

The International Federation of Air Line Pilots' Associations



**I·F·A·L·P·A**

The Global Voice of Pilots

# **RUNWAY SAFETY MANUAL**



**Prepared by the  
IFALPA Aerodrome & Ground Environment Committee**

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*Contents*

<b>Introduction</b>	<b>4</b>
<b>Runway Excursion</b>	<b>5</b>
<b>Aerodrome Information</b>	<b>5</b>
<b>Approach</b>	<b>11</b>
<b>Aircraft Operation and Performance</b>	<b>15</b>
<b>Flight Crew Considerations</b>	<b>17</b>
<b>Post Accident Survivability</b>	<b>18</b>
<b>Runway Incursions</b>	<b>25</b>
<b>Aerodrome Physical Characteristics</b>	<b>26</b>
<b>Standard Taxiway Nomenclature</b>	<b>28</b>

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## Introduction

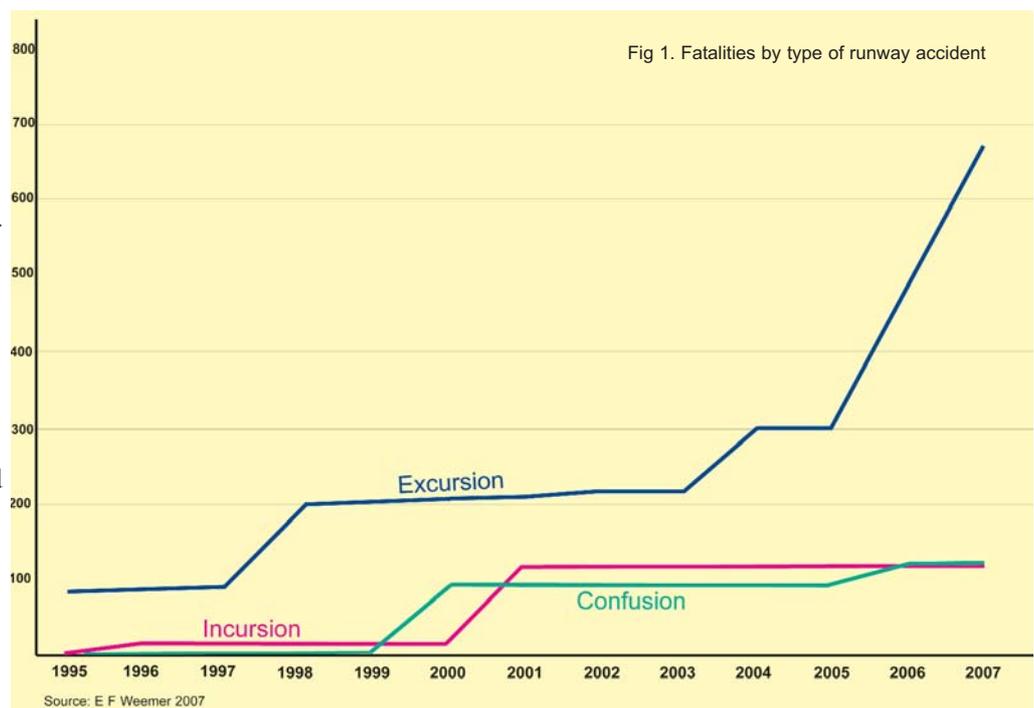
IFALPA's primary interest, as always, is to safeguard the safety of passengers and crews. Accident statistics show that runway related accidents have the second highest casualty rate. As operational pressures increase from environmental constraints and demands to increase capacity there is the distinct possibility that the accident toll will increase. If the overall accident rate is not reduced then as traffic increases, an increase in the frequency of accidents will, inevitably, increase possibly to the point where the travelling public begin to lose faith in the safety of air transport and thus endanger the viability of the industry. Clearly, since runway related accidents form a significant percentage of the overall casualty rate then it is worth addressing the risks associated with runways and set about reducing, mitigating the consequences or removing them all together. Pilots, thanks to the nature of their work are in a unique position to observe and experience different airports

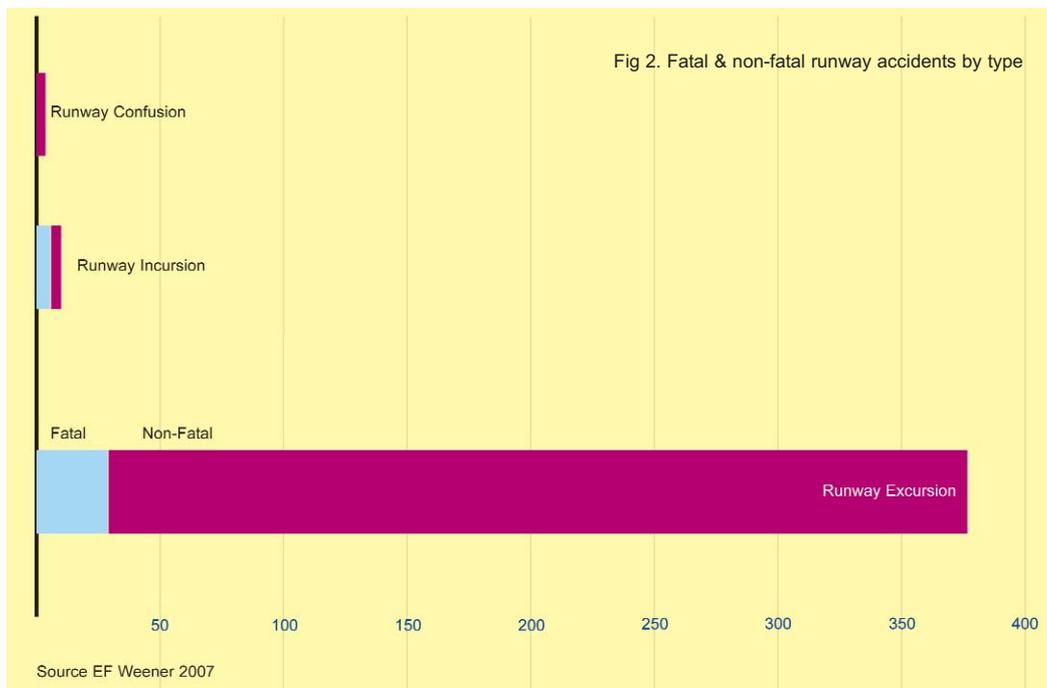


and Air Traffic Control (ATC) systems worldwide and therefore are in a unique position to compare and contrast the effectiveness the variables – to see what works and what doesn't. It is this experience that can be of unrivalled use in determining not only where safety can be improved but also how capacity can be boosted in the most effective way. This manual summarises IFALPA's existing policies aimed at reducing and mitigating the effect of runway related incidents and accidents. In addition, it suggests some new solutions to the challenges posed by runway safety.

## Runway Safety

As a general principle, it is now accepted that runway safety encompasses runway incursions and runway excursions. A runway excursion is defined as when an aircraft departs the runway either by veering off the side or by overrunning the runway end. Meanwhile a runway incursion is when the protected area of a surface of designated for the takeoff or landing of aircraft (paved or unpaved) entered by an aircraft, vehicle or person in error (IFALPA also considers the use of the incorrect runway by a departing or arriving aircraft as an incursion).





## Runway Excursions

According to research carried out by three groups, The Flight Safety Foundation, the Netherlands Lab R and IATA, runway excursions are now the most common type of event leading to accidents in commercial operations. These excursions are generally as a result of a poor approach leading to an abnormal landing or a loss of control on the runway either during takeoff or landing. However, the research has also shown that a runway excursion need not lead to fatalities if the runway area

is designed with a view to enhancing post accident survivability. Survivability is further enhanced by fully trained and equipped rescue and fire fighting services (RFF). Since many excursion events have, as part of their factors, poor approach or adherence to procedures it is worth asking the question why this trend is apparent? A study by Prof. Hudson of the University of Leiden concluded that pilot experience together with poor or inadequate operating procedures does much to explain these phenomena. Interestingly, since scheduling and time keeping pressures have been cited in a number of reports into runway excursion accidents, Prof. Hudson also found that the commercial and other pressures connected the job of being a pilot was less of a factor.

### 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/operational information.

### Runway classification

Dry runway performance is generally based on actual flight test data and is collected without the use of reverse thrust. The results are also modified to take into account the differences between the surfaces used for flight testing and that which is more likely to be encountered in operational service.

Wet runway performance is derived from extensive testing on various types of surface and considers the variations in tyre to runway friction coefficients based on varied tyre inflation pressures and ground speeds. What is also taken into account is the texture of the runway surface.

These are classified as follows:

- 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 vary between 0.004 and 0.02 of an inch (0.1 to 0.5 mm). In the calculations used in JAR25 and FAR25 the surface texture assumed for tyre to surface friction coefficients is between B and C. Studies by both the JAA and FAA agreed that grooved and PFC surfaces offer substantial benefits in wet conditions, and 70% of the

## Runway Safety Manual

dry runway braking performance is available from a properly constructed and maintained grooved and porous friction course runways in wet conditions.

### Drainage Analysis

There are various research efforts to determine the drainage capacity in relation to rainfall rates and runway characteristics, such as texture depth and runway geometry. These research activities vary from actually determining the effect of rainfall rates under laboratory conditions to merely empirical methods. An example is the research in the Netherlands following a Transavia B757 accident at Schiphol airport. Under laboratory conditions the amount of rainfall was determined resulting in water levels exceeding the texture depth of the runway surface texture available at Schiphol airport. Water levels exceeding the surface texture depth are an indication of standing water occurring on the runway. Depending on the scale of the phenomenon this is an indication of runway flooding. Since runway flooding is a dangerous runway condition, proper application of these tools might benefit safety by providing a warning to flight crews. Due to obvious shortcomings of the method (rain intensity measurement, crosswind effects, and runway irregularities) and since long before the runway becomes flooded friction capabilities are well reduced, these tools should not be used for dry or wet runway state definitions.

### Runway state definitions

To enhance the safety of operations it is clear that crews of arriving aircraft have an understanding of the prevailing conditions at an airport and more importantly can gain an expectation of how their aircraft is likely to handle. For this to happen there must be a harmonised system of runway condition reporting. At present there is a lack of harmonisation of the runway state definitions of the various regulatory bodies (see Fig 2). Some of the definitions are ambiguous and allow for an interpretation of the conditions that succumbs to commercial pressures. Specifically, there is a disconnect between the treatment of grooved/PFC runways in JAR-OPS and scientific research into dry, damp and wet runway states. That said there is an attempt towards harmonisation in the proposals to change ICAO Annex 6 and JAA DNPA-OPS 47 Proposal

#### ESDU data 71026

**Damp:** Surface appears discoloured compared to the dry condition but no standing water is present, such as dew, very light rain and in the final stages of the drying process after rain.

**Wet:** An average condition in which water depths are small but difficult to measure reliably because considerable differences are likely to occur over short distances. Overall, water may be present up to the tops of the surface asperities with scattered puddles of greater depth.

**Flooded:** Large areas with standing water above the tops of the surface asperities. The rain required to produce flooding depends very much on the macro-texture depth, the camber or cross-fall of the runway surface, the available drainage paths and the wind direction and strength. It is rare for a runway to be completely flooded, but flooded conditions often occur where a runway follows the original ground contours through a hollow or depression or at, for example, runway intersections.

#### JAR-OPS 1.480 Amendment 13

**Dry runway:** A dry runway is one which is neither wet nor contaminated, and includes those paved runways which have been specially prepared with grooves or porous pavement and maintained to retain 'effectively dry' braking action even when moisture is present.(a)(10)

**Damp runway:** a runway is considered damp when the surface is not dry, but when the moisture on it does not give it a shiny appearance.

**Wet runway.** A runway is considered wet when the runway surface is covered with water, or equivalent, less than specified in subparagraph (a)(2) above or when there is sufficient moisture on the runway surface to cause it to appear reflective, but without significant areas of standing water.

**Contaminated runway:** A runway is considered to be contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following:

Surface water more than 3 mm (0.125 in) deep, or by slush, or loose snow, equivalent to more than 3 mm (0.125 in) of water Snow which has been compressed into a solid mass which resists further compression and will hold together or break into lumps if picked up (compact-ed snow); or ice, including wet ice.

#### ICAO Airport Services Manual Part 2 (Document 9137)

**Damp:** The surface shows a change of colour due to moisture.

**Wet:** the surface is soaked but there is no standing water.

**Water patches:** significant patches of standing water are visible.

**Flooded:** extensive standing water is visible.

Fig 3 - Current runway state definitions

### JAA DNPA-OPS 47 Proposal

**Dry runway:** A dry runway is one which is clear of contaminants and visible moisture within the required length and the width being used.

**Wet runway:** A runway that is neither dry nor contaminated is considered wet.

**Contaminated runway:** A runway is considered to be contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following: Standing water or slush more than 3 mm (0.125 in) deep; Loose snow more than 20 mm (0.75 in) deep; or Compacted snow or ice, including wet ice.

### ICAO Annex 6 Proposal (ICAO State Letter 07/47)

**Dry runway:** A dry runway is one which is clear of contaminants and visible moisture within the required length and the width being used.

**Wet runway:** A runway that is neither dry nor contaminated.

**Contaminated runway:** A runway is contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by: Water or slush more than 3 mm (0.125 in) deep ; Loose snow more than 20 mm (0.75 in) deep; or Compacted snow or ice, including wet ice.

**Grooved or Porous Friction Course Runway:** A paved runway that has been prepared with lateral grooving or a porous friction course (PFC) surface to improve braking characteristics when wet.

Fig 4 - Proposed runway state definitions

(see Fig 4). What is interesting is that the JAA proposal includes the following commentary: “The purpose of this proposal is to remove the provision that allows damp paved runways to be considered as dry for the purpose of performance calculations. This is because evidence has become available which establishes that a damp runway does not provide an equivalent braking surface as a dry runway. In the light of such evidence, it is clearly not appropriate for JAR-OPS 1 to continue to allow damp runways to be considered as dry”.

While the ICAO supporting notes for the Annex 6 change also point out that as well as the volume and area of a runway that is contaminated it is also important where on the surface the contamination is noting “if less than 25 per cent of the runway surface area is covered with water, slush, snow, or ice, but it is located where rotation or lift-off will occur, or during the high speed part of the take-off roll, the effect will be far more significant than if it were encountered early in take-off while at low speed. In this situation, the runway should be considered to be contaminated. Similarly, a runway that is dry in the area where braking would occur during a high speed rejected takeoff, but damp or wet (without measurable water depth) in the area where acceleration would occur, may be considered to be dry for computing takeoff performance. For example, if the first 25 per cent of the runway was damp, but the remaining runway length was dry, the runway would be wet using the definitions above. However, since a wet runway does not affect acceleration, and the braking portion of a rejected takeoff would take place on a dry surface, it would be appropriate to use dry runway takeoff performance.”

While these revised definitions are to be applauded since they are more concise than the existing definitions IFALPA argues that they haven't lead to the urgently needed harmonisation of definitions and proposes that the following be adopted as a global standard:

### IFALPA Proposal

**Grooved or Porous Friction Course Runway:** A paved runway that has been prepared with lateral grooving or a PFC surface to improve braking characteristics when wet.

*Note: When a runway has a skid resistant surface, such as grooved or porous friction course and meets the friction level classification for runway surface defined in AC 150/5320-12C dated 19 March 1997, then the appropriate authority could provide certain performance credits.*

**Dry runway:** A dry runway is one which is clear of contaminants and visible moisture within the required length and the width being used.

*Note: Dry runway performance is based on nil reverse thrust to take into account poorer friction on operational runway surfaces when compared to the runway used for certification flight testing, dragging brakes, and heat retention and so on. A damp grooved/PFC runway may be considered dry when the aircraft is equipped with an effective and serviceable reverse thrust system. As dry runway performance is based on nil reverse thrust the reduction in friction capability is generally offset by the denial for reverse thrust credit for a well designed, constructed and maintained grooved/PFC runway. However a clear cut off between damp and dry is needed and the guidance provided by Engineering Sciences Data Unit (ESDU) probably best reflects the assumptions on which certified aircraft performance is based. A damp runway in this case would consist of one with a surface that appears discoloured compared to the dry condition as caused by dew, very light rain and in the final stages of the drying process after rain.*

## Runway Safety Manual

**Wet Runway:** A runway that is neither dry nor contaminated.

*Note: Certified wet runway takeoff performance includes the use of reverse thrust since runway friction is addressed directly (calculated performance). Other assumptions include maximum tyre pressure, 20% tyre tread remaining, a conservative runway surface texture representative of normal runways served by transport category aircraft, explicit grooved/ PFC credit including antiskid efficiency and a maximum brake torque based on overhaul limit. The certified takeoff performance is representative of a well soaked runway without standing water.*

**Contaminated runway:** A runway is contaminated when more than 25 per cent of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by: Contaminants which result in displacement and/or impingement drag that affects the aircraft acceleration capability or when the runway friction capability is reduced below that of a wet runway.

*Note: In certain situations, it may be appropriate to consider the runway contaminated even when it does not meet the above definition. For example, if less than 25 per cent of the runway surface area is covered with water, slush, snow, or ice, but it is located where rotation or lift-off will occur; or during the high speed part of the takeoff roll, the effect will be far more significant than if it were encountered early in the takeoff while at low speed. In this situation, the runway should be considered to be contaminated.*

*Similarly, a runway that is dry in the area where braking would occur during a high speed rejected takeoff, but damp or wet (without measurable water depth) in the area where acceleration would occur, may be considered to be dry for computing takeoff performance. For example, if the first 25 per cent of the runway was damp, but the remaining runway length was dry, the runway would be wet using the definitions above. However, since a wet runway does not affect acceleration, and the braking portion of a rejected takeoff would take place on a dry surface, it would be appropriate to use dry runway takeoff performance. 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). Current regulations stipulate strict thresholds for considering a runway to be contaminated. IFALPA questions the validity of these thresholds for all aircraft and suggests leaving the determination of these thresholds for the different contaminants a decision for the aircraft manufacturers. Braking action should be classified as good, medium or poor. In the absence of adequate correlation between friction measurements and aircraft performance the FAA Advisory Circular 91-79 provides useful guidance.*

**Flooded Runway:** A runway is flooded when large areas with standing water above the tops of the surface asperities are present.

*Note: Runway flooding can cause a reduction in friction capabilities beyond those assumed in scheduled performance data for wet runways. When the water level continues to rise aquaplaning may occur and when displacement and impingement drag become a factor the runway should be considered contaminated. Laboratory research in combination with empirical methods may give insight into the drainage capacity of a runway under certain weather conditions. These methods could be used to warn flight crews about possible flooding and can be used to determine the usability factor. Due to the uncertainties involved, such as measurement of rain intensity, crosswind effects, runway deterioration, etc. These methods should not be used to determine dry or wet runway state.*

**Usability factor:** The percentage of time during which the use of a runway or system of runways is not restricted because of the crosswind component or because of runway flooding.

*Note: Runway grooving or the application of a Porous Friction Course top layer are effective ways to improve runway friction characteristics when wet. Introduction of a usability factor similar to crosswind requirements would introduce a requirement for airports prone to frequent or high intensity rain to improve the runway friction characteristics. The runway design in combination with the maintenance program should be such that the usability factor of an aerodrome is not less than 95% for the aeroplanes the aerodrome is intended to serve.*

IFALPA believes that 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 of displacement and impingement drag on aircraft performance should be assessed as well the effects of any contaminants on aircraft braking. The effects of contaminants on aircraft braking 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 utilized.

*Note: Since present runway friction measures are not correlated with factual aircraft behaviour and performance and new system is envisioned. The Midway accident showed that it is possible to derive friction and performance data directly from aircraft data. When this is possible after an accident, it should also be possible before one. Therefore an automatic system which would send measured friction data from the aircraft to a central data unit which would give a continuous indication to the operators and airport authorities, would give an excellent indication on runway / aircraft relation.*

Runway braking efficiency should be classified in three categories:

 **Good:** Aircraft handling is normal.

 **Medium:** Normal piloting skills with minor adjustments are required to keep the aircraft under control

 **Poor:** Exceptional piloting skills and major adjustments are required to keep the aircraft under control.

### 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 is clearly shown in the limit values in Fig 5. The same lack of correlation between operational friction measurements on contaminants with a wet component is found on wet runways. The ICAO Airport Services Manual contains a correlation method linking the Minimum Friction Level values from the table below to aircraft wet runway dispatch performance, however this correlation should be considered outdated and a revision is overdue. 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 transmit a continuous indication to operators and airport authorities. Such a system could improve our understanding of aircraft behaviour on contaminated runways and could significantly improve friction reporting and decision making.

<p>DEPOSITS OVER TOTAL RUNWAY LENGTH (Observed on each third of the runway starting from their end with the lower designation number)</p> <p>NIL - CLEAR AND DRY 1 - DAMP 2 - WET (or water patches) 3 - RIME OR FROST COVERED 4 - DRY SNOW 5 - WET SNOW 6 - SLUSH 7 - ICE 8 - COMPACTED OR ROLLED SNOW 9 - FROZEN RUTS OR RIDGES</p>	F)																												
MEAN DEPTH (mm) FOR EACH THIRD OF TOTAL RUNWAY LENGTH	G)																												
<p>FRICITION MEASUREMENTS ON EACH THIRD OF RUNWAY LENGTH AND FRICTION MEASURING DEVICE</p> <table> <thead> <tr> <th>MEASURED OR CALCULATED COEFFICIENT</th> <th>or</th> <th>ESTIMATED SURFACE FRICTION</th> <th></th> </tr> </thead> <tbody> <tr> <td>0.40 and above</td> <td></td> <td>GOOD</td> <td>- 5</td> </tr> <tr> <td>0.39 to 0.36</td> <td></td> <td>MEDIUM/GOOD</td> <td>- 4</td> </tr> <tr> <td>0.35 to 0.30</td> <td></td> <td>MEDIUM</td> <td>- 3</td> </tr> <tr> <td>0.29 to 0.26</td> <td></td> <td>MEDIUM/POOR</td> <td>- 2</td> </tr> <tr> <td>0.25 and below</td> <td></td> <td>POOR</td> <td>- 1</td> </tr> <tr> <td></td> <td></td> <td>UNRELIABLE</td> <td>- 9</td> </tr> </tbody> </table> <p>(When quoting a measured coefficient use the observed two figures followed by an abbreviation of the friction measuring device used. When quoting an estimate use single digit figures)</p>	MEASURED OR CALCULATED COEFFICIENT	or	ESTIMATED SURFACE FRICTION		0.40 and above		GOOD	- 5	0.39 to 0.36		MEDIUM/GOOD	- 4	0.35 to 0.30		MEDIUM	- 3	0.29 to 0.26		MEDIUM/POOR	- 2	0.25 and below		POOR	- 1			UNRELIABLE	- 9	H)
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CRITICAL SNOWBANKS (if present, insert height (cm)/distance from the edge of runway (m) followed by "L", "R", "LR" (if applicable))	J)																												

Fig 5. SNOWTAM

Although the SNOWTAM presentation does not necessarily imply a correlation between measured or calculated friction coefficient and aircraft braking action, the same values are found in the ICAO Airport Services Manual Part 2 (Reference ICAO Doc 9137) and presented as a correlation which is only acceptable on compacted snow and ice covered runways. Unfortunately many operators instruct their pilots to use the above table as a valid correlation for all reported contaminants and even allow performance calculations with accuracy to two decimal places by using modern onboard performance tools. Just as problematic is the policy by some airport authorities to refrain from runway state reporting because of unreliable friction measurements leaving the flight crew with no information at all.

IFALPA believes that the effect of all natural or unnatural contaminants on aircraft performance should be assessed, when-

## Runway Safety Manual

ever it is not possible to fully clear the runway, taxiway or apron of these contaminants. The effects of displacement and impingement drag on aircraft performance should be assessed as well as the effects of any contaminants on aircraft braking. The effects of contaminants on aircraft braking 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 utilised.

### 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 will no longer be accurate for calculating the required landing distance once the runway is wet. Unfortunately, at present the significance of such NOTAMs are not well understood by pilots and dispatchers. Furthermore a number of operators do not supply performance data for these conditions and for certain aircraft this information is not provided by the manufacturer either. Even so, the provision of this information risks masking the underlying problem “treating the symptom rather than the disease”. IFALPA believes that if airport operators have in place an effective runway maintenance programme they will have sufficient lead time to implement preventative and/or corrective maintenance to ensure reasonable wet weather performance.

### Dispatch to contaminated runways

There are proposals to allow dispatch to a destination with a contaminated or slippery runway based on wet runway field length requirements (source ICAO state letter 07/47, IFALPA reaction 08ADO029). The intent of these proposals is not to penalise airlines with considerable weight reductions required whenever a destination runway is contaminated, as the runway may have been cleared by the time the aircraft is scheduled to arrive rendering the loss of payload unnecessary. Clearly, this reasoning has merit and is perhaps acceptable for long haul flights. However, on short haul flights there is little chance of a significant change in the runway’s condition while the flight is enroute and, therefore, it is not acceptable and this provision should have a minimum flight duration imposed. Failure to set a minimum limit will, effectively, remove the dispatch requirements for contaminated runways for all flights which would result in an unacceptable erosion of the already degraded safety margins compared with wet or dry runways. As safety margins for contaminated runways are already less than for wet or dry runways, the proposal would rely on actual or recommended landing distance data for the safe execution of landings and as the dispatch weight may be based on wet runways this distance will become even more critical.

Apart from a time limit for application of such a procedure there should always be a way out when runway clearing or weather improvement has not occurred and as such alternate planning should always be based on the full forecast, including contamination if present. Also for the purpose of flight planning whenever such a procedure would be allowed, the destination should be considered to be below operating limits with appropriate consequences for alternate planning.

### Dispatch versus in-flight requirements.

Proper planning should cater for deviations in operating conditions upon arrival compared with the assumptions made during flight planning. This means that different margins are required for the dispatch phase with inherently larger uncertainties when compared with in-flight checks for the actual landing. Looking at slippery and contaminated runways, current dispatch regulations provide for a decreasing safety margin where the uncertainties with regard to the runway state



The well known ICAO SNOWTAM format (source Annex 15) implies a relationship between measured or calculated friction and the estimated surface condition. This assumption is NOT correct.

(contaminant type, thickness, effective braking action) are greater. This is a contradiction and puts more emphasis on the actual landing distances, which unfortunately inherit most of the inaccuracies as far as braking performance estimates are concerned. With the more critical actual landing distances on slippery and contaminated runways it is therefore essential that use is made of conservative estimates for actual braking performance.

## Approach

A good landing generally follows a good approach. IFALPA defines a good approach as one that it is stable (in other words the aircraft is in landing configuration and stable in speed and flightpath) before reaching 1,000 feet AGL. This reflects the FSF Approach and Landing Accident Reduction (ALAR) programme which says in its Briefing Note 7.1 that there are three essential parameters which must be stable to ensure a safe approach aircraft track (which could be curved if that type of approach is flown), flight path angle, and airspeed. If an aircraft does not meet these criteria by the 1000ft (IFR) gate (500ft in VFR) then a missed approach or go-around should be executed. If the approach becomes unstabilised after passing the 1000ft gate (for example as a result of windshear or microburst) a go-around should also be executed. Unstable approaches are the result of a number of factors but a recurring theme is the rushed approach resulting in aircraft having an excess of altitude and energy as it reaches the 1000ft gate. Air Traffic Control services (ATC) has a key role to play in the energy management of an approach. The need to maintain higher than ideal speed for spacing, late runway or flight path changes can all lead to rushed, unstabilised, approaches. Standard operating procedures should include the operator's 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 unstable approach.

### Approach Information

Before starting an approach pilots should be furnished with the following information about the airport and this information should be delivered in the order set out below:

-  The runway in use
-  Runway wind direction and speed (this should also include information about gusts and wind shifts) In accordance with Appendix 3 of ICAO Annex 3 the acceptable variance parameters for surface wind reporting should be:
  - ▶ Direction:  $\pm 10$  degrees
  - ▶ Velocity:  $\pm 1$  kt up to 10 kts and  $\pm 10\%$  above 10 kts
  - ▶ Mean surface wind:  $\pm 2$  kts
-  QNH and QFE (the latter in accordance with local regulations or if requested by the crew)

### Stabilised Approach Procedure

One of the factors that often appears in reports into runway excursion events is an unstabilised approach. Therefore, establishing the aircraft on the flight path as defined in the published approach procedure without excessive manoeuvring or variation in speed is of paramount importance. IFALPA defines a stabilised approach as one where the aircraft is in its

The Stable Final Approach:

Stable: Heading, Airspeed, Rate of descent and Configuration at three miles and 1,000 ft

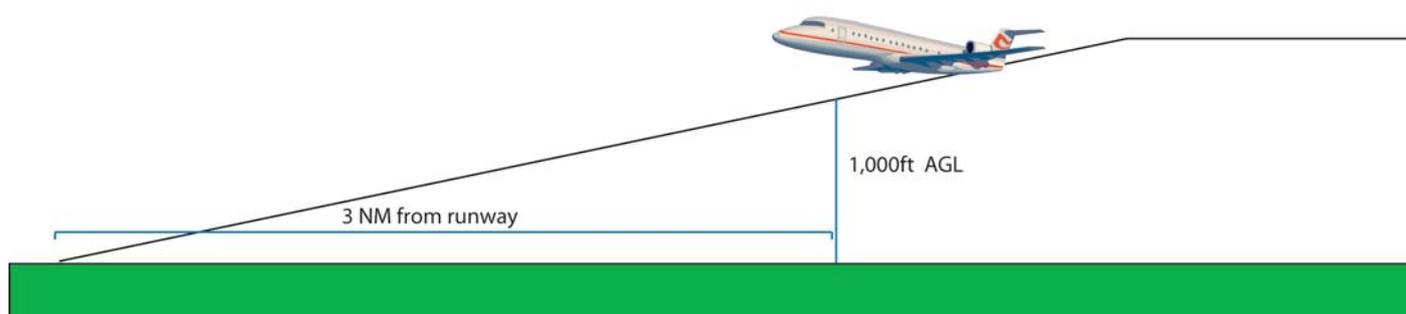


Fig 6 A stable approach in vertical & lateral speed should be established by 1,000ft AGL in IFR (500ft VFR).

## Runway Safety Manual

landing configuration (landing flap set and wheels down) and is stable in path, vertical profile and speed at or before 1,000 ft AGL in instrument metrological conditions (IMC) and 500ft in visual metrological conditions (VMC). If the aircraft deviates from a stable condition between the 1,000ft or 500ft 'gates' and the beginning of the transition to the pre-touch-down flare then a go-around should be carried out.

### Operator SOPs

The elements of a stabilised approach should be defined by the operator's standard operating procedures (SOPs). These elements should include as a minimum:

All flights must be stabilised before reaching 1000ft in IMC and 500ft in VMC and stay stabilised until 50 feet above the threshold

Callouts confirming a stabilised approach must be made at these gates.

Any deviation from a stabilised approach below the 1000ft or 500ft gate must result in a go-around.

The operator shall establish the parameters under which an approach is considered stabilised. This will include minimum power setting, crossing altitude deviation tolerances, configuration, maximum sink rate, completion of check lists, and crew briefings.

### Go-around.

Standard operating procedures should include the operator's policy with regard to the decision to go-around encouraging the crew to carry out a go-around if the approach is not stable by the IMC or VMC gates or becomes de-stabilised from the parameters at any time after passing the gates but before beginning the flare. This policy should be re-enforced by inclusion in the operator's training syllabus.

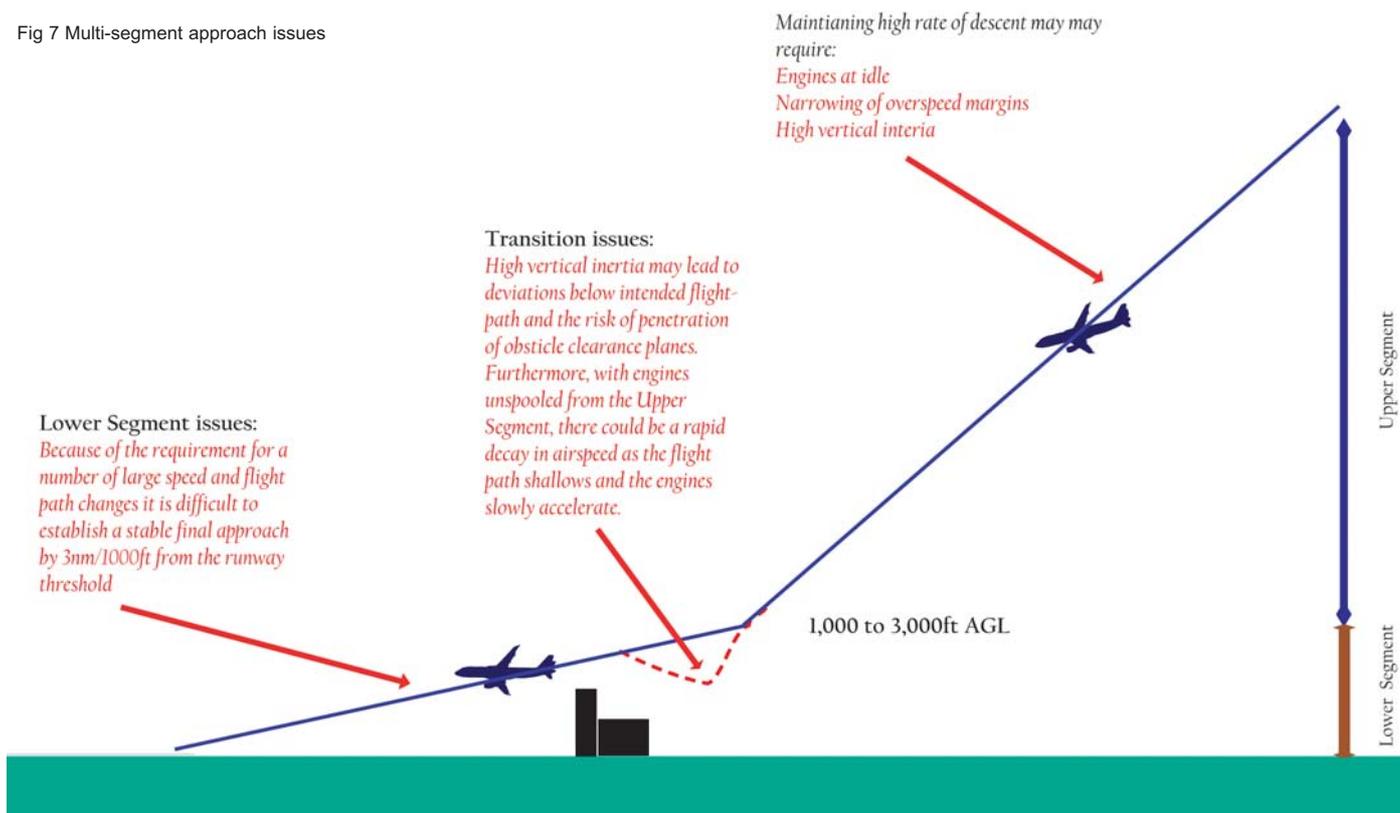
### Flight path design

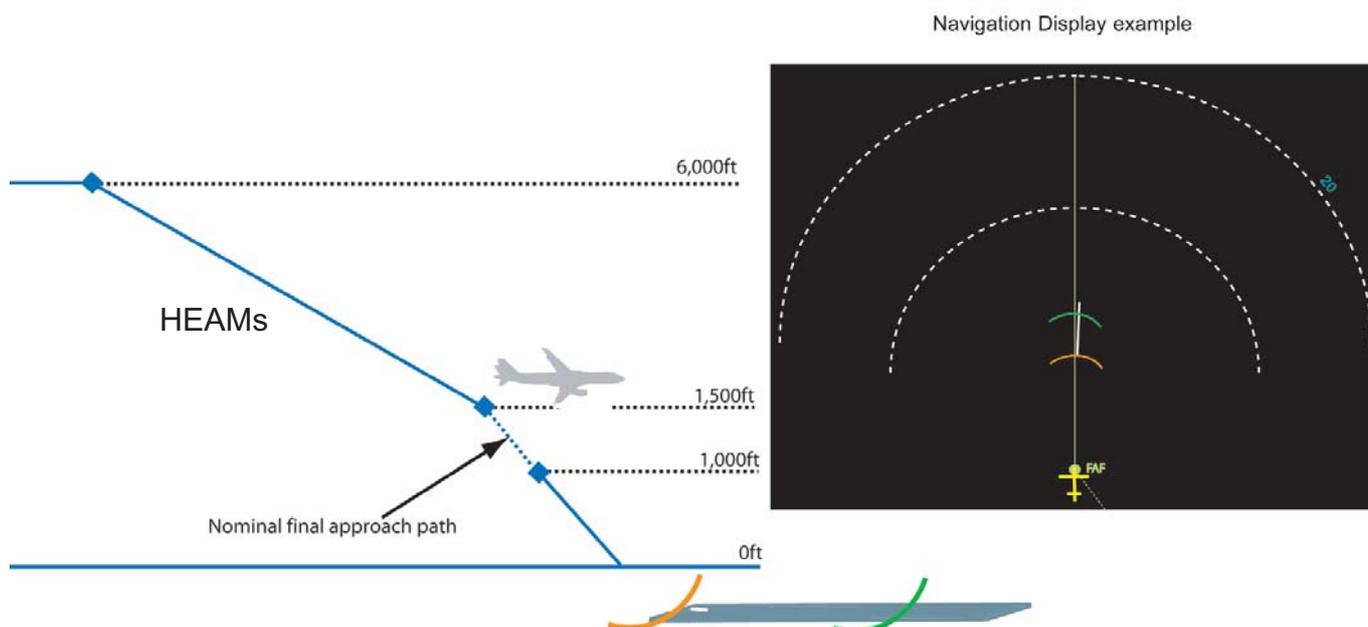
The approach flight path design must take into account and meet the performance capabilities of the aircraft and crews expected to use it. The advent of noise emission reduction strategies like Continuous Descent Approaches (CDA) place more emphasis on energy management. IFALPA believes that ICAO Annex 11 and specifically Chapter 22.2 – Objectives of air traffic services - should also include a codicil that the vertical path profile should be designed in such a way that stabilised approach criteria can be met.

### Runway assignment and runway change

The assignment of a runway to be used for landing must be assigned as soon as possible but in any case before start of an approach in order to give ample time for approach preparation and briefing. Last minute changes of runway can lead to a loss of situational awareness and lead to a rushed approach and, in turn, runway excursions. Therefore this type of runway

Fig 7 Multi-segment approach issues





*The aircraft is high on the approach so the high energy limit arc (amber) is at the runway threshold while the green arc showing the path for a stable approach is well down the runway. Therefore the only solution here is to go around.*

In addition to maximising the use of existing procedures, training and the aircraft's instruments to enhance situational awareness in the approach phase. There are additional measures which can be helpful in avoiding rushed approaches HEAMs is a good example.

assignment change should be avoided and crews should consider rejecting a runway change if it received after the beginning of the final approach. On the subject of runway selection and allocation it is worth considering that while the selection of the landing runway should take into account noise abatement 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" the PIC has the final say in runway selection.

### Situational awareness aids

In addition to maximising the use of existing procedures, training and the aircraft's instruments to enhance situational awareness in the approach phase. There are additional measures which can be helpful in avoiding rushed approaches including the use of:

Emerging technology – the "energy circles" - the HEAM system on Airbus aircraft for example can be a useful indicator when assessing an approach.

Approach lights - Precision approach guidance should be used whenever it is available. In the visual segment of the Visual Approach Slope Indicators (VASI) or Precision Approach Path Indicators (PAPI) should be used to help maintain the correct vertical flight path angle for a stable approach. For this reason airports should ensure that VASIs or PAPIs are illuminated during daylight as well as at night and irrespective of the prevailing visibility conditions.

Approach angle - Another factor that can lead to a runway excursion is an incorrect flare technique. The aim should always be to achieve a positive main wheel contact within the confines of a runway's touchdown zone. Data has shown that the standard three degree approach tends to deliver the most consistent flare/touchdown that meets operational guidelines. Therefore, the approach path for both the visual and instrument approaches should be designed to be as close to this value as possible for aircraft of conventional design and 5.5 degrees for aircraft designed for steep approaches.

### Wake separation

Clearly, encounters with wake turbulence can lead to an approach becoming unstabilised and therefore the basis of wake separation minima should in addition to that laid down in ICAO Annex 11 and should minimise the likelihood of wake turbulence beyond that which could be considered as light.

## Runway Safety Manual

### Aircraft operating procedures

Day to day operations should adequately be covered by certification and of course, operation of the aircraft should always be in line with what has been set out in the certification process but at the same time it must always be considered in performance calculations. For example, thrust reverser system must be fully operational and brake and tyre condition within certified tolerances, for the data to be valid.

Conditions and assumptions must be totally comparable with day to day line operations.

Yet another factor that features in runway excursion incidents and accidents is a deceleration rate that is insufficient to slow the aircraft in the runway distance remaining or a loss of directional stability. It is worth considering the factors that can result in this problem:

 **Inaccurate performance calculations** – landing (or takeoff) weights that are used for performance calculations while tending to err to the conservative have when sufficiently inaccurate, been a factor. Higher than optimal airspeed on final approach clearly presents the risk of an excess of energy on landing that, in turn, could (and has) lead to a runway excursion.

 **Deviation from reference values** – The values used to develop landing or takeoff required distance figures will be rendered inaccurate if they airspeed is allowed to build to higher values than are calculated. Excess energy might also be the result of a tailwind component.

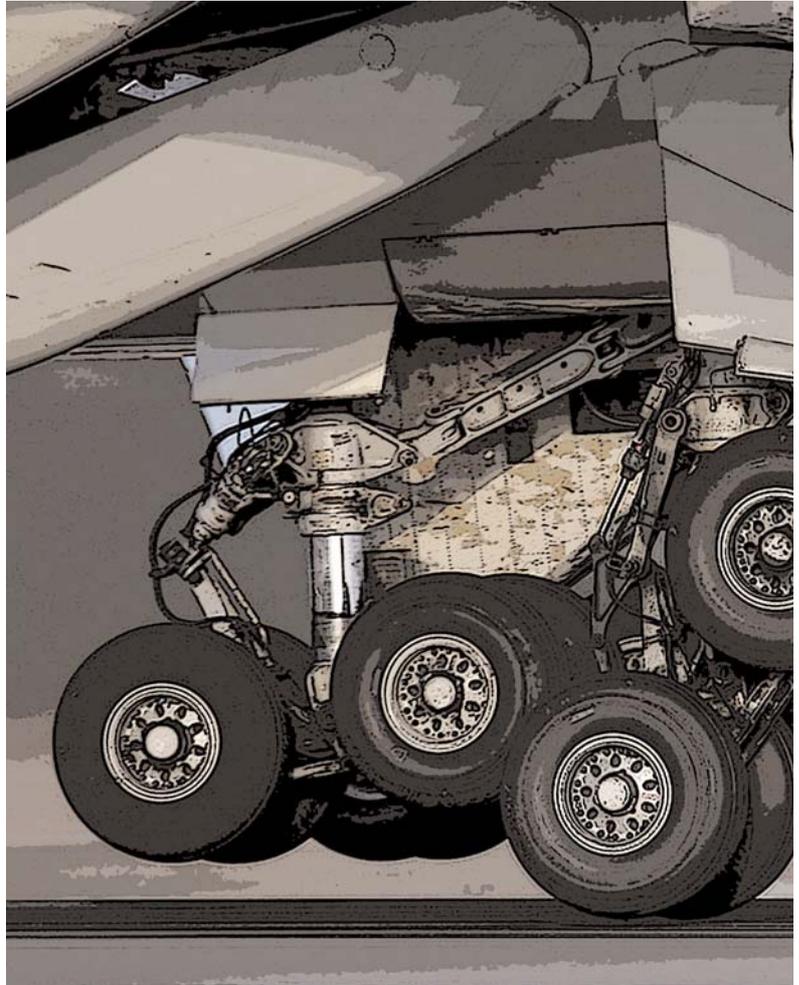
 **Measured and/or reported braking action** – there are often discrepancies between the reported braking action and that which is actually encountered. This can be due to a wide variety of reasons. Among the elements leading to inaccuracy is the equipment used. At present, several different types of runway friction measuring equipment are in use around the world, as a result, this equipment may produce different results for the same runway conditions which then may not give an accurate representation of actual aircraft behaviour. Furthermore, the terms used in describing runway conditions “good, fair and poor” leave a lot to be desired in the accuracy stakes. Therefore IFALPA believes that the goal should be the establishment of a worldwide common standard for evaluation of runway surface condition and its correlation with actual aircraft braking performance.

Insufficient controllability – due to adverse wind characteristics (gusts, crosswinds etc) in isolation, or in concert with, poor runway friction.

### 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. Autobrakes automatically compensate for the impact of rudder input and will continue to deliver symmetrical braking; equally, full braking performance will be applied on wheel spin-up following touchdown. Therefore, the use of autobrakes is strongly recommended in accordance with the aircraft operating manual especially in adverse or crosswind landings.

Note: The US FAA has indicated that manufacturers recommend use of autobrakes over manual braking in the operating manuals of aircraft that have them fitted. However, a number of airlines have revised this procedure in an effort to reduce brake and tyre wear. Reduce brake use also allows a reduction in turnaround time since the hold over for brake cooling is



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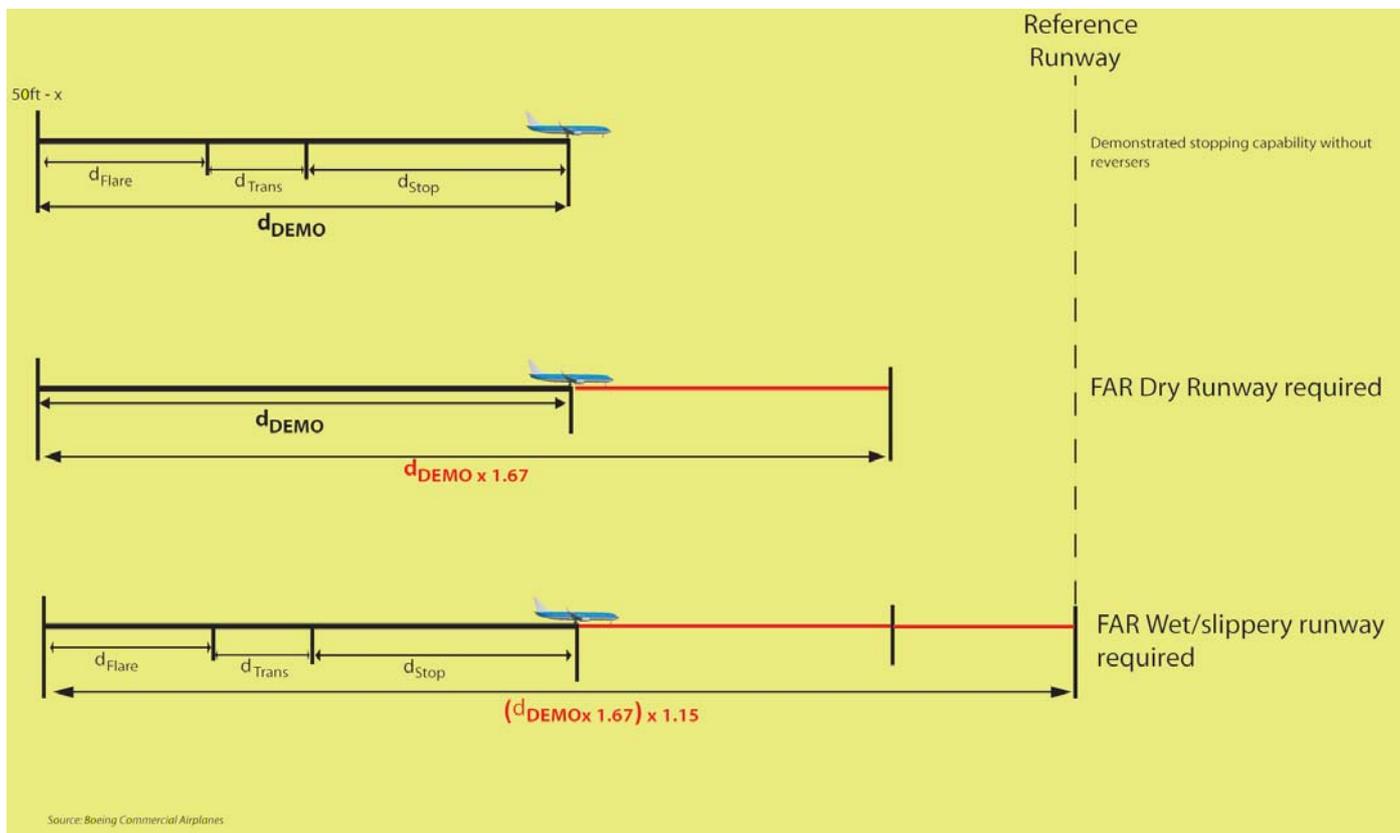


Fig 6: As this chart shows certification requirements should provide ample margin for wet runway conditions. However this is not always the case and the performance data is based on the approach and landing being flown within manufacturer guidelines.

reduced. A June 2004 FAA Notice “Use of autobrakes for landings in adverse conditions” recommended a review of airlines’ policies on the use of autobrakes and urges them to use the manufacturer recommended practice.

### Reverse thrust

As the performance of wheel braking systems has improved and the logic of the systems has evolved (aiming at a rate of deceleration rather than a braking pressure) and the pressure to reduce noise emissions at airports has increased, the use of reverse thrust has declined. Another accelerant to this process has been commercial pressure to reduce fuel burn and engine wear. However, it is worth noting that reverse thrust provides additional deceleration benefits especially on runways with reduced friction. Using reverse thrust can be a vital component for a safe landing roll or Rejected Take Off (RTO) and as a result crews should be prepared to use full reverse thrust if required. This has become a question of mindset and therefore a change in training may be required to help to change the mindset of crews with regard to the use of reverse thrust.

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. This is unacceptable since this kind of restriction necessarily increases the risk of runway excursion. The only determining factor for the use of reverse thrust should be operational.

The calculation of landing distances should take into account the anticipated use of reverse thrust, in other words if less than full reverse thrust is not to be used then crews should not apply the reverse thrust credit to their landing distance calculations. On contaminated runways additional factors must also be considered, for example if one reverser is inoperative then its pair on the opposite wing must also be considered as unserviceable and therefore no reverse thrust credit should be applied.

### Aircraft operating procedures and performance data

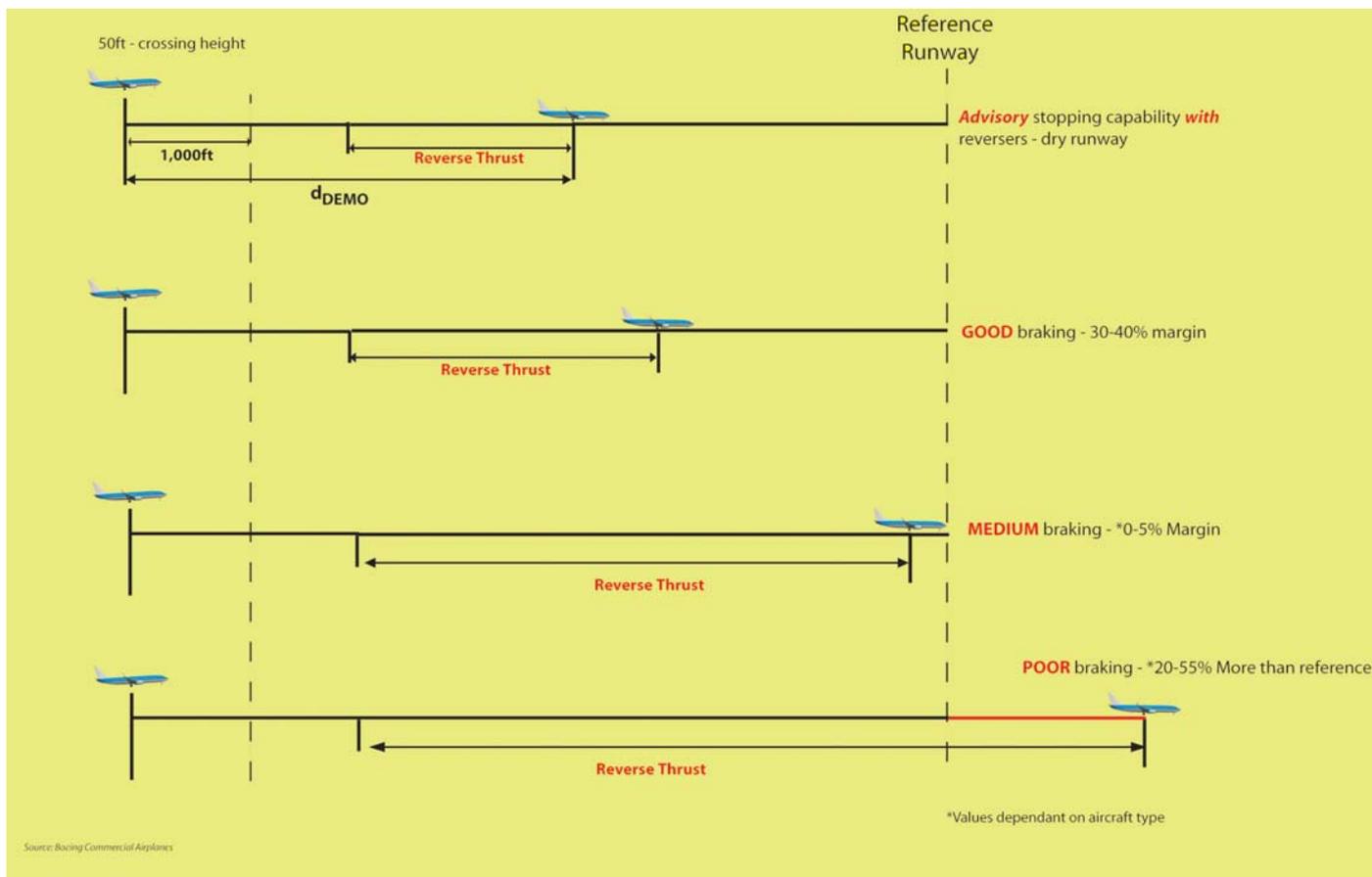
**Certification and validation** -The operation should adequately be covered by certification. This short general policy statement implies that the operational use of aircraft should always be done in line with certified procedures. The certification is thus the basis for all operations. That means that certification standards, conditions and assumption must be totally comparable with day to day line operations.

#### Aircraft technical status

The full thrust reverser system must be serviceable in order to receive any thrust reverse credit.

Tyre tread depth – shall not be less than 3mm.

Brake wear to the overhaul limit is taken into account for a Rejected Take Off (RTO) at V1. In order to ensure that wear remains within acceptable tolerances a means must be provided to indicate when wear has reached the lower limit. This is



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defined as the maximum wear that would still permit a successful RTO at Maximum Take Off Weight (MTOW). Whatever the means employed it must be reliable and readily visible to aid regular inspections. The Flight Test Guide does not require the brakes to be at the fully worn limit during testing, however the test data should be corrected to represent fully worn brakes however it is also worth noting that the ability to absorb the kinetic energy is not linked to the distance required to do so. Unlike the acceptable parameters for RTO testing (where it is acceptable for brakes and tyres to be destroyed) landing certification should be based on testing that allows the repeated use of the equipment. As such, it will introduce some margins on both brake wear and tyre tread depth minimums.

A fully worn brake is the worst-case condition for energy absorption capability. However, the new brake condition is the worst-case condition for performance for some heat sink materials (The heat sink is the mass of the brake that is primarily responsible for

absorbing energy during a stop. For a typical brake this would consist of the stationary and rotating disc assemblies). The FAA acknowledges this and a new brake accelerate-stop test requirement, with the new brake defined as a brake worn no more than 5 percent of its usable wear range, was added in TSO-C135. The applicable requirements in section 25.735 were



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.

amended requiring an energy absorption capability throughout the defined wear range of the brake. While considering these issues it is worth raising a point about the weights used for calculation purposes. Standard passenger weights must always be used and these should be in line with average actual weights. Since the average human size and weight is on the increase operators should update these values every five years as well as when new markets are developed in order that these figures are as accurate as possible.

### Flight crew considerations

As always training should be representative of the intended operation. Airlines should develop training programmes that heighten awareness and theoretical knowledge of the elements that lead to runway excursions. As a minimum this training should place an emphasis on the importance of effective Cockpit Resource Management (CRM) and a basic understanding of the risk posed by excursions. Even more effective would be the inclusion of training regarding situational awareness especially as regards critical runway lengths, the impact of weather and the terrain surrounding an aerodrome. In any case runway excursion avoidance training should also include:

 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 - Preparations for the approach should include anticipation of possible diversions in relation to operator policy. Intentions of the crew briefing should contribute to the appropriate mindset. It should be used to create a high level of situational awareness. The need to execute a go-around if stable approach criteria are not met should be emphasised. This training should be re-enforced with the introduction of either a 'No fault' GA policy or better still making a GA a 'normal' operation which does not require a report.

 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 but also through the establishment of a company culture which re-enforces safety as pre-eminent over all other commercial considerations.

 Attention should be given to stress management.

 Flare technique in relation to rate of descent, floating

Cross and tail -wind techniques

 Use of thrust reversers, including the effects of environmental policies in which idle reverse as maximum R/T is stipulated. Always use full REV unless conditions are confirmed safe to use idle reverse;

 Use of differential braking and automatic braking

 Adverse runway and weather conditions,

### Non-normal situations

Passenger behaviour- Attention should be given to the unpredictable nature of passenger behaviour, especially in relation to non normal conditions. A post 9/11 effect is that passengers are tempted to do what they feel appropriate in a specific situation even when this would mean contradicting (cabin) crew directives. This changed passenger behaviour requires adopted training.

In addition, an understanding of performance criteria, to include the effects of excess threshold crossing height, excess threshold crossing speed, assumed touchdown point, and use of declared distances should also be included in the training

## Runway Safety Manual

suite. IFALPA argues that this training should be mandatory and that the implementation and operation of this training should be monitored by the national civil aviation authority.

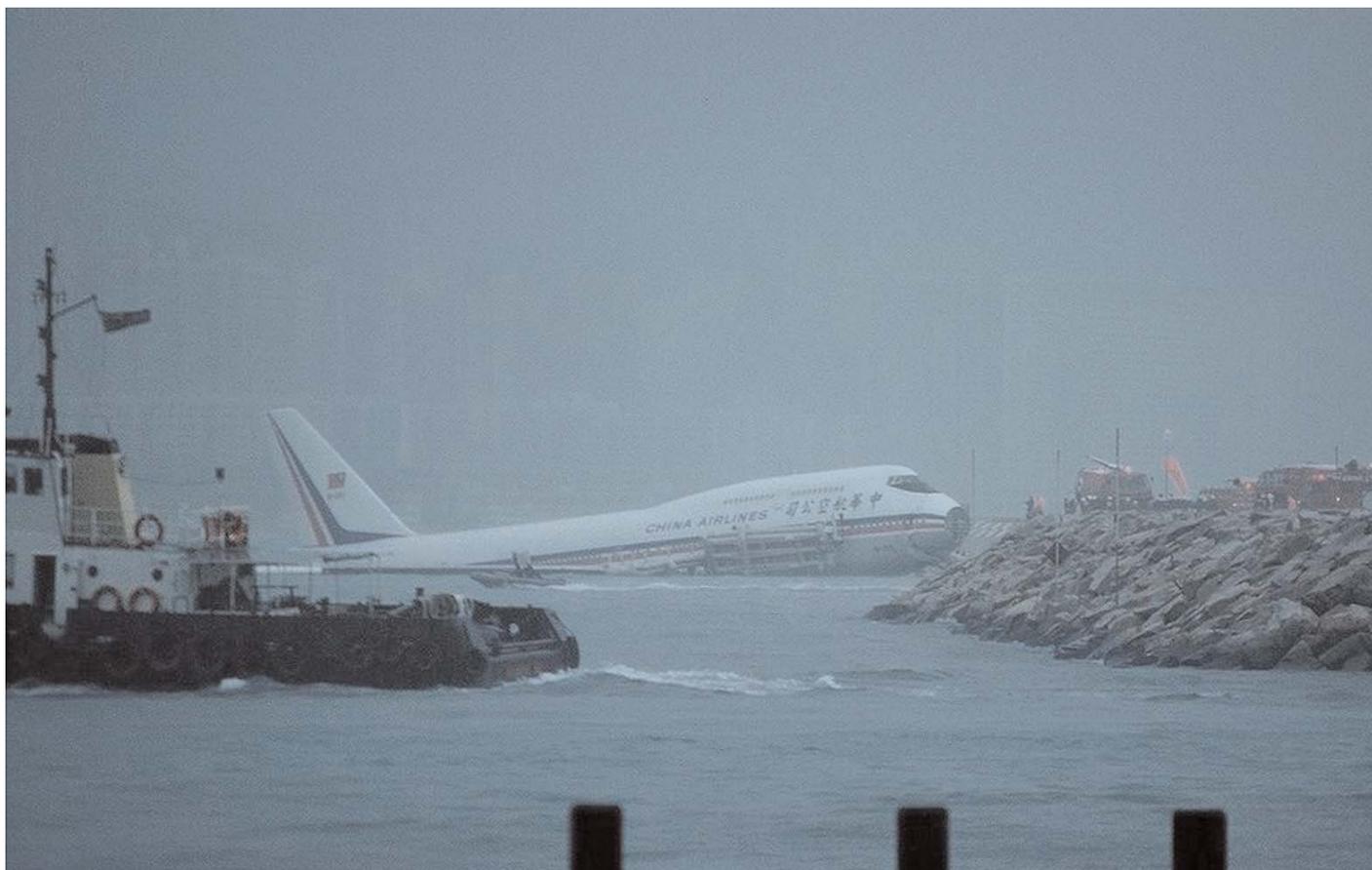
Beyond enhanced training initiatives, operators should specify minimum experience and training criteria on aircraft type for short or special runway operation, operation in adverse weather conditions and x-wind restriction in relation to experience. The programme can be further enhanced by ensuring that crew proficiency is maintained by reviewing operational aspects of runway safety every three years. Crews should be kept proficient by training on an annual basis regarding/covering critical factors which can lead to runway excursions. In a number of high profile runway excursion accidents, in addition to commercial pressures being revealed as an element, fatigue has also been cited as a contributing factor and therefore operators should endeavour to reduce fatigue risk by respecting Flight Time Limitations (FTLs) so that a safe flight is maintained even in challenging conditions (diversions to alternate, adverse wx, non normal conditions). Operators should provide an adequate crew rest and/or a relief scheme. Schedules should be timely and adapted when difficult conditions (adverse weather conditions, extreme delays) prevail.

Additionally, airlines should consider what critical incident support measures they have in place. Operators should develop a system to provide adequate support for crew involved by an incident or accident. As a principle, crew should be regarded as not fit for flight, directly after being involved in an incident or accident.

For these training and operational initiative to reach their full potential they must be underpinned by the establishment of a 'just culture' by airlines. The just culture principle holds that the purpose of reporting non-normal incidents is for the purpose of risk identification only. For more information about the just culture and IFALPA's commitment to the concept see the Position Statement 09POS02 which can be found on the IFALPA website at: [www.ifalpa.org/statements](http://www.ifalpa.org/statements)

## Improving post accident survivability

So far this document has dealt with the Federation's proposals to reduce the occurrence of runway excursions. But nevertheless, and if accident statistics are anything to go by, excursion events will continue to happen and therefore IFALPA has as a goal the mitigation of the risk posed by excursions. If we consider that risk is defined as the chance of an excursion happening multiplied by the severity of the consequences of the event. It is clear that there is much to be improved in air safety by reducing that severity and by extension, improving accident survivability. History has shown that when an aircraft comes to a halt after an excursion upright and without major damage and easily reached by rescue and fire fighting (RFF) teams the number of deaths and injuries sustained is dramatically reduced. Over a number of years IFALPA has developed a series of proposals about how an optimised runway environment can create the optimum survivability. These include, but are not limited to, the runway surroundings, airport emergency response plans, cabin crew performance and the aircraft structure. In the following pages a number of these proposals are set out.



## The runway environment

After the overrun at Chicago Midway in December of 2005, several complaints were voiced about the location of the airport. Like so many, Midway is surrounded by urban sprawl, yet again like almost any major airport when it was first laid out (in the case of Midway during the 1930s) it was located well outside the city it served yet the expansion of the city combined with poor town and country planning allowed the city to grow until it literally surrounded the airport. The failure at Midway was not just the planning strategy that allowed city street to be within a few hundred metres of the runway end but the fact that this error was compounded by a failure to install an arrestor bed (subsequently installed). IFALPA urges that city planners consider the safety implications of their decisions as they assess development of land in the vicinity of airports. Airports too have a role to play in this process as they are often integral to the planning and development process.

## Runway End Safety Areas

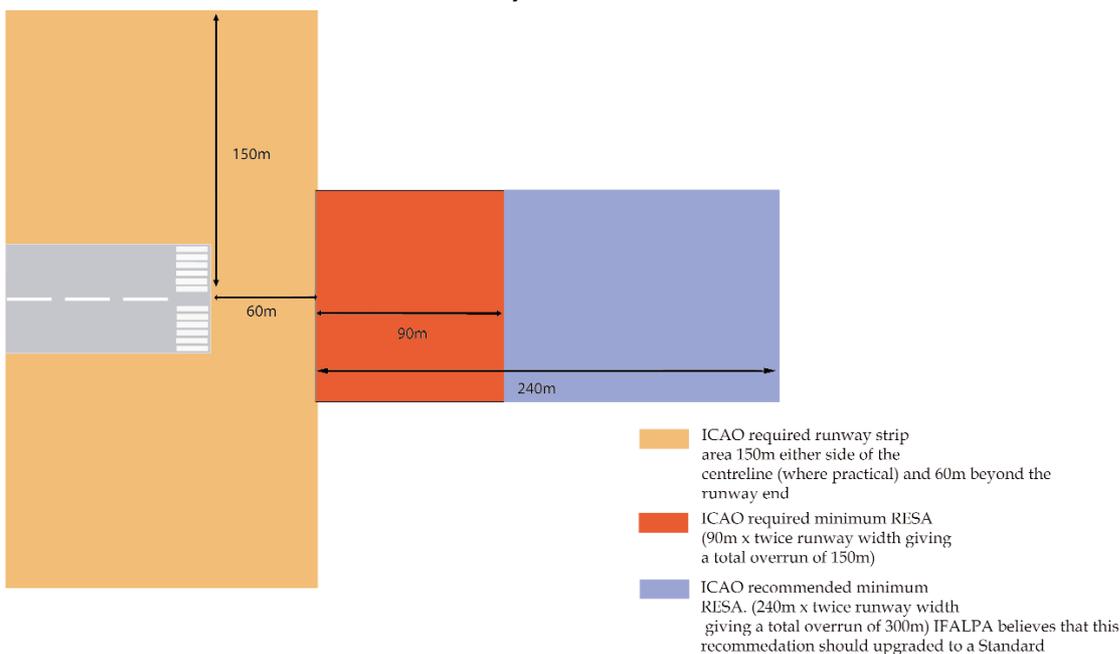
In Annex 14 to the Chicago Convention, ICAO lays down as part of the aerodrome design section its Standards and Recommendations for runway strip and runway end safety areas. At Code 3&4 runways (See fig 3) ICAO says that runways should be contained within a runway strip that is flat, firm and free of non-frangible obstructions. These runway strips must extend a minimum of 150m either side of the runway centreline and at least 60m beyond the end of the runway end (including any stopway). The width requirement is reduced to 75m at code 1&2 runways and the length requirement is dropped to 30m at non-instrument code 1 runways. (ICAO Annex 14 Vol 1 para 3.4 runway strips). In addition to the runway strip requirements, Annex 14 demands that at code 3&4 runways a runway end safety area (RESA) which extends a minimum of 90m beyond the end of the runway strip and twice the width of the runway is established. ICAO goes on to recommend that RESAs extend 240m at code 3&4 runways and 120m at code 1&2 runways and equal to the graded portion of the runway strip are established. (Annex 14 Vol 1 para 3.5). IFALPA believes that improvements in runway safety can best be achieved by avoiding runway related accidents and incidents. If, however, an accident occurs then additional runway safety measures already in place, could enhance survivability. One of these measures is safeguarding the runway environment.

Therefore IFALPA contends that the RESA dimensions laid out in Annex 14 Recommendations should be adopted as a Standard, in other words the minimum requirement. Data from past incidents and accidents has shown that in the overwhelming majority of cases aircraft overrunning a runway leave the paved surface at a speed of less than 70kts and come to a halt within 300m of

the runway end and therefore it is clear that the risk of injury or death for passengers, crews and passersby is significantly mitigated by a RESA meeting these dimensions. IFALPA also recognises that at some airports it is impossible to establish an adequate RESA due to the location of the runway and the surrounding terrain and topography. In this case IFALPA believes that airports should install an Engineered Materials Arresting System (EMAS). An EMAS is an arrestor bed of crushable concrete blocks which works by transferring the energy from an overrunning aircraft

Fig 8: RESA dimensions code 3&4 runways

RESA Dimensions Code 3 and 4 Runways





EMAS is a good alternative if a 240m RESA is not available. At geographically and topographically challenged airports where the system has been installed a number 'saves' have taken place of aircraft from a GIII and SF340 up to a 747-200F.

ports, it still remains a fact that hundreds of the world's runways do not comply with the recommendation (or an EMAS alternative) and therefore the lives of passengers and crews are being needlessly exposed to risk. IFALPA believes the '60+240'x twice runway width Recommendation be upgraded to a Standard forthwith. In a number of cases simple things and low cost items like filling in of ravines or culverts will provide the safety area we call for. Where the physical space does not exist then the solution to the problem has been developed and proven its worth in the real world. Accordingly, there is no excuse to delay the creation of adequate RESAs or, alternatively, the installation of an EMAS.

## Rescue & Fire Fighting

### Definitions

**Critical rescue and fire fighting access area.** A rectangular area, symmetrical about the runway, having a width of 300 m (1000 feet) and a length exceeding that of the runway by 2000 m (6600 feet).

**Rapid response area (RRA).** A rectangular area that includes the runway and the surrounding area. Its width extends 500 ft (152m) outward from each side of the runway centreline, and its length is 1650 ft (500m) beyond each runway end.

ICAO para. 2.11.3 requires that significant changes in the level of protection normally available at an aerodrome for rescue and fire fighting shall be notified to the appropriate air traffic services units and aeronautical information units to enable those units to provide the necessary information to arriving and departing aircraft and be the subject of a Class I Notam. When such a change has been corrected, the above units shall be advised accordingly.

ICAO para. 2.11.4 A significant change shall be expressed in terms of the new category of the rescue and fire fighting service available at the aerodrome.

All taxiway bridges shall have a width at least equal to that of the taxiway plus the width of the shoulder. Additional width shall be provided in the form of a traffic lane to ensure the simultaneous use of the bridge by aircraft and emergency vehicles.

### IFALPA Policy

In accordance with its desire to seek commonality of the ICAO provisions with the Standards of the National Fire Protection Association (NFPA Document 403), IFALPA considers that the Recommended Practices in Section 9.1 should be upgraded to the status of ICAO Standards, without change of text, by deleting Recommendation" and changing "should" to "shall" wherever it appears.

Two new sub-paragraphs to 9.2.1 should be added as under: "9.2.1.x The licensing authority of the State shall be responsible for the provision of the rescue and fire fighting service. The licensing authority shall also be responsible for the proficiency and maintenance of the rescue and fire fighting service. When the rescue and the fire fighting service is downgraded

into the action of crushing the concrete of the system. As a result, aircraft can be brought to a halt within the confines of the bed 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. Accordingly, the Federation has been campaigning for many years for the RESA Recommendation to be upgraded and enforced as an ICAO standard and further that the installation of an EMAS is recognised to the 60m-240m RESA at space restricted airports.

While the ICAO recommended RESA has been applied at a number of airports, especially those constructed more recently, and an EMAS has been installed at a number of terrain/topographically challenged airports,



Critical rescue and fire fighting access area. A rectangular area, symmetrical about the runway, having a width of 300 m (1000 feet) and a length exceeding that of the runway by 2000 m (6600 feet). A Rapid response area (RRA). A rectangular area that includes the runway and the surrounding area. Its width extends 500 ft (152m) outward from each side of the runway centreline, and its length is 1650 ft (500m) beyond each runway end.

*to a lower category than required at that aerodrome, or is completely withdrawn, the licensing authority of the State of aerodrome shall be responsible for the prevention of operation of any aeroplane for which the appropriate minimum category of rescue and fire fighting service is not available”.*

and;  
*“The licensing authority shall demonstrate its compliance with the provisions of the ICAO Training Manual, Doc. 7192 AN/857 and also its responsibilities detailed in the ICAO Airport Services Manual, Part I, Chapters 10 and 13”.*

Add two further new sub-paragraphs to 9.2.1 to read as follows: *“9.2.1.z Regardless of the functional control of RFF services on the aerodrome, a high degree of mutual aid shall be prearranged between such services on aerodromes and any off-airport fire or rescue agencies serving the environs of the aerodrome.”* and *“9.2.1.xx The aircraft operator shall ensure that provisions have been made for the security of the aircraft until such time as a legally appointed accident investigation authority assumes responsibility. The aerodrome manager or authority having jurisdiction may assist or assume the authority in the absence of the aircraft operator.”*

**9.2.3** The level of protection to be provided at an aerodrome shall be determined based on the dimensions of the largest aeroplanes using the aerodrome.

The aerodrome category for rescue and fire fighting shall be determined in accordance with Table 9-1.9.2.8 Both principal and complementary agents shall be provided at an aerodrome.

**9.2.9 Recommendation.**- The principal extinguishing agent shall be: a) a foam meeting the minimum performance level A; or b) a foam meeting the minimum performance level B; or c) a combination of these agents; except that the principal extinguishing agent for aerodromes in categories 1 to 3 shall meet the minimum performance level B. and add *“9.2.9.x All foam concentrates shall be approved or listed based on the following performance test requirements. (i) Performance level B foams such as aqueous film forming foams (AFFF) shall meet the applicable fire extinguishing and the burnback performance requirements for the 50 sq ft (4.6m<sup>2</sup>) fire test in accordance with Military Specification MIL-F-24385, 7 January 1994. (ii) Performance level A foams such as film forming fluoroprotein foam (FFFP), protein foam (P) and fluoroprotein foam (FP) agents shall meet the applicable fire extinguishing and burnback performance requirements of Underwriters Laboratories Inc. Standard UL-162 (Type 3 application), July 6 1993.”*

**9.2.10** Extinguishing agents equivalent to or better than the following shall be available for aircraft fire fighting:

- Potassium bicarbonate dry chemical; or
- Halon 1211.”

With respect to the quantities of water/foam, we propose that ICAO adopt the NFPA 403 current standards as indicated in the table reproduced below:

The quantity of foam concentrate separately provided on vehicles for foam production shall be in proportion to the quantity

## Runway Safety Manual

of water provided and the foam concentrate selected. The amount of foam concentrate should be sufficient to supply at least two full loads of such quantity of water.”

**9.2.x** Compatibility of Agents - Chemical compatibility shall be assured between foam and complementary agents when used simultaneously or consecutively.” “9.2.y Combustible Metal Agents - Extinguishing agents for combustible metal fires shall be provided in portable fire extinguishers that are rated for Class D fires in accordance with Section 1-4 of NFPA 10, ‘Standard for Portable Fire Extinguishers’. At least one nominal 10 kg extinguisher shall be carried on each vehicle specified in Table 9-4.”

**9.2.20 Rescue equipment** commensurate with the level of aircraft operations shall be provided on the rescue and fire fighting vehicle(s).

**9.2.21** It shall be demonstrated that the rescue and fire fighting services are capable of achieving a response time not exceeding two minutes to any part of the movement area and critical rescue and fire fighting access area in all conditions of visibility and surface conditions when flight operations are in progress.”

*Note: Response time is the time between the initial call to the rescue and fire fighting service and the first effective intervention at the accident by the rescue and fire fighting service.*

**9.2.24** Any vehicle required to deliver the amounts of extinguishing agents specified in Table 9-2 shall arrive no more than 30 seconds after the first responding vehicle(s) so as to provide continuous agent application.” “

**9.2.x** Before operations in less than Standard Visibility are conducted at any aerodrome it should be demonstrated that the Rescue and Fire Fighting Service has the capability to locate a distressed aircraft and operate effectively in the conditions prevailing when such operations are in progress.”

*Note: The IFALPA definition for Standard Visibility is ½ statute mile or 800 metres (2600 feet) RVR.*

**9.2.y Recommendation:** A Crash Locator Device should be constructed to the same specification as to impact, fire and corrosion resistance, as is the Voice and Flight Data Recorder. A Crash Locator Device should have an independent, rechargeable power source. Additional features should include: The device should be activated either by the pilots, if able, or independently by an inertia type switch in the event of flight crew incapacitation. Upon immersion in water, the device should be both ejectable and floatable. The transmissions



used should be the same in all countries of the world, and selected so as to avoid confusion with existing locators at airports. A test procedure should be available in order for the serviceability of the unit to be determined. A malfunction warning should be located in the cockpit. Rescue and Fire Fighting Services should be equipped with a homing device, capable of receiving signals from the Crash Locator Device. The presentation to the personnel of the RFF service should be unambiguous and easily read.”

9.2.26 Emergency access roads shall be provided on an aerodrome so as to facilitate achieving minimum response times. Particular attention shall be given to the provision of ready access to the critical rescue and fire fighting access

area. Where a fence is provided, most appropriate access to outside areas shall be provided.

Emergency access roads shall be capable of supporting the heaviest vehicles which will use them, and be usable in all weather conditions. Roads within 90 m of a runway shall be surfaced to prevent surface erosion and the transfer of debris to the runway. Sufficient vertical clearance shall be provided from overhead obstructions for the largest vehicles. 9.2.28 When the surface of the road is indistinguishable from the surrounding area, or in areas where snow may obscure the location of the roads, edge markers shall be placed at intervals of about 10 m.

**Recommendation:** A discrete communication system shall be provided linking a fire station with the control tower, any other fire station on the aerodrome and the rescue and fire fighting vehicles.

**Recommendation:** An alerting system for rescue and fire fighting personnel, capable of being operated from that station, shall be provided at a fire station, any other fire station on the aerodrome and the aerodrome control tower. Concepts on

9.2.31 are as follows from IFALPA policy:

IFALPA considers that this Recommendation should be upgraded to the status of a standard and expanded to encompass the operational requirements by the addition of the following text:

*“The operational communications system shall provide a primary and, where necessary, an alternate effective means for direct communication between the following, as applicable: the alerting authority such as the control tower or flight service station, airport manager, fixed-base operator, or airline office and the aerodrome RFF service; the air traffic control tower or flight service station and RFF vehicles en-route to an aircraft emergency or at the accident/incident site; the fire department alarm room and RFF vehicles at the accident/incident site; the aerodrome rescue and fire fighting services and appropriate mutual aid organisations located on or off the aerodrome, including an alert procedure for all auxiliary personnel expected to participate; the rescue and fire fighting vehicles; and the aircraft and fire fighting vehicles. direct VHF Flight Crew Fire Fighter Communications.*

*The minimum number of rescue and fire fighting vehicles provided at an aerodrome shall be in accordance with the following tabulation:*

*During flight operations, sufficient trained personnel shall be detailed and be readily available to ride the rescue and fire fighting vehicles and to operate the equipment at maximum capacity. These trained personnel shall be deployed in a way that ensures that minimum response times can be achieved and that continuous agent application at the appropriate rate can be fully maintained. Consideration must also be given for personnel to use hand lines, ladders and other rescue and*



Where a fence is provided, most appropriate access to outside areas shall be provided. Emergency access roads shall be capable of supporting the heaviest vehicles which will use them, and be usable in all weather conditions.

## Runway Safety Manual

*fire fighting equipment normally associated with aircraft rescue and fire fighting operations*

*A person shall be appointed to direct the aerodrome rescue and fire fighting services. The responsibilities of this person shall include overall administrative supervision of the organisation, effective training of personnel and operational control of emergencies involving aircraft within the aerodrome jurisdiction.”*

All rescue and fire fighting personnel shall meet the requirements of NFPA 1003 ‘Standard for Airport Fire Fighting Professional Qualifications’.

All rescue and fire fighting and other authorised personnel shall be given suitable uniforms or identifying insignia to prevent any misunderstanding as to their right to be in the fire area or the aircraft movement area of an aerodrome during an emergency.

Approved protective clothing and equipment, including protective coat, protective trousers, helmet, gloves and self contained breathing apparatus (SCBA), shall be provided, maintained, and readily available for use by all rescue and fire fighting personnel.

SCBA for rescue and fire fighting personnel shall meet the requirements of NFPA 1981 ‘Standard for Self Contained Breathing Apparatus for Fire Fighters.’

Station/work uniforms worn by rescue and fire fighting personnel shall meet the requirements of NFPA 1975’ Standard on Station/Work Uniforms for Fire Fighters’.”

Other than rescue and fire fighting vehicle driver/operators, all rescue and fire fighting personnel engaged in any rescue or fire fighting operation shall wear complete protective clothing, including SCBA, and shall not remove any protective clothing or SCBA until they are in a safe area and so directed by the officer in charge.”

### Passengers & Cabin Crew

As society evolves so individuals in general have become more assertive in their behaviour and also more inclined to question those perceived as being in authority. It appears that the days when you could reasonably expect passengers to follow crew instructions have ended. Following the overrun by Air France 358 in 2005, the cabin crew had decided, correctly, not to open certain doors due to the proximity of flames from the post crash fire. However groups of passengers unilaterally decided to overrule the crew and open them anyway exposing themselves and those around them to greater danger.

Therefore it appears that a scientific study into group behaviours in a survivable post crash environment is warranted. From the results of such a study new crowd control techniques might be developed together with the training to implement them.

Meanwhile, cabin crew remain vital in the avoidance of accidents, as an information resource and as a vital component in maximising post accident survivability.

**Key elements of the role include:**

-  The timing of the ‘brace’ call one minute before expected impact – although this is of less use in most runway excursions which tend to happen without any forewarning.
-  Clear, timely and precise evacuation calls
-  The guidance and/or control of unruly or fearful passengers
-  Fire fighting, control during evacuation

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## Runway Incursions



The 1977 collision of two 747s at Tenerife remains the industry's worst accident, and it was the result of a runway incursion.

### Introduction

Runway incursions are defined as any person, aircraft or vehicle that enters a runway by mistake. This definition includes aircraft attempting takeoff or landing on a runway other than the one assigned. Incursions present a significant threat to air safety. Indeed, no discussion of the runway incursion threat is complete without recalling that air transport's worst accident (in Tenerife in 1977) was the result of a runway incursion.

More recently, as a result of the runway incursion accident at Milan Linate in 2004 much work has been carried out in an effort to develop strategies to reduce the frequency of runway incursions and, as result, some excellent guidance including the European Action Plan of the Prevention of Runway Incursions and the ICAO Runway Incursion Prevention Manual has been developed. It is not the intention of this document to replicate these works which, broadly speaking, advance short and medium term solutions but to consider longer term strategies to 'design out the problem' as well as add IFALPA's additional input to the existing anti-incursion projects.

That said, IFALPA strongly supports some of the short term tactical initiatives like the Local Runway Safety Teams (LRST). LRSTs are made up of representatives of operational users of an airport, vehicle drivers, air traffic controllers, airport operations and pilots and are an excellent means of creating innovative solutions to incursion risks at their airports. Therefore, the Federation actively encourages its Member Associations to take part in LRSTs and supports this initiative with a range of LRST and Airport Liaison Representative training programmes. These training programmes are not only of benefit to pilots but also since they are rooted within IFALPA and ICAO's framework bring a consistency to the meetings. While the hallmark of the LRST is its local knowledge and a flexibility to deal with airport specific challenges, if the solutions are to be truly effective in the multinational nature of airport operations (and perhaps implemented at other airports) it is essential that the solutions developed remain within the ICAO framework.

Ideally, local deviations from the ICAO Standards and Recommended Practices (SARPs) should only happen during trials of new technologies or techniques enroute to their implementation or rejection as an ICAO SARP. An excellent example of this is the Runway Status Lights (RWSL) programme developed by the Massachusetts Institute of Technology and currently under trial by the FAA in various guises at a number of US airports (for more information about the RWSL see the Sept-Oct 2008 edition of InterPilot).

At existing airports, the tendency towards 'organic' growth and development of airports has lead to the existence of incursion 'hotspots'. IFALPA's view is that it is not enough to merely recognise that hotspots (with their potential for tragedy)

## Runway Safety Manual

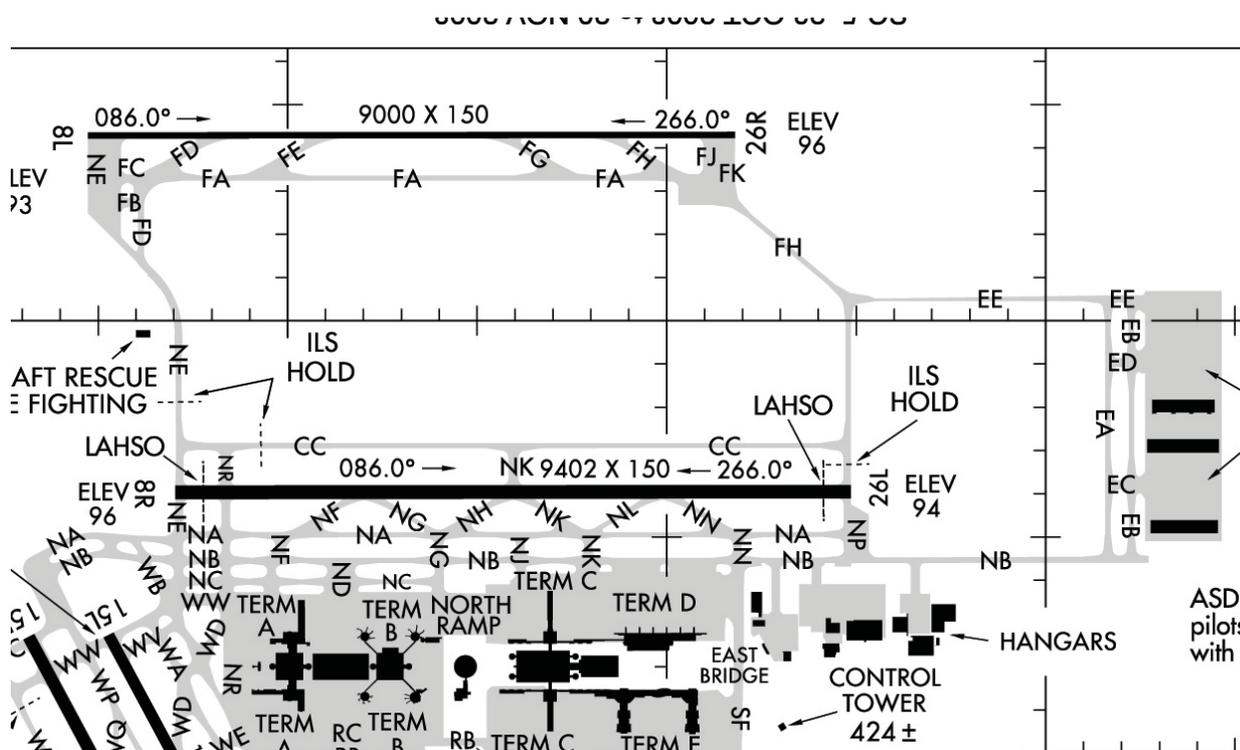
exist but that they must be identified and then within a reasonable timeframe, either removed or their effect mitigated. The same can also be said for the development of procedures to enhance airport capacity that are planned without a full analysis of the effect on incursion risk (remember that risk is defined as the potential for incursion multiplied by the severity of the consequences). Simultaneous operations on intersecting runways, the concept of Land and Hold Short (LAHSHO) are classic examples of procedurally increased risk. As is the use of high speed runway exits as runway entry points, a policy that was a direct cause of a fatal collision at Paris Charles de Gaulle in 2000.

### Longer term solutions

IFALPA's firmly held belief is that future airports should endeavour to design out the risk of runway incursions and that furthermore, this should as far as is practical be a concept applied to expansion of existing airports. Obvious examples of the former are Munich with its parallel runway and midfield terminal/apron complex layout or Hong Kong which adopts the same principle. Examples of the latter are the northern east/west runway at Houston Bush connected to the terminal/apron complex with end around taxiways and at Atlanta Hartsfield which also uses an end around taxiway to connect the new runway. One of the primary causes of runway incursions and confusion is as the result of a loss of spatial and positional awareness in poor visibility or night operations (a factor at Tenerife, Linate, Taipei and Lexington). Yet the technology to help improve situational awareness already exists. Motorists for example have enjoyed the benefits of GPS mapping systems when travelling to unfamiliar destinations and slowly these types of systems are finding their way onto aircraft. Indeed ground mapping systems have been installed on the A380 and are expected to feature on both the 787 and A350.

### Aerodrome physical characteristics

The primary focus of the design of the active areas of an airport should be safety of operation. Clearly then the reduction the potential for runway incursions is an integral part of this goal and so 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. One of the obvious solutions is a design where runway crossings are not required by aircraft or vehicles transiting from one part of an airport to another. For airport operators engaged in expansion or upgrade there is guidance on all aspects of the design of aerodromes available in the ICAO Aerodrome Design Manual. However the Aerodrome Design Manual does not adequately cover the importance of airport layout in reducing the potential for runway incursions. As a general principle the airport's layout should be instinctive and logical to its users. Taxiways shall 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 shall be limited as much as possible and avoided where not absolutely required for the safe flow of traffic.



When the northern runway was constructed at Houston Bush (KIAH) the design of the connecting taxiway system allowed for crossings of 8R/26L to be at low energy points near either end. While this solution is not as effective as an 'end around taxiway' it significantly mitigates the effect of a runway incursion.

**Key elements to include in a low incursion risk airport design are:**

 Runway Crossings prevented by design

 Stop bars at runway/taxiway intersections

 The taxiway system should be designed to minimize restriction to aircraft movement to and from the runways and apron areas. It should be 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 for a runway shall be restricted to those required for lining up for takeoff and shall be perpendicular to that runway.

 The requirement and possibility to cross a runway should be avoided at all times. If there would be a requirement for aircraft and/ or vehicles to cross a runway than a perimeter or “end around” taxiway or a perimeter service must be built.

 If a runway crossing is unavoidable and the end around option is not available, then traffic flows should be modified so that they are only at points where traffic on the runway will be at low speed.

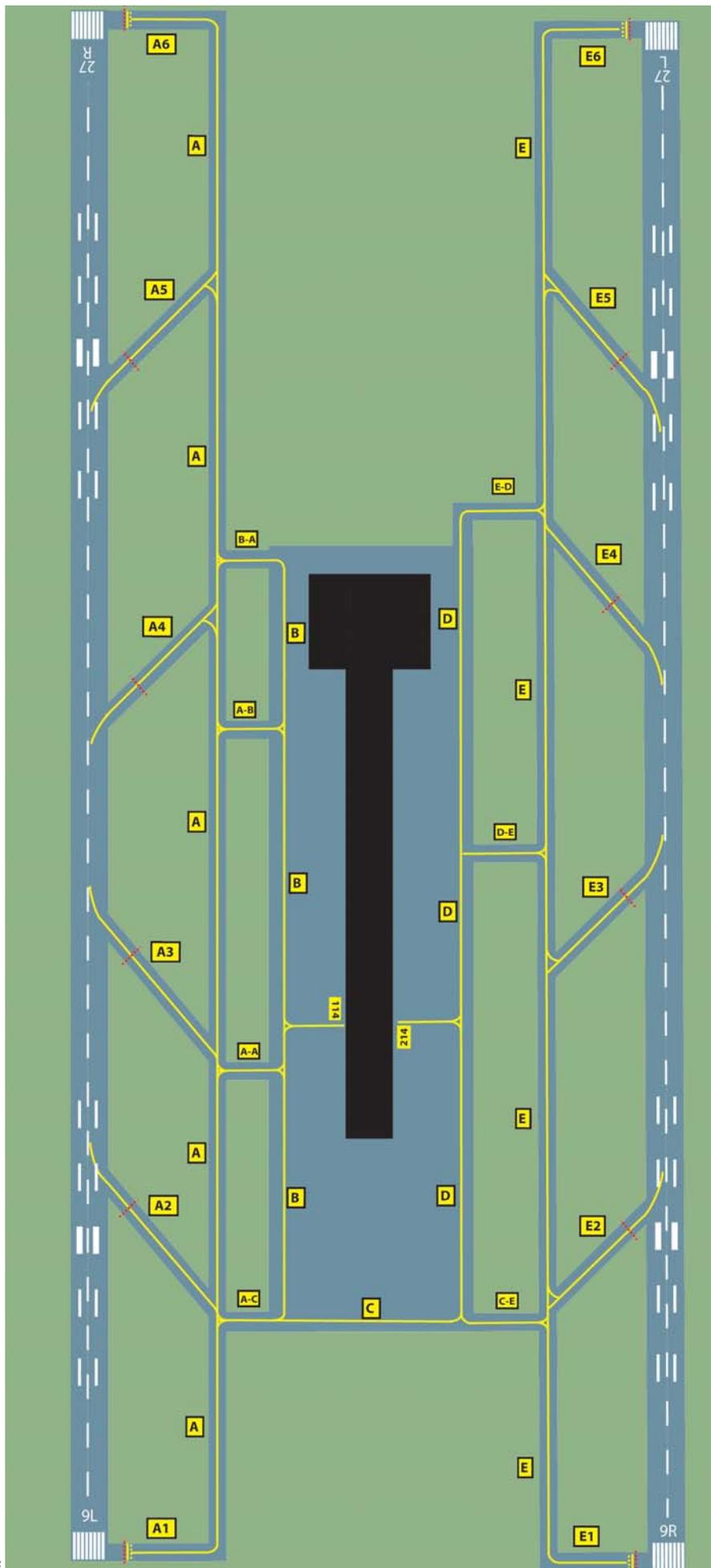
 A runway exit taxiway should include a straight portion following the turnoff curve sufficient for an existing aircraft to come to a full stop, clear of both the duty runway and an intersecting taxiway

 Rapid exit taxiways shall be constructed in such a way that crossing another runway via a rapid exit taxiway is not possible.

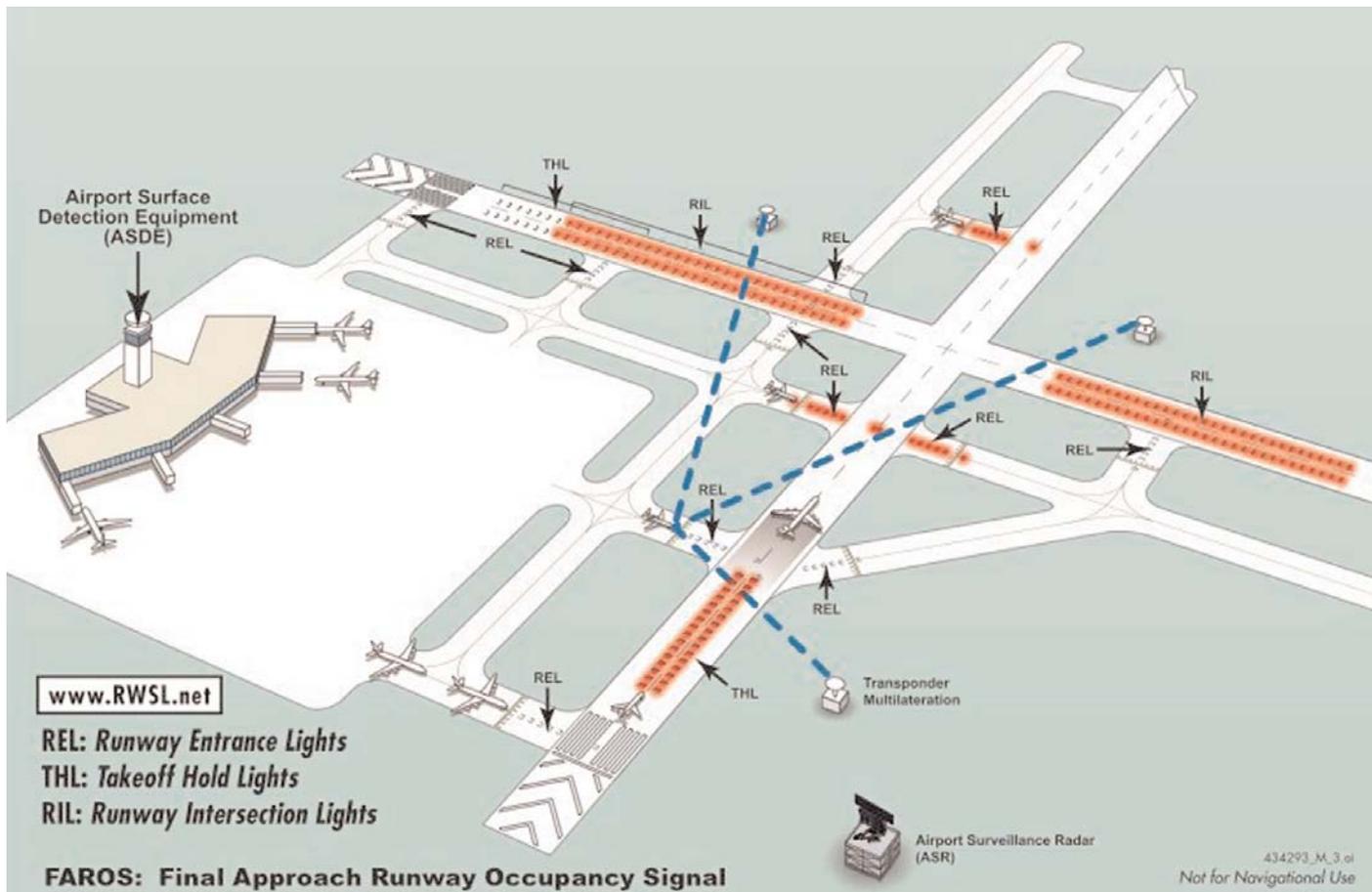
 Taxiway designation shall follow the principle that as few as possible different names are given to one routing. However, a taxiway that intersects with a runway should have different designations on either side of that runway.

### 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



Runway crossings prevented by design, the installation of stopbars at every runway/taxiway intersection, perpendicular entrance taxiways near runway ends are all key features of the low incursion risk airport.



to reduce runway incursions is the installation of 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. In addition newer innovations, for example automatically operated runway status lights, are another option which may enhance safety. Certainly early trials of the system at San Diego and Dallas – Ft Worth and laterally Boston Logan have shown encouraging results. With early data from DFW revealing at least two ‘saves’ by the system.

***For Stop bar systems to be truly effective they must have the following elements***

 Stop bars shall be selectively switch-able by the appropriate air traffic controller.

 Stop bars shall be installed at all aerodromes where a runway crossing is possible, and provided at every runway-holding position serving a runway, including non active runways.

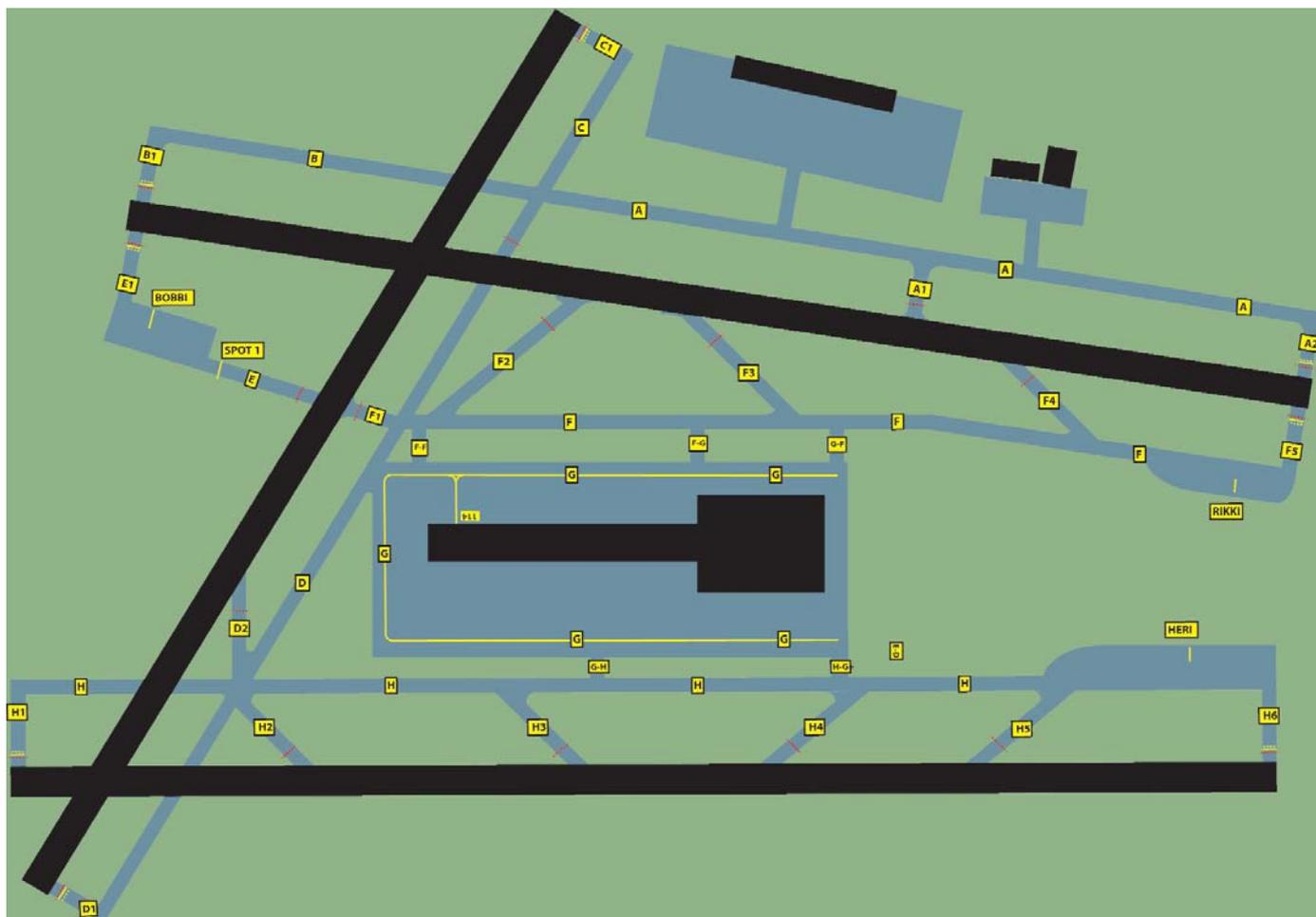
 Aircraft shall not cross red stop bars unless contingency measures are in force. Contingency measures should cover all cases where the stop bars or controls are unserviceable.

### Taxiway nomenclature

At present there is no worldwide standard for taxiway designation which leads to the potential for confusion. For example the clearance “taxi to C2” could be a clearance to a taxiway, a holding position or even a gate. At airports with complex layouts illogically named taxiways have created confusion and this has contributed to a heightened risk. Certainly in the past misunderstandings of taxiway clearances has lead to runway incursions and accidents. ICAO Annex 14 calls for taxiways to be identified using a letter, letters or a combination letter(s) and numbers. While ICAO recommends that use of the letters I, O or X is avoided (to avoid confusion with the numbers 0 and 1 or a closed designation) as well as the words inner and outer, these are not a requirement and, furthermore, the Annex offers no guidance to a systemic application of designations.

To reduce the risk there must be a standardised taxiway designation system and this system should be as logical as possible for ease of use. In IFALPA Annex 14 such a system is proposed

## IFALPA Taxiway designation system



 Primary route taxiways should be designated using only one letter (e.g. A, T, J).

 The allocation of letter should start at one end of the airport and continue sequentially to the opposite end (i.e. from east to west or north to south)

 The letters I, O, S, and Z should not be used to avoid confusion with the numbers 1, 0, 5 and 2 the letter X should not be used since there is a potential for confusion with a closed designation.

 Different taxiways shall not have the same or a similar designation.

 Taxiways that connect to the runway should have an alpha numeric designation (e.g. A1, A2, and A3...A12). The numbering should start at one end of the runway and follow a logical sequence to the other end, whilst not leaving out any numbers and maintaining a logical sequence.

 Taxiways crossing a runway should be avoided. Where this is not possible, the taxiways shall have different names on either side of the runway. For example taxiway K on the east side of a runway will become L on the Westside. In the event that it is a link taxiway, for example K5 on the east side, both letter and number should change on the west side retaining as closely as possible the designation logic (to L4 perhaps).

 Connecting taxiways (intersections, links between major traffic routes) shall be named in such a way that they cannot be mistaken as runway entrances/exit and are logically connected to the taxiways they serve (e.g. AC connects taxiways A and C).

 Different taxiways on the same aerodrome shall not have the same or similar designations.

## Runway Safety Manual

 Holding Points shall have unique names, starting with the word “point” so that they cannot be mistaken for taxiways. They should be logically connected to the taxiway which they serve.

 Intermediate holding points shall be designated by the word “spot” and then the number (e.g. Spot 7)

 Apron stand designators shall use a discretely different naming convention and shall not conflict with any other taxiway designators at the airport. This can best be achieved by providing gates a three digit number (e.g. 203, 785 etc...)

 The use of standard taxi routes is recommended to reduce congestion on ground frequencies and to make taxi clearances predictable.

## Use of aircraft external lights to aid runway incursion prevention



It is a widely held belief that the use of aircraft external lights could be an effective tool as part of a runway incursion prevention programme. However, at present there are no globally accepted guidelines for the use of aircraft external lights while on the ground. However, the following guidelines have been developed by the IFALPA Aerodrome & Ground Environment Committee in association with EUROCONTROL and the US FAA.

While the suggestions made in these guidelines should help to improve the visibility of aircraft operating in the maneuvering area of an airport they should not be seen as replacing proper monitoring of radio and other communications.

The captain is responsible for ensuring operating limitations and established operating procedures are observed. The captain always has the final authority to use the aircraft lights as deemed necessary for the safe execution of flight (including ground movement operations).

Clearly, there are issues associated with the use of external lights which must be addressed for example the impact of dazzle effect from strobes, landing lights and some high power taxi and runway turn off lights especially in certain weather conditions (snow, fog etc.) and the impact of external light use on others must always be considered.

Guidelines for the use of aircraft lights during ground operations:

To the extent possible and consistent with aircraft equipment, operating limitations, and flight crew procedures, the illumination of aircraft exterior lights day or night should be as follows:

**FLIGHT CREW PROCEDURES****STARTING (Engines running)**

Anti Collision lights / rotating beacon	ON
Logo lights	ON (Note 1)

**TAXI-OUT (Moving on own power) ( Note 1)**

Taxi light	ON (Notes 2/3)
Navigation / Position lights	ON (night); Operators Policy (day)
Turnoff lights	ON (Notes 2/3)

**CROSSING (ANY) RUNWAY (Note 4)**

Strobe lights	ON
Turnoff lights	ON
Landing lights	ON
TAKE OFF	

Entering the runway:

Strobe lights	ON
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*Take off clearance received:*

Landing lights	ON
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**TAXI-IN (runway vacated) (Note 1)**

Landing lights	OFF
Strobe lights	OFF
Runway Turn off lights	ON (Notes 2/3)

*Note 1: During the hours of darkness anytime the aircraft is in motion on the ground or in the air below 10,000ft/FL100.*

*Note 2: To signal intent to other pilots, consider turning taxi and runway turn off lights off when stopped, yielding, or as a consideration to other pilots or ground personnel.*

*Note 3: Runway turn-off and taxi lights should always be ON during taxi. Outside the runway they may be temporarily switched off to avoid the blinding or dazzling effect, they should always be used when crossing a runway.*

*Note 4: When crossing a runway, the factual status of the runway, active or not, does not have any effect on the use of lights. Operators or Captains should consider turning ALL exterior lights on when crossing any runway.*