as recommendations for stowing at low speed.
- Crosswinds may create interference with reverse thrust. Appropriate guidelines should be provided regarding crosswind limits for reverse thrust use, if necessary. The flight crew may have to reduce reverse thrust or store the reversers to restore directional control.

Accounting for Drag of Loose Contaminants

Loose contaminants result in additional contaminant drag due to the combination of displacement of the contaminant by the airplane tires and impingement of the contaminant spray on the airframe. This contaminant drag provides an additional force helping to decelerate the airplane, which reduces the distance needed to stop the airplane. Because contaminant drag increases with contaminant depth, the deeper the contaminant is, the shorter the stopping distance will be. The procedure for reporting contaminant depths is to report the mean depth of the contaminant along the reported portion of the runway surface. Contaminant depths are unlikely to be uniform over the runway surface (or reported portion of the runway surface), so it is possible there will be areas of lesser contaminant depth. Contaminant depths are reported in Runway Condition Reports (RCR) whenever, above a specified minimum depth, there is a significant change in the contaminant layer as specified in ICAO Doc 9981 PANS-Aerodromes.
However, the actual contaminant depth is may be less than the reported depth for the following reason:

- In a stable weather environment (that is, no additional precipitation onto the runway surface), the contaminant depth is likely to decrease as successive airplanes traverse through it and displace the contaminant.

If the actual contaminant depth is less than the reported value, using the reported value to determine contaminant drag will result in a higher drag level than actually exists, leading to an optimistic stopping distance prediction. Therefore, it is recommended not including the effect of contaminant drag in the calculation of landing distances for time-of-arrival landing performance assessments. If the effect of contaminant drag is included, it should be limited to no more than the drag resulting from 50 percent of the reported depth.

If the effect of contaminant depth is included in the landing distance data, then data should be provided for the reportable contaminant depths identified in ICAO Doc 9981 PANS-Aerodromes up to the maximum contaminant depth for each contaminant for which landing operations are permitted.

Note.- Due to issues of potential structural damage from spray impingement and engine ingestion, the maximum recommended depths for landing operations for loose contaminants are shown in the table below, unless greater depths are demonstrated to be free of structural damage and engine ingestion issues.

Loose Contaminant	*Maximum Depth*	*Specific Gravity*
Standing Water	*15mm*	*1.0*
Slush	*15mm*	*0.85*
Dry Snow	*130mm*	*0.2*
Wet Snow	*30mm*	*0.5*

If the effect of contaminant depth is included in the landing distance data, then data should be provided for the specific gravities in the table above.

Publication

Landing performance data may be published as tabulated information in either the flight manual and/or the operations manual.

It is encouraged that tabulated data is supplemented with electronic computation tools. When this is the case, the tools should comply with applicable industry norms. It is recommended that it should be designed in such way that it actively supports the flight crew in establishing the worst acceptable condition rather than calculating only for the user-defined conditions.

If the data is not approved by the State of Design, it should be labelled as advisory. In any case, the assumptions on which the data was built should be made available, in particular regarding whether any margin is basically included in the data. Instructions for its use should be provided.

Any limitations of the data and the operations it covers should be clearly stated, for example maximum contaminant depths. Operators should provide guidance on maximum crosswind as a function of runway surface condition.

Advisory Data

Many manufacturers have developed advisory data that uses different assumptions from those described in this appendix and that may be acceptable to the State of Operator for the Performance Check at Time of Landing if it can be appropriately mapped to the runway surface conditions listed in the RCAM. Such data should at minimum reflect operational procedures and in addition to the parameters for which flight manual distances are furnished account for approach speed increments, runway slope and outside temperature.

Appendix 5. Absence of Landing Performance data from the manufacturer/ Generic Factors

[JO8900.1] -For some older airplanes still in service the manufacturer may not provide advisory data for a time-of-arrival assessment. This is especially true for those manufacturers no longer in business. In this case the Landing Distance Factors (LDFs) from the table below may be used. To find the Landing Distance Required (LDR) multiply the flight manual (Dry, Unfactored) Landing Distance by the applicable LDF in table below for the runway conditions existing at the time of arrival. If the landing distances furnished in the flight manual are presented as factored landing distances, then those data must be adjusted to remove the applicable dispatch factors applied to that data.

The LDFs given in table below includes a 15 per cent safety margin, and an air distance representative of normal operational practices. They account for variations of temperature up to ISA+20°C, runway slopes between -2 per cent and +2 per cent and an average approach speed increment of 5kts up to 20kts. They may not be conservative for all configurations in case of unfavourable combinations of these parameters.

Runway Condition Code	**6**	**5**	**4**	**3**	**2**	**1**
Braking Action	Dry	Good	Good-to-Medium	Medium	Medium-to-Poor	Poor
Runway Description	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
Turbojet, No Reverse	1.67	2.6	2.8	3.2	4.0	5.1
Turbojet, With Reverse	1.67	2.2	2.3	2.5	2.9	3.4
Turboprop Note 2	1.67	2.0	2.2	2.4	2.7	2.9

Note 1.- Runway Descriptions may be found in the RCAM for each RCC or Braking Action.

Note 2.- These LDFs apply only to modern turboprops with efficient disking drag. For older turboprops without adequate disking drag use the Turbojet, No Reverse LDFs

Note 3.- The LDFs can apply to any type of anti-skid system i.e. fully-modulating, quasi-modulating or on-off system.

Appendix 6. Performance Check At Time of Landing - Considerations for Flight Crew

The impetus behind the introduction of a Performance Check at Time of Landing is to enhance the awareness of flight crews regarding the braking action they can expect in given conditions. This appendix provides information for flight crew on how to interpret and use the information provided with the RCR and how to deal with specific situations.

The Performance Check At Time of Landing or confirmation of the validity of dispatch calculations should be done before top of descent. The aim of this check is to ensure that a safe landing can be made under the expected conditions on the planned runway, and potentially to determine the worst likely degraded condition (further reduced braking action, worsening longitudinal or crosswind) for which this remains the case. It begins with acquiring the latest available weather information and the RCR via ATIS, ATS or other means and determining the landing mass. Before the calculations, the flight crew should consider following points:

Apparent inconsistencies

The RCR provides the current Runway Condition Code (RWYCC) and the contaminant type, coverage and depth for each third.

The reported RWYCC does not necessarily match the one associated with the contaminant type in the Runway Condition Assessment Matrix (RCAM). The aerodrome operator uses all available means of assessing runway slipperiness and determining the RWYCC accordingly. This can include AIREP(s), State approved friction measuring devices and all other observations that support a higher or lower RWYCC as judged by a trained person.

Upgrading of a primary RWYCC 5, 4, 3 or 2 determined from the observed contaminant type is not allowed. The flight crew may thus trust the reported RWYCC if it is equal or lower than the corresponding contaminant stated as plain language.

A RWYCC 1 or 0 can in exceptional cases be upgraded to a maximum of 3 even when the contaminant that has caused this primary classification has not been removed. It may have been treated with sand or gravel, or simply provide exceptional friction due to its inherent characteristics as assessed by trained aerodrome personnel. Upgrade procedures are described in Doc 9981 PANS-Aerodromes. The plain language part of the RCR will reflect the reason for upgrade.

As a general rule, the runway contaminant type and depth permit determination of a RWYCC, but a RWYCC can never give contaminant type and depth.

AIREPs

Trials have shown that there is reasonable consistency in AIREPs and runway surface conditions. If the flight crew hears or the ATS relays an AIREP about worse braking action than the RWYCC would correlate in the RCR the flight crew should downgrade the RWYCC used in the calculations accordingly.

Coverage

Performance computations assume a homogenous distribution of the contaminant along the entire length and width runway. Coverage reported as 25 per cent may be significantly less and is provided only for situational awareness. Performance calculations may then assume a dry or wet runway as appropriate, but any coverage in excess of 25 per cent should be considered as if the entire runway was covered. In other words a runway will be considered contaminated if one of the thirds has contaminant coverage in excess of 25 per cent.

Layered contaminants

The RCR restricts the list of layered contaminants that can be reported. The most frequent cases are included, but some scenarios cannot be reported with specific terminology. In those cases, the aerodrome operator will strive to report the performance-relevant condition. When necessary, free text may be used to describe the actual condition.
In most cases, layered contaminants lead to less than poor braking action and do not permit operation unless appropriately mitigated by the airport in order to allow upgrading of the reported RWYCC. An exception is dry snow on top of compacted snow or wet snow on top of compacted snow, which is classed as medium braking action. The depth reported in conjunction with this contaminant refers only to the top layer of loose snow and may thus be used directly in selecting the appropriate contaminant for performance computations, when the manufacturer has chosen to provide landing performance as a function of contamination rather than RWYCC. Even when this is not the case, the flight crew should take care that the reported depth does not exceed the maximum depth of loose snow.

Significant differences between runway thirds

Aeroplane performance tables and computation tools assume a homogenous contaminant type and depth along the entire runway length and width. However, there may be significant differences reported between the runway thirds.
The flight crew may use the most penalizing contaminant for performance computation. However, this may be excessively conservative. For this reason the operator may have policies about disregarding a part of the runway. In such a case the operator should give explicit guidance also for crosswind analysis. For example the flight crew could use only two last thirds for landing distance calculations; or if the runway end was much more slippery than the first two thirds and it is clearly possible to bring the aeroplane to a full stop in the less slippery part (two first thirds), the flight crew could be given a possibility to omit the last third.
Computations accounting for different conditions in each runway third are not available from manufacturers as regulation specifies that the contaminant should be assumed to be evenly distributed for establishing performance. Additionally, this capability may not be desirable, as the computed landing distance with such a method has been shown to be very sensitive to aeroplane speed evolution vs. location on the runway and may thus not be representative of what will be achieved during the actual stop.

Slippery wet runway

A runway is Slippery Wet if braking deceleration for the wheel braking or directional control is noticeably reduced when the water depth is less than 3 mm. Slippery Wet is reported by NOTAM and should be mentioned in the awareness section of the RCR. In such a case the RWYCC is reported to be 3 and this should be used in the performance calculations (note: RWYCC for wet runway is 5).

Shallow layers of contaminants in active precipitation

The RCR reports depths of contamination if at least one third of a runway is considered as contaminated. Flight crews are encouraged to consider the age of an RCR and compare it to experienced precipitation rate using TAF and/or METARs to achieve conservative assessments.

[FAA SAFO 15009] For non-grooved or non-PFC runways, experience has shown that wheel braking may be degraded when the runway is very wet, even when the runway has not been reported as Slippery Wet. If active moderate or heavy precipitation exists, the operator should consider additional conservatism in their performance check at time of landing.

For grooved or PFC runways, experience has shown that wheel braking is degraded when the runway is very wet. If active heavy precipitation exists, the operator should consider additional conservatism in their assessment of performance at time of landing.

The root cause of the wet runway stopping performance shortfall is not fully understood at this time; however issues that appear to be contributors are runway chracteristics such as texture (polished or rubber contaminated surfaces), drainage, puddling in wheel tracks and active precipitation. Analysis of this data indicates that 30 to 40 percent of additional stopping distance may be required in certain cases where the runway is very wet, but not flooded.

Possible methods of applying additional conservatism when operating on a runway which experience has shown is degraded when very wet are assuming a braking action of medium (RWYCC 3) when computing performance at time of landing or increasing the factor applied to such an assessment established with landing performance data for RWYCC 5 (good braking action). It may also be appropriate to consider reduced crosswind limits and to ensure prompt application of braking means after touch-down, including the use of maximum reverse thrust until a safe stop is ensured.

Operators should be aware of the runway maintenance program and wet runway friction capability at the airports to which they operate. Mitigation should be considered at airports where aircraft operators have a reason to suspect that the runway is not maintained in a condition such as to provide surface friction characteristics at or above the minimum friction level specified by the State (see Annex 14, Vol I., 10.2.2) while very wet during active precipitation.

Conditions when a flight crew should consider requesting a confirmation of RWYCC or an RWYCC is not available

Some circumstances are prone to rapid changes in the runway surface conditions, or how they affect aeroplane braking action and lateral control. In such a case the flight crew should ask for a recent report, if the last available report is likely not to correctly reflect the prevailing conditions at time of landing. Examples of such conditions are

- Active precipitation
- Runway contaminated with Compacted Snow or Ice with an OAT below -3°C or a difference between OAT and dewpoint of 3K or less.

If a recent report is not available, the flight crew should consider an appropriate lower RWYCC in their assessment of the worst likely degradation of the conditions.

Wet grooved/PFC runways

Whenever an operator uses a performance credit for specific operations on grooved or PFC runways, the performance data has usually been prepared appropriately by the manufacturer and approved by the State of the Operator. Its use may be subject to operational conditions and procedures. It is the responsibility of the operator to ensure that the runway has been constructed and maintained in accordance with the applicable standards, such as those laid out in the Aerodrome Design Manual (Doc 9157). The extent of the performance credit given in the data should not be assumed to be valid systematically on all runways that in appearance have grooved or PFC surfaces.

Treated runways

Information about sanding and chemical treatment information is shown in situational awareness part of RCR. The aerodrome operator decides the use of these treatments as they have the best understanding of their effectiveness. Inadequately applied sand or sand displaced by aeroplane traffic may not be efficient and the initial effect of chemicals may be a degradation of the achievable friction. As the reported RWYCC already takes into account their effect on performance no automatic extra credit can be attributed to sanding or chemical treatment when calculating the landing distance. Possible text LOOSE SAND in RCR is for flight crew situational awareness and meant to avoid Foreign Object Damage (FOD) to the engines.

Partial cleared runway length

Any change to take-off and/or landing distances available is always communicated by NOTAM. The RCR may only repeat the NOTAM if there is a change for the LDA as a reminder for inbound flight crew. Departing flight crews should have fresh NOTAMs and calculate take-off performance accordingly.

If for any reason part of the runway length has not been cleared in due time, the runway is considered to be usable by its full length and the uncleared contaminant reflected in the RWYCC in the RCR. Policies mentioned in paragraph "Significant differences between runway thirds" may be applied. The flight crew may also consider postponing the landing.

Partial cleared runway width

The cleared runway width may be limited for various reasons in adverse weather. Situation is often ad hoc and NOTAM communications is too slow to reach flight crews in time. Therefore, partial cleared width may be reported by RCR. Operators should have explicit policies for partial cleared runways analysis i.e. minimum allowable cleared width for each aeroplane type and possible reductions in maximum allowed crosswind.

Friction reporting

It is emphasized that there is no strong correlation between measured coefficient of friction (mu-value) and aeroplane braking action, especially for slush and wet snow. Although studies have also shown that measured friction coefficients depend greatly on the device used and they do not correlate uniformly with aeroplane performance, States may provide friction measurements in the dedicated situational awareness section of RCR. Only use such information for performance calculations, if the State has developed and promulgated in its AIP a method for reporting friction and correlating it with airplane performance (braking action). Operators should in this case have procedures for flight crews on how to

use this information. When such procedures are not available, flight crew should request and rely on RWYCC for the performance assessment.
Flight crew must be aware that this information may vary from State to State and require specific methods of correlation.

Approach runway overrun awareness and alerting systems

It is good airmanship to compare the Distance At Time of Landing with the in-air alerting threshold of a runway overrun awareness and alerting systems, if installed. However, the flight crew should be aware of the limitations of such systems. It may not always be approved for use for contaminated runways (worse than wet).

Dealing with ambiguous information

If for any reason the information seems ambiguous to the flight crew, they should actively search for clarification. Obvious reasons may be wrong insertion to the computation tool or outdated information. All available sources should be used to clarify conflicting information. In case of unresolved situation the flight crew should use conservative decision making and prioritize flight safety.

Appendix 7. Pilot Procedures and Flying Techniques when landing on length limited runways

Note.- The general guidance below is considering landing on length limited runway only. It does not consider missed approach climb requirements, obstacles in missed approach area, RWY bearing strength or other limiting factors.

Approach Preparation & Briefing

- Acquire the latest available meteorological and Runway Condition Report (RCR), preferably not more than 30 minutes before the expected landing time.
- Evaluate likelihood of significant changes to runway surface conditions, based on age of the report and evolution of outside conditions
- Set limits for deteriorating conditions. Establish to which value a parameter (wind/RWYCC) can deteriorate before go-around is needed. Include this value in the approach briefing for enhanced CRM during the approach.
- Evaluate if another runway can provide significantly better safety margins (due different LDAs, greater margins can/may be achieved in tail wind conditions). Request this runway as desired to reduce risk exposure.
- In performance calculations:
    - Use correct RWY. Calculate both RWYs if there is a chance for a late RWY change.
    - Use correct elevation and slope if not automatically set
    - Use conservative wind in variable and gusty conditions i.e. use max. tailwind or min. headwind.
    - Use conservative temperature i.e. higher temperature if expecting temperature rise for example due to sun rise.
    - Do not use higher QNH/QFE than reported.
    - Interpret the Runway Condition Code (RWYCC) correctly.

        - When RWYCC is given on each RWY third, apply company procedures when available (see Appendix 6). By default use the worst RWYCC of the three for the whole RWY.
        - If receiving RWYCC, AIREP and/or friction measurement, consider using the worst reported condition.
        - Consider RWYCC reporting time and rapidly changing weather. Adjust if necessary.
    - Insert the intended approach speed.
    - Select intended braking method.
    - Select intended reverse and flap settings.
    - Select correct use of automation (autopilot/autothrust). Avoid autoland if possible.
    - Remember to include any defects and their influence.
    - Compare calculations to x-check.
- Check that the x-wind is in limits
- Set autobrake as required
- Brief intended flying methods throughly
- Note runway safety areas and/or EMAS

Approach

- Ensure that all landing distance calculation parameters are still valid (current) and that runway surface condition has not degraded to a level below the worst acceptable one determined in the approach preparation. It has been recommended to prefer basing this assessment on the wind reported by METAR whenever it is more conservative than that provided by the Tower. It may be more representative of prevailing conditions as it is averaged over a longer period.
- Arm spoilers
- Fly correct approach speed. Excess approach speed increases the stopping distance by around 8 per cent per 5kt and can additionally lead to extended flare.
- Fly stabilized approach. Be stable latest at 1000ft AGL.
- Avoid autoland, follow manufacturer restriction on the use of auto-rollout on contaminated runways.
- Use correct aiming point.
- Just before touchdown ensure that the airplane trajectory is parallel to the RWY centreline.
- If not all of the above are fulfilled, go around.

Touchdown

- Touch down on the centreline at the intended touchdown point.
- With a brief flare, make a firm touchdown to ensure weight on wheels. Aerodynamic braking is less efficient than wheel braking. Slow derotation can delay autobrake onset and affect anti-skid efficiency.
- Apply wheel braking as soon as possible in accordance with operations manual.
- Lower the nose gear without delay.
- Apply appropriate reverse as soon as possible in accordance with operations manual.
- Do not initiate go-around after selecting reverse.

Deceleration

- Maintain all deceleration methods, including reverse, until you can ensure that the airplane will stop on the remaining runway.
- Maintain aerodynamic control during the whole deceleration.
- In case of loss of directional control (airplane weathercocking), reduce reverse thrust to idle. Apply appropriate reverse again after gaining directional control.
- To achieve asymmetric braking when required on slippery runways, completely release the pedal on the opposite side of the desired turn, as partial release may not result in commanding less than the friction limited braking
- Remember that "popular RWY exit points usually provide less braking action than surrounding surfaces".
- Slow down to very slow taxi speed before attempting to turn the tiller.

Appendix 8. Situational Awareness Section of the Runway Condition Report

The Runway Condition Report (RCR) contains two sections:
- The aeroplane performance section contains all items that are directly relevant to the computation of performance,
- The situational awareness section, which may list information that pilots should be aware of with regards to operations in winter conditions.

The following table lists the items that can appear in the situational awareness section, and what they mean to flight crew.

General guidance below gives suggestions on how flight crews should take situational awareness information into consideration in briefings and actual flight operations in cold weather conditions.

Situational awareness info	Situational awareness for flight crew
reduced runway length	- Check that correct LDA is used in landing performance calculations. - Check the position of the runway threshold in use.
drifting snow on the runway	- Be aware of optical illusion of "moving runway" in crosswind conditions.
loose sand on the runway	- Be aware of sand injection to engines if using reverse thrust. - Adjust performance calculations according to the intended use of reversers.
chemical treatment on the runway	- Some operators may collect this information because of brake wear.
snowbanks on the runway	- Be aware of snowbanks if cleared width is less than full runway width. There is a danger of losing directional control or snow injection into the engines.
snowbanks on taxiway	- Avoid taxing so that snow could inject into the engines.
snowbanks adjacent to the runway	- Avoid taxing so that snow could inject into the engines.
taxiway conditions	- Adjust taxing speed & techniques accordingly
apron conditions	- Adjust taxing speed & techniques accordingly
State approved and published use	- Use only if approved by the operator.

of measured friction coefficient	
plain language remarks	- Note any other relevant information.

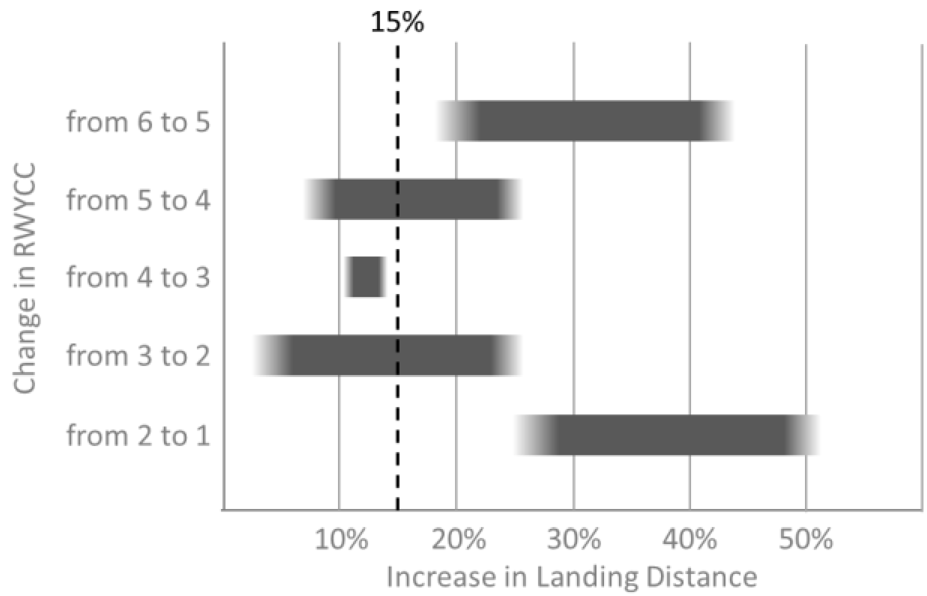
Appendix 9. Policy on Landing Distance Margin

[JO8900.1 4-503] The distance used for a time of landing assessment, based on Annex 8 Part IIIB 2.2.7.1 f) and for which the model is described in Appendix 4 of this manual, should include a safety margin of at least 15 percent when based on manual wheel braking. [SAFO06012]This safety margin represents the minimum distance margin that should exist between the expected operational landing distance at the estimated time of landing and the landing distance available, accounting for all known variables, such as the meteorological (temperature and wind) and runway surface conditions, runway slope, threshold crossing height and airspeed, aeroplane configuration and mass, and the intended use of aeroplane ground deceleration devices.

When developed in accordance with the recommendations of Appendix 4, the distance at time of landing is a distance that can realistically be achieved in line operations but does not include margins. It assumes a stabilized approach in outside conditions consistent with the computation assumptions. As long as they do not occur simultaneously in an unfavourable manner, the minimum acceptable margin above appropriately covers the effects of variations, such as:

- Variations in the airborne phase
- Unreported runway surface degradation
- Inaccuracy or lack in timeliness of runway surface condition reporting
- Variability of wind
- Aircraft system failures late during the approach and landing phase.

It should be noted however that an error in condition reporting by one RWYCC is rarely covered by the recommended margin of 15 per cent, as illustrated in the chart below. The Aerodrome operational personnel should make the best attempt to accurately report runway surface conditions, rather than seeking a systematically conservative assessment. Conservatism is recommended in the judgement of observations versus criteria such as 3mm depth or 25 per cent coverage, but not on the RWYCC. “Conservatism” is different from “downgrade” motivated by other observations or local knowledge. The fact that flight crews are asked to evaluate the worst acceptable runway surface condition is an additional safeguard against lack of conservatism.



The flight crew may disregard the operational margin in exceptional circumstances, e.g. emergency situations. Not all aeroplanes configurations resulting from in-flight failures of aircraft systems are emergencies, and some emergencies are independent of system failures affecting landing performance. Exceptional circumstances may not be restricted to those cases where an emergency is declared, and it is not intended that the flight crew must declare an emergency to be permitted to land with less than the full 15 per cent margin, unless otherwise required.

Appendix 10. AIREPs

The pilot's role in the runway surface condition reporting process does not end once the airplane safely exits the runway. While the airport operator is responsible for generating the Runway Condition Codes for a runway, pilots are responsible for providing accurate braking action reports. It is the pilot's assessment of the manner in which an aircraft responds to the application of wheel brakes.

The airport operator assesses the runway surface conditions that result in the Runway Condition Codes assigned to the runways. However, it is pilot braking action reports that provide feedback to the airport operator regarding the accuracy of the assigned codes relative to the observed runway surface conditions.

Air Traffic Control passes these braking action reports to the airport operator, who in turn uses them in conjunction with the Runway Condition Assessment Matrix (RCAM) to determine if it is necessary to downgrade the Runway Condition Code (RWYCC) until action can be taken to improve the runway surface condition. These reports thus play an important part in the cycle of runway surface condition assessment and reporting.

Since both the ATC and the airport operator rely on accurate braking action reports, it is important that pilots understand the terminology as per Doc 4444 PANS-ATM used for these reports and how to provide an accurate report.

The terminology to be used in AIREPs closely correlates with the RWYCC and RCAM (Table 4 of Doc 9981 PANS Aerodromes Chapter 1).

Table 4 – Correlation of runway condition code and pilot reports of runway braking action

Pilot report of runway braking action	Description	Runway condition code (RWYCC)
N/A		6
GOOD	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal	5
GOOD TO MEDIUM	Braking deceleration OR directional control is between good and medium	4
MEDIUM	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	3
MEDIUM TO POOR	Braking deceleration OR directional control is between medium and poor	2
POOR	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced	1
LESS THAN POOR	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	0

Pilots should become familiar with this terminology in line with Doc 4444 PANS ATM Chapter 12 and be ready to use it when providing controllers with braking action reports. It has been argued that the differences between two consecutive levels of the six braking action categories between “Good” and “Less than Poor” may be too subtle for the pilot to detect. It is acceptable for the pilot to report on a more coarse scale of “Good”, “Medium” and “Poor”.

During busy times, runway inspection and maintenance may be less frequent and needs to be sequenced with arrivals. Therefore, aerodrome operators may depend on braking action reports to confirm that the runway surface condition is not deteriorating below the assigned Runway Condition Code.
Whenever requested by ATC, or if the assessed braking action is less than previously reported, pilots should provide a braking action report. This especially important where the experienced braking action differs from the braking action associated with any RWYCC code currently in effect for that portion of the runway. When they match up, it provides both the pilot and the airport operator some additional confidence in the reported runway codes.

These reporting terms are included in the RCAM. When it is appropriate to do so, pilots should use the matrix to assess the airplane's deceleration and direction control during landing using the descriptions provided in the matrix and report their braking action during the landing.
It is important not to jeopardize aircraft control or safety during taxi to make the report. Pilots should provide the report when it is safe to do so.

These AIREPs play an important role in preventing runway excursions. Reports of braking action below the reported RWYCC may influence a pilot's decision to continue with a landing, especially if the report is provided by a similar type of airplane.

If runway surface conditions deteriorate enough that "Less Than Poor" braking action is reported, the runway will be closed to further operations until the airport operator can improve the runway's condition. Providing braking action reports is a significant role that pilots play in preventing runway excursions for all airplanes.

Aeroplane deceleration results from several forces:

- Aerodynamic drag forces, generated by the airframe and in particular the ground spoilers,
- Reverse thrust, if available, and
- Wheel braking.

The difficulty in making reports of braking action for the pilot is that these reports are intended to characterize only one of these elements, the availability of wheel braking. When operating on long dry or wet runways, pilots apply low autobrakes or partial pedal braking. For most landings, only idle reverse thrust is used. Landing on slippery or contaminated runways requires a different technique and results in the energy dissipation by the three means listed above in different proportions than during a "normal" landing. Aerodynamic drag and reverse thrust are most effective at high speed, and initially can, by themselves, generate a deceleration rate that can be close to that experienced in non-performance limited landings. The lack of wheel to ground friction during the high speed portion may thus not be immediately apparent to the pilot. As the aeroplane decelerates, drag and reverse thrust become less effective, and thrust reversers may be stowed between 70 and 60kts in line with manufacturer recommendations for normal landings (they can typically be maintained extended to full stop if necessary, but when not required to ensure a safe stop, manufacturers recommend stowage to avoid reingestion). During the low speed portion, the deceleration is thus to a large extent created by the wheel brakes. It is consequently in this phase that the reduced braking action is most noticeable to the pilot. The pilot should however attempt to characterize the entire length of runway used during the stop in an AIREP.

Furthermore, flight crew must understand that a report will only be relevant when the braking demand has exceeded the braking action available, i.e. the anti-skid system, if installed, has regulated brake pressure below that commanded by the pilot or the autobrake system to avoid skidding and/or maintain close to optimum slip ratio. The braking is then called "friction limited". Braking occurs when the tyre is slowed relative to the runway by applying pressure on the brakes. The maximum braking force occurs when the tyre speed is around between 7 and 15 per cent slower than the ground speed of the airplane, which is called the slip ratio. On slippery runways the tyre may have a tendency to stop due to lack of friction. Most modern airplanes are equipped with Anti-Skid Systems that prevent such skidding to occur and optimize the slip ratio for maximum braking. Friction limited braking thus occurs when the pilot, or the anti-skid system when available, has to adjust brake pressure to avoid skidding. There is usually no indication in the cockpit to inform the pilot that the anti-skid system is cycling. Also note that this may not occur on all wheels simultaneously.

When using manual braking, the pilot can thus to some extent judge the available braking action by the amount of pedal deflection above with no increase in deceleration occurs. Brake pressure control may not be linear with pedal deflection. Note that when using autobrakes, the system targets an overall airplane deceleration rate. At low target values, the system may release the brake pressure to a large extent when the target can be achieved with aerodynamic and reverse thrust only. In autobrake mode, the pilot can only detect lack of braking action when the target deceleration is not achieved, which means that the braking demand is above the existing capability and the braking is thus friction limited. Cockpit deceleration indications may not be accurate enough as an indicator of whether the requested deceleration is achieved or not. In such a case the commander needs to use best judgement on whether to report braking action.

Reduced lateral control due to reduced cornering forces may be an indicator of reduced wheel to ground friction during the high speed portion of the stop.

The difficulties for a pilot in making an accurate report illustrated here have led to research and development activities to use aircraft data recorded during the ground run to identify the available braking action objectively. Such technologies may soon become available to assist the pilot in this task.

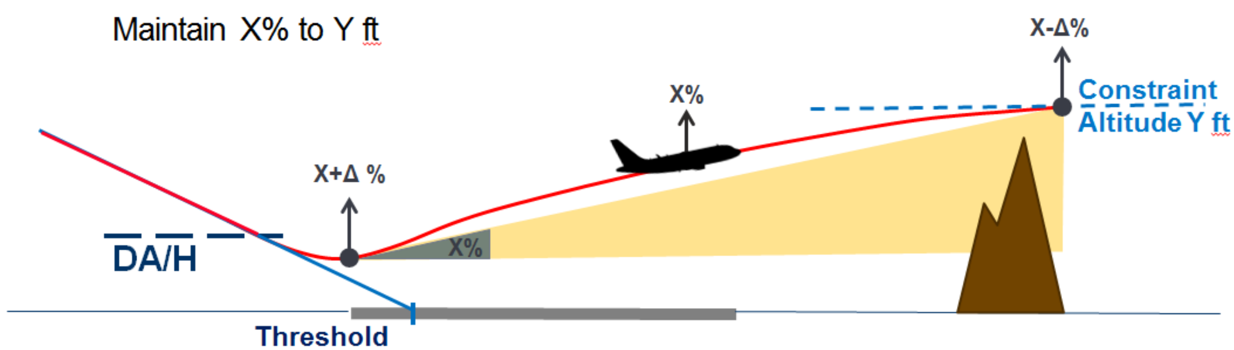
Despite their subjectivity and accuracy issues, the runway surface condition assessment process depends on pilots furnishing Braking Action Reports, which are often the most recent information available and that presents the advantage of reflecting actual aircraft behaviour. They can then be used by the aerodrome operator to validate the reported runway surface condition and to determine whether the runway needs to be downgraded and actions taken to improve the surface condition. These braking action reports are also important to airplanes arriving on the runway in between the runway condition assessments performed by the aerodrome operator.

When a pilot receives an AIREP late during the approach that indicates worse than previously reported braking action, he/she must assess whether it is still possible to stop his/her airplane on the intended runway. A report from a preceding airplane is all the more reliable when it emanates from another aircraft with landing performance capabilities similar to his/her own. The pilot should however be conscious that even similar airplanes may be operated at a very different mass and approach speeds. Once an AIREP has been judged to be relevant, the pilot should be able to compare the reported braking action with the worst acceptable degradation of runway surface conditions still acceptable for his/her landing, which he should determine during the initial approach preparation, as described in Appendix 7 of this manual.

Appendix 11. Missed Approach

Instrument approach procedures may include a minimum go-around gradient exceeding the standard minimum 2.5 per cent. Such go-around gradients are typically applicable up to a given altitude or a given location along the go-around flight path. They are published as all-engine gradients that may be conditioned by obstacle clearance, but may also be set to meet noise or ATC constraints. They may thus be penalizing when considering an engine failure for the go-around computation as per applicable regulations.

A simple analysis may involve only checking that the published climb gradient can be achieved up to the published altitude constraint. It is understood that the published gradient defines a plane that may not be penetrated up to the altitude constraint. Verifying that the published climb gradient is complied with at airport elevation would not fulfil this requirement as available thrust, and thus climb capability, decreases with altitude. However, verifying climb capability at the constraint altitude would be penalizing. Checking the published climb gradient at an appropriate intermediate height between runway elevation and the constraint altitude allows to assure that published climb constraints are met up to the constraint altitude. Checking the constraint at a height half-way between runway elevation and constraint altitude would typically allow clearance of the published climb plane, but this should be validated with a flight path analysis for each aeroplane type and for the range of conditions in which operations are intended.



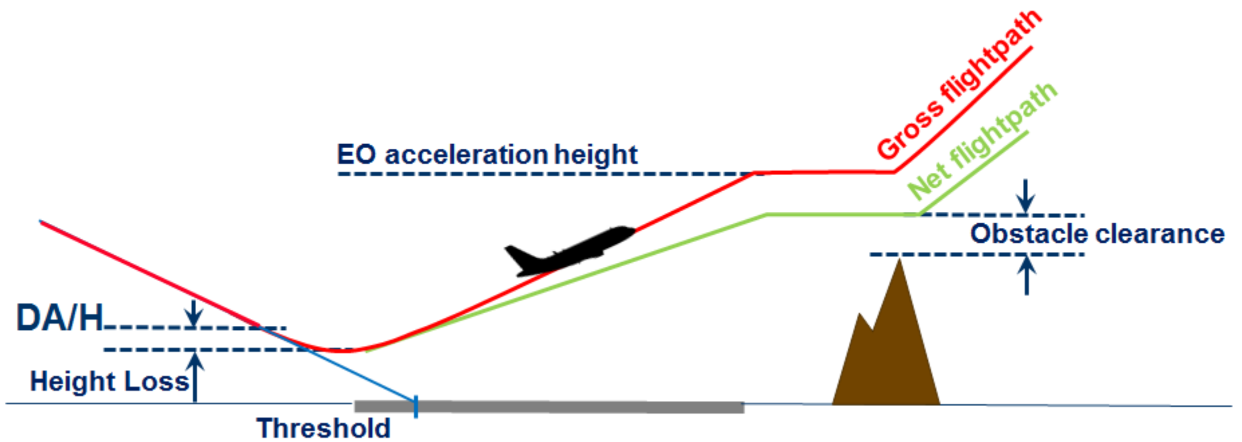
Whenever compliance with published go-around gradients with one engine inoperative limits the maximum allowable landing mass, it may be beneficial to conduct a specific obstacle clearance analysis. Regulations do not specify the criteria for obstacle clearance during go-around, but it is generally considered that flying an Engine Out Standard Instrument Departure (EOSID) developed for the same runway will in most cases be safe, as these procedures consider a gross to net gradient penalty, an obstacle clearance of 35 to 50ft and the certified time limit on applying maximum take-off thrust (10 or 5 minutes depending on the applicable certification standard). They are also developed for higher mass than that typically occurring at landing.

If no EOSID is available for the runway, a specific procedure may have to be developed. Aspects to consider for such a study are:

- Decision height,
- Aeroplane mass, approach speed and configuration,
- Operational outside conditions such as wind and temperature,
- Aeroplane acceleration capability,
- Appropriate obstacle clearance criteria (net flight path, clearance height, loss of gradient in turns),

- Aeroplane flight path and procedure end point (typically en-route altitude or a holding fix), and
- Maximum take-off and go-around thrust time limit.

For high altitude constraints an intermediate acceleration and clean-up may be required to comply with the latter criterion.



The obstacle accountability area for missed approaches as defined in regulatory texts have been set out for all-engine procedure design. Obstacle accountability areas for take-off do not apply to go-around, but provide a baseline for the identification of relevant obstacles during go-around. In defining the obstacle accountability area, the precision of the aeroplane guidance (visual, ground based, RNP) should be considered.

In most cases, identification of the critical obstacle and the required gradient to clear this obstacle will allow dispatchers and flight crews to check go-around criteria on a day to day basis with their standard performance information and tools.

Appendix 12. Requirements for Operator and Pilot Training on Runway Surface Condition Assessment and Reporting

The introduction of the Runway Condition Report based on RCAM and RWYCC in conjunction with new performance data must be trained to flight crew. While the methodology establishes a clear link between the observation, reporting and accounting for runway surface conditions in performance, it also creates new paths to errors that flight crew should be aware of. Contents of training may among other be based on the content of this Manual.

Training Length

It is recommended that overall training time allotted be no less than one hour and 30 minutes. As, beyond pure knowledge and skills the training the correct attitude should be part of the objectives, it is preferable that the course includes face-to-face parts with an instructor and not only self-study.

Training Syllabus

It is recommended that a training syllabus include the following as a minimum:

- History of Runway Surface Condition Reporting
  - Accident history
  - Reasoning and description of the reporting method
- The Purpose of New Runway Surface Condition Reporting
- Matrix Fundamentals
  - RCAM Layout
    - Differences between those published for aerodromes and flight crew
    - Format in use
    - The use of runway friction measurements
    - The use of temperature
    - The concept of “performance buckets” and ICAO Runway Surface Condition Codes
  - Runway Contaminant Definitions
  - Depth Measurements
  - Use of “Slippery wet”
  - Downgrade/Upgrade Criteria
- Flight Crew related actions
  - Difference between a calculation and an assessment
  - Effects aircrew task loading on receiving condition reporting
- Types of Runway Contamination and its Effects
  - General Types of Contaminant
    - Solid
    - Loose
    - *Deformable*
- Aircraft Landing Performance
  - Effects of contamination during take-off
  - Effects of contamination during landing
  - Airport items used for landing
    - Visual Cues
    - CAT III Cues
  - Components of a pilot braking report
    1. How to give an accurate report
    2. When reports are not valid
- Operational Observations with Friction Devices
- Critical Areas of the Runway
- Safety considerations
  - Types of errors possible

  - Mindfulness principals necessary for high reliability
  - Safety reporting
- Documentation and Records

Paths to Errors:

- Techniques used as a best practice for one organization may not be applicable for others. Example: Some airports who spend a great deal of time operating in winter conditions may develop observational techniques that rely on extensive experience and apprenticeship. Other airports may find it hard to match that same level of expertise. Using vehicle braking observations for example may not be a best practice if the airport does not have the exposure to winter conditions long enough to maintain this type of corporate knowledge.
- Misunderstanding terminology. Technical discussions involving runway observations and aircraft vehicle performance can involve similar sounding terms and even numbers, "MU" being a primary example. It is essential that anyone using an RCAM have a clear understanding of what terms are and how they are related.
- Timeliness of Communication. Beyond 180 NM, it is normal for flight crews to pull information from airports in order to make assessments. Between 180 and 40 NM, any change in condition reporting will need to be communicated to the flight crew. Inside 40 nm, any chance in runway surface condition will need to be pro-actively pushed to the aircraft. Any changing condition that occurs too quickly for the flight crew can invalidate their assessment and lead to unexpected risk.
- Conflicting reports between pilots and aerodromes. There may be a range of aircraft performance indicators for a given runway. In some cases, the pilot report of braking action (AIREP) may be more accurate than the condition report. These reports can be more or less conservative than the original report by the aerodrome. If an operator wishes to base their risk management process on an AIREP that is less conservative than a runway condition report, that process must be carefully designed so that an equivalent level of quality assurance regarding risk exposure can be demonstrated and maintained.
- Operational bias. Much of the observational criteria for an RCAM depend on judgment that can be subject to social, political, and economic pressures. The difference between 3mm and 5mm of contaminant or between wet snow and slush can have a large effect on operations. It is a human factors norm that people tend to bias perceptions in favor of what they expect to hear and see and disregard information that does not fit into a pre-planned expectation. This lack of mindfulness can contribute greatly to errors in perception, assessment, and reporting of runway surface conditions from both flight crews and airports.
- Inadequate quality assurance processes. There are five (5) skills which are essential for ensuring the RCAM process is successfully applied to operations. They are:
  - Pilot Braking Action Reports (AIREP). Pilots must be trained so as to both understand the physics the reports represent as well as the techniques necessary to produce an accurate observation.

- Runway Friction Readings. The friction measuring devices should meet the standard and correlation criteria set or agreed by the State It must be properly calibrated and operated.
- Runway Coverage. Errors in reporting percentage coverage and how to report in thirds can produce highly deceptive information to the flight crews.
- Vehicle Braking. Airport operators must have experience and training in order to use ground equipment as an observation platform for observing a runway.
- Slippery Wet Runway. Slippery Wet conditions must be effectively observed and reported.

Appendix 13. Prior Operational Provision applicable from 14 July 1949

13.1 Purpose and scope

The purpose of this appendix is to illustrate the level of performance intended by the provisions of Annex 6 Chapter 5 as applicable to the types of aeroplanes described below.

The Standards and Recommended Practices in Annex 6 effective on 14 July 1949 contained specifications similar to those adopted by some Contracting States for inclusion in their national performance codes. A very substantial number of civil transport aeroplanes have been manufactured and are being operated in accordance with these codes. Those aeroplanes are powered with reciprocating engines including turbo-compound design. They embrace twin-engined and four-engined aeroplanes over a mass range from approximately 4 200 kg to 70 000 kg over a stalling speed range, V_{S0} from approximately 100 to 175 km/h (55 to 95 kt) and over a wing loading range from approximately 120 to 360 kg/m^2. Cruising speeds range over 555 km/h (300 kt). Those aeroplanes have been used in a very wide range of altitude, air temperature and humidity conditions. At a later date, the code was applied with respect to the evaluation of certification of the so-called “first generation” of turboprop and turbo-jet aeroplanes.

Although only past experience can warrant the fact that this appendix illustrates the level of performance intended by the Standards and Recommended Practices of Chapter 5, it is considered to be applicable over a wide range of aeroplane characteristics and atmospheric conditions. Reservation should however be made concerning the application of this appendix with respect to conditions of high air temperatures. In certain extreme cases, it has been found desirable to apply additional temperature and/or humidity accountability, particularly for the obstacle limited take-off flight path.

This appendix is not intended for application to aeroplanes having short take-off and landing (STOL) or vertical take-off and landing (VTOL) capabilities.

No detailed study has been made of the applicability of this example to operations in all-weather conditions. The validity of this example has not therefore been established for operations which may involve low decision heights and be associated with low minima operating techniques and procedures.

13.2 Stalling speed — minimum steady flight speed

13.2.1 For the purpose of this appendix, the stalling speed is the speed at which an angle of attack greater than that of maximum lift is reached, or, if greater, the speed at which a large amplitude pitching or rolling motion, not immediately controllable, is encountered, when the maneuver described in 13.2.3 is executed.

Note.— It should be noted that an uncontrollable pitching motion of small amplitude associated with pre-stall buffeting does not necessarily indicate that the stalling speed has been reached.

13.2.2 The minimum steady flight speed is that obtained while maintaining the elevator control in the most rearward possible position when the maneuver described in 13.2.3 is executed. This speed would not apply when the stalling speed defined in 13.2.1 occurs before the elevator control reaches its stops.

13.2.3 Determination of stalling speed — minimum steady flight speed

13.2.3.1 The aeroplane is trimmed for a speed of approximately $1.4V_{S1}$. From a value sufficiently above the stalling speed to ensure that a steady rate of decrease is obtainable, the speed is reduced in straight flight at a rate not exceeding 0.5 m/s^2 (1 kt/s) until the stalling speed or the minimum steady flight speed, defined in 13.2.1 and 13.2.2, is reached.

13.2.3.2 For the purpose of measuring stalling speed and minimum steady flight speed, the instrumentation is such that the probable error of measurement is known.

13.2.4 V_{S_0}

V_{S_0} denotes the stalling speed if obtained in flight tests conducted in accordance with 13.2.3, or the minimum steady flight speed, CAS, as defined in 13.2.2, with:

a) engines at not more than sufficient power for zero thrust at a speed not greater than 110 per cent of the stalling speed;

b) propeller pitch controls in the position recommended for normal use during take-off;

c) landing gear extended;

d) wing flaps in the landing position;

e) cowl flaps and radiator shutters closed or nearly closed;

f) centre of gravity in that position within the permissible landing range which gives the maximum value of stalling speed or of minimum steady flight speed;

g) aeroplane mass equal to the mass involved in the specification under consideration.

13.2.5 V_{S_t}

V_{S_t} denotes the stalling speed if obtained in flight tests conducted in accordance with 13.2.3, or the minimum steady flight speed, CAS, as defined in 13.2.2, with:

a) engines at not more than sufficient power for zero thrust at a speed not greater than 110 per cent of the stalling speed;

b) propeller pitch controls in the position recommended for normal use during take-off;

c) aeroplane in the configuration in all other respects and at the mass prescribed in the specification under consideration.

13.3 Take-off

13.3.1 Mass

The mass of the aeroplane at take-off is not to exceed the maximum take-off mass specified in the flight manual for the altitude at which the take-off is to be made.

13.3.2 Performance

The performance of the aeroplane as determined from the information contained in the flight manual is such that:

a) the accelerate-stop distance required does not exceed the accelerate-stop distance available;

b) the take-off distance required does not exceed the take- off distance available;

c) the take-off path provides a vertical clearance of not less than 15.2 m up to D = 500 m (50 ft up to D = 1 500 ft) and 15.2 + 0.01 [D – 500] m (50 + 0.01 [D – 1 500] ft) thereafter, above all obstacles lying within 60 m plus half the wing span of the aeroplane plus 0.125D on either side of the flight path, except that obstacles lying beyond 1 500 m on either side of the flight path need not be cleared.

The distance D is the horizontal distance that the aeroplane has travelled from the end of the take-off distance available.

Note.— This need not be carried beyond the point at which the aeroplane would be able, without further gaining in height, to commence a landing procedure at the aerodrome of take-off or, alternatively, has attained the minimum safe altitude for commencing flight to another aerodrome.

However, the lateral obstacle clearance is liable to be reduced (below the values stated above) when, and to the extent that, this is warranted by special provisions or conditions which assist the pilot to avoid inadvertent lateral deviations from the intended flight path. For example, particularly in poor weather conditions, a precise radio aid may assist the pilot to maintain the intended flight path. Also, when the take-off is made in sufficiently good visibility conditions, it may, in some cases, be possible to avoid obstacles which are clearly visible but may be within the lateral limits noted in 13.3.2 c).

Note 1.— The procedures used in defining the accelerate-stop distance required, the take-off distance required and the take-off flight path are described in the Appendix to this example.

Note 2.— In some national codes similar to this example, the specification for "performance" at take-off is such that no credit can be taken for any increase in length of accelerate-stop distance available and take-off distance available beyond the length specified in Section 1 for take-off run available. Those codes specify a vertical clearance of not less than 15.2 m (50 ft) above all obstacles lying within 60 m on either side of the flight path while still within the confines of the aerodrome, and 90 m on either side of the flight path when outside those confines. It is to be observed that those codes are such that they do not provide for an alternative to the method of elements (see the Appendix to this example) in the determination of the take-off path. It is considered that those codes are compatible with the general intent of this example.

13.3.3 Conditions

For the purpose of 13.3.1 and 13.3.2, the performance is that corresponding to:

a) the mass of the aeroplane at the start of take-off;

b) an altitude equal to the elevation of the aerodrome;

and for the purpose of 13.3.2:

c) the ambient temperature at the time of take-off for 13.3.2 a) and b) only;

d) the runway slope in the direction of take-off (landplanes);

e) not more than 50 per cent of the reported wind component opposite to the direction of take-off, and not less than 150 per cent of the reported wind component in the direction of take-off. In certain cases of operation of seaplanes, it has been found necessary to take account of the reported wind component normal to the direction of take-off.

13.3.4 Critical point

In applying 13.3.2 the critical point chosen for establishing compliance with 13.3.2 a) is not nearer to the starting point than that used for establishing compliance with 13.3.2 b) and 13.3.2 c).

13.3.5 Turns

In case the flight path includes a turn with bank greater than 15 degrees, the clearances specified in 13.3.2 c) are increased by an adequate amount during the turn, and the distance D is measured along the intended track.

13.4 En route

13.4.1 One engine inoperative

13.4.1.1 At all points along the route or planned diversion therefrom, the aeroplane is capable, at the minimum flight altitudes en route, of a steady rate of climb with one engine inoperative, as determined from the flight manual, of at least

1) $K\left(\frac{V_{S_0}}{185.2}\right)^2 m/s$, V_{S_0} being expressed in km/h;

2) $K\left(\frac{V_{S_0}}{100}\right)^2 m/s$, V_{S_0} being expressed in kt;

3) $K\left(\frac{V_{S_0}}{100}\right)^2 ft/min$, V_{S_0} being expressed in kt;

and K having the following value:

$K = 4.04 - \frac{5.40}{N}$ in the case of 1) and 2); and

$K = 797 - \frac{1\,060}{N}$ in the case of 3)

where N is the number of engines installed.

It should be noted that minimum flight altitudes are usually considered to be not less than 300 m (1 000 ft) above terrain along and adjacent to the flight path.

13.4.1.2 As an alternative to 13.4.1.1 the aeroplane is operated at an all engines operating altitude such that, in the event of an engine failure, it is possible to continue the flight to an aerodrome where a landing can be made in accordance with 13.5.3, the flight path clearing all terrain and obstructions along the route within 8 km (4.3 NM) on either side of the intended track by at least 600 m (2 000 ft). In addition, if such a procedure is utilized, the following provisions are complied with:

a) the rate of climb, as determined from the flight manual for the appropriate mass and altitude, used in calculating the flight path is diminished by an amount equal to

1) $K\left(\frac{V_{S_0}}{185.2}\right)^2 m/s$, V_{S_0} being expressed in km/h;

2) $K\left(\frac{V_{S_0}}{100}\right)^2 m/s$, V_{S_0} being expressed in kt;

3) $K\left(\frac{V_{S_0}}{100}\right)^2 ft/min$, V_{S_0} being expressed in kt;

and K having the following value:

$K = 4.04 - \frac{5.40}{N}$ in the case of 1) and 2); and

$K = 797 - \frac{1\,060}{N}$ in the case of 3)

where N is the number of engines installed;

b) the aeroplane complies with 13.4.1.1 at 300 m (1 000 ft) above the aerodrome used as an alternate in this procedure;

c) after the engine failure considered, account is taken of the effect of winds and temperatures on the flight path;

d) it is assumed that the mass of the aeroplane as it proceeds along its intended track is progressively reduced by normal consumption of fuel and oil;

e) it is customary to assume such fuel jettisoning as is consistent with reaching the aerodrome in question.

13.4.2 Two engines inoperative *(applicable only to aeroplanes with four engines)*

The possibility of two engines becoming inoperative when the aeroplane is more than 90 minutes at all engines operating cruising speed from an en-route alternate aerodrome is catered for. This is done by verifying that at whatever such point such a double failure may occur, the aeroplane in the configuration and with the engine power specified in the flight manual can thereafter reach the alternate aerodrome without coming below the minimum flight altitude. It is customary to assume such fuel jettisoning as is consistent with reaching the aerodrome in question.

13.5 Landing

13.5.1 Mass

The calculated mass for the expected time of landing at the aerodrome of intended landing or any destination alternate aerodrome is not to exceed the maximum specified in the flight manual for the elevation of that aerodrome.

13.5.2 Landing distance

13.5.2.1 *Aerodrome of intended landing*

The landing distance at the aerodrome of the intended landing, as determined from the flight manual, is not to exceed 60 per cent of the landing distance available on:

a) the most suitable landing surface for a landing in still air; and, if more severe,

b) any other landing surface that may be required for landing because of expected wind conditions at the time of arrival.

13.5.2.2 *Alternate aerodromes*

The landing distance at any alternate aerodrome, as determined from the flight manual, is not to exceed 70 per cent of the landing distance available on:

a) the most suitable landing surface for a landing in still air; and, if more severe,

b) any other landing surface that may be required for landing because of expected wind conditions at the time of arrival.

Note.— The procedure used in determining the landing distance is described in the Appendix to this example.

13.5.3 Conditions

For the purpose of 13.5.2, the landing distances are not to exceed those corresponding to:

a) the calculated mass of the aeroplane for the expected time of landing;

b) an altitude equal to the elevation of the aerodrome;

c) for the purpose of 13.5.2.1 a) and 13.5.2.2 a), still air;

d) for the purpose of 13.5.2.1 b) and 13.5.2.2 b), not more than 50 per cent of the expected wind component along the landing path and opposite to the direction of landing and not less than 150 per cent of the expected wind component in the direction of landing.

EXAMPLE FOR PRIOR OPERATIONAL PROVISION APPLICABLE FROM 14 JULY 1949 ON AEROPLANE PERFORMANCE OPERATING LIMITATIONS — PROCEDURES USED IN DETERMINING TAKE-OFF AND LANDING PERFORMANCE

1. General

1.1 Unless otherwise specified, Standard Atmosphere and still air conditions are applied.

1.2 Engine powers are based on a water vapour pressure corresponding to 80 per cent relative humidity in standard conditions. When performance is established for temperature above standard, the water vapour pressure for a given altitude is assumed to remain at the value stated above for standard atmospheric conditions.

1.3 Each set of performance data required for a particular flight condition is determined with the engine accessories absorbing the normal amount of power appropriate to that flight condition.

1.4 Various wing flap positions are selected. These positions are permitted to be made variable with mass, altitude and temperature in so far as this is considered consistent with acceptable operating practices.

1.5 The position of the centre of gravity is selected within the permissible range so that the performance achieved in the configuration and power indicated in the specification under consideration is a minimum.

1.6 The performance of the aeroplane is determined in such a manner that under all conditions the approved limitations for the engine are not exceeded.

1.7 The determined performance is so scheduled that it can serve directly in showing compliance with the aeroplane performance operating limitations.

2. Take-off

2.1 General

2.1.1 The take-off performance data are determined:

a) for the following conditions:

1) sea level;
2) aeroplane mass equal to the maximum take-off mass at sea level;
3) level, smooth, dry and hard take-off surfaces (landplanes);
4) smooth water of declared density (seaplanes);

b) over selected ranges of the following variables:

1) atmospheric conditions, namely: altitude and also pressure-altitude and temperature;
2) aeroplane mass;
3) steady wind velocity parallel to the direction of take-off;
4) steady wind velocity normal to the direction of take-off (seaplanes);
5) uniform take-off surface slope (landplanes);
6) type of take-off surface (landplanes);
7) water surface condition (seaplanes);
8) density of water (seaplanes);
9) strength of current (seaplanes).

2.1.2 The methods of correcting the performance data to obtain data for adverse atmospheric conditions include appropriate allowance for any increased airspeeds and cowl flap or radiator shutter openings necessary under such conditions to maintain engine temperatures within appropriate limits.

2.1.3 For seaplanes appropriate interpretations of the term landing gear, etc., are made to provide for the operation of retractable floats, if employed.

2.2 Take-off safety speed

2.2.1 The take-off safety speed is an airspeed (CAS) so selected that it is not less than:

a) $1.20V_{S_t}$, for aeroplanes with two engines;

b) $1.15V_{S_t}$, for aeroplanes having more than two engines;

c) 1.10 times the minimum control speed, V_{MC} established as prescribed in 2.3;

where V_{S_1} is appropriate to the configuration, as described in 2.3.1 b), c) and d).

2.3 Minimum control speed V_{S_t}

2.3.1 The minimum control speed, V_{MC}, is determined not to exceed a speed equal to 1.2 V_{S_t} where V_{S_t} corresponds with the maximum certificated take-off mass with:

a) maximum take-off power on all engines;

b) landing gear retracted;

c) wing flaps in take-off position;

d) cowl flaps and radiator shutters in the position recommended for normal use during take-off;

e) aeroplane trimmed for take-off;

f) aeroplane airborne and ground effect negligible.

2.3.2 The minimum control speed is such that, when any one engine is made inoperative at that speed, it is possible to recover control of the aeroplane with the one engine still inoperative and to maintain the aeroplane in straight flight at that speed either with zero yaw or with a bank not in excess of 5 degrees.

2.3.3 From the time at which the engine is made inoperative to the time at which recovery is complete, exceptional skill, alertness, or strength on the part of the pilot is not required to prevent any loss of altitude other than that implicit in the loss of performance or any change of heading in excess of 20 degrees, nor does the aeroplane assume any dangerous attitude.

2.3.4 It is demonstrated that to maintain the aeroplane in steady straight flight at this speed after recovery and before retrimming does not require a rudder control force exceeding 800 N and does not make it necessary for the flight crew to reduce the power of the remaining engines.

2.4 Critical point

2.4.1 The critical point is a selected point at which, for the purpose of determining the accelerate-stop distance and the take-off path, failure of the critical engine is assumed to occur. The pilot is provided with a ready and reliable means of determining when the critical point has been reached.

2.4.2 If the critical point is located so that the airspeed at that point is less than the take-off safety speed, it is demonstrated that, in the event of sudden failure of the critical engine at all speeds down to the lowest speed corresponding with the critical point, the aeroplane is controllable satisfactorily and that the take-off can be continued safely, using normal piloting skill, without reducing the thrust of the remaining engines.

2.5 Accelerate-stop distance required

2.5.1 The accelerate-stop distance required is the distance required to reach the critical point from a standing start and, assuming the critical engine to fail suddenly at this point, to stop if a landplane, or to bring the aeroplane to a speed of approximately 6 km/h (3 kt) if a seaplane.

2.5.2 Use of braking means in addition to, or in lieu of, wheel brakes is permitted in determining this distance, provided that they are reliable and that the manner of their employment is such that consistent results can be expected under normal conditions of operation, and provided that exceptional skill is not required to control the aeroplane.

2.5.3 The landing gear remains extended throughout this distance.

2.6 Take-off path

2.6.1 *General*

2.6.1.1 The take-off path is determined either by the method of elements, 2.6.2, or by the continuous method, 2.6.3, or by any acceptable combination of the two.

2.6.1.2 Adjustment of the provisions of 2.6.2.1 c) 1) and 2.6.3.1 c) is permitted when the take-off path would be affected by the use of an automatic pitch changing device, provided that a level of performance safety exemplified by 2.6 is demonstrated.

2.6.2 *Method of elements*

2.6.2.1 In order to define the take-off path, the following elements are determined:

a) The distance required to accelerate the aeroplane from a standing start to the point at which the take-off safety speed is first attained, subject to the following provisions:

   1) the critical engine is made inoperative at the critical point;

   2) the aeroplane remains on or close to the ground;

   3) the landing gear remains extended.

b) The horizontal distance traversed and the height attained by the aeroplane operating at the take-off safety speed during the time required to retract the landing gear, retraction being initiated at the end of 2.6.2.1 a) with:

   1) the critical engine inoperative, its propeller windmilling, and the propeller pitch control in the position recommended for normal use during take-off, except that, if the completion of the retraction of the landing gear occurs later than the completion of the stopping of the propeller initiated in accordance with 2.6.2.1 c) 1), the propeller may be assumed to be stopped throughout the remainder of the time required to retract the landing gear;

   2) the landing gear extended.

c) When the completion of the retraction of the landing gear occurs earlier than the completion of the stopping of the propeller, the horizontal distance traversed and the height attained by the aeroplane in the time elapsed from the end of 2.6.2.1 b) until the rotation of the inoperative propeller has been stopped, when:

   1) the operation of stopping the propeller is initiated not earlier than the instant the aeroplane has attained a total height of 15.2 m (50 ft) above the take-off surface;

   2) the aeroplane speed is equal to the take-off safety speed;

   3) the landing gear is retracted;

   4) the inoperative propeller is windmilling with the propeller pitch control in the position recommended for normal use during take-off.

d) The horizontal distance traversed and the height attained by the aeroplane in the time elapsed from the end of 2.6.2.1 c) until the time limit on the use of take-off power is reached, while operating at the take-off safety speed, with:

1) the inoperative propeller stopped;

2) the landing gear retracted.

The elapsed time from the start of the take-off need not extend beyond a total of 5 minutes.

e) The slope of the flight path with the aeroplane in the configuration prescribed in 2.6.2.1 d) and with the remaining engine(s) operating within the maximum continuous power limitations, where the time limit on the use of take-off power is less than 5 minutes.

2.6.2.2 If satisfactory data are available, the variations in drag of the propeller during feathering and of the landing gear throughout the period of retraction are permitted to be taken into account in determining the appropriate portions of the elements.

2.6.2.3 During the take-off and subsequent climb represented by the elements, the wing flap control setting is not changed, except that changes made before the critical point has been reached, and not earlier than 1 minute after the critical point has been passed, are permitted; in this case, it is demonstrated that such changes can be accomplished without undue skill, concentration, or effort on the part of the pilot.

2.6.3 *Continuous method*

2.6.3.1 The take-off path is determined from an actual take-off during which:

a) the critical engine is made inoperative at the critical point;

b) the climb-away is not initiated until the take-off safety speed has been reached and the airspeed does not fall below this value in the subsequent climb;

c) retraction of the landing gear is not initiated before the aeroplane reaches the take-off safety speed;

d) the wing flap control setting is not changed, except that changes made before the critical point has been reached, and not earlier than 1 minute after the critical point has been passed, are permitted; in this case, it is demonstrated that such changes can be accomplished without undue skill, concentration, or effort on the part of the pilot;

e) the operation of stopping the propeller is not initiated until the aeroplane has cleared a point 15.2 m (50 ft) above the take-off surface.

2.6.3.2 Suitable methods are provided and employed to take into account, and to correct for, any vertical gradient of wind velocity which may exist during the take-off.

2.7 Take-off distance required

The take-off distance required is the horizontal distance along the take-off flight path from the start of the take-off to a point where the aeroplane attains a height of 15.2 m (50 ft) above the take-off surface.

2.8 Temperature accountability

Operating correction factors for take-off mass and take-off distance are determined to account for temperature above and below those of the Standard Atmosphere. These factors are obtained as follows:

a) For any specific aeroplane type the average full temperature accountability is computed for the range of mass and altitudes above sea level, and for ambient temperatures expected in operation. Account is taken of the temperature effect both on the aerodynamic characteristics of the aeroplane and on the engine power. The full temperature accountability is expressed per degree of temperature in terms of a mass correction, a take-off distance correction and a change, if any, in the position of the critical point.

b) Where 2.6.2 is used to determine the take-off path, the operating correction factors for the aeroplane mass and take-off distance are at least one half of the full accountability values. Where 2.6.3 is used to determine the take-off path, the operating correction factors for the aeroplane mass and take-off distance are equal to the full accountability values. With both methods, the position of the critical point is further corrected by the average amount necessary to assure that the aeroplane can stop within the runway length at the ambient temperature, except that the speed at the critical point is not less than a minimum at which the aeroplane can be controlled with the critical engine inoperative.

3. Landing

3.1 General

The landing performance is determined:

a) for the following conditions:

   1) sea level;

   2) aeroplane mass equal to the maximum landing mass at sea level;

   3) level, smooth, dry and hard landing surfaces (landplanes);

4) smooth water of declared density (seaplanes);

b) over selected ranges of the following variables:

1) atmospheric conditions, namely: altitude and also pressure-altitude and temperature;
2) aeroplane mass;
3) steady wind velocity parallel to the direction of landing;
4) uniform landing-surface slope (landplanes);
5) type of landing surface (landplanes);
6) water surface condition (seaplanes);
7) density of water (seaplanes);
8) strength of current (seaplanes).

3.2 Landing distance

The landing distance is the horizontal distance between that point on the landing surface at which the aeroplane is brought to a complete stop or, for seaplanes, to a speed of approximately 6 km/h (3 kt) and that point on the landing surface which the aeroplane cleared by 15.2 m (50 ft).

3.3 Landing technique

3.3.1 In determining the landing distance:

a) immediately before reaching the 15.2 m (50 ft) height, a steady approach is maintained, landing gear fully extended, with an airspeed of not less than 1.3 V_{S_0} ;

b) the nose of the aeroplane is not depressed in flight nor the forward thrust increased by application of engine power after reaching the 15.2 m (50 ft) height;

c) the wing flap control is set in the landing position, and remains constant during the final approach, flare out and touch down, and on the landing surface at air speeds above 0.9 V_{S_0} . When the aeroplane is on the landing surface and the airspeed has fallen to less than 0.9 V_{S_0} , change of the wing-flap-control setting is permitted;

d) the landing is made in a manner such that there is no excessive vertical acceleration, no excessive tendency to bounce, and no display of any uncontrollable or otherwise undesirable ground (water) handling characteristics, and such that its repetition does not require either an exceptional degree of skill on the part of the pilot, or exceptionally favourable conditions;

e) wheel brakes are not used in a manner such as to produce excessive wear of brakes or tires, and the operating pressures on the braking system are not in excess of those approved.

3.3.2 In addition to, or in lieu of, wheel brakes, other reliable braking means are permitted to be used in determining the landing distance, provided that the manner of their employment is such that consistent results can be expected under normal conditions of operation and that exceptional skill is not required to control the aeroplane.

3.3.3 The gradient of the steady approach and the details of the technique used in determining the landing distance, together with such variations in the technique as are recommended for landing with the critical engines inoperative, and any appreciable variation in landing distance resulting therefrom, are entered in the flight manual.

Appendix 14. Prior Operational Provision applicable from 1 May 1953

14.1 Purpose and scope

The purpose of the following appendix is to illustrate the level of performance intended by the provisions of Annex 6 Chapter 5 as applicable to the types of aeroplanes described below.

This material was contained in substance in Attachment A to the now superseded edition of Annex 6 which became effective on 1 May 1953. It is based on the type of requirements developed by the Standing Committee on Performance* with such detailed changes as are necessary to make it reflect as closely as possible a performance code that has been used nationally.

A substantial number of civil transport aeroplanes have been manufactured and are being operated in accordance with these codes. Those aeroplanes are powered with reciprocating engines, turbo-propellers and turbo-jets. They embrace twin- engined and four-engined aeroplanes over a mass range from approximately 5 500 kg to 70 000 kg over a stalling speed range, V_{S_0}, from approximately 110 to 170 km/h (60 to 90 kt) and over a wing loading range from approximately 120 to 350 kg/m^2. Cruising speeds range up to 740 km/h (400 kt). Those aeroplanes have been used in a very wide range of altitude, air temperature and humidity conditions.

Although only past experience can warrant the fact that this appendix illustrates the level of performance intended by the Standards and Recommended Practices of Chapter 5, it is considered to be applicable, except for some variations in detail as necessary to fit particular cases, over a much wider

* The ICAO Standing Committee on Performance, established as a result of recommendations of the Airworthiness and Operations Divisions at their Fourth Sessions, in 1951, met four times between 1951 and 1953.

range of aeroplane characteristics. Reservation should, however, be made concerning one point. The landing distance specification of this appendix, not being derived from the same method as other specifications, is valid only for the range of conditions stated in the example for this Appendix.

This appendix is not intended for application to aeroplanes having short take-off and landing (STOL) or vertical take-off and landing (VTOL) capabilities.

No detailed study has been made of the applicability of this appendix to operations in all-weather conditions. The validity of this example has not therefore been established for operations which may involve low decision heights and be associated with low weather minima operating techniques and procedures.

14.2 Take-off

14.2.1 Mass

The mass of the aeroplane at take-off is not to exceed the maximum take-off mass specified in the flight manual for the altitude and temperature at which the take-off is to be made.

14.2.2 Performance

The performance of the aeroplane, as determined from the information contained in the flight manual, is such that:

a) the accelerate-stop distance required does not exceed the accelerate-stop distance available;

b) the take-off run required does not exceed the take-off run available;

c) the take-off distance required does not exceed the take-off distance available;

d) the net take-off flight path starting at a point 10.7 m (35 ft) above the ground at the end of the take-off distance required provides a vertical clearance of not less than 6 m (20 ft) plus 0.005D above all obstacles lying within 60 m plus half the wing span of the aeroplane plus 0.125D on either side of the intended track until the relevant altitude laid down in the operations manual for an en-route flight has been attained; except that obstacles lying beyond 1 500 m on either side of the flight path need not be cleared.

The distance D is the horizontal distance that the aeroplane has travelled from the end of the take-off distance available.

Note.— This need not be carried beyond the point at which the aeroplane would be able, without further gaining in height, to commence a landing procedure at the aerodrome of take-off or, alternatively, has attained the minimum safe altitude for commencing flight to another aerodrome.

However, the lateral obstacle clearance is liable to be reduced (below the values stated above) when, and to the extent that, this is warranted by special provisions or conditions which assist the pilot to avoid inadvertent lateral deviations from the intended flight path. For example, particularly in poor weather conditions, a precise radio aid may assist the pilot to maintain the intended flight path. Also, when the take-off is made in sufficiently good visibility conditions, it may, in some cases, be possible to avoid obstacles which are clearly visible but may be within the lateral limits noted in 14.2.2 d).

Note.— The procedures used in determining the accelerate-stop distance required, the take-off run required, the take-off distance required and the net take-off flight path are described in the Appendix to this example.

14.2.3 Conditions

For the purpose of 14.2.1 and 14.2.2, the performance is that corresponding to:

a) the mass of the aeroplane at the start of take-off;

b) an altitude equal to the elevation of the aerodrome;

c) either the ambient temperature at the time of take-off, or a declared temperature giving an equivalent average level of performance;

and for the purpose of 14.2.2:

d) the surface slope in the direction of take-off (landplanes);

e) not more than 50 per cent of the reported wind component opposite to the direction of take-off, and not less than 150 per cent of the reported wind component in the direction of take-off. In certain cases of operation of seaplanes, it has been found necessary to take account of the reported wind component normal to the direction of take-off.

14.2.4 Power failure point

In applying 14.2.2 the power failure point chosen for establishing compliance with 14.2.2 a) is not nearer to the starting point than that used for establishing compliance with 14.2.2 b) and 14.2.2 c).

14.2.5 Turns

The net take-off flight path may include turns, provided that:

a) the radius of steady turn assumed is not less than that scheduled for this purpose in the flight manual;

b) if the planned change of direction of the take-off flight path exceeds 15 degrees, the clearance of the net take-off flight path above obstacles is at least 30 m (100 ft) during and after the turn, and the appropriate allowance, as prescribed in the flight manual, is made for the reduction in assumed gradient of climb during the turn;

c) the distance D is measured along the intended track.

14.3 En route

14.3.1 All engines operating

At each point along the route and planned diversion therefrom, the all engines operating performance ceiling appropriate to the aeroplane mass at that point, taking into account the amount of fuel and oil expected to be consumed, is not less than the minimum altitude (see Annex 6 Chapter 4, 4.2.6) or, if greater, the planned altitude which it is intended to maintain with all engines operating, in order to ensure compliance with 14.3.2 and 14.3.3.

14.3.2 One engine inoperative

From each point along the route and planned diversions therefrom, it is possible in the event of one engine becoming inoperative to continue the flight to an en-route alternate aerodrome where a landing can be made in accordance with 4.2 and, on arrival at the aerodrome, the net gradient of climb is not less than zero at a height of 450 m (1 500 ft) above the elevation of the aerodrome.

14.3.3 Two engines inoperative *(applicable only to aeroplanes with four engines)*

For each point along the route or planned diversions therefrom, at which the aeroplane is more than 90 minutes' flying time at all engines operating cruising speed from an en-route alternate aerodrome, the two engines inoperative net flight path is such that a height of at least 300 m (1 000 ft) above terrain can be maintained until arrival at such an aerodrome.

Note.— The net flight path is that attainable from the expected gradient of climb or descent diminished by 0.2 per cent.

14.3.4 Conditions

The ability to comply with 14.3.1, 14.3.2 and 14.3.3 is assessed:

a) either on the basis of forecast temperatures, or on the basis of declared temperatures giving an equivalent average level of performance;

b) on the forecast data on wind velocity versus altitude and locality assumed for the flight plan as a whole;

c) in the case of 14.3.2 and 14.3.3, on the scheduled gradient of climb or gradient of descent after power failure appropriate to the mass and altitude at each point considered;

d) on the basis that, if the aeroplane is expected to gain altitude at some point in the flight after power failure has occurred, a satisfactory positive net gradient of climb is available;

e) in the case of 14.3.2 on the basis that the minimum altitude (see Annex 6 Chapter 4, 4.2.6), appropriate to each point between the place at which power failure is assumed to occur and the aerodrome at which it is intended to alight, is exceeded;

f) in the case of 14.3.2, making reasonable allowance for indecision and navigational error in the event of engine failure at any point.

14.4 Landing

14.4.1 Mass

The calculated mass for the expected time of landing at the aerodrome of intended landing or any destination alternate aerodrome is not to exceed the maximum specified in the flight manual for the altitude and temperature at which the landing is to be made.

14.4.2 Landing distance required

The landing distance required at the aerodrome of the intended landing or at any alternate aerodrome, as determined from the flight manual, is not to exceed the landing distance available on:

a) the most suitable landing surface for a landing in still air; and, if more severe,

b) any other landing surface that may be required for landing because of expected wind conditions at the time of arrival.

14.4.3 Conditions

For the purpose of 14.4.2, the landing distance required is that corresponding to:

a) the calculated mass of the aeroplane for the expected time of landing;

b) an altitude equal to the elevation of the aerodrome;

c) the expected temperature at which landing is to be made or a declared temperature giving an equivalent average level of performance;

d) the surface slope in the direction of landing;

e) for the purpose of 14.4.2 a), still air;

f) for the purpose of 14.4.2 b), not more than 50 per cent of the expected wind component along the landing path and opposite to the direction of landing and not less than 150 per cent of the expected wind component in the direction of landing.

EXAMPLE FOR PRIOR OPERATIONAL PROVISION APPLICABLE FROM 1 MAY 1953 ON AEROPLANE PERFORMANCE OPERATING LIMITATIONS —
PROCEDURES USED IN DETERMINING TAKE-OFF AND LANDING PERFORMANCE

1. General

1.1 Unless otherwise stated, reference humidity and still air conditions are applied.

1.2 The performance of the aeroplane is determined in such a manner that the approved airworthiness limitations for the aeroplane and its systems are not exceeded.

1.3 The wing flap positions for showing compliance with the performance specifications are selected.

Note.— Alternative wing flap positions are made available, if so desired, in such a manner as to be consistent with acceptably simple operating techniques.

1.4 The position of the centre of gravity is selected within the permissible range so that the performance achieved in the configuration and power indicated in the specification under consideration is a minimum.

1.5 The performance of the aeroplane is determined in such a manner that under all conditions the approved limitations for the engine are not exceeded.

1.6 While certain configurations of cooling gills have been specified based upon maximum anticipated temperature, the use of other positions is acceptable provided that an equivalent level of safety is maintained.

1.7 The determined performance is so scheduled that it can serve directly in showing compliance with the aeroplane performance operating limitations.

2. Take-off

2.1 General

2.1.1 The following take-off data are determined for sea level pressure and temperature in the Standard Atmosphere, and reference humidity conditions, with the aeroplane at the corresponding maximum take-off mass for a level, smooth, dry and hard take-off surface (landplanes) and for smooth water of declared density (seaplanes):

a) take-off safety speed and any other relevant speed;

b) power failure point;

c) power failure point criterion, e.g. airspeed indicator reading;

} associated with items d), e), f)

d) accelerate-stop distance required;

e) take-off run required;

f) take-off distance required;

g) net take-off flight path;

h) radius of a steady Rate 1 (180 degrees per minute) turn made at the airspeed used in establishing the net take-off flight path, and the corresponding reduction in gradient of climb in accordance with the conditions of 2.9.

2.1.2 The determination is also made over selected ranges of the following variables:

a) aeroplane mass;

b) pressure-altitude at the take-off surface;

c) outside air temperature;

d) steady wind velocity parallel to the direction of take-off;

e) steady wind velocity normal to the direction of take-off (seaplanes);

f) take-off surface slope over the take-off distance required (landplanes);

g) water surface condition (seaplanes);

h) density of water (seaplanes);

i) strength of current (seaplanes);

j) power failure point (subject to provisions of 2.4.3).

2.1.3 For seaplanes appropriate interpretations of the term landing gear, etc., are made to provide for the operation of retractable floats, if employed.

2.2 Take-off safety speed

2.2.1 The take-off safety speed is an airspeed (CAS) so selected that it is not less than:

a) $1.20V_{S_t}$, for aeroplanes with two engines;

b) $1.15V_{S_t}$, for aeroplanes having more than two engines;

c) 1.10 times the minimum control speed, V_{MC}, established as prescribed in 2.3;

d) the minimum speed prescribed in 2.9.7.6;

where V_{S_t} is appropriate to the take-off configuration.

Note.— See Example 1 for definition of V_{S_t}.

2.3 Minimum control speed

2.3.1 The minimum control speed is such that, when any one engine is made inoperative at that speed, it is possible to recover control of the aeroplane with the one engine still inoperative and to maintain the aeroplane in straight flight at that speed either with zero yaw or with a bank not in excess of 5 degrees.

2.3.2 From the time at which the engine is made inoperative to the time at which recovery is complete, exceptional skill, alertness, or strength, on the part of the pilot is not required to prevent any loss of altitude other than that implicit in the loss of performance or any change of heading in excess of 20 degrees, nor does the aeroplane assume any dangerous attitude.

2.3.3 It is demonstrated that to maintain the aeroplane in steady straight flight at this speed after recovery and before retrimming does not require a rudder control force exceeding 800 N and does not make it necessary for the flight crew to reduce the power of the remaining engines.

2.4 Power failure point

2.4.1 The power failure point is the point at which sudden complete loss of power from the engine, critical from the performance aspect in the case considered, is assumed to occur. If the airspeed corresponding to this point is less than the take-off safety speed, it is demonstrated that, in the event of sudden failure of the critical engine at all speeds down to the lowest speed corresponding with the power failure point, the aeroplane is controllable satisfactorily and that the take-off can be continued safely, using normal piloting skill, without:

a) reducing the thrust of the remaining engines; and

b) encountering characteristics which would result in unsatisfactory controllability on wet runways.

2.4.2 If the critical engine varies with the configuration, and this variation has a substantial effect on performance, either the critical engine is considered separately for each element concerned, or it is shown that the established performance provides for each possibility of single engine failure.

2.4.3 The power failure point is selected for each take-off distance required and take-off run required, and for each accelerate-stop distance required. The pilot is provided with a ready and reliable means of determining when the applicable power failure point has been reached.

2.5 Accelerate-stop distance required

2.5.1 The accelerate-stop distance required is the distance required to reach the power failure point from a standing start and, assuming the critical engine to fail suddenly at this point, to stop if a landplane, or to bring the aeroplane to a speed of approximately 9 km/h (5 kt) if a seaplane.

2.5.2 Use of braking means in addition to, or in lieu of, wheel brakes is permitted in determining this distance, provided that they are reliable and that the manner of their employment is such that consistent results can be expected under normal conditions of operation, and provided that exceptional skill is not required to control the aeroplane.

2.6 Take-off run required

The take-off run required is the greater of the following:

1.15 times the distance required with all engines operating to accelerate from a standing start to take-off safety speed;

1.0 times the distance required to accelerate from a standing start to take-off safety speed assuming the critical engine to fail at the power failure point.

2.7 Take-off distance required

2.7.1 The take-off distance required is the distance required to reach a height of:

10.7 m (35 ft), for aeroplanes with two engines,

15.2 m (50 ft), for aeroplanes with four engines,

above the take-off surface, with the critical engine failing at the power failure point.

2.7.2 The heights mentioned above are those which can be just cleared by the aeroplane when following the relevant flight path in an unbanked attitude with the landing gear extended.

Note.— Paragraph 2.8 and the corresponding operating requirements, by defining the point at which the net take-off flight path starts as the 10.7 m (35 ft) height point, ensure that the appropriate net clearances are achieved.

2.8 Net take-off flight path

2.8.1 The net take-off flight path is the one-engine-inoperative flight path which starts at a height of 10.7 m (35 ft) at the end of the take-off distance required and extends to a height of at least 450 m (1 500 ft) calculated in accordance with the conditions of 2.9, the expected gradient of climb being diminished at each point by a gradient equal to:

0.5 per cent, for aeroplanes with two engines,

0.8 per cent, for aeroplanes with four engines.

2.8.2 The expected performance with which the aeroplane is credited in the take-off wing flap, take-off power condition, is available at the selected take-off safety speed and is substantially available at 9 km/h (5 kt) below this speed.

2.8.3 In addition the effect of significant turns is scheduled as follows:

Radius. The radius of a steady Rate 1 (180 degrees per minute) turn in still air at the various true airspeeds corresponding to the take-off safety speeds for each wing-flap setting used in establishing the net take-off flight path below the 450 m (1 500 ft) height point, is scheduled.

Performance change. The approximate reduction in performance due to the above turns is scheduled and corresponds to a change in gradient of

$$\left[0.5\left(\frac{V}{185.2}\right)^2\right] \quad \text{\% where V is the true airspeed in km/h; and}$$

$\left[0.5\left(\frac{V}{100}\right)^2\right]$ % where V is the true airspeed in knots.

2.9 Conditions

2.9.1 *Air speed*

2.9.1.1 In determining the take-off distance required, the selected take-off safety speed is attained before the end of the take-off distance required is reached.

2.9.1.2 In determining the net take-off flight path below a height of 120 m (400 ft), the selected take-off safety speed is maintained, i.e. no credit is taken for acceleration before this height is reached.

2.9.1.3 In determining the net take-off flight path above a height of 120 m (400 ft), the airspeed is not less than the selected take-off safety speed. If the aeroplane is accelerated after reaching a height of 120 m (400 ft) and before reaching a height of 450 m (1 500 ft), the acceleration is assumed to take place in level flight and to have a value equal to the true acceleration available diminished by an acceleration equivalent to a climb gradient equal to that specified in 2.8.1.

2.9.1.4 The net take-off flight path includes transition to the initial en-route configuration and airspeed. During all transition stages, the above provisions regarding acceleration are complied with.

2.9.2 *Wing flaps*

The wing flaps are in the same position (take-off position) throughout, except:

a) that the flaps may be moved at heights above 120 m (400 ft), provided that the airspeed specifications of 2.9.1 are met and that the take-off safety speed applicable to subsequent elements is appropriate to the new flap position;

b) the wing flaps may be moved before the earliest power failure point is reached, if this is established as a satisfactory normal procedure.

2.9.3 *Landing gear*

2.9.3.1 In establishing the accelerate-stop distance required and the take-off run required, the landing gear are extended throughout.

2.9.3.2 In establishing the take-off distance required, retraction of the landing gear is not initiated until the selected take-off safety speed has been reached, except that, when the selected take-off safety speed exceeds the minimum value prescribed in 2.2, retraction of the landing gear may be initiated when a speed greater than the minimum value prescribed in 2.2 has been reached.

2.9.3.3 In establishing the net take-off flight path, the retraction of the landing gear is assumed to have been initiated not earlier than the point prescribed in 2.9.3.2.

2.9.4 *Cooling*

For that part of the net take-off flight path before the 120 m (400 ft) height point, plus any transition element which starts at the 120 m (400 ft) height point, the cowl flap position is such that, starting the take-off at the maximum temperatures permitted for the start of take-off, the relevant maximum temperature limitations are not exceeded in the maximum anticipated air temperature conditions. For any subsequent part of the net take-off flight path, the cowl flap position and airspeed are such that the appropriate temperature limitations would not be exceeded in steady flight in the maximum anticipated air temperatures. The cowl flaps of all engines at the start of the take-off are as above, and the cowl flaps of the inoperative engine may be assumed to be closed upon reaching the end of the take-off distance required.

2.9.5 *Engine conditions*

2.9.5.1 From the starting point to the power failure point, all engines may operate at maximum take-off power conditions. The operative engines do not operate at maximum take-off power limitations for a period greater than that for which the use of maximum take-off power is permitted.

2.9.5.2 After the period for which the take-off power may be used, maximum continuous power limitations are not exceeded. The period for which maximum take-off power is used is assumed to begin at the start of the take-off run.

2.9.6 *Propeller conditions*

At the starting point, all propellers are set in the condition recommended for take-off. Propeller feathering or pitch coarsening is not initiated (unless it is by automatic or auto-selective means) before the end of the take-off distance required.

2.9.7 *Technique*

2.9.7.1 In that part of the net take-off flight path prior to the 120 m (400 ft) height point, no changes of configuration or power are made which have the effect of reducing the gradient of climb.

2.9.7.2 The aeroplane is not flown or assumed to be flown in a manner which would make the gradient of any part of the net take-off flight path negative.

2.9.7.3 The technique chosen for those elements of the flight path conducted in steady flight, which are not the subject of numerical climb specifications, are such that the net gradient of climb is not less than 0.5 per cent.

2.9.7.4 All information which it may be necessary to furnish to the pilot, if the aeroplane is to be flown in a manner consistent with the scheduled performance, is obtained and recorded.

2.9.7.5 The aeroplane is held on, or close to the ground until the point at which it is permissible to initiate landing gear retraction has been reached.

2.9.7.6 No attempt is made to leave the ground until a speed has been reached which is at least:

15 per cent above the minimum possible unstick speed with all engines operating;

7 per cent above the minimum possible unstick speed with the critical engine inoperative;

except that these unstick speed margins may be reduced to 10 per cent and 5 per cent, respectively, when the limitation is due to landing gear geometry and not to ground stalling characteristics.

Note.— Compliance with this specification is determined by attempting to leave the ground at progressively lower speeds (by normal use of the controls except that up-elevator is applied earlier and more coarsely than is normal) until it has been shown to be possible to leave the ground at a speed which complies with these specifications, and to complete the take-off. It is recognized that during the test manoeuvre, the usual margin of control associated with normal operating techniques and scheduled performance information will not be available.

2.10 Methods of derivation

2.10.1 *General*

The take-off field lengths required are determined from measurements of actual take-offs and ground runs. The net take-off flight path is determined by calculating each section separately on the basis of performance data obtained in steady flight.

2.10.2 *Net take-off flight path*

Credit is not taken for any change in configuration until that change is complete, unless more accurate data are available to substantiate a less conservative assumption; ground effect is ignored.

2.10.3 *Take-off distance required*

Satisfactory corrections for the vertical gradient of wind velocity are made.

3. Landing

3.1 General

The landing distance required is determined:

a) for the following conditions:

   1) sea level;

   2) aeroplane mass equal to the maximum landing mass at sea level;

   3) level, smooth, dry and hard landing surfaces (landplanes);

   4) smooth water of declared density (seaplanes);

b) over selected ranges of the following variables:

   1) atmospheric conditions, namely: altitude, or pressure-altitude and temperature;

   2) aeroplane mass;

   3) steady wind velocity parallel to the direction of landing;

   4) uniform landing surface slope (landplanes);

   5) nature of landing surface (landplanes);

   6) water surface condition (seaplanes);

   7) density of water (seaplanes);

   8) strength of current (seaplanes).

3.2 Landing distance required

The landing distance required is the measured horizontal distance between that point on the landing surface at which the aeroplane is brought to a complete stop or, for seaplanes, to a speed of approximately 9 km/h (5 kt) and that point on the landing surface which the aeroplane cleared by 15.2 m (50 ft) multiplied by a factor of 1/0.7.

Note.— Some States have found it necessary to use a factor of 1/0.6 instead of 1/0.7.

3.3 Landing technique

3.3.1 In determining the measured landing distance:

a) immediately before reaching the 15.2 m (50 ft) height, a steady approach is maintained, landing gear fully extended, with an airspeed of at least $1.3V_{S_0}$;

Note.— See Example 1 for definition of V_{S_0} .

b) the nose of the aeroplane is not depressed in flight nor the forward thrust increased by application of engine power after reaching the 15.2 m (50 ft) height;

c) the power is not reduced in such a way that the power used for establishing compliance with the balked landing climb requirement would not be obtained within 5 seconds if selected at any point down to touch down;

d) reverse pitch or reverse thrust are not used when establishing the landing distance using this method and field length factor. Ground fine pitch is used if the effective drag/weight ratio in the airborne part of the landing distance is not less satisfactory than that of conventional piston-engined aeroplane;

Note.— This does not mean that reverse pitch or reverse thrust, or use of ground fine pitch, are to be discouraged.

e) the wing flap control is set in the landing position, and remains constant during the final approach, flare out and touch down, and on the landing surface at airspeeds above $0.9V_{S_0}$. When the aeroplane is on the landing surface and the airspeed has fallen to less than $0.9V_{S_0}$, change of the wing-flap-control setting is acceptable;

f) the landing is made in a manner such that there is no excessive vertical acceleration, no excessive tendency to bounce, and no display of any other undesirable handling characteristics, and such that its repetition does not require either an exceptional degree of skill on the part of the pilot, or exceptionally favourable conditions;

g) wheel brakes are not used in a manner such as to produce excessive wear of brakes or tires, and the operating pressures on the braking system are not in excess of those approved.

3.3.2 The gradient of the steady approach and the details of the technique used in determining the landing distance, together with such variations in the technique as are recommended for landing with the critical engine inoperative, and any appreciable variation in landing distance resulting therefrom, are entered in the flight manual.