Runway Safety Guide

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1 INTRODUCTION

Aviation safety is a shared responsibility between pilots, operators and regulators. It is by working together that we are able to identify risks and develop effective mitigation strategies to further improve the safety performance of the aviation system.

This Runway Safety Guide has been developed by IFALPA's Aerodrome Ground Environment (AGE) Committee, with input from pilot Member Associations (MA's) and in consultation with the Aircraft Design Operations (ADO) Committee for technical counsel. The primary focus of this guide is to safeguard the operation of aircraft within the aerodrome environment. Accident statistics have shown that runway related accidents have the second highest casualty rate in aviation. The global aviation industry is faced with the challenging demand of diminishing land accessibility and an increase in number passengers and cargo shipments travelling by air. It is our focus and our goal to ensure the safe standard of the global aviation industry through best practices, techniques and proposals for regulations.

Flight crews must manage the risks of excursions, incursions and runway confusion. All three areas pose significant, yet different risks to the safety of aircraft, passengers, crew and the environment. IFALPA is in a unique position to harness the skills, knowledge and experience of the global pilot community in developing recommendations to assist aerodrome and aircraft operators as well as aircraft and equipment manufacturers in adopting the best safety practices possible.

The Runway Safety Guide is based on the safety best practices and standards in the aviation industry. It provides suggestions for improvements and solutions, recognising the challenges faced by the 21st century aviation industry.

2 RUNWAY SAFETY

When discussing the topic of runway safety, we focus on three principal incident types: runway excursions, runway incursions, and runway confusion. A runway excursion occurs when an aircraft departs the runway surface, either by veering off the side or running off the end, referred to as an overrun. A runway incursion occurs when an aircraft enters a protected area or surface of an active runway without a clearance. Finally, runway confusion occurs when an aircraft uses a runway or other surface that was not designated or assigned to it for the purposes of landing or taking off.

attributed to unstable approaches, mechanical malfunctions, meteorological occurrences (such as a contaminated runway) and other contributing factors. Following a runway excursion, the survivability of the crew and passengers is enhanced by fully equipped and well-trained Rescue and Fire Fighting (RFF) services, as well as the provision of a runway end safety area or an arresting system such as an Engineered Materials Arresting System (EMAS). Such measures are essential to provide the best chance for minimizing injury or death to passengers or crews following an incident or accident.

2.1 RUNWAY EXCURSIONS

A runway excursion is occurrence involving the departure, wholly or partially, of an aircraft from the runway surface during take-off, landing, taxiing or while manoeuvring[1]. Runway excursions can be

[1] ICAO Runway Safety Team Handbook, 2nd Edition, June 2015

2.2 Runway Incursions

A runway incursion is defined as any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft. The ICAO Manual on the Prevention of Runway Safety Incursions (Doc 9870) provides specific guidance on the establishment and objectives of a runway incursion prevention program. At airports, the tendency towards 'organic' growth and development has led to the existence of runway incursion 'hotspots' which are depicted on aerodrome charts. IFALPA's view is that it is not enough to merely recognise that these hotspots exist, once they are identified and they must either be removed or have their effects mitigated within a reasonable timeframe.

Caution must also be exercised during the development of procedures to enhance airport capacity. Experience shows that such procedures have been planned without a full analysis of the effect on incursion risk. Simultaneous operations on intersecting runways, the concept of Land and Hold Short (LAHSHO), are classic examples of procedurally increased runway incursion risk. Such risks generally involve severe consequences. Historically, runway incursions have contributed to some of the world's worst aviation accidents, such as the Tenerife disaster in 1977.

2.3 Runway Confusion

Runway confusion occurs when an aircraft makes unintentional use of an incorrect runway or a taxiway for landing or take off. This particular issue occurs more often at aerodromes with parallel runway configurations where it is relatively easy to mistake runways and/or taxiways during the day or night. It should be noted that with parallel runway configurations, the 'confusion' of a parallel taxiway to the runway should be briefed appropriately as a 'threat' prior to departure.

KEY ELEMENTS OF AIRPORT DESIGN FOR LOW RUNWAY INCURSION RISK

- Runway crossings are avoided by design.
- Stop bars are provided at runway/taxiway intersections and in use 24/7.
- Taxiway system designed to minimize restriction to aircraft movement to and from the runways and apron areas. Capable of maintaining a smooth, continuous flow of aircraft ground traffic at the maximum practical speed with a minimum of acceleration or deceleration.
- Entrance Taxiways to a runway are restricted to those required for lining up for take-off and perpendicular to that runway.
- No requirement to cross a runway. If there is a requirement for aircraft and/ or vehicles to cross a runway, a perimeter or "end around" taxiway or a perimeter service are provided.
- If a runway crossing is unavoidable and the end around option is not available, traffic flows are modified so that they are only at points where traffic on the runway will be at low speed.
- Runway exit taxiway include a straight portion following the turnoff curve sufficient for an existing aircraft to come to a full stop, clear of both the active runway and an intersecting taxiway.
- Rapid exit taxiways are constructed in such a way that crossing another runway via a rapid exit taxiway is not possible.
- Taxiway designation follows the principle that as few as possible different names are given to one routing. However, a taxiway that intersects with a runway should have different designations on either side of that runway. *Note: IFALPA has produced policy on taxiway naming.*

Flight crews can reduce the risk of runway confusion through the use of the following mitigations:

- Conducting thorough pre-departure and approach briefings and assess the associated threats.
- Pay careful attention and read back assigned runways, taxiways and holding points using correct phraseology.
- When conducting a non-precision, circling or visual approach, take sufficient time during the approach briefing to confirm how you will positively identify the correct runway and landing environment.
- When taxing at the aerodrome ensure the correct taxiway or runway signage, orientation and markings are used in conjunction with the aerodrome chart to positively identify your position on the aerodrome. If unsure of your position, stop the aircraft and ask Ground (Surface Movement Control) for instructions or assistance.
- When lining up on the runway for take-off, check that it is the assigned runway by using the markings (e.g. 25R) and ensuring that the ILS localizer (if available) is centered.
- Confirm that the markings and lighting match what you expect, i.e. that markings and lighting are for runways.

2.4 Stable Approach

Although airline operators generally define more specific requirements to their stable approach criteria, IFALPA recommends the following ***MINIMUM*** stabilised approach criteria:

- the aircraft is in its landing configuration (landing flap set and wheels down) and
- is stable in path, vertical profile and speed at or before 1000 feet above ground level in instrument meteorological conditions and 500ft in visual meteorological conditions.

This reflects the Flight Safety Foundation Approach and Landing Accident Reduction (ALAR) program which states in its Briefing Note 7.1 that the three essential parameters to a stable approach are tracking, flight path angle and airspeed.

Note: these are the minimum criteria and your airline may have imposed higher limits.

If an aircraft does not meet these criteria by the 1000ft (IFR) or 500ft (VFR) gate, then a missed approach or go-around should be executed. If the approach becomes unstable after passing the stabilization height, for example as a result of wind shear or microburst, a go-around should also be executed. Causes of unstable approaches can be and include: fatigue, schedule pressure, crew or ATC induced circumstances, lack of situational awareness and excessive energy (speed) or altitude, to name a few.

One of the few recurring issues is the 'rushing' of an approach by pilots. Conducting a thorough yet concise briefing can help to eliminate any ambiguities, while enhancing overall situational awareness. This combined with the ability to detect, correct and decide during the approach phases increases the chances of a safe and efficient approach and landing. Some examples of positive correction would be requesting further track miles to facilitate descent, advising ATC if unable to comply with an instruction, or asking for a clarification of an instruction where ambiguity may exist.

There is strong evidence that a stable approach is easier to achieve with precision or PBN-approach than with traditional non-precision, circling or visual approach. Operators' standard operating procedures should include a policy with regard to the decision to go-around, encouraging the crews to do so in case the approach is not stabilized. Operators should promote a non-punitive "go-around" policy and remind crews that approaches should be discontinued if any safety criteria are not met, for example, an occupied runway, an incursion or an unstable approach.

✈ LEARN MORE
Unstable Approaches – Risk Mitigation Policies, Procedures and Best Practices

2.5 Approach Flight path design

The approach flight path design must consider and meet the performance capabilities of the aircraft and crews expected to use it. The increased use of noise emission reduction strategies such as Continuous Descent Approaches (CDA) place more emphasis on energy management.

Approach Procedures with Vertical Guidance (APV) assist flight crews to achieve a stabilized approach. IFALPA supports the concept that all Non Precision Approaches (NPA) must be flown using the continuous descent final approach (CDFA) technique unless otherwise approved by the authority for a particular approach to a particular runway".

The corollary being that all approaches designed without a FAF are not encouraged; and should be avoided until they can be replaced by more efficient procedures in accordance with ICAO PANS Operations (Doc 8168) Chap.II.2.3.1.

IFALPA, therefore, has two strong positions:

1. Replace multi-step-down profiles by one or more continuous segments at constant slope; and
2. Replace circling approaches by approaches with lateral and vertical guidance wherever terrain clearance considerations permit.

The multi-step down profiles and circling approaches are considered obsolete and their design poses an unnecessary high risk in the twenty first century. Circling approaches have been universally regarded as dangerous and have attributed to countless Controlled Flight into Terrain (CFIT) accidents.

> ✈ LEARN MORE
> IFALPA Position on Vertical Approach Profile

> ✈ LEARN MORE
> IFALPA Position on Circling Approaches

IFALPA supports the concept that an approach should have a constant slope, ideally 3 degrees. If approach requires 3.5 degrees or steeper path or contains any segments with steeper than 3.5 degrees fight path, and rates of descent in excess of 1,000 feet per minute below 1,500 feet AAL (above aerodrome level), they should only be implemented as an exception and primarily for terrain reasons. Furthermore, any approach that deviates outside of the standard recommendations should be thoroughly researched and the appropriate safety mitigations should be undertaken prior to their implementation. In addition, the aircraft should be certified for such operations, the crew trained appropriately and the aerodrome and runway installed with the required approach and landing facilities and aids.

IFALPA promotes the global implementation of approaches designed on the concept of Performance Based Navigation (PBN).

> ✈ LEARN MORE
> IFALPA Position on Performance-Based Navigation

2.6 Missed Approach / Go Around

If the stabilized approach criteria cannot be achieved or maintained in accordance with the parameters defined by the airline operator in its operations manual or if the approach has become destabilized at any subsequent point beyond the stabilization altitude gate, a go-around should be executed.

Operators should reinforce this policy through their various training and checking programs. An operations training program should cover various go-around situations to enhance flight crew decision making and operating techniques. Thus, providing pilots with a range of scenarios and situations where a missed approach will need to be conducted and equip them with the skills and confidence to do so.

The option to go-around exists until the deployment of reverse thrust/power and spoilers. When a go-around has been initiated, it must be continued until the missed approach altitude has been reached, following the relevant procedures for the missed approach. Reversing a go-around decision can be hazardous to the safety of flight and it should be made clear that once a missed approach has been initiated it should be completed in its entirety.

Operators should establish and communicate a non-punitive go-around policy and encourage their flight crews to adhere to the stabilization criteria that are stipulated in their operations manual. Flight crew should be encouraged to include the missed approach procedure and any pertinent details as part of the approach briefing to improve situational awareness of all crew members.

✈ LEARN MORE
IFALPA Briefing on Go-Around, Missed Approach and Baulked Landings

3 AERODROMES AND AIRPORTS

3.1 AERODROME INFORMATION

Information about an aerodrome must always be factual, accurate, timely, relevant and representative of the conditions prevailing at an aerodrome at a given point in time. For this information to be as effective as possible in conveying the information to crews, it must be presented in a standardised "pilot friendly" format that is easily understood and as concise as possible. The information passed to crews should include, but is not limited to, latest weather, runway surface characteristics, condition and other relevant safety or operational information.

3.2 AERODROME PHYSICAL CHARACTERISTICS AND EQUIPMENT

The primary focus of the design of the active areas of an airport should be safety of operation. The ICAO Aerodrome Design Manual (Doc. 9157) provides the base elements for good aerodrome design. However, there are design area above and beyond the recommendations in the manual which can reduce the potential for runway incursions.

Runway incursion prevention measures should be a part of the design and construction of new runways and taxiways as well as for modification and upgrade of existing infrastructure. A key element of this is a design where runway crossings are not required by aircraft or vehicles transiting from one part of an airport to another.

As a general principle the airport's layout should be instinctive and logical to its users. Taxiways should be constructed in such a way that the normal routing between the runway(s) and parking stands is logical and as simple as possible. The number of taxiway intersections should be limited, as much as possible, and avoided where not absolutely required for the safe flow of traffic.

Stop Bars/Runway Status Lights

Runway incursions can and have taken place in all types of weather, visibility and lighting conditions. One of the most effective means to reduce runway incursions is the installation of runway guard lights and stop bar lights at taxiway/runway intersections. To be fully effective, these lights must be used at all times when an airport is in operation day or night. Newer innovations, such as automatically operated runway status lights, provide an additional independent barrier to prevent runway incursions.

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IFALPA Briefing on Runway Status Lights

For Stop bar systems to be truly effective they must have the following characteristics:

- Be selectively switch-able by the appropriate air traffic controller,
- Be installed at all aerodromes with runway crossings,
- Be provided at every runway holding position serving a runway, including non-active runways, and

- In the event of control failure, procedures are in place so that aircraft do not cross red stop bars unless contingency measures are in force.

3.3 Runway Categories

Dry runway performance is generally based on actual flight test data without the use of reverse thrust.

Wet performance is classified as following;

A	Very smooth concrete and some smooth asphalt – Category A runways are very smooth surfaces and are of a type that is not frequently used by transport category aircraft.
B	Lightly textured concrete and small aggregate asphalt
C	Heavily textured concrete and harsher types of asphalt – this is the most heavily textured type of un-grooved runway
D	Shallow and/or widely grooved or scored surfaces and large aggregate asphalt
E	Deep grooved and or Open textured and Porous Friction Course (PFC) surfaces

The surface texture in Categories A to C varies between 0.1 to 0.5 mm (0.004 and 0.02 of an inch). In the calculations used in aircraft certification regulations [CS25 (EASA) and CFR25 (FAA)], the surface texture assumed for tire to surface friction coefficients is between B and C. Studies by both EASA and the FAA showed that grooved and Porous Friction Course (PFC) surfaces offer substantial benefits in wet conditions; and that 70% of the dry runway braking performance is available from a properly constructed and maintained grooved or PFC runway in wet conditions. Grooving is to be considered as one method to maintain adequate friction on the runway, but a grooved runway should not give any credit in performance calculations (dispatch or in flight) i.e. a wet grooved runway should still be regarded as “wet” and not “dry” or “partly dry” for the purpose of the performance calculations.

3.4 Runway state definitions

Flight crews need to have a proper understanding of the runway they are about to use to ensure operational safety. There is a need for pilots to review the atmospheric conditions, as well as the runway condition, prior to arriving or departing. To facilitate this, there must be a globally harmonized system of runway condition reporting. At present there is a lack of harmonization in runway condition reporting.

Runway condition reporting should be done in three separate sections: Touch Down Zone (TDZ), Middle (MID) Zone and End (END) Zone. The runway condition can vary between each individual section. Some of the definitions are ambiguous and allow for an interpretation of the conditions that risks being manipulated by commercial pressures or could lead to operational confusion.

The following definitions are problematic for flight crews and require special consideration operationally:

Damp

There is clear evidence that a damp runway does not provide an equivalent braking surface as a dry runway. Where the runway is reported as “damp”, it is advisable to use “wet” when calculating performance for landing and takeoff. This will always result in a more conservative calculation. Dry runway landing performance is based on NO reverse thrust to take into account poorer friction on operational runway surfaces.

Slippery when wet / wet slippery

“Slippery when Wet/ Wet slippery” is a runway state in which runway maintenance should take place. A uniform minimum friction level should be specified by ICAO and used globally for harmonization (see RCAM Matrix below). A NOTAM should be published and remain in place until the required runway maintenance has taken place. This allows the flight crew to estimate surface friction using the weather information in performance assessment phase of a departure or arrival. In performance calculations “Slippery when wet / wet slippery” runway should be treated as the runway with medium braking action. States are discouraged from stating “Slippery when wet / wet slippery” in the AIP as a permanent condition as the required maintenance to provide a proper level of friction should be performed. In addition, the ICAO Friction Task Force's recommendation is to stop using the term "Slippery when wet", as the relationship between the term and aircraft performance has not been established.

Standing water

Standing water is an ICAO runway surface condition descriptor for water depth greater than 3mm. Moving water of a depth greater than 3 mm is also reported as standing water by convention. Standing water can cause a reduction in friction capabilities beyond those assumed in scheduled performance data for wet runways. When standing water is present on a runway there is a risk that aquaplaning may occur. The expected speed for aquaplaning should be defined by the airplane manufacturer.

Pilots should be aware that the standard aquaplaning rule-of-thumb is based on a smooth tire (no tread) and that this rule of thumb is valid whenever the water depth on the runway exceeds the existing tire tread depth.

Flooded

It is impossible to quantify the water depth for the moment when "standing water" becomes "flooded".

Regardless, the runway is considered 'Wet' for takeoff and landing calculations as the most conservative approach, even if the runway is damp.

Note: Laboratory research in combination with empirical methods may give insight into the drainage capacity of a runway under certain weather conditions. These methods should be used to warn flight crews about possible flooding. Due to the uncertainties involved, such as measurement of rain intensity, crosswind effects, runway degradation etc, these methods should not be used to determine dry or wet runway state.

Contaminated

A runway is contaminated when a significant portion of the runway surface area within the length and width being used is covered by one or more of the substances listed in the runway surface condition descriptors. This can be across the whole length of the runway or in isolated sectors. The substances are as follows:

- Compacted snow
- Dry snow
- Frost
- Ice
- Slush
- Wet ice
- Wet snow

Note: Under certain conditions such as the presence of salt or moisture certain winter contaminants can have unexpected low friction capability. Examples are slush, wet snow and coastal airports with contaminated runways, or contaminated runways in combination with high humidity content (dew point depression 3 degrees Celsius or below).

Note: Braking action should be classified as good, medium to good, medium, medium to poor or poor. However, as pilots do not have training on how to assess braking action the (subjective) PIREPS should use only the Good-Medium-Poor-scale.

The effect of all natural or unnatural contaminants on aircraft performance should be taken into account. Displacement and impingement drag affects aircraft acceleration and braking characteristics. The effects of contaminants on aircraft braking may be provided as generic braking action values for a particular aircraft depending on the type and amount of contaminant or may be based on friction measurements. Generic braking action values or friction measurements should adequately correlate with aircraft performance. In case adequate correlation between generic braking action values or measured friction values with aircraft performance is not possible, sufficiently large safety factors should be utilized.

Note: Present Continuous Friction Measuring Equipment (CFME) runway friction measures are not well correlated with actual aircraft behavior and performance. New aircraft systems are under development. Such automatic systems which send measured runway/aircraft friction data from the aircraft to a central data unit would give a timely indication to aircraft operators and airport operator. This capability does not mean a previous calculation will be always accurate. For example, following aircraft may have a slightly different ground track, the geometry of aircraft landing gear may be different and aircraft landing weight will/may be different.

As explained above, the friction values do not correlate directly with any of the runway braking efficiencies (Good, Medium etc.). RCR (Runway Condition Report) - a new ICAO global reporting format for runway condition reporting- has been introduced. RCR uses the codes presented in the table below and simplifies the coding as the contaminants will be reported in plain language. RCR will be defined in ICAO Annex 15 and PANS ADR (Aerodromes).

Runway Condition Assessment Matrix (RCAM)				
Assessment Criteria		**Downgrade Assessment Criteria**		
Code	Runway Condition Description	**Mu (μ)** [1]	**Vehicle Deceleration Or Directional Control Observation**	**RWY Braking effiency**
6	• Dry		---	---
5	• Frost • Wet (Includes Damp and1/8" or less depth of Water) ***3mm or less depth of:*** • Slush • Dry Snow • Wet Snow	40 or Higher	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal	Good
4	***-15ºC and Colder outside air temperature:*** • Compacted Snow	39 to 30	Braking deceleration OR directional control is between Good and Medium.	Good to Medium
3	• Wet ("Slippery when wet" runway) • Dry Snow or Wet Snow (Any depth) over Compacted Snow ***Greater than 3mm depth of:*** • Dry Snow • Wet Snow ***Warmer than -15ºC outside air temperature:*** • Compacted Snow		Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	Medium
2	***Greater than 1/8" depth of:*** • Water • Slush	29 to 21	Braking deceleration OR directional control is between Medium and Poor.	Medium to Poor
1	• Ice [2]		Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	Poor
0	• Wet Ice [2] • Water on top of Compacted Snow [2] • Dry Snow or Wet Snow over Ice [2]	20 or Lower	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	Less than poor

Runway State NOTAMs

Whenever the friction measurement of a runway drops below the Minimum Friction Level (MFL), a "Slippery when wet" Notice to Airmen (NOTAM) should be issued warning crews of the runway's surface condition since landing performance charts or automatic calculation programs will no longer be accurate for calculating the required landing distance once the runway is wet. It is important for flight crews and dispatchers to understand the significance of such NOTAMs. Operators should supply performance data for these conditions as provided by the manufacturer, in the event that the manufacturers do not have the performance data, it should be calculated and shared with operators.

Minimum Friction Level (MFL) is minimum friction level specified by the State (see Annex 14, Vol I., 10.2.2) when surface friction characteristics, often during active precipitation, reach level when runway maintenance should take place according to the runway maintenance program.

Even so, the provision of this information risks masking the underlying problem, i.e. "treating the symptom rather than the disease". Airport operators should have in place an effective runway maintenance programs that give sufficient lead time to implement preventative and/or corrective maintenance to ensure reasonable wet weather performance.

Dispatch to contaminated runways

The flight crew should conduct 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 condition. 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 most cases, it is expected that the landing distance verification can simply to confirm that the assumptions used at the time of dispatch are adequate and no further calculations are required.

3.5 Runway Drainage

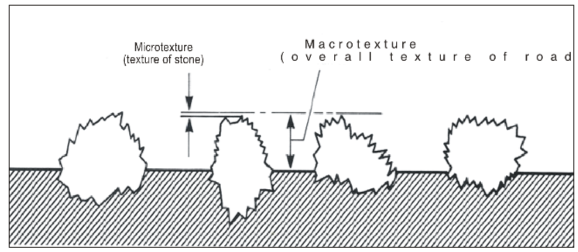
With the introduction of aircraft with higher approach and landing speeds, braking performance on pavement surfaces has become more critical as, under certain conditions, aquaplaning or loss of friction can occur, resulting in poor braking performance or possible loss of directional control. The phenomenon of aquaplaning is complex, but the principal parameter which determines the speed at which aquaplaning will occur is tire pressure. High macrotexture on the runway surface has a positive effect by facilitating drainage of the tire-runway contact area. On typical airliners, dynamic aquaplaning can be expected to occur in the runway conditions above ground speeds of 110kts to 130 kts. Once started, the dynamic aquaplaning effect may remain a factor down to speeds significantly lower than those necessary to trigger it.

Efforts should be concentrated on ensuring high skid-resistance in pavement design and maintenance. There are factors that contribute to the degradation of a runway, they include, but are not limited to; runway conditions such as texture (polished or rubber contaminated surfaces), drainage, puddling in wheel tracks and active precipitation. Experience with regards to runway performance indicates that an additional 30-40% stopping distance may be required where the runway is very wet, but not flooded. On the other hand, a runway surface that is designed, constructed and maintained to have good water drainage, minimizes the risk of aquaplaning and provides aircraft braking performance shown to be better than that used in the airworthiness standards for a wet, smooth runway. The problem of friction on runway surfaces affected by water can be expressed primarily as a generalized drainage problem consisting of three distinct criteria:

1. Surface drainage (surface shape, slopes (both longitudinal and transverse directions)
2. Tire/ground interface drainage (macrotexture) effective especially for high speeds and directional control; and
3. Penetration drainage (micro texture) effective especially for lower speeds.

Today there are technologies available that can measure runway surface shape and slopes very accurately. Also, rain fall rate can be measured accurately, as equipment installed at some airports has demonstrated. Mathematical analysis of runway drainage characteristics, in combination with expected local precipitation rates and duration, including heavy tropical rainfall, if applicable, verified by actual measurements on the runway, is recommended in determining the actual drainage capability. “Drainage demand”, therefore, is a local variable which will essentially determine the engineering effort required to achieve proper drainage. The objective is to drain water off the runway using the shortest path possible and specifically away from the area of the wheel path. To promote the most rapid drainage of water, the runway surface should be cambered, except where a single cross fall from high to low in the direction of the wind most frequently associated with rain would ensure rapid drainage. Drainage capability can, in addition, be enhanced by special surface treatments, such as grooving or a Porous Friction Course (PFC), which, in the latter case, drains water initially through voids of a specially treated wearing course. An appropriate maintenance program should ensure adequate side drainage, rubber removal and cleaning of runway (non-winter) contaminants.

Various studies have been performed over the past decades to relate rain intensity and runway characteristics to water depth on the runway. Water depth on the runway determines what aircraft performance data should be used (“regular” wet or standing water performance).



3.6 RUNWAY FRICTION & BRAKING

Industry research and scientific projects are currently assessing the feasibility of determining runway friction coefficients through real-time transmission of braking efficiency data from landing aircraft. Whilst this method would provide valuable runway status information to other runway users, ATC and airport authorities, the design and operating philosophy of such equipment must be safe and suitable for normal line operations. Safety aspects, such as reliability across aircraft types and braking systems used, need to be evaluated. In addition, it is undesirable if the aeroplane transmitting the data is itself put at risk, i.e. the runway friction is unknown until the aeroplane starts to use it (take-off or landing).

Ground-based braking action measuring devices should, therefore, remain in use for several reasons:

- There might be a lack of regular or recent aircraft-based data.
- There is a need for braking action measurement following runway maintenance/blowing/sweeping.
- Ground-based measurements provide a backup and maintain redundancy.

- An aircraft-based system can only measure braking action on the part of the runway the aircraft has used from touchdown to the taxiway, leaving some areas without measurements, such as the runway area before the touchdown zone, the stop end (aircraft seldom use full runway) and the other parts of the runway not used during the landing roll.

Using aircraft as a friction-measuring device can be a safety enhancement provided the flight crew fully understands what the system is designed to do, how it will do it, how it affects operations and, how the data generated will be used. Such a system may be part of the solution to the non-standardized friction measuring devices currently operating and improve the relationship between measured braking action and actual deceleration of aircraft, but its implementation should ensure that it does not create an additional level of complexity.

Runway braking efficiency should be classified in five categories:

Good
Braking deceleration is normal for the wheel braking effort applied AND directional control is normal
Good to Medium
Braking deceleration OR directional control is between a normal state and a medium state which sees a noticeable reduction in either directional control or braking deceleration
Medium
Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced
Medium to Poor
Braking deceleration OR directional control is between Medium and Poor
Poor
Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced

"Less than poor" can be reported if braking deceleration is minimal to non-existent or directional control is uncertain. This is a condition for runway closure and runway maintenance to remove contamination and/or improve braking.

As Airline pilots are not trained to evaluate braking efficiency and controllability and some pilots are rarely exposed to winter operations, a pilot report should be considered to be quite subjective.

Note: Pilot reports may "downgrade" a runway's braking action, but cannot "upgrade" it; for upgrades, a friction measuring device must be used.

3.7 Operational Friction Measurement

Runway friction measurements are part of a comprehensive runway maintenance program which includes rubber deposit removal and maintenance of sufficient runway drainage. ICAO guidelines for maintenance friction measurements are intended to guarantee adequate runway friction characteristics when the runway is wet. Variations in the results from different friction testing equipment are a widely known fact. The same lack of correlation between operational friction measurements on contaminants with a wet component is found on wet runways. IFALPA believes that there should be an evaluation of the feasibility of an onboard system which would send measured friction data from the aircraft to a central data unit which, in turn would transmit a continuous indication to operators and airport authorities.

> ✈ LEARN MORE
> IFALPA Position on Aircraft as Friction Measuring Device

Although the SNOWTAM presentation does not necessarily imply a correlation between measured and calculated friction coefficient and aircraft braking action, the same values are found in the ICAO Airport Services Manual Part 2 (ICAO Doc 9137). Just as problematic is the policy by some airport service providers to refrain from reporting the runway state, because of unreliable friction measurements, leaving the flight crew unaware of the real-time runway condition. The effect of all natural or unnatural contaminants on aircraft performance should be assessed, whenever it is not possible to fully clear the runway, taxiway or apron of these contaminants. The effects on aircraft performance should be assessed as well as the effects of any contaminants on aircraft braking. These effects may be provided as generic (effective) braking action values for a particular aircraft depending on the type and amount of contaminant or may be based on friction measurements. Generic braking action values or friction measurements should adequately correlate with aircraft performance. In case adequate correlation between generic braking action values or measured friction values with aircraft performance is not possible, sufficiently large safety factors should be used. IFALPA actively participated in the TALPA ARC and ICAO Friction Task Force (FTF) work to improve friction reporting. As long as there remains a large number of different kinds of friction measuring devices and a lack of proven, more accurate and authority approved generic braking action values, following the TALPA ARC / FTF runway condition assessment matrix/table is the best course of action.

4 Operational Information & Performance Data

4.1 Aircraft Performance

An accurate aircraft performance is a crucial factor for a safe takeoff or landing. Proper planning should cater for deviations in conditions upon arrival or prior to departure compared with the assumptions made during the flight planning phase. This means that different margins are required for the dispatch phase calculations with inherently larger uncertainties when compared with inflight calculations for the actual landing or prior to departure.

Performance calculations should consider contaminated runways. The flight crew should always refer to the aircraft QRH or appropriate performance manual to calculate the take-off distance required and landing distance required. It is, however, essential to understand that the distances given in a QRH are advisory. Likewise, the accuracy of performance figures calculated by on-board performance tools is based on the information inserted, which may not be accurate (e.g. ATIS wind direction/wind speed). Pilots should be aware of these limitations and operators should include these as part of their training program.

Dispatch calculations are a useful guide for flight crew during the flight planning stage, but actual conditions or variations must be included in the final calculation phase. Ultimately, this can be considered as a risk mitigation strategy to runway excursions.

Using actual conditions in final calculations can be considered a risk mitigation strategy for runway excursions

4.2 Braking

Incorrect use of brakes has been cited as a factor in a number of runway excursion events. Rudder input to counter the effects of a crosswind for example can lead to asymmetric brake pressure to be applied and will reduce deceleration rates especially if the runway surface friction is reduced through contamination. This reduction in brake efficiency is compounded by a reduction in brake efficiency caused by the 'cornering effect' imposed by crosswind side loads. Anti-skid helps in directional control by delivering symmetrical braking action. IFALPA supports the aircraft manufacturer's recommendation with regard to the use of fully operational and working autobrakes. A number of airlines have revised this procedure in an effort to reduce brake and tire wear. The Flight Safety Foundation recommends the "Use of autobrakes for landings in adverse conditions" in conjunction with the manufacturer's Flight Crew Training Manual (FCTM) for best practices and techniques.

✈ LEARN MORE
FSF ALAR Briefing Note 8.5
Wet or Contaminated Runways

Autobrakes are designed to achieve predetermined deceleration and anti-skid helps in directional control. However, while autobrakes are

Maximum decelerating force requires full manual braking and reverse thrust. Use of autobrakes is helpful to ensure prompt application of brakes since the pilot does not have to take the time to shift feet up to the brake pedals which may be a delaying factor during crosswind landings.

recommended they do not necessarily provide maximum stopping capability.

The maximum decelerating force requires full manual braking and reverse thrust. Use of autobrakes is helpful to ensure prompt application of brakes since the pilot does not have to take the time to shift feet up to the brake pedals which may be a delaying factor during crosswind landings.

4.3 REVERSE THRUST

As the performance of wheel braking systems has improved and the logic of the systems has evolved (to achieve a rate of deceleration rather than a braking pressure) coupled with an increased pressure to reduce noise emissions at airports the use of reverse thrust has declined. In addition, there has been commercial pressure to reduce fuel burn and engine wear. Reverse thrust provides additional deceleration benefits especially on runways with reduced friction. Using full reverse thrust can be a vital component for a safe landing or Rejected Take off (RTO) and as a result crews should be prepared to use full reverse thrust when required. Special training may be needed with regard to the need to use full reverse thrust, when the runway is not dry or the length runway is limited.

Airport procedures too may need altering. As mentioned above, at a number of airports the use of reverse thrust is prohibited or restricted for noise abatement. The restriction on the use of reverse thrust needs to be mitigated appropriately by the crew and will vary operationally. The calculation of landing distances should take into account the anticipated use of reverse thrust, in other words if the crew is planning to use less than full reverse thrust then crews should not apply the reverse thrust credit to their landing distance calculations. Aircraft defects affecting performance must be taken into consideration. For example, on contaminated runways, if one reverser is inoperative then its pair on the opposite wing should also be considered as unserviceable and therefore reverse thrust credit should not be applied.

Using excess reverse thrust (more than stated in the FCOM) may lead to difficulties in obtaining proper directional control due disturbed airflow over vertical stabilizer. This is especially true with tail mounted engines.

4.4 RUNWAY ASSIGNMENT AND RUNWAY CHANGE

The runway to be used for landing should be assigned prior to the final stages of approach or STAR (Standard Terminal Arrival) and preferably as part of the STAR clearance. Last minute changes of runway assignment can lead to a loss of situational awareness and put unnecessary pressure on flight crew during a high workload phase of flight. Therefore, late changes of assigned runways should be avoided and crews should consider rejecting a runway change if it is received after the beginning of the final approach.

Similarly, late change of takeoff runway may cause loss of situational awareness, rushed takeoff with incorrect takeoff performance calculations and lead to a runway incursion or, in case of a rejected takeoff, a runway excursion. The takeoff runway should be assigned in due time before start-up clearance and preferably as part of the airways clearance. The selection of the landing runway may take into account noise abatement, but this should never be at the expense of safety and a thorough risk assessment of any noise abatement procedure should be carried out before it is implemented. Furthermore, it is also worth remembering that in accordance with ICAO Annex 2 (para 2.4) “The pilot in command of an aircraft shall have the final authority as to the disposition of the aircraft while in command”. In other words, the PIC has the final say in runway selection.

4.5 FLIGHT CREW CONSIDERATIONS

As always training should be representative of the intended operation. Airlines should develop training programs that heighten awareness and theoretical knowledge of the elements that lead to runway excursions, incursions and confusion. As a minimum, this training should place an emphasis on the importance of effective Non-Technical Skills, including Cockpit Resource Management (CRM), and a basic understanding of the possible risks. Even more effective would be the inclusion of training regarding situational awareness; especially aeroplane performance on critical length runways (i.e. short or contaminated runways), the impact of weather and the terrain surrounding an aerodrome. The training should encompass, at a minimum, the following elements;

- Aerodrome specific issues such as abnormal glide path angle, high elevation, abnormal runway dimensions, environment causing wind changes/windshear etc.
- Energy Management - during initial training special attention should be given to the following factors contributing to energy management: Energy management during normal descent and final approach in relation to variables (wind, gusts, weight, configurations, non-normal configurations)
- Go Around (GA) – The approach briefing should include the actions required to conduct a Go Around or Missed Approach should it be required. It should be used to create a high level of situational awareness, in the event of the approach becoming unstable or in the event a landing cannot be affected from the approach. *The need to execute a go-around if stable approach criteria are not met should be emphasized*.
- A 'No fault' or 'No Blame' go-around policy.
- Non-Technical Skills (NTS)-Cockpit Resource Management (CRM) - Standard call outs should be used in case of any deviations. Operators should provide CRM based procedures for optimum crew coordination and the role of the pilot monitoring during final approach, landing and roll out.
- Computing by crew during flight - calculations such as landing distance and other performance critical items should be in line with the phase of flight. Crew workload should be reduced by simplifying procedures. Procedures should be precise, unambiguous and short.
- Target Fixation - "get home-itis" should be avoided by the development of the CRM model and also through the establishment of a company culture which re-enforces safety as pre-eminent over all commercial considerations.
- Attention should be given to stress management.
- Flare technique in relation to rate of descent, floating & touch down zone.
- Cross- and tail-wind landing techniques.
- Use of thrust reversers, including the effects of environmental policies in which idle reverse as minimum is stipulated. Always use full Reverse unless conditions are confirmed safe to use idle reverse. Crews should reference the appropriate performance manuals to verify calculations.
- Use of differential braking and automatic braking.
- Adverse runway and weather conditions.

5 Improving Post Accident & Incident Survivability

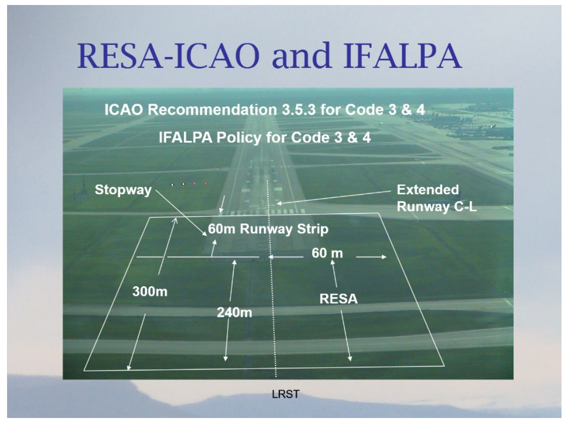
A considerable part of aviation safety is related to the sequence of events following an accident or incident. The post incident and accident survivability of passengers and crew is just as important as the prevention of an incident or accident. If we consider that risk is defined as the chance of an event happening multiplied by the severity of the consequences of the event, there can be a in increase in the level of safety by reducing that severity and by extension, improving accident survivability. Experience has shown that when an aircraft comes to a halt after an excursion upright, without major damage and is easily reached by Rescue and Fire Fighting (RFF) teams the number of deaths and injuries sustained is eliminated or dramatically reduced. IFALPA has developed a series of proposals about how an optimized runway environment can improve accident and incident survivability. These include, but are not limited to, the runway surroundings, airport emergency response plans, cabin crew performance and the aircraft structure.

5.1 Runway End Safety Areas (RESA)

ICAO Annex 14 stipulates the requirements for the runway strip and runway end safety areas. ICAO describes a RESA as an *area symmetrical about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aircraft undershooting or overrunning the runway.* The dimensions of a RESA for the various categories of runways can be found in the appropriate section of ICAO Annex 14. The provision of a runway end safety area is a critical safety factor in reducing the severity of runway excursions and improving post-accident survivability.

Data collected from past incidents and accidents has shown that, in the majority of cases, an aircraft overrunning a runway and leaving the paved surface at a speed of up to 70 knots will come to a halt within 300 metres of the runway end. Therefore, the risk of injury or death to passengers, crew and rescue teams is significantly mitigated by the installation of a RESA that meets these dimensions.

IFALPA recognizes that at some aerodromes it may be impossible for an adequate (full length) RESA to be installed due to surrounding terrain and topography. In this instance, IFALPA advocates the installation of an arresting system, such as an Engineered Material Arresting System (EMAS).



5.2 Arresting Systems

Arresting systems consist of crushable concrete blocks or lightweight foam from recycled glass which works by transferring or converting the energy from an overrunning aircraft into the action of crushing the concrete/foam material. Irrespective of the material, EMAS systems work in the same way and produce the same result. As a result, an aircraft can be brought to a halt within the confines of the bed, generally without injury to passengers or crew. Critically, an overrun into an EMAS will result in little or no damage to the aircraft and therefore the risk of a post overrun fire is dramatically reduced. Whilst the ICAO recommended RESA has been applied at a number of airports, especially those constructed more recently; an EMAS has been installed at a number of terrain/topographically challenged airports to provide protection to an aircraft in the event of a runway excursion. EMAS has proven to be effective in practice and is already credited with a number of aircraft "saves".

For an EMAS to be effective, it is important that flight crew is made aware of its existence at a runway end. Having appropriate aeronautical chart markings and depictions will inform pilots that an EMAS exists on a runway, providing them with the necessary operational information in the event of an emergency or malfunction.

It is essential that flight crew are aware of an arresting system at the aerodrome so that they can consequently include it in their departure or arrival briefing. This constitutes a means of safe practice in the event of a runway excursion.

5.3 AERODROME RESCUE & FIRE FIGHTING (ARFF)

Originally the ICAO terminology was CFR (Crash Fire Rescue) and this was recently changed to RFF (Rescue and Fire Fighting) to increase the emphasis on rescue, as saving lives is the primary objective of an airport fire service. It was recognised that situations where rescue and firefighting services are required do not necessarily involve a crash. A pre-requisite for rescue is the need for fire control.

Under normal conditions an evacuation would be initiated by the flight crew; however, possible incapacitation of the flight crew and/or passengers requires the immediate intervention of the airport fire fighters to commence the rescue of all occupants. With the advent of the RFF vehicle that can be driven and operated by one fire fighter, this one person is required to operate the vehicle and therefore is not available for rescue. Fire fighters additional to this driver/operator are required to operate hand hose lines, ladders, forcible entry tools and specialised rescue equipment in order to initiate the immediate removal of injured survivors from the danger area.

ARFF Response Time

The ICAO Standard for RFF is that they must be able to achieve a response time of 3 minutes (2 minutes being the Recommended Practice response time) to any part of the aerodrome movement area in good visibility conditions. Response time is to be considered the time between the initial call to the ARFF Service, and the time when the first responding vehicle(s) are in position to apply foam at the rate of at least 50% of the discharge rate specified for the category of airport. Any other vehicles required to deliver the amounts of extinguishing agent should arrive no more than 1 minute after the first responding vehicle(s) so as to apply continuous agent application. IFALPA believes that ARFF vehicles should be able to operate in all weather conditions, associated with that airport and that plans should be in place for aircraft accidents that occur outside the movement's areas.

ARFF Category

ICAO determines the ARFF Category for an aerodrome based on the size of the aircraft, for example a B777 is a Category 9 and A319 is Category 6. There is now a proposal before ICAO to allow aircraft to operate to airports that have a lower category subject to a risk assessment by the air operator. This replaces the old system of a remission factor which was prescriptive rather than outcome based factor. In terms of an alternate, the lowest category allowed is normally Category 4. In reality, this means that very little ARFF coverage will be available. In some States, such as Australia, commercial air transport aircraft are allowed to operate to airports that have low passenger movements without any ARFF cover.

6 RUNWAY SAFETY TEAMS

The ICAO Runway Safety team handbook defines a Runway Safety Team (RST) as; "A team comprised of representatives from the aerodrome operator, air traffic service providers, airlines or aircraft operators, pilot and air traffic controller associations and any other group with a direct involvement in runway operations at a specific aerodrome, that advise the appropriate management on the potential runway safety issues and recommend mitigation strategies". Ideally, the Aerodrome Operator should take the lead on the coordination and implementation of the RST at their particular location.

Runway Safety Teams are essential to the open dialogue and communication between all stakeholders at an aerodrome, regardless whether it is regional, domestic, international. IFALPA remains a strong advocate of professional pilot participation in the Runway Safety Team by pilots who regularly operate to and from that particular aerodrome. Pilots who retain local knowledge of an aerodrome's procedures and characteristics are able to provide reputable firsthand knowledge of the aerodrome's strengths and weaknesses.

The RST should cover a wide range of issues related to runway safety, including but not limited to, the following ICAO occurrence categories:

- Abnormal runway contact
- Bird strike
- Ground collision
- Ground handling
- Runway excursion
- Runway incursion
- Loss of control on ground
- Collision with obstacle(s)
- Undershoot / overshoot, aerodrome
- Use of the wrong runway (runway confusion)
- High Speed Rejected Take-Off
- Wildlife Event
- Damage from Foreign Object Debris (FOD)

The role of the RST should cover, but not be limited to, the following;

- Working together to understand the operating difficulties of personnel working in other areas and recommending areas for improvement
- Providing a single forum for the sharing of local runway safety data, emerging threats, lessons learnt and key initiatives
- Considering the outcome of investigation reports to establish local hot spots or problem areas at the aerodrome
- Identifying local problem areas and suggesting improvements
- Providing input on systemic issues for the National RSG.

It is important to the success of the RST that it is made up of regular attendees and representatives that participate actively. Having different people present at every meeting may reduce the effectiveness.