

Runway Pavement Characteristics and Maintenance

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GENERAL

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PURPOSE

The purpose of this OTAC is to offer guidance to aerodrome operators undertaking measuring and monitoring of friction characteristics of the runway and describes the way the assessment should be carried out using Continuous Friction Monitoring Equipment (CFME). This OTAC is also intended to raise awareness of a supporting tool.

RELATED REQUIREMENTS

This Circular relates to OTAR Part 139.

CHANGE INFORMATION

Minor editorial changes.

ENQUIRIES

Enquiries regarding the content of this Circular should be addressed to Air Safety Support International at the address on the ASSI website www.airsafety.aero or to the appropriate Overseas Territory Aviation Authority.

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Glossary

For the purpose of this OTAC the following terms apply:

Term	Definition
Continuous Friction Measuring Equipment (CFME)	A device designed to produce continuous measurement of runway friction values
Design Objective Level (DOL)	The target friction level, to be achieved on a new or resurfaced runway within one year of the new surface becoming operational
Friction Level	The overall average friction value calculated from a minimum of 10 average friction values obtained over a rolling distance of 100 metres within a portion of the pavement
Macrotecture	The surface texture of the pavement. Macrotecture is the coarse texture evidenced by the aggregate or by artificially applied texture such as grooving. It is primarily used to increase bulk water drainage, thereby reducing the tendency for aeroplane tyres to experience dynamic aquaplaning. If a runway has a good macrotecture it allows water to escape beneath the tyre, then the friction value will be less affected by speed.
Maintenance Planning Level (MPL)	The friction level below which should trigger the need to undertake a runway maintenance programme. The State-set friction level below which a runway maintenance programme should be undertaken.
Microtexture	Microtexture is the texture of individual pieces of aggregate that can be felt but cannot be directly measured. Microtexture is important in penetrating very thin water films. It is the main contributor to friction characteristics.
Minimum Friction Level (MFL)	The friction level below which will require the runway to be notified by NOTAM as 'may be slippery when wet'.
NOTAM	A notice to airmen distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.
Portions of the Pavement	One third of the declared runway width. Each portion shall be of equal width: referred to as The central trafficked portion and two outer portions.
Runway Designation Marking (RDM)	A two digit number defining the runway bearing relative to magnetic North when viewed from the direction of approach.
Runway Friction Assessment	A friction assessment carried out under conditions of self-wetting for the purposes of establishing the friction level of a runway.

1 Introduction

- 1.1 ICAO Annex 14 sets only the principles which cover the provision of paved runway surfaces with acceptable friction characteristics [Attachment A, Section 7]. ICAO Document 9157, Part 1 – Runways and Part 2 – Pavements provide additional detail regarding the specification of runway surfaces.

Note, 9157, Part 2 – provides similar information regarding taxiways, aprons and holding bays.

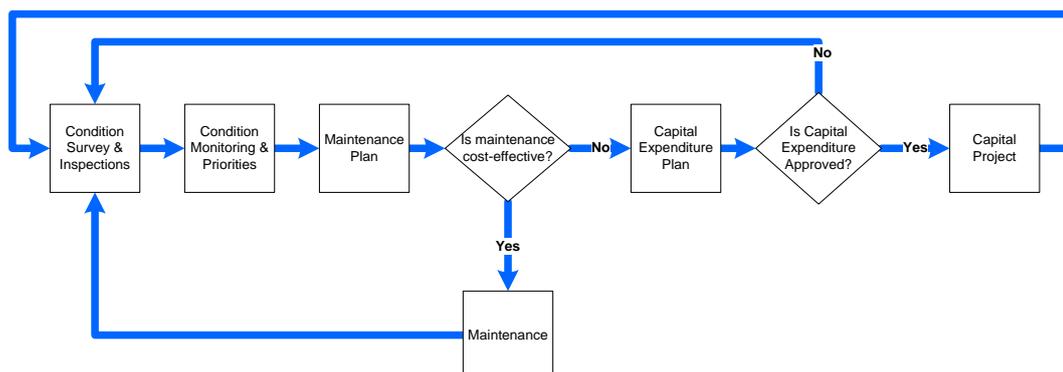
- 1.2 Aerodrome operators are required by Annex 14 to undertake friction assessment periodically to determine the friction characteristics of runways.
- 1.3 The measurement serves two purposes. First, it enables the identification of runways with low runway surface friction when wet, so maintenance can be planned. Second, it provides qualitative information to aerodrome operators about the condition of the runway surface, thus permitting the development of a more objective, evidence based maintenance programme and, therefore, justifying development of budgets.
- 1.4 States must establish and define the Minimum Friction Level (MFL) or maintenance friction level which will require NOTAM advice, if reached for any given runway. States must also establish a Maintenance Planning Level (MPL) of runway friction surface below which prompt corrective action is required.
- 1.5 The objective of the assessment programme should be to identify a downward trend in runway surface friction characteristics and plan preventative maintenance before the runway surface friction coefficient falls to the MPL.
- 1.6 The criteria should be published in the aeronautical information publication (AIP). When a runway surface that does not meet the criteria is found, a NOTAM should be issued until such time as corrective action has been taken.

2 The runway pavement

- 2.1 Clearly, the runway pavement should be designed and constructed to accommodate the planned traffic. A runway pavement is required to fulfil three basic functions as follows:
- a) **Provide adequate bearing strength** - the structure of the pavement made with appropriate materials;
 - b) **Provide good riding qualities** - the geometric shape of the pavement surface; and
 - c) **Provide good surface characteristics** - the texture of the actual surface and drainage when it is wet.
- 2.2 Other requirements include longevity and ease of maintenance.
- 2.3 The texture and slope of the surface are the most important runway surface friction characteristics of runway pavements.
- 2.4 These criteria address, in addition to the economic dimension, the availability of the pavement for aircraft operations. ICAO Document 9157 Part 1 – Runways, and Part 3 – Pavements, provide additional information/specification.

- 2.5 Though this document focuses on runway surface friction, it is assumed that the runway pavement meets these criteria and that the aerodrome operator has, as part of its SMS, a system to monitor and ensure the airfield paved surfaces are suitable, serviceable and safe for aircraft operations. All pavements require maintenance, and aerodromes should have a programme of regular surface inspections and preventative maintenance to support and protect the condition and serviceability of paved surfaces. The system should evaluate pavement condition; the need and priority for any maintenance identified and, eventually, renewal of the pavement or part of it. Figure 1 is an example of a 'closed loop' maintenance process.

Figure 1 Closed loop maintenance process



3 The principles of runway surface friction

- 3.1 Aircraft braking coefficient is dependent upon the surface friction between the tyres and the pavement surface. Less friction means reduced aircraft braking coefficient and less aircraft braking response; the aircraft will take longer to slow and/or stop and the more likely to skid.

- 3.2 Friction is expressed as the coefficient of friction; this is the ratio of:

- the friction force (F) - between two surfaces in contact and
- the normal force (N) - which exists between the object resting on the surface and the surface

$$\text{ie } \frac{F}{N}.$$

This ratio is particularly, but not exclusively, dependent upon:

- The physical characteristics of the two surfaces.
- The prevailing temperature at the point of contact.
- The speed of movement of the object (the tyre) over the surface.

4 Recognised best practice

- 4.1 Detail of best practice is not readily available through ICAO. However, UK CAA publication CAP 683 – The Assessment of Runway Surface Friction Characteristics describes a method of assessment that is an example of a comprehensive assessment programme using Continuous Friction Measuring Equipment (CFME) as required by ICAO.

- 4.2 The objective of CAP 683 is to offer guidance on the procedures for undertaking runway surface friction assessments and to define the criteria by which friction values should be assessed, on applicable runways under specified conditions.
- 4.3 ASSI strongly recommends adoption of the methodology of run patterns for friction assessment that are set out in CAP 683 (see Table 3 and Figure 2), whilst applying the levels as set out in Annex 14 for any given CFME. Annex 14 refers to ICAO Document 9137 Part 2 friction levels for new and existing runway surfaces.
- 4.4 In addition, aerodrome operators must ensure that the CFME is kept in good working order and maintained and operated as required by its manufacturer. This may include set-up, recalibration and life of components, such as tyres and measuring devices.
- 4.5 As discussed, the measurement of friction is dependent on a number of key properties associated with the surface in question including the measuring device and the interface between the two. There is a complex inter-relationship but the fundamental issues are well understood and form the basis of recommendations in the ICAO Standards and Recommended Practices (SARPs).
- 4.6 For aircraft, the crucial key operational requirements of the use of a runway surface are that, under wet conditions (Damp and 3mm or less depth of water), a surface is provided that conforms with the characteristics set out in Table 1.

Table 1: Runway Pavement Characteristics

	The Runway	Performance	Outcome
1	Geometry	Provides compliant infrastructure	To facilitate expected aircraft performance
2	Materials	Provides good microtexture	To ensure brakes can work to maximum stopping ability
3	Drainage	Provide good drainage	To minimise the time window when there is a higher risk of loss of control
4	Inspection	Maintain expected performance	Know the condition to avoid deterioration in the level of safety provision
5	Friction	Provide for good braking	Know the current friction level and trend of all areas of the runway

5 Runway friction assessments

- 5.1 The friction characteristics of a runway vary over time as the runway is subject to wear and tear and to the effects of weather and other environmental conditions or after surface maintenance activities.
- 5.2 Aircraft performance calculations assume certain minimum runway friction characteristics. If the friction characteristics of a runway fall below these minima the aircraft may not be able to stop within the runway paved area when landing or in the event of a rejected take-off.

- 5.3 Therefore, runway friction assessments are conducted principally for the benefit of the aerodrome operator to ensure that the condition of the runway surface is adequate and will enable aircraft to operate safely within their performance calculations.
- 5.4 The aerodrome operator should determine the frequency of the assessments that will enable any significant change in runway surface friction characteristics to be identified and, if appropriate, for remedial maintenance to be conducted before the surface characteristics deteriorate to a point at which aircraft performance calculations may no longer be valid.
- 5.5 Table 2 describes the recommended periodicity of runway friction assessments.

Table 2: Recommended interval between runway friction assessments

Average number of movements on the runway per day	Interval between assessments
Less than 400	12 months
400 or more	6 months

- 5.6 The average number of movements on a runway should include the total number of movements on both runway directions and averaged over a one-year period.
- 5.7 Aerodrome operators should be aware that rubber build-up in the touchdown zone may lead to rapid changes in friction characteristics.
- 5.8 Aerodrome operators should monitor the results of assessments and may decrease the interval between assessments if historical results indicate that the surface is deteriorating relatively quickly in order to ensure that maintenance is arranged before the friction characteristics deteriorate below the MPL. Conversely, if historical results indicate that the runway surface is unaffected by traffic and in good condition, a longer interval may be acceptable. The aerodrome operator should record the justification for any variation from the recommended periodicity for assessments.
- 5.9 If the surface characteristics deteriorate beyond a certain level, the aerodrome operator should instigate appropriate maintenance. If the surface characteristics deteriorate to point at which aircraft performance calculations may be no longer valid, pilots must be made aware of this fact through NOTAM; for example, "Runway 10 may be slippery when wet".
- 5.10 A runway friction assessment is conducted under controlled conditions using self-wetting CFME. This establishes the friction characteristics of a runway and identifies those portions of a runway that may require attention.
- 5.11 A runway friction assessment should be undertaken following runway surface maintenance activities that might alter friction level values over any significant portion of the runway, see section 8, or when there is evidence that the runway friction characteristics are adversely affected (eg following pilot reports of unexpectedly poor braking action or visible areas of runway surface wear).

6 Evaluation of runway friction measurement results

- 6.1 A runway friction measurement should be carried out between the pavement ends and should include as much of the pavement surface at a constant run speed as practicable, allowing for acceleration and safe deceleration.

6.2 The measured friction level values should be compared with a number of criteria that provide guidance on the action that may be required. These criteria are:

- The Design Objective Level,
- The Minimum Friction Level, and
- The Maintenance Planning Level.

6.3 The friction level values produced by different CFME vary slightly for any given runway surface friction characteristics.

7 Preventative runway maintenance - Action to be taken as a result of a runway friction assessment

7.1 The aerodrome operator should review the results of each runway friction assessment and take the following action.

- If the friction level value falls below the Maintenance Planning Level, maintenance should be arranged to restore the relevant friction level to a value greater than the Maintenance Planning Level or ideally, to a value equal to or greater than the Design Objective Level.
- If the friction level value falls below the Minimum Friction Level, maintenance should be **urgently** arranged in order to restore the relevant friction level value at least to a value greater than the Maintenance Planning Level and, ideally, to a value equal to or greater than the Design Objective Level.
- If the friction level value falls below the Minimum Friction Level it is important that pilots are warned that aircraft performance calculations may no longer be valid. In this case the aerodrome operator must issue a NOTAM advising only that the runway may be slippery when wet.
- If a runway friction assessment indicates that the friction level falls below the Maintenance Planning Level or the Minimum Friction Level, the aerodrome operator should increase the frequency of runway friction assessments in order to enable any further or rapid deterioration of the runway surface friction characteristics to be identified and, if appropriate, for additional action to be taken.
- If a runway friction assessment falls below the Minimum Friction Level and remedial action cannot be conducted urgently the aerodrome operator should consider withdrawing the runway from use for take-off and/or landing.

8 Assessments made following maintenance activities

8.1 The friction characteristics of a paved surface can alter significantly following maintenance activities.

8.2 A runway friction assessment should be conducted following any significant maintenance activity conducted on the runway affecting the surface and before the runway is returned to service.

- 8.3 If the runway friction assessment indicates that the surface friction characteristics of that portion of the runway that has been subject to maintenance work are poorer than anticipated or fall below the Minimum Planning Level, additional assessments should be carried out to ascertain whether the friction characteristics remain stable or improve. If the affected runway portion is 100m or more in length, the aerodrome operator must issue a NOTAM advising that that portion of the runway may be slippery when wet. The friction characteristics of some runway surfacing materials can improve over time, commonly as a result of the dispersal of oils in the surface layers.
- 8.4 It is recommended that records of runway maintenance activities and resulting surface friction measurement be maintained for at least ten years (longer if possible) in order to permit the suitability of particular techniques and materials to be evaluated when arranging subsequent remedial maintenance work.

9 Runway friction measurement procedures

- 9.1 Runway Friction measurements should be performed using accepted CFME that is recognised within ICAO Document 9137 and in accordance with the manufacturer's operating instructions.

Note: Other CFME may be used for conducting runway friction measurements provided that the relationship between measured friction level values and the Friction Levels shown in the table above are satisfactorily demonstrated to the Regulator.

9.2 General procedures

9.2.1 Equipment Checks

The CFME operator should ensure that the equipment is in full working order and prepared ready to undertake the survey in accordance with the manufacturers operating instructions.

9.2.2 Track Location

As far as possible, the tracks of the measuring wheels should not run down the line of the pavement joints or longitudinal cracks.

9.2.3 Training and Operator Competency

The success of friction measurement in delivering reliable friction data depends greatly on the personnel who are responsible for operating the CFME. All CFME operators should be trained in the operation and maintenance of the CFME. Where a contractor carries out the measurement runs, it is up to the aerodrome certificate holder to satisfy himself as to the competency and experience of the contractor.

9.2.4 Measurement / Survey Conditions

The runway surface should be totally dry during the survey with no wet patches. Dampness, fog and mist conditions might affect the outcome of the survey. The survey should be conducted at an ambient air temperature above 2°C. It is important that all runs start and finish as close as possible to the end of the pavement. In order to enable the analysis software to locate the data relative to each runway threshold correctly a common stationary start position should be established for each run direction. If there is any reason to doubt the accuracy of the friction measurements, the runs should be repeated. Runs should be repeated if precipitation occurs during a run. Aerodrome operators should be aware that cross-winds may affect self wetting assessments and aerodrome operators should seek advice on this issue from their CFME manufacturer.

Table 3 sets out the assessment run pattern for a range of runway widths. Figure 2 illustrates the recommended run pattern, based on standard runway width of 45m. The common start position of the friction wheel(s) for all runs should be marked on the pavement, at each end, before commencing the survey.

9.2.5 Check Runs

In order to check the repeatability of assessment runs and that the CFME remains within tolerance throughout the survey, two check runs should be made during the assessment. Guidance on this procedure should be sought from the CFME manufacturer. Check runs should be performed on a portion of the runway that does not traverse any other runs.

9.2.6 Assessment Runs

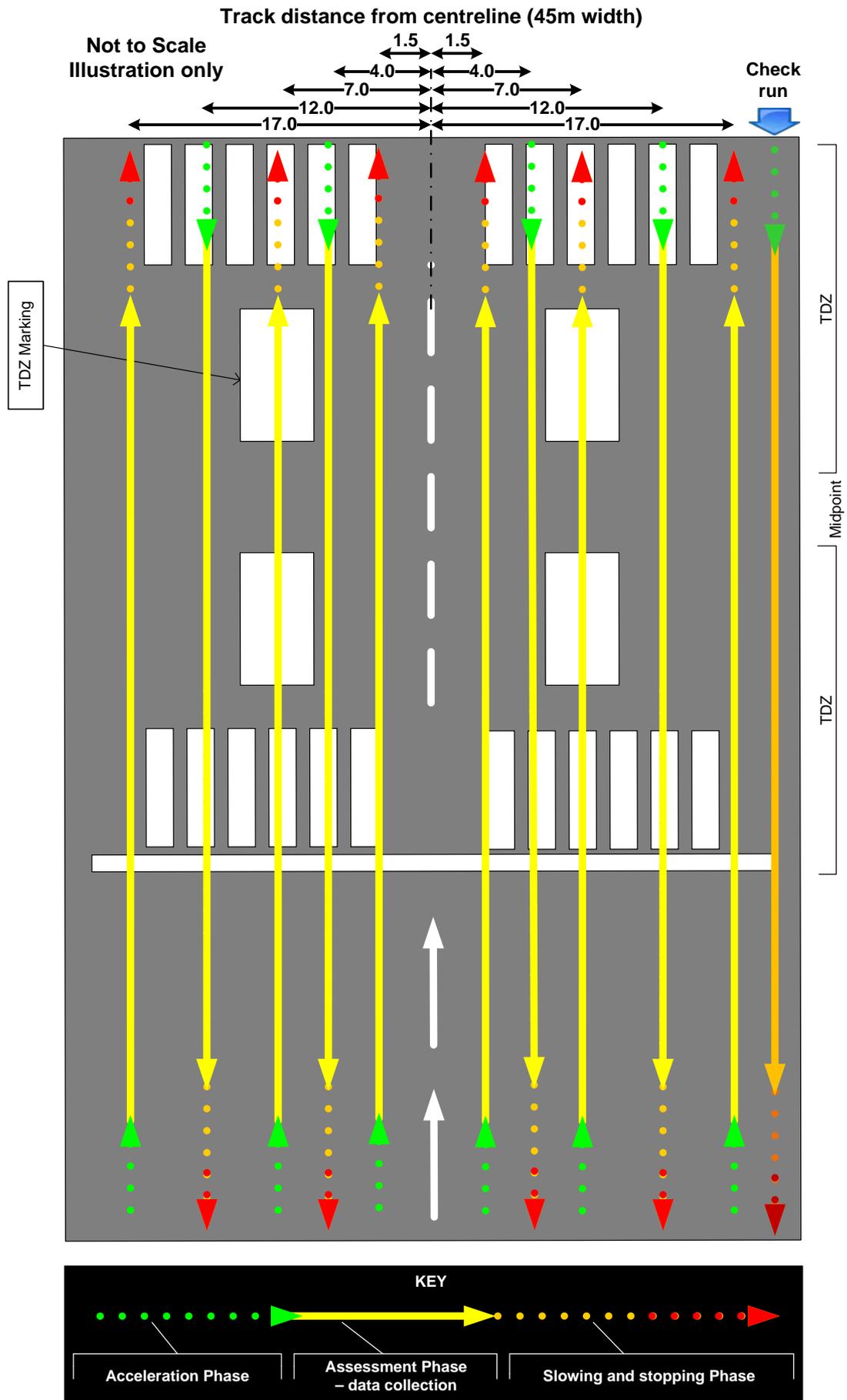
The aerodrome operator should ensure that all assessment runs are evenly spaced, that they run parallel to the runway centreline and are laterally separated by a distance no greater than 5 metres. The run pattern for a runway with Touchdown Zone (TDZ) Markings should be planned so as to include one run either side of the centreline to pass through the centre of the painted TDZ markings.

Table 3: Recommended format for Runway Friction Assessment Runs based on standard runway widths

Standard Runway Widths	Recommended lateral displacement of standard runs each side of the centreline (Metres)				
	Central Portion			Outer Portion	
18 Metres	1.5	3	6	-	-
23 Metres	1.5	3	6	9	-
30 Metres	1.5	4	7	12	-
45 Metres	1.5	4	7	11	17

(Source CAP 683 October 2010)

Figure 2: Example Assessment Runs tracks



10 SCARF Toolkit

- 10.1 Jacobs has developed the Surface Characteristics Assessment of Runway Friction (SCARF) Toolkit which provides a reference point or baseline against all the above categories in Table 1. It is intended to be used by aerodromes as a decision support tool to aid consideration and review of the detailed issues that need to be evaluated for each runway.
- 10.2 A 'RAG' (Red, Amber, Green) formatting is used to help focus on the key issues and decisions to be made. Further information about SCARF is at Appendix A. A blank uncompleted Master SCARF Toolkit is available from the ASSI website, and aerodrome operators are invited to download it and use it as part of their pavement condition monitoring programme.
- 10.3 The information contained in these documents should be used as a basis for aerodrome operators to establish their system for assessing runway surface characteristics and the necessary correlation with the aerodrome pavement maintenance programme.

Appendix A – SCARF Toolkit

A1.1 The toolkit is an Excel spreadsheet with a defined set of colour coded data entry cells. It intended to be an evidence based assessment using a variety of data sources the outcome of which is used to determine the rating of the current status of each runway characteristic against a pre-determined threshold.

A1.2 It is separated into four parts, each focusing on a different area of interest contributing to runway friction. At the end of each part there is room for a summary conclusion to be provided based on an assessment of the data within that part.

A1.2.1 Part A - General Data

This includes general data regarding the aerodrome as well as a summary of the previously recorded friction assessments which are assessed against ICAO friction assessment thresholds published in Annex 14 and referenced by OTARs.

Also provided is a summary of key recommendations based on the current SCARF review.

A1.2.2 Part B - Design and Construction

This is split into three parts and is focused on the fixed characteristics directly affecting friction and are the result of the construction or last resurfacing. This section relies on topographic surveys or data from the construction and 'as-built' drawings.

The Geometry section considers the transverse gradient of the pavements which affects the drainage of surface water and reduces the probability of water ponding. Ponding of water on the runway may lead to increased risk of aquaplaning and increase the stopping distances.

The section on Materials considers the type of aggregate used in the surface course as this is the most important characteristic affecting runway friction. The selection of an aggregate with good microtexture is the most important decision an aerodrome can make in the interests of preserving good long-term runway friction. For instance, an aggregate like Gritstone has an ideal crystalline structure that ensures a durable microtexture that maintains its friction characteristics under traffic use compared to limestone, flint and sandstone which become polished more rapidly.

The section on Drainage focuses on the local drainage under the aircraft tyres provided by the characteristics of the surface. Good macrotexture will allow for rapid surface water drainage at the tyre-surface contact point particularly at high speeds where a high macrotexture provides dynamic drainage under tyre-pressure (the tyre forces the water away through the macrotexture). Grooving of the surface is a way of increasing macrotexture, and once installed it is essential the grooves are well formed and maintained free of debris. This will aid the removal of surface water by drainage reducing the risk of ponding which, if allowed to exist, may lead to increased stopping distances and aquaplaning.

A1.2.3 Part C - Maintenance (Action Required)

This section assesses the maintenance activities that are essential to maintaining and monitoring friction levels.

The section on Drainage considers routine inspection of local drainage. For example, anything hindering the drainage, including debris on the side of the runway and rutting in the wheel tracks.

The section on inspection looks at the current runway condition and maintenance procedures to see if alterations to the process would be of value.

The section on Friction looks at the current friction survey and process of evaluation with advice given for any possible improvements.

A1.2.4 **Part D - Performance Feedback**

This considers operational issues based on analysis of feedback from pilot reports and Operations who may have observed excessive drag, poor braking or excessive roughness. It also considers the type of operations and the number of flights that may be operating close to safe local limits.

A1.3 Each parameter assessed within the Toolkit is considered for five general locations along the runway:

- Runway ends (2 No.) where friction cannot be measured.
- Touchdown zone areas (2 No.) where there tends to be most wear and friction can be impacted by rubber deposits.
- Runway central third (midpoint) where aircraft are generally in the roll out phase or taxiing.