AIRCRAFT PERFORMANCE

ICAO ESAF WORKSHOP OF 19TH – 20TH OCTOBER 2021

PREPARED BY: CAPT. BEATRICE M. WAKHUNGU

FLIGHT OPERATIONS INSPECTOR

KENYA CIVIL AVIATION AUTHORITY

GLOBAL REPORTING FORMAT (GRF)

Emerging safety issues (ESI) in aircraft performance ushered in the global reporting format (GRF). This is a harmonized methodology developed by the international civil aviation organization (ICAO) for assessing and reporting runway surface conditions whenever a contaminant is present on an operational runway. It defines the information regarding runway surface condition that is communicated to flight crew, as it is directly relevant to aircraft performance.

Aircraft manufacturers provide performance information that can be used by the flight crew in their assessment of take-off and landing performance and GRF expounds on how to use the available data to build their awareness of the situation and its potential development.

Kenya Civil Aviation Authority has send out implementation action plan to all stakeholders for the applicability date of 4th November 2021. An AIC 17/21 and AC (CAA-AC-GEN040) have been circulated to the industry for advisory and information on GRF requirements.

Runway Surface Condition - Assessment and Reporting

Runway accidents and incidents are aviation's number one safety related risk category. A primary factor contributing to this risk includes runway excursions during take-off or landing in adverse weather conditions when the runway surface may be contaminated by snow, ice, slush or water, with a potentially negative impact on an aircraft's braking, acceleration or controllability.

GRF is an important means by which the risk of runway excursion can be mitigated and the safety of runway operations improved.

The report is intended to cover conditions found in all climates. It can be provided to the flight crew via various channels, such as the revised SNOWTAM or air traffic control. This is a conceptual change for airports as it no longer just reports a series of observations and measurements, but it also turns this information into an overall assessment of the effect that the surface condition has on the aeroplane performance.

The reporting process begins with the evaluation of a runway by human observation, normally performed by airport operations staff using runway condition assessment matrix (RCAM). A description of the surface contaminant based on its type, depth and coverage for each third of the runway, is then used to obtain a runway condition code (RWYCC) specific to the conditions observed. The evaluation and associated RWYCC are used to complete a standard report called the runway condition report (RCR) which is then forwarded to air traffic control (ATC) and the aeronautical information service (AIS) for onward dissemination to pilots.

The RWYCC reflects the expected braking capability as a function of the surface conditions. Pilots use the RCR provided to determine the expected performance of their aircraft (e.g. landing distance), by correlating the RWYCC or the reported runway condition description with performance data provided by the aircraft manufacturer. This helps pilots to correctly carry out their landing and take-off performance calculations for wet or contaminated runways. Pilots should also report their own observations of runway conditions once a landing has been completed, thereby confirming the RWYCC or providing an alert to changing conditions.

Training Requirements

Both airline operators and flight crew should be appropriately trained on runway surface condition assessment and reporting, and the impact on the aircraft performance data. While the methodology establishes a clear link between the observation, reporting and accounting for runway surface conditions in performance, it also creates new paths for errors that should be highlighted during the proactive training of crew. As the assessment of the runway condition, friction measurement, and estimation of braking action are not an exact science, it is important that training emphasizes that the methodology provides a toolset permitting an approximate assessment of the aeroplane performance rather than establishing exact aeroplane behaviour in terms of numbers.

The introduction of the runway surface condition assessment and reporting format has highlighted some specific areas that should be addressed as part of a training plan, including:

— Techniques used as a best practice for one organization may not be applicable for others.
Example:
Airports that operate frequently 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.

— Misunderstanding terminology. Technical discussions on runway observations and aircraft vehicle performance can have similar sounding terms and even numbers: “MU” being a primary example. Anyone using an RCAM should understand what the terms are, and how they are related.

— Timeliness of communication. Beyond 180 NM, flight crew may obtain information from airports in order to make runway surface condition assessments. Between 180 and 40 NM, any change in condition reporting must be communicated to the flight crew. Within 40 NM, any change in runway surface condition must be pro-actively communicated to the aircraft. Any change in condition that occurs too quickly for the flight crew to take notice of can invalidate their assessment and lead to unexpected risk.

— Conflicting reports between pilots and aerodromes. There may be a range of aeroplane performance indicators for a given runway. In some cases, the AIREP of braking action 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, the process must be carefully designed to demonstrate and maintain an equivalent level of quality assurance regarding risk exposure.

— Operational bias. Much of the observational criteria for an RCAM depends on judgment that can be subject to social, political and economic pressures. The differences between 3 mm and 5 mm 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 favour 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 the perception, assessment and reporting of runway surface conditions from flight crews and airports

General Considerations for Aeroplane Performance on Contaminated Runways/ Adverse Weather Operations

Aircraft deceleration results from a combination of factors. First, there are the aerodynamic drag forces generated by the airframe and, in particular, the ground spoilers. Second, reverse thrust may be used if available. Finally, deceleration occurs from wheel-to-ground friction, which is of course influenced by the runway surface, as well as by manual or automated braking of the aeroplane.

Performance computations assume a homogenous distribution of the contaminant along the entire length and width of the runway. A runway will be considered contaminated if one of the thirds has contaminant coverage in excess of 25 per cent. Flight crew may use the most penalizing contaminant for performance computation, which may be excessively conservative. For this reason, the operator should have policies about disregarding a part of the runway. In such cases, the operator should give explicit guidance e.g. crosswind analysis, etc.

The operator's manuals should contain specific instructions and information to flight crew members for operating each type of aircraft operated in adverse weather conditions or prohibit such operations. The Authority also reviews the content of the operator's training program to ensure adequate coverage of winter conditions and adverse weather operations.

The following subject areas should be considered in the operator's training program. These items are neither comprehensive nor exclusive, and the Authority may require additional criteria:

a) The requirement for a thorough pre-flight inspection in extreme temperatures;

b) A description of the performance and control problems that would differ from normal conditions during take-off and landing with water, slush, or wet snow on the runway;

c) The speed, weight, and runway length adjustments that would be made when operating on contaminated Rwy

d) Criteria for take-off, en-route, and destination weather conditions;

e) The causes and effects to the aircraft from hydroplaning or aquaplaning;

f) The effects of increased viscosity of fluids in cold temperatures;

g) Adverse effect of cold temperatures on hydraulic fittings and seals;

h) The effects of cold weather conditions to fuel pumps and fuel filter drains;

i) Fuel contamination, fuel leaks caused by cold weather operations;

j) The hazards associated with wet snow or slush in wheel wells when entering freezing temperatures;

k) Techniques and procedures for braking, steering, and reversing with water, slush or snow on taxiways and Rwy

l) De-icing and anti-icing procedures and equipment for frost, ice, or snow removal from air foils, control surfaces, and static ports;

m) Proper adjustment of cables and rods used to manipulate flight controls;

n) A description of landing surface conditions and appropriate braking action.

PERFORMANCE DATA COMPUTATION AND ACCEPTANCE

Performance data computation system is defined as the system an operator uses to produce the data required to operate an aeroplane within the performance limitations specified in the aircraft flight manual (AFM). The performance data computation system consists of at least the following components:

- An airport data acquisition,
- Maintenance, and
- Dissemination system (a necessary subsystem for all aeroplanes operated under the civil aviation regulations).

The majority of this data is available from commercial and government aeronautical charting services. Operators of large transport and commuter category aeroplanes, however, require obstacle data for take-off computations that are more detailed than those usually supplied by a standard charting services. Data may also be obtained from the AFM directly or purchased in a digital format suitable for computer processing.

Manual computation procedures or a computer algorithm is used for converting aircraft performance data from the AFM format to the format used by the flight crew. The system must make all necessary computations for determining the maximum allowable weight for take-off and the V speeds to be used at the selected weight, for each variant aircraft operated.

Current Industry Practices: There is a wide range of methods for collecting airport and obstacle data, preparing airport analyses and, for publishing and distributing the performance data. To implement all of these functions, operators may either establish a department within the company or contract the work out. Generally, major operators do more of this process in-house, while smaller operator's contract for these services.

Acceptance Criteria: The Authority accepts any method of performance data computation and presentation that meets the following criteria:

(a) The system must make all of the computations required in the AFM and in the pertinent operating rules;

(b) Provisions must be made in the system for all makes, models, and variations of aircraft used by the operator;

(c) The system must account for all pertinent variables such as temperature, weight, thrust, runway condition, and obstacles;

(d) The system must be appropriate to the operator's requirements. Large, highly complex aeroplanes usually require very different systems from those required for small, simple aeroplanes;

(e) The system must be reliable in that identical answers must be generated each time the process is entered with identical parameters;

(f) The system must be accurate in that it generates performance data that agrees with AFM data within the degree of accuracy inherent in the original AFM data. For example, when the AFM data is accurate to ±2%, the operator's system must produce results that do not deviate from the AFM data by more than ±2%;

(g) The system should be relatively simple, easy to use, and not prone to error;

(h) When simplifying assumptions are made, those assumptions must be clearly and completely stated in the operator's Operations Manual as operator imposed limitations (e.g. a maximum field elevation of 4,000 feet/1220 metres and minimum runway length of 5,000 feet/1520 metres). When the assumptions cannot be met, the actions to be taken by the flight crew, and flight operations officers must be clearly specified. In such cases, operations must be prohibited or alternate procedures specified;

(i) The flight crew procedures for generating, obtaining, and verifying data must be thoroughly described in the procedures section of the Operations Manual. In the case of the same procedure applying to all aircraft variants, they must also be described.

MANUAL COMPUTATION SYSTEM FROM AFM DATA

Operators may choose to have flight crew and flight operations officers, conduct manual data computations from the AFM performance section for each take-off.

This system is flexible because it can be used for any runway for which the required input parameters can be obtained. The disadvantage of such a system is that computations can be difficult, complex, time consuming, and error prone. Flight crew and flight operations officers must be carefully and thoroughly trained in such a system.

While this system is widely used for small aeroplanes, it is impractical for the routine operations of large aeroplanes because of the complexity of the required computations and the high probability of human error. The system is, however, available to the operator for backup in the case of computer failure and for special one-time requirements.

TABULATED DATA METHOD

AFM data may be combined with airport and runway data and published in tabular format, which is usually termed as airport analysis. Typically, the flight crew are provided with a table for each runway and flap setting. They then enter the temperature on the table to determine maximum allowable take-off weight and then enter the actual weight to determine the V speeds. Additional corrections are required for factors such as wet or contaminated runways and winds.

Tabulated data is easier to use, less error prone and requires less training than for AFM data. A tabulated data system reduces, but does not eliminate, human error. A disadvantage of the tabulated data system is that flight crew must maintain an up to date chart for each runway from which operations are authorized. Also, provisions must be made for temporarily shortened runways.

The operator must be capable of generating performance data tables which retain the degree of accuracy inherent in the AFM data. This must be done manually, by carefully picking data points from a graph, entering the data into a computer, and verifying the generated points. The amount of work required to prepare tabulated data from an AFM often precludes operators from generating their own data packages. Often the operator will opt to buy a digital data package from the manufacturer from which to generate the required tables.

SIMPLIFIED DATA METHOD:

A simplified data system is based on a specified set of assumptions about the conditions under which the aircraft will be operated. For example, take-offs might be limited to runways longer than 5,000 feet/1520 metres and less than 4,000feet/1220 metres elevation. In this system, the flight crew is supplied with a simple chart or set of cards which gives the V speeds at specified weight increments. This chart is used on all runways.

The operator performs an airport analysis for each airport served and demonstrates that when the aircraft is operated in accordance with the specified set of assumptions, it will perform either equal to, or better than, the performance required in the applicable regulations on all runways the crew member is authorized to use.

Some of the system's advantages are: its relative simplicity, the lack of crew member error, the ease of crew member training, and the speed with which the crew member can determine V speeds. Some of the system's disadvantages are: it often imposes severe performance penalties on operators, it is inflexible, and operations must either be terminated or an alternate system used when the simplifying assumptions cannot be met (e.g. construction, part of runway closed, ice or rain). The system is best suited for operators who serve a limited number of locations regularly and who operate either at large airport, near sea level, or at moderate temperatures.

REAL TIME METHOD

- Real time data system is one in which the required computations are made immediately before take-off for every flight. Usually the data is relayed to the flight crew member by radio or through Aircraft Communications Addressing and Reporting System (ACARS).

The advantages of such a system are that it is extremely flexible, up to date, and efficient. Changes in obstacles due to construction, weight, temperature, and runway can be handled immediately. Also, the operator can take maximum advantage of the performance capabilities of the aeroplane.

Some disadvantages of the system are that it is expensive, it requires extensive equipment and highly trained personnel to operate, and that adequate backup must be available should the main computer go off line.

EVALUATION OF AN OPERATOR'S SYSTEM

The Authority does not have the capability to verify each data point when accepting the performance data section of a manual. However, the validity and reliability of the computation system itself, can be evaluated. FOIs shall require the operator to provide an analysis, with documentation, of the following:

- Source of the computer program;
- Assumptions on which the computer program is based (for example, they must determine if the correct factors are used for each type of aircraft);
- Source and accuracy of the databases used;
- Operator's capability for handling data;
- Results of parallel manual calculations made with AFM data to confirm results.

When the operator contracts for data or computation, the operator is responsible for the validity of the results. The FOI may accept reputable sources for these services that have been previously evaluated and accepted for another operator without the documentation discussed above. If the contractor's capabilities and qualifications have not been previously established, the FOI shall require the operator to fully substantiate the contractor's qualifications before accepting the operator system.

Operators should procure computer programs from a reliable source. The computer programmers should be qualified in both education and experience. The computer program should be validated by aeronautical engineers and computer specialists.

All of the calculations required in the regulations for the type of aircraft involved must be performed, including en-route and destination calculations.

For real time systems, the operator's method of obtaining data for a specific flight and for transmitting that data to and from the individual performing the calculations must be shown to be accurate and timely.

A designated inspector should review the verification process conducted by the operator. Several runways at different airports should be selected for verification with the AFM data. Short runways with obstacles should be checked by manual calculations, particularly at airports with higher temperatures and elevations.

The operator should be able to identify all of the obstacles evaluated by the computer and the one selected as the limiting obstacle in each case. Under different temperature and weight conditions, a different flap setting may be required, and different obstacles may be controlling. The limiting obstacle under various conditions and flap settings should be verified.

CHALLENGES AND POSSIBLE SOLUTIONS FOR AIRCRAFT PERFORMANCE

Global Reporting Format issues

- Operators should be aware of the runway maintenance program and wet runway friction capability at the airports in 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, while very wet or during active precipitation,
- Runway surface condition assessment and reporting
  there can be difficulties in making reports of braking action for the pilot since these reports are intended to characterize only one of the aeroplane deceleration elements: the availability of wheel braking. Landing on slippery or contaminated runways require different techniques and results in energy dissipation by aerodynamic means, use of reverse thrust, and applied wheel braking in different proportions than during a normal landing. The lack of wheel-to-ground friction during the high speed portion of the landing may thus not be immediately apparent to the pilot.

Dealing with Ambiguous Information

- If, for any reason, the information seems ambiguous to the flight crew, they should actively search for clarification. Error may include the improper insertion of data into the computation tool or outdated information. All available sources should be used to clarify conflicting information. In the case of unresolved situations of ambiguity, the flight crew should use conservative decision making and prioritize flight safety.

- Some airports may continue to provide measured friction values in the RCR. There is no strong correlation between the measured coefficient of friction (mu-value, μ) and aircraft braking action, especially for slush and wet snow. Friction measurements may be provided in the dedicated situational awareness section of the RCR. This information should only be used for performance calculations if the operator has an approved procedure for correlating the reported friction with aircraft performance (braking action). When such procedures are not available, the flight crew should request and rely on RWYCC for the performance assessment.

Challenges associated with Data collection and analysis

1. Accuracy during manual data collection, entries and computations,
2. Data acquisition capabilities for especially smaller operators,
3. Accurate and updated airport data that is supplied by contracted companies,
4. Expensive and complex equipment required for performance computations,
5. Some manual data may carry residual errors during manual computations,
6. Lack of qualified expertise in human resource for data collection and analysis, as well as aircraft performance computations.