



The use of GRF data for assessing the surface condition of contaminated runways to reduce risks associated with aircraft landings

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Abstract:

Aircraft landing is a very critical phase of flight, particularly on contaminated runways where the braking coefficient is weakened by the presence of contaminants, resulting in a longer landing distance. If these parameters are not controlled, runway excursions are highly likely. The Global Reporting Format (GRF) enables specialists to assess runway conditions in order to provide codified and reliable information to flight crews for calculating landing performance and taking the necessary measures to ensure safe landings. This work consists of conducting a study of viable runways (on a defined operating network: domestic airports open to public air traffic) for a specific type of aircraft (B738-NG), following an assessment of the risks associated with landings, taking into account runway characteristics and assumed GRF data for the operations in question. This study was conducted after evaluating aircraft landing performance using a computer application. The input data for this application includes runway conditions published by the relevant ATC services (GRF data), the technical characteristics of aircraft during landing (flaps, automatic braking, reference speed), and weather conditions (temperature and wind). This application can be considered a decision-making aid during flight preparation by flight dispatch personnel (pre-flight) and flight crews (in-flight).

1. Introduction

Runway accidents and incidents are the leading category of safety risk in aviation. A major contributing factor to this risk includes runway excursions during take-off or landing in adverse weather conditions (Charpentier, 2025); The runway surface may be contaminated by snow, ice, slush, or water, with a potentially negative impact on aircraft braking, acceleration, or controllability (SEITBATTALOV, al, 2021). ICAO has therefore introduced a methodology to harmonize the assessment and reporting of runway surface conditions called the GRF (MAIA, al, 2024). This method will improve the flight crew's assessment of aircraft take-off and landing performance. The report is intended to cover conditions in all climates and provides a means for aerodrome operators to quickly and accurately

assess conditions, whether wet, snow, slush, ice (CHU, al 2024, LIU, al, 2026). or frost, including rapidly changing conditions such as those encountered in winter or tropical climates. The information can be provided to the flight crew through various channels, such as the revised SNOWTAM or air traffic control (GUO, 2023). This is a conceptual change for the airport, as it no longer simply reports a series of observations and measurements, but also transforms this information into an overall assessment of the effect of surface conditions on aircraft performance (QIAN, al 2023, SU, al, 2024). This work consists of developing a computer application for assessing the risk associated with the performance of Boeing B737-800 aircraft when landing on runways classified as GRF, highlighting the aircraft's landing performance (LIU, al 2023, ZHU, al, 2024). This assessment will be carried out during the flight

crew briefing, where landing performance, in particular the landing distance required (LDR), will be checked against the manufacturer's data published in the flight manuals (FPPM, FCOM) or DOC10064 for aircraft types that do not have manufacturer information (KETABDARI, al 2021, BORODKIN, al, 2022). Taking into account the condition of the runway in use at the destination and assessing the aircraft's ability to land in advance can be considered a new barrier related to proactive risk management (REISER, al, 2024). and which constitutes a pillar in the security management system (SMS) (LIN al 2025, PYTKA, al, 2025). Based on this, our work is structured as follows: a general presentation concerning GRF data (GRF principle, GRF composition, and their evaluation); we also addressed the evaluation criteria and concluded with a conclusion.

2. Method

The operational performance of aircraft during landing and take-off is highly dependent on the surface condition of runways. This surface condition can be severely degraded when weather conditions are poor. For obvious safety reasons, when such situations arise, it is necessary to implement methods and means to characterize the surface condition of runways in order to provide pilots with the information they need to calculate their aircraft's performance and take operational limitations into account. This characterization consists of identifying the type of contaminant, measuring or estimating its extent (area affected and thickness) and the potential for adhesion of the contaminated runway surface.

3. Global reporting format (GRF):

3.1 GRF principle:

The GRF is based on characterizing the condition of a runway surface, taking into account various data including the nature and thickness of the contaminant and the pilot's braking feel during landing. The effective date set by the ICAO for the GRF concept is November 4, 2021. The effective date set by the ICAO for the GRF concept is scheduled for January 6, 2022.

3.2 The fundamental elements of GRF :

- The Runway Condition Report (RCR).
- The Runway Condition Assessment Matrix (RCAM).
- The Runway Condition Code (RWYCC)

1.3 How the GRF works:

The GRF works as follows: The airport operator assesses the surface condition of the runway in thirds and draws up an RCR (Runway Condition Report), containing an RWYCC (Runway Condition Code) and information describing the surface condition of the runways: type of contamination, thickness, coverage for each third of the runway.

This code is established from a runway condition assessment matrix (RCAM). The RWYCC is used as input data for aircraft performance tables to calculate landing distances.

RCR elements are communicated to pilots by the air traffic services (ATS) organization on the radio frequency or on the ATIS. The RCR is disseminated through aeronautical information using a new SNOWTAM format, if necessary.

3.4 Objectives of the GRF:

- Assess the operational consequences (duration of runway unavailability, frequency occupancy, workload for the various parties involved, system compatibility, etc.).
- Consolidate the chain of information transmission up and down the chain (time taken to transmit information and any responses to AIREP).
- Establish correlations between pilots' AIREPs after landing and the Runway Condition Code (RWYCC) provided by the operator.
- Establish feedback for nationwide implementation by the various stakeholders involved.

3.5 GRF assessment for pilots:

The information communicated to pilots is as follows:

• By SNOWTAM :

The RCR elements (code RWYCC, type of contamination, thickness, coverage) are communicated in GRF format, at the end of field T of the SNOWTAM in the current format, under the heading "GRF data" [note that the information is given for each third of the runway in ascending order of QFU].

Example of GRF data in the SNOWTAM T field in the current format:

T) GRF DATA 05 3/3/3 75/75/100 04/04/04 DRY SNOW/DRY SNOW/DRY SNOW

The maximum validity of SNOWTAM is 8 hours.

• In ATIS :

The RCR elements (code RWYCC, type of contamination, thickness, coverage) and the time of measurement are communicated in place of the corresponding METAR information [note that the

information is given for each third of the runway in the order of the landing direction].

- **By air-to-ground voice communications:**

Only the RWYCC and the measurement time are communicated by default at the frequency. The type of contamination, thickness, and coverage are provided at the pilot's request [note that the information is given for each third of the runway in the order of the landing or take-off direction].

Friction coefficient measurements (CFL or μ) and METAR data related to runway surface conditions are no longer provided.

4. Runway Condition Report (RCR):

Globally, sports regions can experience multiple climate exposures, so the conditions that need to be reported vary considerably. The Course Condition Report (CCR) describes the basic structure that applies to all these climate changes.

The principle behind runway condition reporting is that whenever there is water, snow, ice, or frost on the runway in use, the airport operator must assess the runway surface condition. Based on this assessment, the runway condition code (RWYCC) and a description of the runway surface condition are communicated to the flight crew for use in calculating aircraft performance.

The report is based on the type, depth, and extent of contaminants, and airport operators can better assess runway surface conditions.

The concept of the Runway Condition Report (RCR) is based on :

- a) A consistent set of agreed criteria for assessing runway surface condition, aircraft certification (performance), and operational performance calculation.
- b) A unique runway condition code (RWYCC) linking an agreed set of criteria to the aircraft's landing and takeoff performance tables and to the braking performance observed and ultimately reported by the flight crew.
- c) Indication of the type and depth of contamination associated with take-off performance contamination.
- d) common terminology and standardized conventional expressions for describing the surface condition of runways used by aerodrome operator inspection personnel, air traffic controllers, aircraft operators, and flight crews.

4.1 The basic principles of RCR:

- The runway condition code (RWYCC) must be indicated for each third of the runway being assessed.
- The assessment process must consist of:

- a) Assess the condition of the movement area and report on it.

- b) Communicate the assessed information in the correct format.

- c) Report significant changes without delay.

-The information to be communicated must comply with the Runway Condition Report (RCR), which includes:

- a) Aircraft performance calculation section.

- b) Situation awareness section on the surface condition of runways, taxiways, and aprons.

-The information must be included in the information string presented in the following order, using only AIS-compatible characters:

- a) Aircraft performance calculation section:

- 1) Airport position indicator.

- 2) Date and time of assessment.

- 3) Minimum runway identification number.

- 4) Runway condition codes for each third of the runway.

- 5) Percentage of contaminant coverage for each third of the runway.

- 6) Thickness of non-adherent contaminant for each third of the runway.

- 7) Description of conditions for each third of the runway.

- 8) Width of the runway to which the runway condition code (RWYCC) applies, if it is less than the published width.

- b) Section on awareness of the surface conditions of runways, taxiways, and parking areas:

- 1) Reduced runway length.

- 2) Fine, dry snow on the runway.

- 3) Loose sand on the runway.

- 4) Chemical treatment on the runway.

- 5) Snowdrifts on the runway.

- 6) Snowdrifts on the taxiway.

- 7) Snowdrifts near the runway exceeding the level/profile established in the aerodrome snow plan.

- 8) Condition of taxiways.

- 9) Condition of the apron.

- 10) Approved and published use of the measured friction coefficient by the State.

- 11) Observations in plain language.

5 Track condition assessment matrix (RCAM):

Table used, in conjunction with related procedures, to determine the runway condition code based on a set of observed runway surface conditions and pilot reports on braking effectiveness.

Method to be used by airport operators to report runway surface conditions in the event of contamination; Clearly identifies factors that

influence aircraft take-off and landing performance, particularly braking performance.. It links these factors to the RWYCC (Runway Condition Code), which can be used by flight crews to interpret runway surface conditions and facilitate their assessments before landing and take-off.

5.1 Evaluation criteria:

5.1.1 Runway condition code (RWYCC) :

The RWYCC associated with the relevant runway surface description based on the type of contaminant on the runway, its depth, and the outside air temperature.

An RWYCC is reported at each third of the runway being assessed. The direction for indicating thirds of the runway will be the direction seen from the lowest runway identification number.

5.1.2 Description of the surface of the slopes:

The description is intended to describe the conditions of the runway surface and contaminants (from least to most slippery) directly correlated with the aircraft's take-off and landing performance. Contaminants have different effects depending on their depth and the outside air temperature.

These two criteria are used to determine the RWYCC.

5.1.3 Evaluation criteria for downgrading:

Provides the evaluation criteria that enable the airport operator to subsequently evaluate the runway and validate the RWYCC. It includes :

a) Aircraft deceleration or observation regarding directional control:

This information is to be used by the pilot to assess the estimated braking performance of the aircraft on a given contaminant and to estimate a runway braking action category based on six descriptions.

b) Driver reports on braking efficiency:

Report on braking action on the runway by a pilot, providing other pilots with an indication of the expected degree/quality of breaking the use of any available means to assess runway slipperiness should be considered to support the decision to downgrade or upgrade the RWYCC.

5.2 Using the RCAM:

Airport operators must assess and collect data on:

- The percentage of each third of the runway covered with contaminants.
- The condition of the runway surface and the type of contaminants.
- The depth of the contaminants.

Percentage of each third of the track covered with contaminants:

Percentage of contamination coverage on each third of the runway. A runway is considered contaminated if the coverage exceeds one quarter of the surface area of at least one third of the runway. It is important to remember that whenever the coverage is assessed to be below the 25% threshold for each third of the runway. The flight crew must assume that the runway is dry (uniformly free of moisture, water, and contamination). It has been demonstrated that in conditions of contamination just below the reporting threshold, but concentrated in the most unfavorable location, the assumption of a dry runway still provides positive stopping margins.

Track surface conditions:

There are four track surface conditions in RCAM:

- ➔ **Dry track**
- ➔ **Wet track**
- ➔ **Slippery wet track**

a) Dry runway surface condition:

A runway is considered dry when its surface shows no visible moisture or contamination in the area to be used.

The RWYCC for a dry runway is 6

A dry surface should only be reported when it is necessary to report conditions on one or more thirds.

A dry surface will be reported when this report is the last one, the final report closing a period during which the runway was contaminated.

b) Etat de surface de piste Mouillée :

The runway surface is covered with visible moisture or water up to a thickness of 3 mm inclusive in the area to be used.

The RWYCC for a wet runway is 5.

The assessment of wet runways does not necessarily require direct observation of all affected pavement surfaces.

Credible evidence of wet conditions, such as receiving information indicating rain at the airport, may be used to justify assigning a "wet" RWYCC.

c) Runway surface condition Wet and slippery:

Wet runway where it has been established that a significant portion of the surface has degraded friction characteristics.

The RWYCC for a slippery wet runway is 3.

d) Contaminated runway surface condition:

A runway is contaminated when a significant portion of its surface (whether isolated areas or not), as defined by the length and width used, is covered with one or more of the substances listed in the runway surface condition descriptors.

RWYCCs are not reported for these contaminants—instead, they are reported in the plain language observations section of the RCR.

Types of contaminated runway conditions :

Compacted snow

Melting snow

Wet snow

Dry snow

Standing water

Frost

Wet ice

1. **Stagnant water:** water deeper than 3 mm. Running water deeper than 3 mm is conventionally reported as stagnant water.

2. **Frost:** ice crystals that form from atmospheric moisture on a surface whose temperature is below freezing. Frost differs from ice in that its crystals grow independently and therefore have a more granular texture.

3. **Ice:** water that has frozen or compacted snow that has turned to ice in cold, dry weather.

4. **Wet ice:** ice covered with water or melting ice.

5. **Compacted snow:** snow that has been compressed into a solid mass such that aircraft tires, under operating pressures and loads, roll over the surface without further compacting it or forming significant ruts.

6. **Soggy snow:** snow so saturated with water that it drips when you pick up a handful or squirts when you crush it with your foot.

7. **Wet snow:** snow containing enough water to form a solid, compact snowball without the water escaping.

8. **Dry snow:** snow that is difficult to form into a snowball.

Contaminants are generally divided into two categories:

- “fluid” contaminants: water, wet snow, slush, and dry snow,

- “solid” contaminants: compacted snow, frost, ice, and wet ice.

It is important to be vigilant, as a layer of “fluid” contaminants can cover “solid” contaminants.

Table 1 : RCR-Section aircraft performance calculations

Track Condition Report (RCR)	
Aircraft performance calculation section	
Information	Source
Airfield location indicator	ICAO Doc 7910, Location Indicators
Date and time of assessment	UTC time
Lowest runway identification number	Runway concerned (RWY)
RWYCC for each third of the runway	
Percentage of contamination coverage for each third of the runway	Assessment based on RCAM and associated procedures
Thickness of non-adherent contaminant for each third of the runway	Visual observation for each third of the runway
Description of conditions for each third of the runway	Visual observation assessed for each third of the runway, supplemented by measurements where necessary.
Width of the runway to which the RWYCC applies, if less than the published width	Visual observation for each third of the runway

Table 2: RCR Situational Awareness Section

Situational awareness section	
Runway length	NOTAM
Fine, dry snow on runway	Visual observation on the runway
Non-adherent sand on runway	Visual observation on the runway
Chemical treatment on runway	Known treatment application. Visual observation of residual chemicals on the runway
Snow drifts on runway	Visual observation on the runway
Snow drifts on taxiway	Visual observation on the taxiway
Snow drifts near runway	Visual observation on the runway confined by measurements where applicable.
Condition of taxiways	Visual observation, AIREP, reported by other airport personnel.
Condition of traffic area	Visual observation, AIREP, reported by other airport personnel.
Approved and published use by the State of the measured friction coefficient.	Depends on standards established or agreed upon by the State.
Observations in plain language using only authorized characters in uppercase letters	Any additional operational information that is important to report

Table 3 : Track condition assessment matrix

MATRIX FOR ASSESSING THE STATUS OF OISTES (RCAM)			
Evaluation criteria		Evaluation criteria for downgrading	
Code track condition (RWYCC)	Description of track surfaces	Aircraft declaration or observation regarding directional control	Driver reports on braking efficiency.
6	• Dry	---	---
5	• WET (the track surface is covered with moisture or visible water up to and including 3mm deep)	Normal braking response for wheel braking effort and normal steering control.	GOOD
4		Braking response or steering control between GOOD and POOR.	GOOD TO AVERAGE
3	• SLIPPERY (wet and slippery track)	Significantly reduced braking response for wheel braking effort OR significantly reduced steering control.	AVERAGE
2	Water depth greater than 3mm Standing water	Braking response or steering control between GOOD and POOR	AVERAGE TO POOR
1		Significantly reduced braking response for wheel braking effort OR significantly reduced steering control.	POOR
0		Minimal to zero braking response for wheel braking effort OR steering control.	BELOW POOR

Table 4 : Percentage coverage for contaminants

Estimated percentage	Percentage reported
10 – 25	25
26 – 50	50
51 – 75	75
76 – 100	100

6. Conclusions

The GRF provides pilots with accurate information on runway contamination, enabling them to calculate aircraft take-off and landing distances and thus improve safety levels. The performance and operational limitations of aircraft during landing and take-off depend heavily on the surface condition of the runway, which can be affected by poor weather conditions. In 2018, 24% of accidents resulted in runway excursions. Insufficient braking is the third leading risk factor for runway excursions during landing. Information on possible runway contamination is therefore crucial: only a precise characterization (nature of the contaminant, affected surface area, thickness) allows pilots to take these operational conditions into account for optimal safety, by accurately determining the take-off and landing performance of their aircraft.

Following several aircraft accidents, the International Civil Aviation Organization (ICAO) developed an improved global system for assessing and reporting runway surface conditions (Global Reporting Format or GRF). This system is designed to establish information on runway surface conditions in a more standardized and objective manner than previously, in relation to aircraft performance. It concerns all stakeholders (airport operators, ATS, air operators, aircraft manufacturers).

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