

Unstable Approaches



Risk Mitigation Policies, Procedures and Best Practices **2nd Edition**



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Acronyms

AAL	Above Airport Level
ACTF	Accident Calcification Task Force
AGL	Above Ground Level
ALAR	Approach and Landing Accident Reduction
AMDB	Airport Mapping Database
ANSP	Air Navigation Service Provider
APV	Approach Procedures with Vertical
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATIS	Automatic Terminal Information Service
ATSU	Air Traffic Services Unit
CFIT	Controlled Flight into Terrain
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DH	Decision Height
EAFDM	European Authorities coordination group on Flight Data Monitoring
EFB	Electronic Flight Bag
EGPWS	Enhanced Ground Proximity Warning Systems
ELISE	Exact Landing Interference Simulation Environment
FAF	Final Approach Fix
FDA	Flight Data Analysis
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FMS	Flight Management System
FOBN	Flight Operations Briefing Notes
FOQA	Flight Operations Quality Assurance
FSF	Flight Safety Foundation
GADM	Global Aviation Data Management
GPWS	Ground Proximity Warning System
ICAO	International Civil Aviation Organization



ILS	Instrument Landing System
IMC	Instrument Metrological Conditions
IOSA	IATA Operational Safety Audit
LOC-I	Loss of Control Inflight
MDA	Minimum Descent Altitude
NOTAM	Notice to Airmen
OEM	Original Equipment Manufacturer
OM	Outer Marker
PANS OPS	Procedures for Air Navigation Services — Aircraft Operations
PBN	Performance Based Navigation
PF	Pilot Flying
PIREPs	Pilot Reports
PM	Pilot Monitoring
ROPS	Runway Overrun Prevention System
SAAFER	Situational Awareness & Alerting For Excursion Reduction
SMS	Safety Management System
SOP	Standard Operating Procedure
STAR	Standard Terminal Arrival Route
TAWS	Terrain Awareness and Warning System
TOD	Top-of-Descent
VMC	Visual Metrological Conditions



Abstract

Safety is the number one priority for the entire aviation industry and for many years 'continuous improvement' has been the guiding principle in aviation safety management. A primary goal is to improve crew responses to unexpected and undesired events, which have the potential to erode the margins between safe operations and accidents.

Inevitably safety management resources are finite and must be targeted in ways that offer the greatest opportunities for prevention. During the data period 2011-2015 considered within the following chapters approximately 65% of all recorded accidents occurred in the approach and landing phases of flight, and unstabilized approaches were identified as a factor in 14% of those approach and landing accidents.

A stabilized approach is one during which several key flight parameters are controlled to within a specified range of values before the aircraft reaches a predefined point in space relative to the landing threshold (stabilization altitude or height), and maintained within that range of values until touchdown. The parameters include attitude, flight path trajectory, airspeed, rate of descent, engine thrust and aircraft configuration. A stabilized approach will ensure that the aircraft commences the landing flare at the optimal speed, and attitude for the landing.

The industry as a whole – manufacturers, regulators, professional associations, air navigation service providers (ANSPs), operators, controllers and pilots – must adopt an unequivocal position that the only acceptable approach is a stabilized one, and pilots in particular must take professional pride in achieving it on every occasion. Recognized industry practice is to recommend that a failure by the flight crew to conduct a stabilized approach should result in a go-around.

The industry has developed a number of technological solutions to help minimize unstabilized approaches and more are on the way.



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Section 1—Guidance Overview

1.1 Manual Objective

The purpose of this document is to enhance the overall awareness of the contributing factors and outcomes of unstabilized approaches, together with some proven prevention strategies and to provide a reference based upon the guidance of major aircraft manufacturers and identified industry best practice, against which to review operational policy, procedures and training.

1.2 Manual Content

The material in this manual is based on:

- Airbus Flight Operations Briefing Notes (FOBNI);
- DGAC France. c. 2005. Unstabilised Approaches. Directorate General of Civil Aviation, Department of Safety Management;
- Flight Safety Foundation (FSF) Approach and Landing Accident Reduction; (ALAR) Briefing Note 2.2: Crew Resource Management;
- FSF ALAR Briefing Note 4.2: Energy Management;
- FSF Go-around Decision Making and Execution Project Study [in progress as at December 2015];
- ICAO Doc. 8168 Procedures for Air Navigation Services — Aircraft Operations (PANS OPS) VOL I (Flight Procedures);
- ICAO Doc. 4444 Procedures for Air Navigation Services – Air Traffic Management (PANS ATM);
- IATA Operational Safety Audit (IOSA) Manual 9th Edition;
- IATA 52nd Safety Report;
- Go-around Safety Forum, 18 June 2013, Brussels: Findings and Conclusions;
- Lussier, Marc et al. 2016. Eye on Safety: Unstabilized Approach. Nav Canada: Montreal, Canada;
- European Authorities coordination group on Flight Data Monitoring (EAFDM): developing standardized FDM-based indicators;
- SKYbrary: 2014, Stabilized Approach Awareness Toolkit for ATC. CANSO, Eurocontrol, FSF;
- CANSO Unstable Approaches: Air Traffic Control Considerations.

1.3 Data Sources for Manual

The data supporting this manual are derived primarily from the IATA Global Aviation Data Management (GADM) Accident database, and the IATA 2015 Safety Report. The data period includes the five (5) years from 2011 to 2015.

1.4 Definitions

1.4.1 Accident

An occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

1. A person is fatally or seriously injured as a result of:
 - Being in the aircraft, or
 - Direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
 - Direct exposure to jet blast,

Except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or

2. The aircraft sustains damage or structural failure which:
 - Adversely affects the structural strength, performance or flight characteristics of the aircraft, and
 - Would normally require major repair or replacement of the affected component,

Except for engine failure or damage, when the damage is limited to a single engine (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes), or for minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or

3. The aircraft is missing or is completely inaccessible.

1.4.2 End State

An End State is a reportable occurrence. It is **unrecoverable**.

Note: An unstabilized approach is recoverable and is therefore an Undesired Aircraft State, whereas a runway excursion is not recoverable and is an End State.

1.4.3 Failure to Go-Around after Destabilization during Approach

Flight crew does not execute a go-around after stabilization requirements are not met or maintained.

1.4.4 Fatality

A passenger or crewmember who is killed or later dies of their injuries resulting from an operational accident. Injured persons who die more than 30 days after the accident are excluded.

1.4.5 Flight Crew

This is used throughout this document interchangeable with **pilot(s)**.

1.4.6 Phase of Flight Definition

The phase of flight definitions developed and applied by IATA are presented in the following table:

Approach: Begins when the crew initiates changes in aircraft configuration and/or speeds enabling the aircraft to maneuver for the purpose of landing on a particular runway; it ends when the aircraft is in the landing configuration and the crew is dedicated to land on a specific runway. It may also end by the crew initiating an 'Initial Climb' or 'Go-around' phase.

Go-around: Begins when the crew aborts the descent to the planned landing runway during the 'Approach' phase; it ends after speed and configuration are established at a defined maneuvering altitude or to continue the climb for the purpose of cruise (same as end of 'Initial Climb' phase).

Landing: Begins when the aircraft is in the landing configuration and the crew is dedicated to touch down on a specific runway; it ends when the speed permits the aircraft to be maneuvered by means of taxiing for the purpose of arriving at a parking area. It may also end by the crew initiating a 'Go-around' phase.

Descent: begins when the crew departs the cruise altitude for the purpose of an approach at a particular destination; it ends when the crew initiates changes in aircraft configuration and/or speeds to facilitate a landing on a particular runway. It may also end by the crew initiating an "En-Route Climb" or "Cruise" phase.

Initial Climb: begins at 35 feet above the runway elevation; it ends after the speed and configuration are established at a defined maneuvering altitude or to continue the climb for the purpose of cruise. It may also end by the crew initiating an "Approach" phase.

Note: Maneuvering altitude is based upon such an altitude to safely maneuver the aircraft after an engine failure occurs, or predefined as an obstacle clearance altitude. Initial Climb includes such procedures applied to meet the requirements of noise abatement climb, or best angle/rate of climb.

It is worth noting the definitions considered by the collaborators, such as, the **Approach phase** from an Air Traffic Control Officer (ATCO) perspective, is considered as the transition from the last en-route waypoint in the en-route phase until landing is performed or a missed approach is executed. It includes descent and speed clearances, adherence to a Standard Terminal Arrival Route (STAR), (if applicable) and vectoring to final approach course, for example.

1.4.7 Undesired Aircraft State

A flight-crew-induced aircraft state that clearly reduces safety margins; a safety-compromising situation that results from ineffective error management. An undesired aircraft state is still **recoverable**.

1.4.8 Unstable Approach

The Accident Classification Task Force (ACTF) allocates the factor 'Unstable Approach' to an accident when it *'has knowledge about vertical, lateral or speed deviations in the portion of the flight close to landing'*, (see IATA Safety Report 2015 for more information).

Note: This definition includes the portion immediately prior to touchdown and in this respect, the definition might differ from other organizations. However, accident analysis gives evidence that a 'destabilization' just prior to touchdown has contributed to accidents in the past.

1.5 Collaborative Approach

Consistent stabilized approaches are more likely when effective 'collaboration', 'cooperation' and 'communication' occur between all participants, including the operators, manufacturers, state regulators, training organizations, Air Navigation Service Providers (ANSPs), Air Traffic Control Officers (ATCOs) and of course the pilots themselves, allowing the aircraft to accurately follow the published lateral and vertical approach paths in steady, stabilized flight from a reasonable altitude above touchdown.

Section 2—Background

2.1 The Aim of an Approach

A safe landing and completion of the landing roll within the available runway is the culmination of a complex process of energy management that starts at the top of descent, from which point the sum of kinetic energy (speed) and potential energy (altitude) must be appropriately dissipated to achieve taxi speed before the runway end. This can be a continuous process from start to finish or the continuum may be broken by a holding pattern or protracted level flight, in which case it starts afresh when descent recommences. The pilots have thrust and drag available as primary energy management tools but with the input of the controller they may also use track miles in the equation. The descent and arrival phases can be considered as the wide 'mouth' of a large funnel offering a relatively broad spectrum of speed/altitude/distance relationships within the 'acceptable range. The approach and in particular the final approach, constitutes the narrow 'neck' of the funnel guiding the aircraft precisely to the runway threshold where the energy management options are more limited. Both ATCOs and pilots are experiencing very short decision time, high workload and few options to manoeuvre in this flight phase. The aim of the approach is to deliver the aircraft to the point in space above the runway from which a consistent flare maneuver will result in touchdown at the right speed and attitude, and within the touchdown zone.

2.2 Unstabilized Approaches Synopsis

The safety data from the IATA GADM Accident database show that the approach and landing phases of flight account for the major proportion of all commercial aircraft accidents; 65% of the total accidents recorded from 2011-2015. Unstable approaches were identified as a factor in 14% of those accidents.

Many contributory factors can be identified in each accident but approach-and-landing accidents are frequently preceded by a poorly executed and consequently unstabilized approach, together with a subsequent failure to initiate a go-around.

The aviation community has for some time recognized that establishing and maintaining a stabilized approach is a major contributory factor in the safe conclusion of any flight. The aircraft must have the correct configuration, attitude, airspeed, power/thrust setting and be at the right position over the runway to provide the pilots with the best opportunity for a safe landing. Each of these performance criteria must be within a specified range of values throughout the final approach in order for the approach to be considered 'stabilized'. Individual operators must first define the criteria they require for a stabilized approach based upon their aircraft types, operational requirements, meteorological conditions and acceptable margins of safety. They must then promulgate a policy of strict compliance with the stabilized approach criteria, develop procedures and training to support that policy and use flight data to monitor adherence to the policy in routine operations.

A multidisciplinary approach, through collaboration and communication between all industry stakeholders, as described above, is required for network-wide implementation of effective stabilized approach policies and identified best practices.

The International Air Transport Association (IATA), in collaboration with the International Federation of Air Line Pilots' Associations (IFALPA), the International Federation of Air Traffic Controllers' Associations (IFATCA), and Civil Air Navigation Services Organisation (CANSO), addresses recommendations and guidance to help avoid unstabilized approaches and thereby assist in the reduction of approach-and-landing accidents.

2.3 Data Analysis

Of the total of 407 commercial aircraft accidents recorded in IATA GADM Accident database during the period of 2011 to 2015, 267 or 65% occurred during the approach-and-landing phase and 31 of these involved fatalities.

As seen in the analysis, there is a risk that accidents resulting in death, injury, and aircraft damage can occur during the approach and landing phase of flight. These accidents include runway excursions, Gear up Landing / Gear collapse, hard landings, CFIT and others as illustrated in figure 1.

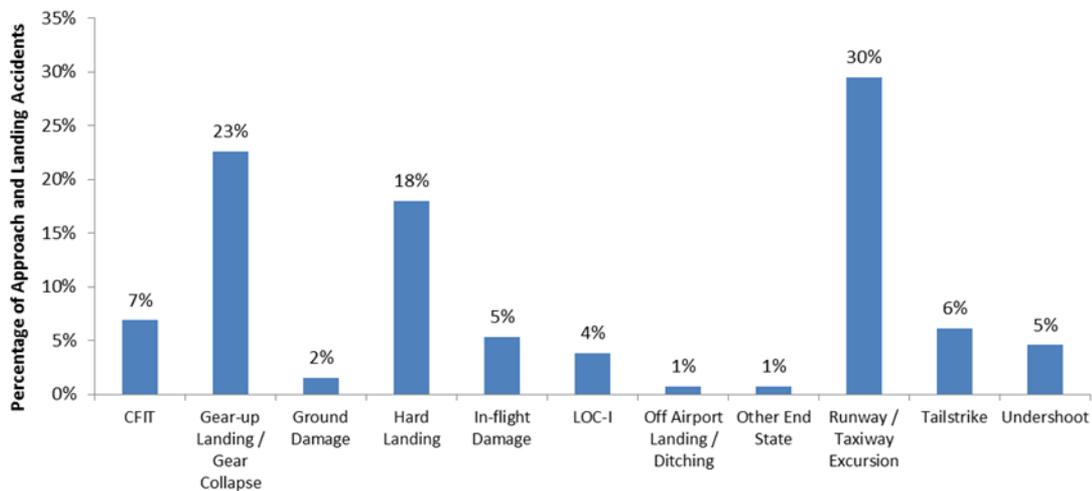


Figure 1. Distribution of Approach and Landing Accident Categories

All stakeholders including operators, flight crew, regulators, ATCOs, and ANSPs should consider the recommendations in this document and take more action to prevent approach-and-landing accidents. Stable approaches significantly increase the chances of a safe landing. Ensuring a stable approach is the first line of defense available to crews against accidents in the critical flight phases of approach and landing. After this first line of defense is crossed, the ability to perform a go around is a critical factor in preventing an unwanted

outcome during or after the approach. Within the 2011-2015 period, 65% of the accidents occurred during the approach and landing phases leading to different types of accidents, some more and some less susceptible to unstable approaches. However, in general terms, about 14% of these accidents occurred in the presence of an unstable approach (generally related to the aircraft's energy state) without a go around performed.

IATA, through the Accident Classification Task Force, assigns contributing factors to accidents to better understand any correlations. Some of the causal factors cited in those accidents were listed in figure 2. Note, 51 or 19% of Approach and Landing accidents could not be classified due to insufficient data. The remainder of the data was classified and the most frequent contributing factors are shown in figure 2.

Latent Conditions (deficiencies in...)		Flight Crew Errors (related to...)	
Regulatory Oversight	34%	Manual Handling / Flight Controls	38%
Safety Management	25%	SOP Adherence / SOP Cross-verification	23%
Flight Operations	16%	Intentional	15%
Flight Ops: Training Systems	13%	Failure to GOA after Destabilized Approach	13%
Maintenance Ops: SOPs & Checking	8%	Unintentional	8%
Environmental Threats		Undesired Aircraft States	
Meteorology	37%	Long / Floated / Bounced / Firm / Off-Center / Crabbed Land	31%
Wind/Winshear/Gusty Wind	22%	Vertical / Lateral / Speed Deviation	27%
Airport Facilities	17%	Unstable Approach	14%
Poor visibility / IMC	14%	Continued Landing after Unstable Approaches	13%
Nav Aids	13%	Unnecessary Weather Penetration	8%
Airline Threats		Countermeasures	
Aircraft Malfunction	24%	Overall Crew Performance	25%
Gear / Tire	18%	Monitor / Cross-check	19%
Maintenance Events	10%	Contingency Management	9%
Operational Pressure	3%	Leadership	7%
Secondary Flight Controls	2%	Captain should show leadership	5%

Source: IATA GADM

Figure 2. LOC-I Top Contributing Factors

Without improvements in the rates of stable approaches flown and stable approach policy compliance, most unstable approaches will continue to a landing, increasing the risk of approach-and-landing accidents.

In the terminology of Threat & Error management (TEM) an unstabilized approach is a serious Undesired Aircraft State (see Definitions above) that can have a catastrophic outcome or 'End State' (also see Definitions above) if not correctly managed by the pilots. 32 accidents or seven percent (7%) of total accidents between 2011 and 2015 were found to have an identified factor of an unstable approach. The analysis revealed that unstabilized approaches resulted in:

- Controlled Flight Into Terrain (CFIT): 6%
- Hard Landing: 41%
- In-flight Damage: 3%
- Loss of Control In-flight: 9%
- Runway / Taxiway Excursion 31%
- Tailstrike: 6%
- Undershoot: 3%

On average, there were about six (6) accidents per year. Figure 3 below illustrates the frequency of events with an unstable approach as a factor over each of the five years of the period:

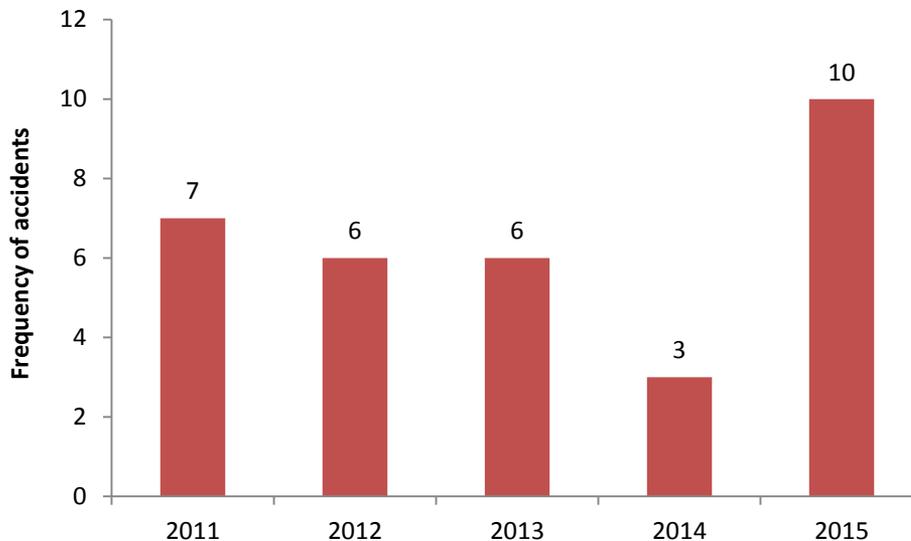


Figure 3. Frequency of accidents with unstable approaches as a factor

Absolute numbers of accidents are not necessarily a good indication of safety performance and are of limited comparative value unless they are normalized by the number of sectors flown per year to create an accident rate. Figure 4 shows the occurrence rates per million sectors flown per year.

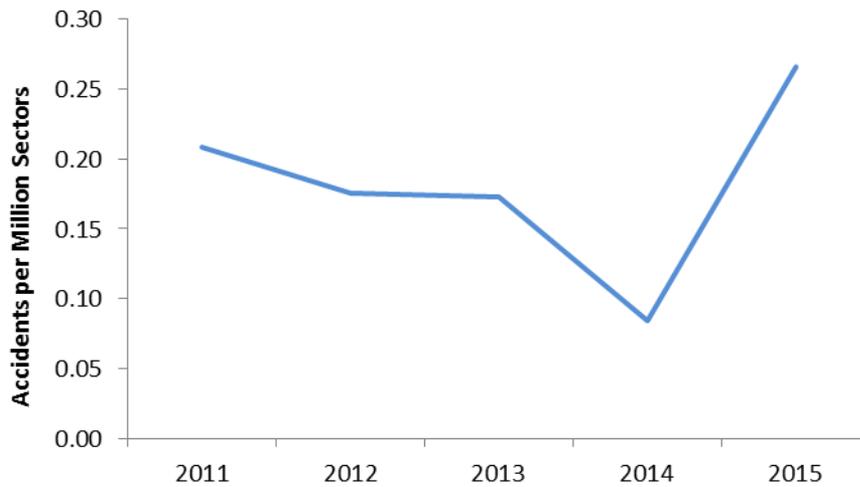


Figure 4. Occurrence Rates per Million Sectors

Note: In order for an event to be considered as an accident, the aircraft involved must meet IATA Accident Criteria and Definition, which is listed in the IATA Safety Report 2015, 52nd edition. An excerpt of this definition can be found in the Definitions section of this document. The percentages quoted in this section represent that proportion of accidents for which there was sufficient data available for the ACTF to make category classifications.

Many studies have been conducted with respect to unstable approaches and approach-and-landing accidents using different data sources, definitions and analytical logic. However, the findings of these studies consistently conclude that unstable approaches have been and continue to be a significant factor in a high proportion of commercial aircraft accidents.

Section 3—Stabilized Approaches (Concept and Global Criteria)

3.1 Defining the Elements of a Stabilized Approach

For stabilized approaches to become the industry standard, it is essential to define a common set of parameters that constitute a stabilized approach. This will ensure that all stakeholders are working towards the same shared outcome. However, there are many variables to be embraced within the global industry including a wide variety of aircraft types, the environmental constraints of certain airports and the operational needs of airlines, airports and ANSPs. Furthermore, the recognition and adoption of the stabilized approach concept has not emerged from a single source with a number of different methodologies and criteria being developed. Generally, these criteria are essentially the same.

Because the aim is to achieve and maintain constant flight path conditions for the approach phase of the flight, it is evident that whatever the target flight characteristics are for the point immediately prior to commencement of the landing flare, these should be the same flight characteristics required to be met at an earlier point during the approach, and maintained thereafter. The desired 'pre-flare' characteristics are defined by the aircraft manufacturer and generally consist of:

- Target approach speed a few knots faster than the desired touchdown speed and on the 'right' side of the total drag curve (corrected for wind if necessary);
- Rate of descent commensurate with the approach angle and approach speed (generally around 600–700 feet per minute for jet aircraft on a 3° approach);
- Landing configuration of gear and flap extended;
- Stable aircraft attitude in all 3 axes;
- Engine thrust stable above idle.

Recognizing that the aircraft is operating in a dynamic environment a tolerable range is defined for each of these parameters (+ 5 knots/- 0 knots airspeed for example), allowing the pilots to make corrective inputs to maintain flight within the stabilized criteria. These defined stable flight characteristics make it easier for pilots to recognize any deviations, decrease the cockpit workload by reducing the variables to external factors only, and provide a clear cue for go-around decision making if one or more of the criteria limits are breached.

Whilst the adoption and conduct of stabilized approaches is recognized as best practice in commercial aviation, individual operators are expected to devise their own specific criteria to suit their aircraft, destination network and operational requirements and to promulgate them in the Operations Manual.

From a previous study conducted by IATA on stabilized approaches, it was apparent that:

- Many operators define a lower stabilization altitude/height for approaches in VMC than IMC;
- Some operators require all approaches to be stabilized at 1,000 feet irrespective of meteorological conditions (this has the advantage of consistency for decision making and for flight data monitoring);
- The required stabilization altitude can range from 1,500 feet to 500 feet.

A recent study conducted by FSF revealed that variations in required stabilization altitudes between operators, between approach types (precision/non-precision) and between meteorological conditions (IMC/VMC) could be a cause for concern and potential confusion. For example, some industry guidance recommends that approaches in IMC must be stabilized by 1,000 feet and in VMC by 500 feet, for precision, non-precision, and unguided approaches alike, while on a circling approach maneuvering is acceptable down to 300 feet.

RECOMMENDATION (1):

- 3.1.1 Aviation safety regulators to require operators to define and apply stabilized approach procedures, including criteria suitable for their operations, and for a mandatory go-around to be flown if they are not met and maintained;
- 3.1.2 All operators to adopt the stabilized approach concept, characterized by maintaining a stable speed, descent rate, attitude, aircraft configuration, displacement relative to the approach path with power/thrust settings appropriate for the flight conditions until the commencement of the landing flare.

3.2 Stabilization Altitude/Height

Airbus Flight Operations Briefing Notes (FOBN) state that the minimum stabilization height constitutes a particular 'gate' or 'window' along the final approach, for example for an ILS approach the objective is to be stabilized on the final descent path at V_{APP} (approach speed) in the landing configuration, at 1,000 feet above airfield elevation in IMC, or at 500 feet above airfield elevation in VMC, after continuous deceleration on the glide slope.

Note: A lower minimum stabilization height may be allowed for circling approaches (e.g. 400 feet).

If the aircraft is not stabilized on the approach path in landing configuration, at the minimum stabilization height, a go-around must be initiated unless the pilot estimates that only small corrections are necessary to rectify minor deviations from stabilized conditions due, amongst others, to external perturbations.

The FSF study also concluded that operators should consider the implementation of two stabilization altitudes/heights on each approach; the first being a point at which the stabilization criteria 'should' be met and the second at which they 'must' be met, or a go-around 'must' be initiated.

RECOMMENDATION (2):

- 3.2.1 Operators to ensure that policy, procedures and training optimize pilots' situational awareness throughout the approach, and specifically in relation to the minimum stabilization altitude/height;
- 3.2.2 Operators to regularly review and if necessary redefine their stabilization criteria.

3.3 Callouts

In order to achieve and maintain stabilized approach, pilots must be constantly aware of each of the required parameters throughout the approach. A 'callout' is required if either pilot observes a deviation from the specified limits of the stabilization criteria or a deviation from the Standard Operating Procedures (SOPs). If the deviation has been observed first by the flying pilot, his or her callout advises the non-flying pilot that he is aware and attempting to correct; if observed by the non-flying pilot, his or her callout will bring the flying pilot's attention to the deviation. Each callout requires a corresponding acknowledgement from the other pilot, which can assist in the early detection of pilot incapacitation. The routine use of callouts in this manner improves communication and enhances situational awareness through the approach.

It should be worth noting that as workload increases an individual's capacity is reduced with hearing being one of the senses first effected. This may reduce the effectiveness of the callout during situations of high workload in the cockpit.

It is recommended that callouts should not be limited to a single occasion at the initial deviation but should continue at reasonable intervals until the deviation is corrected. The repeated callouts ensure continuing awareness until the undesirable condition has been corrected much like the aural warning logic of a Ground Proximity Warning System (GPWS) or Traffic Collision Avoidance System (TCAS) for example, which continues until the hazardous condition is no longer present.

The IOSA Standards Manual 9th Edition contains Standards FLT 3.11.21 which reads:

"The FLT 3.11.21 The Operator shall have a policy and procedures that define and specify the requirements for standardized verbal callouts (standard callouts) by the flight crew during each phase of flight. (GM)

Guidance

Standard callouts are used to improve crosscheck, coordination and mutual crew member awareness and are typically used to:

- Give commands, delegate a task;
- Acknowledge a command or confirm receipt of information;
- Challenge and respond to checklist items;
- Call a change of an indication;
- Identify a specific event;
- Identify exceedences."

Likewise, the IOSA Standards Manual 9th Edition contains Standards FLT 3.11.28 on Altitude Awareness and Altimetry which reads:

“FLT 3.11.28 The Operator shall have policies, procedures and guidance that address altitude awareness, to include:

- (i) Instructions for the use of automated or verbal flight crew altitude callouts and any other actions to be taken by the flight crew to maintain altitude awareness;
- (ii) Policies and/or procedures for the avoidance of altitude deviations;
- (iii) Policies and/or procedures that address call sign confusion during altitude clearance acceptance and readback;
- (iv) Instructions for the flight crew to report the cleared flight level on first contact with ATC, unless specifically requested not to do so by ATC. (GM)

Guidance

The intent of this provision is for the operator to provide policies, procedures and guidance in the OM designed to manage or mitigate potential risks related to the acceptance and maintenance of assigned altitudes.

As an example, OM guidance to address altitude awareness can include instructions for:

- A crosscheck that the assigned altitude is above the minimum safe altitude;
- “1000 to go” standard callout;
- Dual pilot response for ATC altitude clearance;
- “Double point” to altitude window (both pilots physically point to and confirm the new altitude set).”

A silent flight deck philosophy typically limits verbal callouts to the identification of flight parameters being exceeded and other items as determined by the operator.”

Furthermore, the adoption of calls of “STABILIZED”, “UNSTABLE” or “GO-AROUND” at a given point on the approach (stabilization altitude/height for example) may improve decision making and compliance to ensure a timely go-around is carried out. While a “STABILIZED” callout might be required at either 1,000 feet or 500 feet above touchdown, the “GO-AROUND” command can and must be made at any time prior to deployment of thrust reversers. Once again, if such callouts are adopted it is essential that an acknowledgement is made by the other pilot in every case.

Another option to assist pilots in their decision making process would be the installation of a monitoring system to provide alerts if the stabilized approach criteria are not met, similar to wind-shear alerting systems. Among different technologies (see Section 8 of this Guidance Material) two avionics products are available as options – Honeywell's SmartLanding system and Airbus's Runway Overrun Prevention System (ROPS).

RECOMMENDATION (3):

Operators to require pilot callouts to ensure timely awareness of deviations in flight parameters beyond specified limits.

3.3.2 Operators to require that:

- Pilots acknowledge any callout to ensure crew coordination and assist in the detection of pilot incapacitation;
- The flying pilot takes immediate action in response to a callout to correct the deviation and return to within the stabilized approach parameters;
- Following a deviation the pilots assess whether a stabilized approach can be recovered by the required altitude/height;
- If the stabilized approach criteria cannot be met, pilots initiate a go-around without delay.

3.3.3 Operators to require callouts to be continued at reasonable intervals until the deviation is corrected; similar in concept to GPWS or TCAS.

3.4 Standard Operating Procedures (SOPs)

An approach is stabilized only when all of the performance criteria specified by the operator are met. It is therefore essential that the criteria are complementary to the operator's SOPs and that the SOPs are conducive to meeting the stabilized approach criteria. Operators must ensure that SOPs are clear, concise and appropriate, and include the requirement to meet and maintain the stabilized approach criteria, the requirement to go-around if the criteria are not met and guidance for the go-around decision making process. Consistent adherence to SOPs is a demonstrated factor in improving approach and landing safety and can be measured by flight data monitoring.

The performance parameters which are chosen to define a stabilized approach should be selected in accordance with the aircraft manufacturers' guidance and include at least the following:

- A range of speeds specific to each aircraft type, usually by reference to V_{APP} or V_{REF} ;
- A range of power/thrust setting(s) specific to each aircraft type;
- A range of attitudes specific to each aircraft type;
- Crossing altitude deviation tolerances;
- Configuration(s) specific to each aircraft type;
- Maximum rate of descent; and
- Completion of checklists and crew briefings.

ICAO Doc. 8168 Procedures for Air Navigation Services — Aircraft Operations (PANS OPS) VOL I (Flight Procedures) requires under Part III Section 4. Operational Flight Information, Chapter 3, the elements of stabilized approaches to be stated in the operator's SOPs. These elements should include, as a minimum:

- that in instrument meteorological conditions (IMC), all flights shall be stabilized by no lower than 300 meters (1,000 feet) height above threshold; and
- that all flights of any nature shall be stabilized by no lower than 150 meters (500 feet) height above threshold.

The IOSA Standards Manual 9th Edition contains Standard FLT 3.11.59 which reads:

"FLT 3.11.59 The Operator shall have a stabilized approach policy with associated guidance, criteria and procedures to ensure the conduct of stabilized approaches. Such policy shall specify:

- (i) A minimum height for stabilization not less than 1000 feet AAL for approaches in IMC or not less than 500 ft. AAL for approaches in IMC as designated by the operator and/or State where a lower stabilization height is operationally required;
- (ii) A minimum height for stabilization not less than 500 feet AAL for approaches in VMC;
- (iii) Aircraft configuration requirements specific to each aircraft type (landing gear, wing flaps, speed brakes);
- (iv) Speed and thrust limitations;
- (v) Vertical speed limitations;
- (vi) Acceptable vertical and lateral displacement from the normal approach path. (GM)

Guidance

The intent of this provision is for the operator to implement a stabilized approach policy, as well as have guidance, criteria and procedures that ensure the maintenance of the intended lateral and vertical flight path during visual approaches and/or as depicted in published approach procedures without excessive maneuvering. The parameters to be considered at the 1000 ft. AAL and 500 ft. gates as well as in the definition of a stabilized approach are listed in items iii) through vi) of the provision.

The specifications in item i) permit an operator, in accordance with operational requirements approved or accepted by the Authority, to establish stabilization criteria for heights lower than 1000 ft. AAL, but no lower than 500 ft. AAL (IMC or VMC), for approaches designated by the operator and/or State where:

- Lower minimum approach stabilization heights are authorized for turbo-propeller aircraft operations (e.g., 500 feet AAL on VMC/IMC approaches), and/or
- Maneuvering at a lower height AAL is required to meet instrument or other charted approach constraints (e.g. RNAV/RNP approaches, circling approaches and charted visual approaches), and/or
- Aircraft are required to comply with ATC speed constraints on final approach, and/or

- Deviations from selected approach stabilization criteria at a height lower than 1000 feet AAL, but above 500 feet AAL, are operationally required, and the operator can demonstrate pilot adherence to its stabilized approach policy via a continually monitored, managed and active flight data analysis (FDA) program.

The criteria used to conform to the specifications in item vi) also typically address the maneuvering that may be required in accordance with a charted visual or instrument approach procedure.”

RECOMMENDATION (4):

- 3.4.1 Operators to develop SOPs that reflect the aircraft manufacturers' guidance, to include stabilized approach criteria and a non-punitive go-around policy;
- 3.4.2 SOPs must be clear, concise and appropriate, and support mandatory policies for stabilized approaches and go-arounds, together with guidance on the go-around decision making process;
- 3.4.3 Operators to reaffirm the importance of SOPs through policies and training and enforce SOP compliance through effective monitoring and a 'just' process for managing non-compliance.

3.5 Crew Resource Management (CRM)

Many approach and landing accidents included contributory factors related to poor decision-making by flight crews, together with ineffective communication, inadequate leadership and poor management. CRM training was developed as a response to these deficiencies, based on flight data recorder (FDR) and cockpit voice recorder (CVR) data. These data suggested that many accidents were not the result of technical malfunctions, but of the inability of flight crews to respond appropriately to the developing situation (in TEM terminology an undesired aircraft state) prior to the accident. CRM encompasses a wide range of knowledge, skills and in particular attitudes with respect to communication, situational awareness, problem solving, decision making, leadership, and teamwork. CRM can therefore be described as a management system which promotes the optimum use of all available resources, in order to best assure a safe and efficient operation in both routine and abnormal situations.

CRM Components:

- SOPs providing clear, unambiguous roles for the pilot flying (PF) and pilot monitoring (PM) in normal and non-normal operations;
- Briefings to assure 'transparency' and a common understanding of the plan;
- Effective communication between all flight crew members (in the cockpit and in the cabin) and between flight crew and ATC;
- Flight crew coordination, cross-checking and backup.

RECOMMENDATION (5):

- 3.5.1 Operators to ensure that training programs include CRM at initial and recurrent phases, which is appropriate to the cultural constituency of the pilot group.

3.6 Briefing

The importance of briefing techniques should not be underestimated. Effective briefings can influence teamwork, co-ordination, understanding, behavior and communication.

The Airbus FOBN for example states that the descent-and-approach briefing provides an opportunity to identify and discuss factors such as altitude or airspeed restrictions that might require non-standard energy management in the descent. A comprehensive briefing ensures:

- An agreed strategy for the management of the descent, deceleration, configuration and stabilization;
- A common objective and point of reference for the PF and PM.

The descent-and-approach briefing should include the following generic aspects of the approach and landing:

- Approach conditions (i.e., weather and runway conditions, special hazards);
- Lateral and vertical navigation (including intended use of automation);
- Stabilized approach criteria;
- Instrument approach procedure details;
- Go-around and missed approach;
- Diversion;
- Communications;
- Non-normal procedures, as applicable;
- Review and discussion of approach-and-landing hazards; and,
- Expected restrictions, delays and other non-standard aspects of the approach, as advised by ATC.

Specific to the approach and go-around, the briefing could include the following:

- Minimum sector altitude (MSA);
- Terrain and man-made obstacles;
- Other approach hazards, such as visual illusions;
- Applicable minima (visibility or runway visual range (RVR), ceiling as applicable);
- Applicable stabilization altitude/height (approach gate or window);
- Final approach flight path angle and vertical speed;

- Go-around altitude and missed approach procedure.
- Review of any relevant Notices to Airmen (NOTAMs) and Automatic Terminal Information Service (ATIS) remarks that might affect the stability of the approach; and,
- Other non-standard aspects of the approach, as advised by ATC.

RECOMMENDATION (6):

- 3.6.1 Operators to require effective and interactive briefings to enhance flight crew coordination and preparedness for planned actions and unexpected occurrences, by creating a common mental model of the approach.
- 3.6.2 ATC to advise of any known particularities to a given approach/descent profile (e.g. weather conditions, windshear, delays, pilot reports (PIREPs) from previous aircraft, turbulence, orographic activity, etc)

3.7 Crew Coordination, Monitoring and Cross-Check

The following elements of flight crew behavior can contribute to stabilized approaches, facilitate go-around decision making, and improve overall situational awareness:

- Call out acknowledgements;
- Passing altitude calls;
- Excessive flight parameter deviation callouts;
- Monitoring and cross-checking;
- Task sharing;
- Standard calls for acquisition of visual references.

RECOMMENDATION (7):

- 3.7.1 Operators to ensure that SOPs include adequate monitoring and cross-checking to support crew coordination during approach and landing;

3.8 Flight Data Monitoring

The best potential sources of operational data are the operators' own Flight Data Monitoring (FDM), Flight Data Analysis (FDA), or Flight Operations Quality Assurance (FOQA) programs.

The routine download and analysis of recorded flight data has been used by operators for many years as a tool to identify potential hazards in flight operations, evaluate the operational environment, validate operating

criteria, set and measure safety performance targets, monitor SOP compliance and measure training effectiveness.

In non-routine circumstances, when an incident occurs the data can be used to debrief the pilots involved and inform management. In a de-identified format the incident data can also be used to reinforce training programs, raising awareness amongst the pilot group as a whole.

Similarly, ATCOs and ANSPs use of historical and radar data, inter alia, and analysis of specific events can lead to discovering trends, enhancing awareness, improving initial and recurrent training, etc.

With respect to stabilized approaches, standard FDM software will normally assist in:

- Monitoring of the flight parameters used to define stabilized;
- Establishing the level of compliance with the stabilized approach and go-around policies;
- Understanding the factors contributing to unstabilized approaches;
- Identifying correlations between unstabilized approaches and specific airports/runways (e.g., ATC restrictions), individual pilots, specific fleets, etc.;
- Hazard identification in the approach environment, (an element of the Safety Risk Management component of the Safety Management System (SMS) framework).

EAFDM recommends the development of standardized FDM-based indicators to be used by operators for the monitoring of operational risk (LOC-I, runway excursion, CFIT, etc...). These standardized indicators are expected to bring several advantages:

- All operators monitoring common operational risks;
- Ensure that for those identified common risks, operators have relevant indicators in place;
- Facilitate voluntary reporting of FDM summaries in a standardized way.

RECOMMENDATION (8):

- 3.8.1 Operators to establish, implement, and maintain an accident prevention and flight safety program, which includes a comprehensive FDM program;
- 3.8.2 Operators to conduct FDM analysis to identify and monitor precursors of unstable approaches;
- 3.8.3 De-identified data from the FDM program to be used in initial and recurrent training programs, including the creation of simulator scenarios (evidence based training);
- 3.8.4 Operators to work with ANSP/Air Traffic Services Unit (ATSU) to implement procedural changes to systematically reduce the rate of unstabilized approaches at runways identified as higher risk by FDM data analysis.
- 3.8.5 Exchange data and information amongst stakeholders to enhance global understanding.

Section 4—Effect of Unstabilized Approaches

4.1 What is an Unstabilized Approach?

An unstabilized approach is any approach that does not meet the stabilized approach criteria defined by the operator in its SOPs.

If the stabilized approach criteria are not met or, having been met initially, are subsequently breached, the pilots may correctly initiate a go-around, or they may sometimes continue to landing. In the latter case, this may be because they failed to recognize that the approach was unstabilized or alternatively they may have intentionally failed to comply with the stabilized approach policy for emergency or other reasons. In a recent study by IATA, some flight crew were found to be under considerable pressure to continue approaches such as peer pressure, commercial pressure to reduce delays, perceptions about their companies' go-around policies, fatigue, etc.

The continuation of an unstabilized approach to landing, contrary to SOPs, may result in the aircraft touching down too fast, too hard, outside the touchdown zone (long or short), off the runway center-line, in the incorrect attitude or incorrectly configured for landing. These may in turn lead to a 'bounced' landing, aircraft damage, runway excursion or landing short.

An unstabilized approach may have any number of contributing factors (weather, tailwind, fatigue, workload, poor planning, pilot error, ATC interaction, procedures, approach design, etc.), which can be encountered at any stage of the descent, arrival and approach. Effective management process begins in the cruise phase as plans are made and approach briefings delivered.

RECOMMENDATION (9):

- 4.9.1 Operators to train flight crew to recognize and correct flight parameter deviations before they develop to the extent that a stabilized approach cannot be achieved or maintained. If these corrective actions fail then the only safe solution is a go-around.

4.2 Factors Leading to Unstabilized Approaches

Human error and procedural non-compliance have been identified as primary contributing factors to unstabilized approaches. Procedural non-compliance may be inadvertent due to an error or a lack of knowledge, or alternatively the result of an intentional violation but in either case represents an undesirable deviation that increases risk. However, there are many other factors, both threats and errors that can contribute to an approach being unstabilized, including:

- Loss of situational awareness;
- Poor visibility and visual illusions;

- Inadequate recognition of the effect of wind conditions;
- Adverse weather (e.g. strong or gusty winds, windshear, turbulence, tailwind);
- Inadequate monitoring by flight crew;
- Excessive altitude and/or airspeed (inadequate energy management) early in the arrival or approach;
- Excessive altitude and/or airspeed too close to the threshold;
- Flight crew fatigue;
- Commercial pressure to maintain flight schedule;
- Peer pressure;
- Failure of automation to capture the glideslope requiring late intervention;
- Loss of visual references;
- Premature or late descent caused by failure to positively identify the final approach fix (FAF);
- Late descent clearance due to traffic;
- Malfunctioning ground-based navigational aids;
- Radar vectoring that did not end on the intermediate approach segment, either laterally or vertically; Final intercept vectoring above approach slope (especially if combined with a downwind component at altitude);
- The breakdown of flight crew and ATC communications;
- ATC requiring crew to fly higher, faster, or shorter routings (challenging clearances);
- ATC pressure to maximize number of movements;
- ATC restrictions or directives;
- Procedures and approaches design;
- Noise abatement operational procedures including late extension of landing gear, reduced flap setting, continuous descent operations;
- Lack of monitoring by the Pilot-Non-Flying / Pilot Monitoring;
- Late change of runway, including a parallel runway "sidestep";
- Instructions to keep the approach as tight as possible during a downwind visual approach;
- Speed restriction inappropriate to the type of aircraft and/or to the weather conditions prevailing at the airport (e.g. low ceiling, visibility, tail wind at altitude, etc.);
- Terrain and obstacles near the airport;
- ATC misunderstanding of operational characteristics of various aircraft types.

In order for stabilized approaches to become routine it is essential that the operator's policy is unequivocal in requiring compliance, that training and SOPs support the policy and that every unstabilized approach that is continued is reviewed. Pilots must regard an unstabilized approach that is continued as a failure rather than viewing an abandoned approach and go-around in that way. The operator must also adopt a non-punitive response to go-arounds, in spite of any commercial implications associated with delays and cost.

Operators may underestimate the dangers posed by unstabilized approaches, and their policies and SOPs may do little to ensure that pilots follow the relevant procedures. Pilots and operators should understand the importance of stabilized approach criteria as critical elements of flight safety.

RECOMMENDATION (10):

- 4.10.1 Operators to enhance the awareness of the pilots and management personnel of the contributing factors to – and risks associated with – unstabilized approaches.
- 4.10.2 Operators to adopt and promote a policy of compliance with stabilized approach criteria and mandatory go-around.
- 4.10.3 Enhance the awareness of controllers and management personnel of the contributing factors to – and risks associated with – unstabilized approaches.

Section 5—Mitigation of Unstabilized Approaches

5.1 Mitigation of Unstabilized Approaches

Any approach that fails to meet or maintain the stabilized approach criteria constitutes an undesired aircraft state in the terminology of TEM. In order to avoid this developing further into an unrecoverable 'end state' it is vital that the pilots take action to adequately manage the undesired aircraft state. The flight crew must:

- Recognize that the approach is unstable;
- Communicate with fellow crew members;
- Take immediate action to rectify the situation;
- Monitor the corrective action.

To avoid an unstabilized approach in the first place, it is important for flight crew:

- To be aware of the stabilized approach criteria;
- To be aware of the aircraft horizontal and vertical position in respect to a stabilized approach at all times, even when under radar control;
- To comply with the stabilized approach criteria published in their SOPs;
- To advise ATC when unable to comply with a clearance that would result in the aircraft being too high and/or too fast, would require approach path interception from above or would unduly reduce separation from other aircraft;
- To advise ATC when unable to comply with instructions that are incompatible with a stabilized approach;
- To advise ATC when reducing or increasing speed to achieve a stabilized approach;
- To decline late changes of landing runway when approach stabilization would become marginal or impossible;
- To prepare for visual approaches by briefing speed/altitude/configuration gates, equivalent to those of an instrument approach and follow the published 'visual approach' pattern in the manufacturer's or operator's SOP;
- To execute a go-around if the approach cannot be stabilized by the stabilization altitude/height or subsequently becomes unstabilized;
- To be alert to the approach becoming unstabilized on very short final or in the flare;
- To be aware that it may be possible to go-around even after touchdown as long as reverse thrust has not been selected.

Additionally, from an ATCO's perspective, ICAO Procedures for Air Navigation Services – Air Traffic Management document (PANS-ATM – Doc 4444) contains provisions intended to mitigate unstabilized approaches:

- 6.5.1.4 – At aerodromes where standard instrument arrivals (STARs) have been established, arriving aircraft should normally be cleared to follow the appropriate STAR. The aircraft shall be informed of the type of approach to expect and runway-in-use as early as possible.
- 6.6.3 – If it becomes necessary or operationally desirable that an arriving aircraft follow an instrument approach procedure or use a runway other than that initially stated, the flight crew shall be advised without delay.
- 8.9.3.6 – Aircraft vectored for final approach should be given a heading or a series of headings calculated to close with the final approach track. The final vector shall enable the aircraft to be established in level flight on the final approach track prior to intercepting the specified or nominal glide path if an MLS, ILS or radar approach is to be made, and should provide an intercept angle with the final approach track of 45 degrees or less."

ATC can contribute to stabilized approaches by:

- Issuing proper clearances and providing timely and accurate weather information;
- Ensuring that aircraft are managed safely in the final stage of flight before landing;
- Understanding the risks of unstabilized approaches;
- Understanding the influence of ATC on stabilized approaches;
- Recognizing that most jets are not made to 'go down and slow down';
- Recognizing when an aircraft is having difficulty achieving speed and/or descent instructions;
- Being prepared to react if a crew decline instructions or advise difficulty in complying with previously accepted instructions;
- Being prepared for a go-around and avoid unnecessary changes to the missed approach procedure;
- Being prepared to instruct a go-around if safety consideration requires it;
- Issuing landing clearances as soon as possible;
- Avoiding last-minute changes, maintain interventions in short final to a strict minimum;
- Informing the pilot in advance if you plan to:
 - request a high speed on final for separation purposes;
 - vector the aircraft to intercept closer to the FAF;
 - maintain the aircraft at a higher than normal altitude for the intercept;
 - intercept the extended center line/localizer at a greater than normal procedural angle.

- Maintaining continuous situational awareness when it comes to weather conditions that could affect approach stabilization by the crew:
 - downwind on final approach;
 - wind shear;
 - low ceiling;
 - contaminated runway, etc.
- Being responsive to pilot requests;
- Avoiding routine vectoring of aircraft off a published arrival procedure only to shorten the flight path;
- Giving preference to approaches with vertical guidance (ILS, MLS, GLS etc.);
- When aircraft are being vectored, issue track miles to the airport and keep the flight crew informed of the plan.

Furthermore, ICAO Procedures for Air Navigation Services – Air Traffic Management document (PANS-ATM – Doc 4444) describes what information ATCOs are expected to provide the flight crew during and before the final approach. This information has already been identified as a way to mitigate unstabilized approaches:

- “6.6.4 – At the commencement of final approach, the following information shall be transmitted to aircraft:
 - significant changes in the mean surface wind direction and speed;
 - the latest information, if any, on wind shear and/or turbulence in the final approach area;
 - the current visibility representative of the direction of approach and landing or, when provided, the current runway visual range value(s) and the trend.
- 6.6.5 - During final approach, the following information shall be transmitted without delay:
 - the sudden occurrence of hazards (e.g. unauthorized traffic on the runway);
 - significant variations in the current surface wind, expressed in terms of minimum and maximum values;
 - significant changes in runway surface conditions;
 - changes in the operational status of required visual or non-visual aids;
 - changes in observed RVR value(s), in accordance with the reported scale in use, or changes in the visibility representative of the direction of approach and landing.”

RECOMMENDATION (11):

- 5.11.1 Operators to ensure that pilots are aware of and understand the risks associated with unstabilized approaches;
- 5.11.2 Operators to ensure that pilots are aware of and understand the stabilized approach criteria;



- 5.11.3 Operators to work with pilots to improve compliance with SOPs;
- 5.11.4 ANSPs/ATSUs to improve controllers' awareness of the risks associated with ATC actions during approach through initial and recurrent training;
- 5.11.5 ANSPs/ATSUs to ensure that controllers provide accurate information on changing meteorological and runway surface conditions to aircraft on approach;
- 5.11.6 ATC to communicate better with aircraft under control if their intention to use non-standard procedures (see ATC can contribute to a stabilized approaches).



Section 6—Go-Around Decision-Making

6.1 Go-Around

A go-around can be initiated for a number of reasons, including failure to acquire or loss of the required visual reference for a landing, late change in wind direction and/or velocity, a runway incursion and of course when it has not been possible to meet or maintain the stabilized approach criteria. Failure to execute a go-around is a leading risk factor in approach and landing accidents and one of the primary contributing factors for landing runway accidents. A study by FSF estimated that industry wide 97% of unstabilized approaches are continued to landing.

As with the stabilized approach policy it is the responsibility of operators to develop and promulgate a clear policy on go-arounds, which states that a go-around is a normal flight maneuver to be initiated whenever a continued approach would not be safe or when the approach does not meet the stabilized approach criteria. The policy must also state that there will be no punitive response from management to a go-around and that conversely any failure to go-around when appropriate will be followed up.

Two independent sources of information on the go-around policy are:

- ICAO Doc. 8168 PANS OPS 1 states the need for operators to publish a 'go-around policy'. This policy should state that if an approach is not stabilized in accordance with the parameters previously defined by the operator in its operations manual or has become destabilized at any subsequent point during an approach, a go-around is required. Operators should reinforce this policy through training.
- The IOSA Standards Manual 9th Edition contains the Standard FLT 3.11.60 which reads:

"FLT 3.11.60 The Operator shall have a policy that requires the flight crew to execute a missed approach or go-around if the aircraft is not stabilized in accordance with criteria established by the Operator. (GM)

Guidance:

The intent of this provision is for an operator's stabilized approach policy to address the actions to be taken by the flight crew in the event of deviations from the criteria that define a stabilized approach, and to designate the minimum altitude at which a go-around must be accomplished if the aircraft is not stabilized in accordance with the operator's stabilization criteria."

In addition to the stabilized approach parameters for a go-around mentioned in previous sections, parameters should also include visibility minima required before proceeding past the Approach Ban Point, usually at 1,000 feet or the final approach fix (FAF). The flight parameter deviation criteria and the minimum stabilization altitude/height at or below which the decision to land or go-around should be made, must also be defined in SOPs.

If all go-around policies met these requirements and were effective in driving flight crew decision making, the industry accident rate would be reduced. This is because there is probably no other routine operational decision that so clearly marks the difference between a safe choice and a less safe one.

As stated in the 1st edition that the Flight Safety Foundation 'Go Around Decision Making and Execution Project' was launched to research and answer the question "why are we so poor at complying with established go-around policies", and determine strategies to address the findings. This project is ongoing at the time of writing this edition and will also examine the psychosocial role of flight operations management in the non-compliance phenomenon, as well as the risks associated with flying the go-around maneuver itself.

One reason why a go-around is not carried is a perception that the risk of executing the go-around maneuver is higher than continuing the approach. This may be due to unfamiliarity with the go-around maneuver outside of simulator training or potentially to bad weather in the vicinity of the missed approach path.

Pilots need to regard the go-around as a normal phase of flight, to be initiated whenever the conditions warrant. Nevertheless, the go-around is like any other phase of flight and has potential safety issues associated with it. Increased training and awareness of the dynamic nature of the go-around maneuver are vital to reduce the risk of undesirable outcomes.

Analysis of accident data indicates that common go-around related safety issues were:

- Ineffective go-around initiation;
- Loss of control during the go-around;
- Failure to fly the required track;
- ATC failure to maintain separation from other aircraft;
- Significant low level wind shear;
- Wake turbulence created by the go-around aircraft itself creating a risk for other aircraft.

If the FSF prediction is correct and without improved compliance with stabilized approaches, most unstable approaches will continue to a landing, significantly increasing the risk of approach and landing accidents.

Additionally, in regards to unstabilized approaches, ICAO Procedures for Air Navigation Services – Air Traffic Management document (PANS-ATM – Doc 4444) contains provisions detailing circumstances where ATCOs are expected to direct/suggest an aircraft to do a go around:

"8.9.6.1.8 - An aircraft making a radar approach should:

- a) be directed to execute a missed approach in the following circumstances:
 - i. when the aircraft appears to be dangerously positioned on final approach; or

- b) be advised to consider executing a missed approach in the following circumstances:
 - i. when the aircraft reaches a position from which it appears that a successful approach cannot be completed."

RECOMMENDATION (12):

- 6.12.1 Operators to implement a genuine non-punitive go-around policy, reminding flight crew that go-arounds are normal flight maneuvers;
- 6.12.2 Operators to emphasize to flight crews the importance of making the proper go-around decision and callout "GO AROUND", if the approach exhibits any element of an unstabilized approach;
- 6.12.3 Operators to review go-around policy, procedures and training to maximize their effectiveness, clarity and understanding;
- 6.12.4 The importance of flight crew being prepared for a go-around and being 'go-around minded' to be emphasized;
- 6.12.5 Operators to enhance awareness of go-around policy non-compliance rates, and the significant impact non-compliance has on approach and landing accident risk;
- 6.12.6 Operators to ensure go-around policies are clear, concise and unambiguous, and include management follow up procedures for non-compliance;
- 6.12.7 ANSPs/ATSUs should review and if necessary enhance the provision of go-around risk awareness training for ATCs;
- 6.12.8 ATCOs should keep altitude and route clearances to a minimum during a go-around, as it adds workload to an already busy flight crew;
- 6.12.9 If absolutely necessary, altitude and/or route clearances during a go-around should suit the missed approach procedure in order to minimize the workload in the cockpit.

6.2 Go-Around Decision

When many accidents could have been prevented with a sound go-around decision, the question remains why flight crew try to salvage a bad approach rather than abandon it and start again.

As part of the FSF go-around study, a psychological survey was developed to understand the etiology of compliant versus non-compliant go-around decision making. This evaluated pilots' experiences using a series of questions exploring the psychological precursors of risk assessment and decision-making. A second survey was designed to assess managers' perceptions and experiences of the issue of unstable approaches and how they are managed.

The lack of a correct go-around decision is the leading risk factor identified in approach and landing accidents. The decision to execute a go around where recommended should not be rushed in order to ensure

a well flown and executed maneuver. Once the decision is made, the pilots must maintain positive control of the flight trajectory and accurately follow the published missed approach, in accordance with manufacturer's recommendations and operator's SOPs. Following the initiation of a go-around no attempt should be made to reverse the decision and to land. Conversely, even when the pilots have decided to land at decision altitude, the option remains for them to go-around at any point up until reversers are deployed.

Factors affecting the go-around decision extend beyond the flight deck and management should consider:

- Implementation and operation of a non-punitive policy for go-arounds;
- Fuel policies which allow pilots to carry additional fuel when they consider it necessary, without undue interference from management;
- Acceptance of the delay and costs associated with go-arounds;
- Provision of simulator time for the practice of go-arounds from altitudes other than decision altitude;
- Requirement for approach briefings to include the conditions in which the approach may be continued and must be discontinued;
- Use in training of real examples of go-arounds to reaffirm the non-punitive policy.

RECOMMENDATION (13):

- 6.13.1 Operators to publish clear and concise SOPs which separate the decision to go-around or continue with regard to stabilized approach criteria from the decision at the approach minimum with regard to visual references;
- 6.13.2 Operators to provide go-around training in simulator sessions that requires decision making with regard to stabilized approach criteria, both above and below the decision altitude.

6.3 Factors Governing the Go-Around Decision

- Premature or late descent caused by failure to positively identify the FAF;
- Inadequate awareness of wind conditions;
- Incorrect anticipation of airplane deceleration;
- Over confidence of achieving a timely stabilization;
- Flight crew too reliant on each other to call excessive deviations or to call for a go-around;
- Visual illusions;
- Lack of operator policy (or lack of clarity of such policy), organizational culture and training to support go-around decision making with regard to the stabilized approach criteria;
- Lack of practice/confidence in performing a go-around maneuver, especially from altitudes other than decision altitude.

6.4 When to Initiate a Go-Around

Whenever the safety of a landing appears to be compromised. Typically, this occurs for one of these reasons:

- Instructed by ATC; ATC may instruct a go-around for a variety of reasons, including inadequate separation, landing runway occupied or traffic on a parallel runway;
- Abnormal aircraft conditions; an aircraft system malfunction or erroneous indication may make a landing unsafe;
- Abnormal approach conditions; speed and altitude, either ATC or pilot related;
- Environmental factors; sudden and/or un-forecast changes in environmental conditions like tailwind, windshear or precipitation;

These unexpected events may require a go-around even after the airplane has touched down following a stable approach.

- Whenever the stabilized approach criteria are not met at the required stabilization altitude and maintained thereafter until landing;
- Whenever the landing cannot be made within the touchdown zone; in the case of a long flare or 'floated' landing.

RECOMMENDATION (14):

- 6.14.1 Operators to ensure that flight crew are prepared for a go-around throughout the entire approach;
- 6.14.2 Operators to enforce the requirement for a go-around as opposed to continuing an unstabilized approach;
- 6.14.3 Operators to emphasize to flight crews the importance of making the proper go-around decision.

6.5 Organizational Factors

Certain aspects of the organizational culture of Operators can have a significant effect upon the frequency of unstabilized approaches and the behavior of flight crews when an approach does not meet the stabilized approach criteria. The following have been demonstrated to reduce the frequency of unstabilized approaches and increase the likelihood of a go-around when appropriate:

- A comprehensive FDM program ensuring that approach performance of the whole pilot group and of the individuals therein, are immediately visible and properly addressed;
- Mandatory requirement to initiate a go-around when stabilized approach criteria are not met;
- Consistent non-punitive response to go-arounds;
- Absence of commercial pressure with regard to completing an approach;
- Consistent management response to non-compliance with stabilized approach criteria, to include safety debriefs, and retraining as appropriate;
- Implementation of safety technologies when technically and financially feasible.

6.6 Go-Around Below Minima

Pilots are all familiar with the 'land/go-around' decision at decision altitude which is based upon the available visual references in relation to the published minima. They may be less familiar with the same decision in the final part of the approach below decision altitude, which may be based upon visual references but may also be driven by other factors such as runway incursion or perhaps less obviously a breach of the stabilized approach criteria. Below decision altitude:

- If a go-around is indicated the decision must not be delayed;
- Go-around can be initiated until the selection of the reverse thrust;
- Once a go-around has been initiated, it must be completed;
- Reversing a go-around decision is hazardous, especially when close to touch down.

In accordance with IATA IOSA Standard Manual 'FLT 3.11.60 The Operator shall have a policy that requires the flight crew to execute a missed approach or go-around if the aircraft is not stabilized in accordance with criteria established by the Operator. (GM)'

6.7 Training

Go-arounds carried out during training are most frequently conducted in the same conditions, i.e. in the landing configuration at Minimum Descent Altitude (MDA) or Decision Height (DH) and often with the help of the autopilot. Flight crews are rarely trained to execute a go-around at lower or higher altitudes where controlling the aircraft can be more difficult because of the differing sequence of actions to be performed.

When developing crew training programs, operators are encouraged to create unexpected go-around scenarios at intermediate altitudes with instructions that deviate from the published procedure; this addresses both go-around decision-making and execution. The training should also include go-around execution with all engines operating, including flight path deviations at a low altitude and go-arounds from long flares and bounced landings. Operators should also consider go-arounds at light weight with all engines operative in order to demonstrate the higher dynamics.

Furthermore, training should also address the following:

- Unstabilized approaches at the stabilization altitude but also cover destabilization after being stabilized, especially at low altitude (below MDA/DH);
- The go-around procedure is rarely flown and is a challenging maneuver. Flight crew must be sufficiently familiar with flying go-arounds through initial and recurrent training;
- Go-around training should include a range of operational scenarios, including go-arounds from positions other than DA/MDA and the designated stabilized approach altitude. Training should include go-around from higher and lower altitudes and rejected landings. Scenarios should involve realistic simulation of surprise, typical landing weights and full power go-arounds;

- Somatogravic head-up illusions during the unfamiliar forward acceleration in a go-around can lead to the incorrect perception by the flight crew that the nose of the aircraft is pitching up. This illusion can cause pilots to respond with an inappropriate nose down input on the flight controls during the execution of a go-around. Such responses have led to periodic accidents;
- Somatogravic illusions during the initiation of a go-around. Simulators that combine the possibilities of both the hexapod and the human centrifuge are already available and in use, (e.g., for military training). They can be used to demonstrate the illusions during go-around initiation and train pilots for a correct reaction on the heads-up illusion. As preventive means, crews are recommended to brief the go-around, not delay it, respect minima, monitor the flight parameters and fly the go-around pitch and the Flight Director bars where available.

There are also cases when the flight crew engage the autopilot to reduce the workload, but instead put the aircraft in an undesired situation due to a lack of situational awareness with the automation.

RECOMMENDATION (15):

- 6.15.1 Operators to implement appropriate education and training to enhance flight crew decision making and flying techniques to perform a safe go-around in any situation;
- 6.15.2 Operators should include lessons learned from past occurrences in go-around training;
- 6.15.3 Operators should incorporate training on somatogravic illusions during the initiation of a go-around. Simulators that combine the possibilities of both the hexapod and the human centrifuge are already available and in use, (e.g., for military training);
- 6.15.4 Operators' go-around training should include a range of operational scenarios, including go-arounds from positions other than DA/MDA and the designated stabilized approach altitude. Training should also include go-around from higher and lower altitudes and rejected landings. Scenarios should involve realistic simulation of surprise, typical landing weights and full power go-arounds;
- 6.15.5 Manufacturers to ensure that go-around procedures presented in pilot training and manuals are applicable to go-arounds commenced at any stage on final approach up to and including landings rejected after touchdown;
- 6.15.6 ANSPs/ATSUs should include go-around education and training in all parts of ATCOs training;
- 6.15.7 When possible, ANSPs/ATSUs should ensure simulated scenarios of go-around are included in initial and recurrent training;
- 6.15.8 Awareness campaigns, best practices from the industry should be shared to the best extent possible and guidance material should be made available to ATCOs on unstabilized approaches and go-around;
- 6.15.9 If possible, integrate the subjects of go-around, radar utilization and visual approaches in a joint pilots/controllers safety session or committee.

Operators should not limit training scenarios to the initiation of a go-around at the approach minimum or missed approach point. Training scenarios should focus on current operational threats as well as traditional situations.

RECOMMENDATION (16):

- 16.1.1 When developing flight crew training programs, operators are encouraged to create unexpected go-around scenarios at intermediate altitudes with instructions that deviate from the published procedure; this addresses both go-around decision making and execution;
- 16.1.2 The training should also include go-around execution with all engines operating, including level-off at a low altitude and go-arounds from long flares and bounced landings;
- 16.1.3 Operators should also consider go-arounds not only at heavy weight and one engine inoperative, which are the typical scenarios, but also at light weight with both engines operative in order to experience the higher dynamics. Crews should fly the go-around pitch and Flight Director bars and adapt the thrust to remain within flight parameters;
- 16.1.4 Training should emphasize the significance of thrust reverser deployment for a go-around decision. From a technical point of view, a go-around may always be initiated before reverser deployment and never after reverser application;
- 16.1.5 Introduce destabilized approach simulator training scenarios, which emphasize that deviations from the stabilized approach profile at low altitudes (below MDA/ DH) should require execution of a go-around;
- 16.1.6 Operators should consider the time loss due to go around as necessary for safe operations. Therefore, commercial pressure should not be imposed on flight crews. Pilots may be reluctant to go-around if they feel the fuel state does not support it. A go-around should be considered as potentially occurring on every flight and so the flight must be fueled to allow for a go-around without resulting in a low-fuel situation. A no fault go-around policy should be promoted by the operators. If pilots are fearful of disciplinary action they will be less likely to go around when they should;
- 16.1.7 ATC should be reminded that any aircraft might execute a bailed landing or missed approach. This will involve startle and surprise for the ATC just as it might for the flight crew involved. They should understand that the flight crew will immediately be involved in stabilizing the flight path, changing configuration, and communicating with each other. The flight crew will communicate with ATC as soon as they are able and ATC should provide or approve an altitude and direction of flight. They should also understand that the aircraft might be entering a fuel critical state such that routing and sequencing for diversion or subsequent landing must be without undue delay.

Section 7—Descent and Approach Profile Management

7.1 Descent and Approach Profile

Inadequate management of descent-and-approach profile may lead to:

- Loss of vertical situational awareness;
- Inadequate terrain separation; and/or,
- Rushed and unstabilized approaches.

An Airbus FOBN states that 70% of rushed and unstabilized approaches involve inadequate management of the descent-and-approach profiles and/or an incorrect management of energy level; this includes:

- Aircraft higher or lower than the desired vertical flight path; and/or,
- Aircraft faster or slower than the desired airspeed.

To ensure that flight crews meet the stabilized approach criteria at the required point, they must actively monitor and manage the profile from the very start of the descent.

In all cases there exists an optimal lateral and vertical profile for arrival and approach and this is generally reflected in the published procedures, although operators should develop mitigating measures for procedures that are not conducive to a stabilized approach.

Flight crew should start their descent preparation and approach briefings as soon as all pertinent data have been received – ten (10) minutes prior to top of descent is a good target for completion. Strict adherence to SOPs for Flight Management Systems (FMS) setup will assist in descent planning and execution, including confirmation of FMS navigation accuracy, crosscheck of all data entries, review of terrain and other approach hazards.

7.2 Aircraft Energy Management

The inadequate management of aircraft total energy (potential energy plus kinetic energy, plus an element of chemical energy from engine power/thrust) during descent, arrival and approach is a factor in unstabilized approaches. Either a deficit of energy (being low and/or slow) or an excess of energy (being high and/or fast) on approach may result in:

- Loss of control inflight (LOC-I);
- Controlled flight into terrain (CFIT);

- Landing short;
- Hard landing;
- Tail strike; and/or;
- Runway excursion

Large aircraft especially are designed to have highly efficient low drag aerodynamic characteristics and possess a great deal of energy in the cruise that must be dissipated appropriately throughout the descent, arrival, approach, landing and landing rollout. Aircraft must meet certain criteria on approach to be able to land safely, and controlling an aircraft during the descent and approach phases essentially becomes a task of energy management. In an unstable approach, the rapidly changing and abnormal condition of the aircraft may lead to a loss of control. Therefore, active energy monitoring and management is critical to reducing the risk of unstabilized approaches and abnormal landings.

Aircraft total energy is a function of airspeed and altitude but is affected by the following:

- Environmental factors;
- Vertical speed or flight path angle;
- Drag (caused by speed brakes, slats/flaps and landing gear); and,
- Thrust.
- Flight crew must monitor aircraft energy and control these variables in order to:
- Maintain the appropriate energy condition for the flight phase; or
- Recover the aircraft from a low- or high-energy condition.

ATC can assist flight crew by issuing instructions with appropriate consideration to aircraft performance for a given phase of flight/approach, timely interception of the desired final approach path and the provision of useful information like track miles to touchdown. Furthermore, ATC can greatly reduce the risk of an unstable approach by limiting to the minimum changes to the descent profile once the aircraft has started the descent.

Section 8—Technology and Operational Enhancement

8.1 Operational Enhancement

Air traffic and airspace management procedures are evolving to minimize the risk of an unstabilized approach:

Many newer aircraft support Required Navigational Performance (RNP) operations, which enhance safety by standardizing approach procedures, providing lateral and vertical guidance to help in flying stabilized approaches, and in avoiding obstacles down to lower altitudes above the runway threshold.

Performance Based Navigation (PBN) can deliver safety benefits by providing flight crew with vertical as well as lateral guidance from top of descent to touchdown. PBN provides for fully managed approaches, lower approach minima, a well-defined descent profile and improved terrain separation.

8.2 Technology Enhancement

Honeywell's Enhanced Ground Proximity Warning System (EGPWS) helps reduce CFIT risks by constantly monitoring terrain and obstacles in proximity of the aircraft. Pilots can see nearby terrain and obstacles displayed on cockpit screens to enhance situational awareness but they are alerted only when there is a risk of reduced terrain separation.

EGPWS uses aircraft inputs such as position, attitude, air speed, glideslope, and an internal terrain database, to predict a potential conflict between the aircraft's flight path and terrain or an obstacle.

A software extension of the EGPWS, Honeywell's SmartLanding warns pilots aurally and visually when they are flying outside predefined criteria in relation to speed, flight path trajectory and touch down point during approach.

SmartLanding encourages compliance with stabilized approach criteria, such as:

- Aircraft should be stable at 1000 feet;
- Aircraft **MUST** be stable at 500 feet;
- Aircraft is properly configured to land;
- Aircraft is on the correct vertical path;
- Aircraft is at the correct speed.

Enhancements in development at Boeing include improved traffic displays (both airborne and on the ground), monitoring and alerting for unstable approaches and long landings, optimized runway exiting guidance, taxi guidance, and improved crew awareness of take-off and landing performance – particularly for short, wet or contaminated runways.

8.3 Monitoring of Realistic Aircraft Landing Performance

Technology enhancements include:

1. Airport Moving Map Display, is an enhancement of the Airport Mapping Database (AMDB) and a fully functional tool within the Electronic Flight Bag (EFB). Airport moving maps integrate published charts with real time aeronautical data based on aeronautical information publications, revision and distribution processes for aeronautical data products (FMS databases and Route Manuals), adding tailored information according to client requirements.

Some of the goals are to:

- Improve situational awareness,
 - Reduces runway incursion/excursion risks,
 - Prevent take-off from wrong runway, and
 - Reduce pilot workload.
2. Boeing's Situational Awareness & Alerting For Excursion Reduction (SAAFER) strategy offers flight deck technology, procedural enhancements and training aids to improve pilot awareness and decision making during approach. It recognizes that whilst new aircraft can be delivered with the latest safety technologies installed, older types still in service may require modification, retrofit or more innovative solutions. The strategy aims to address all types over time. Lower cost 'quick fix' elements of the SAAFER initiative include improved approach and landing procedures, and training and awareness tools to educate pilots.
 3. Airbus Runway Overrun Prevention System (ROPS) is an on-board cockpit technology that is designed to increase pilots' situational awareness during landing, in order to reduce exposure to runway excursion risk. It continuously monitors total aircraft energy and landing performance capability versus runway end point. It is integrated with the aircraft flight management and navigation systems and provides pilots with a real-time, constantly updated picture on the navigation display of where the aircraft will stop on the runway in wet or dry conditions.

The system combines data on weather, runway condition and topography, aircraft weight and configuration to alert pilots to unsafe situations, assisting them go-around decision-making and/or the timely application of retardation on touchdown.

Some of the goals are to:

- Improve situational awareness,
- Reduce runway excursion risks,

- Predict realistic operational landing distance in relation to runway end,
 - When necessary provide alerts,
 - Complement a stabilized approach policy.
4. Airbus Advanced ILS Simulation – Exact Landing Interference Simulation Environment (ELISE) is a software application for air navigation service providers and airport operators to effectively eliminate interference to an Instrument Landing System (ILS) signal, due to aircraft, vehicles, buildings and other objects in close proximity to the runway.

In addition to improved safety ELISE enables increased runway capacity and the optimization of airside land usage.

RECOMMENDATION (16):

- 8.16.1 Operators to equip their aircraft with technological solutions to reduce unstabilized approaches and support go-around decision making;
- 8.16.2 Operators to use the latest EGPWS version, keep the terrain database current and provide GPS position data to the EGPWS;
- 8.16.3 Operators to implement vertically guided approaches that facilitate stabilized approaches;
- 8.16.4 Manufacturers should continue development of stable approach and energy management monitoring and alerting systems.

Section 9—Conclusion

It is commonly accepted within the industry that flying a stabilized approach is important to the safe completion of a flight, and this should be the fundamental aim of all parties involved in the conduct and management of approaches. Other factors such as good flying skills, timely and appropriate decision making, adequate flight path management, adherence to SOPs, proper approach design, adequate ATC procedures and training, and effective monitoring by the flight crew contribute to achieving a stabilized approach.

Accident/incident data identifies unstabilized approaches as one of the most significant safety issues remaining to be addressed. Most operators have developed and implemented stabilized approach policies and defined the relevant criteria in their SOPs to help flight crews in go-around decision making but there is evidence of widespread non-compliance.

The decision to initiate a go-around whenever an approach cannot be stabilized, or cannot otherwise be completed safely, is critical to the reduction of approach and landing accident risk.

Training programs must address identified operational risks and not simply follow the regulatory minimum requirement. Specifically flight crew must be trained to fly an accurate go-around from all stages of the approach.

To manage the risk of unstabilized approaches, it is important to enhance operational procedures and training for both flight crew and ATC, to promote the adherence of SOPs, to inform and improve go-around decision making, encourage implementation of PBN, and to consider installing the proactive on-board technology that is currently available.

