

Safety first

The Airbus Safety Magazine

Edition August 2010

CONTENT:

- ▶ A380 - Flutter tests
- ▶ Operational Landing Distances
A new standard for in-flight
landing distance assessment
- ▶ Go Around handling
- ▶ A320 landing gear downlock
- ▶ Situation awareness
and decision making



Issue **10**

New Standards. Together



AIRBUS

Safety First

The Airbus Safety Magazine

For the enhancement of safe flight through increased knowledge and communications

Safety First is published by the Flight Safety Department of Airbus. It is a source of specialist safety information for the restricted use of flight and ground crew members who fly and maintain Airbus aircraft. It is also distributed to other selected organisations.

Material for publication is obtained from multiple sources and includes selected information from the Airbus Flight Safety Confidential Reporting System, incident and accident investigation reports, system tests and flight tests. Material is also obtained from sources within the airline industry, studies and reports from government agencies and other aviation sources.

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A380
Serial Number 009
Landing at Toulouse-
Blagnac Airport

Safety First, #10 August 2010. Safety First is published by Airbus S.A.S., 1, rond point Maurice Bellonte, 31707 Blagnac Cedex/France. Editor: Yannick Malinge, Vice President Flight Safety, Nils Fayaud, Director Product Safety Information. Concept Design by Airbus Multi Media Support Ref. 20100819. Computer Graphic by Quat'coul. Copyright: GSE420.0100/10. Photos copyright Airbus. Photos by ExM Company: H. Berenger, P. Masclat, H. Goussé. Printed in France by Airbus Print Centre.

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Yannick MALINGE

Vice President
Flight Safety

Editorial

Dear Customers and Aviation Safety Colleagues,

For the first time in this magazine we will feature a new type of subject, which is directly pertinent to aircraft safety but to which line pilots are normally never exposed to: flutter.

The first article of this magazine, “A380 –Flutter tests”, is the first of a series of briefings, which provide an insight into Airbus test flights, as part of the airworthiness process.

On several occasions (particularly during the Safety Conferences) we tackled the theme of runway excursion, which is the main category of accidents in Air Transport. In issue #8 of Safety First, we presented the Runway Overrun Protection System (ROPS), which is an innovative design feature that assists crews in the Go Around decision making process. In parallel to this design enhancement, the Authorities are also looking at a new way of assessing the landing distance in-flight. This issue of Safety First will describe the new requirements that the FAA is expected to issue.

The other main subject of this magazine is related to one of the most important and difficult topics during some critical phases of flight: situation awareness and decision making. An article will depict the mental process involved and will explain why reaching a good decision may be a difficult exercise, especially in a dynamic situation.

Go Arouns are precisely events where the situation awareness and decision making process are key and which take place in dynamic situations. Independently of the decision itself, Go Arouns are rare events and in-service experience underlines the need to reinforce the strict adherence to the published operating procedures. The enclosed “Go Around handling” article will summarize the key steps that a crew should follow when going around.

I hope you will enjoy reading this issue of Safety First.

Yannick MALINGE
Vice President Flight Safety

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Nils FAYAUD

Director Product Safety Information

Information

Magazine distribution

If you wish to subscribe to Safety First, please fill out the subscription form that you will find at the end of this issue.

Please note that the paper copies will only be forwarded to professional addresses.

Your articles

As already said, this magazine is a tool to help share information.

We would appreciate articles from operators, that we can pass to other operators through the magazine.

If you have any inputs then please contact Nils Fayaud at:

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Safety Information on the Airbus websites

On the AirbusWorld website we are building up more safety information for you to use.

The present and previous issues of Safety First can be accessed to in the Flight Operations Community- Safety and Operational Materials chapter-, at <https://w3.airbusworld.com>

Other safety and operational expertise publications, like the Getting to Grips with...brochures, e-briefings etc...are regularly released as well in the Flight Operations Community at the above site.

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News **SAVE THE DATE**

17th Flight safety conference

Rome, 21-24 March 2011

Following the successful event in Brussels, in March of this year, we are pleased to announce that the 17th Flight Safety Conference will take place in Rome, Italy, from 21st to 24th of March 2011.

The Flight Safety Conference provides an excellent forum for the exchange of information between Airbus and customers. The event is a dedicated forum for all Airbus operators. We do not accept outside parties. This ensures that we can have an open dialogue to promote flight safety across the fleet.

As always we welcome presentations from you. The conference is a forum for everybody to share information, so if you have something you believe will benefit other operators and/or Airbus, please contact Christopher Courtenay at:

e-mail:

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The formal invitations with information regarding registration and logistics and the preliminary agenda will be sent to our customers in December 2010.

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**Claude LELAIE**

Senior Vice President Product Safety

A380 - Flutter tests

1. Definition of flutter

Flutter is the coupling of different oscillation modes on a system. Let's take an example on an aircraft. In flight, due to its flexibility, the wing can oscillate in torsion and in flexion. The frequencies of these two motions are depending on speed. If, in some conditions, they are identical or very close one to the other, there can be an "auto-excitation". It means that the oscillation on one axis can amplify the other one and vice-versa, therefore increasing the energy. If the amplitude becomes too large, a rupture may occur very quickly.

This phenomenon is similar to what happens when a child is on a swing. Moving the legs at the right frequency amplifies the motion of the swing and increases the global energy.

Flutter can also occur on structures other than aircraft. Some of you may have seen the impressive images of the rupture of the Tacoma suspension bridge in the USA, about 60 years ago. The very strong wind led to amplify several oscillation modes until the rupture. Now all suspension bridges must be sized to resist to the strongest winds.

2. Flutter characteristics

On an airplane, flutter is characterized by oscillations diverging very quickly. Therefore, the risk of flutter inside the flight envelope, and even well outside the borders to have a safety margin, are not acceptable. On big transport aircraft,



Figure 1
A380 first flight
over the Pyrenees

there is a huge number of vibration modes of different parts: wings, engines, empennage, control surfaces... On top of this, it depends on the quantity of fuel in the wings and in the empennage, on the speed and many other parameters.

Theoretical computations are now very reliable and allow to determine in advance the potentially critical conditions. They are based on mathematical models of the structure of the aircraft. These models are then adjusted thanks to ground tests where the aircraft is excited with variable frequency oscillators. Such tests are performed on a development aircraft before the first flight and last several days. Despite this good level of analysis, exploring the flight envelope in speed and Mach must be done carefully.

Four engines aircraft give more frequently difficulties in the area of flutter. The reason is that the external engines may be strong contributors to various oscillations.

3. Flutter test flights

Flutter flights are obviously risky. Until the full opening of the flight

envelope, the crews perform these tests with all the safety equipment: parachutes, helmets, life jackets, lifeboat... The emergency evacuation door (tunnel going through the cargo door) is also armed.

Several parameters have to be considered: CAS, Mach, weight, fuel repartition. For the same flight conditions, for example, it is often necessary to perform flights with various amounts of fuel in the tank of the horizontal tail plane: full, half full and then empty, because this difference modifies the oscillation frequencies and therefore the flutter characteristics.

Safety must be ensured well above VMO, because in case of wind gradient, this value may well be exceeded. In flight, the regulations ask for the demonstration that the aircraft is free of flutter up to VD (D for Dive, as in some cases, this speed can only be demonstrated in a dive). The difference between VMO and VD is usually around 50 kts on a classical aircraft. But on fly-by-wire aircraft, this margin has been reduced thanks to the high speed protection. In case of over speed the aircraft will react to limit the speed excursion. Depending on the type of aircraft, if the protec-



Figure 2
A380 3/4 front view

tions are lost, the maximum authorized speed may be reduced according to what has been validated. On the A380, we have $VMO = 340$ kt and $VD = 375$ kt.

What has been explained for speed is also valid for Mach Number. On the A380, the values are $MMO = 0,89$ and $MD = 0,96$.

Above VD and MD , the certification regulations require a theoretical demonstration that there is a supplementary speed and Mach margin where the aircraft is clear of flutter.

For each test point in flight, oscillations at variable frequencies are sent to some flight controls via a specific computer. A single test lasts 3 minutes. The frequency increases during the first part, then decreases to come back to the initial value. The crew can feel well the coupling modes as, at this time, there is an increase of the amplitude of the oscillation. If necessary, the test can be stopped immediately either by the pilots or by the flight test engineers. It is difficult to know in advance what amplitude is adapted for each speed in order to have a sufficient structural response for a proper analysis. Therefore the engineers have at their disposal several levels of ex-

citation for each mode. Sometimes in flight, test points are restarted to obtain an amplitude well adapted for the analysis, but not too strong to avoid damages of the airplane.

All parameters are transmitted by telemetry to the ground. Each test point is analysed by specialists, as soon as the measurements are completed. This review takes a variable time, according to the degree of confidence and coherence with the models. Sometimes the clearance to go ahead for the following test point is given immediately. The crew may also have to wait several minutes for the clearance. It has also happened on some programmes that the flight had to be stopped for further analysis.

Flight controls are excited in different ways. For the ailerons, there are symmetrical and anti-symmetrical modes. For the first ones, the ailerons of both wings are deflected simultaneously in the same direction. For the anti-symmetrical modes they are in opposition (like in a roll control mode). Most of the tests are performed with the ailerons but some are also done using elevators or rudder.

The test points have to be performed in direct law in order to avoid introducing flight controls deflec-

tions due to an outside source. In the past, before the A380, the pilots were not authorized to touch the side stick during the test and therefore execution was rather difficult. The altitude was maintained using the trim wheel. The bank angle was kept close to zero with very small pressure on the pedals. At high Mach, differential thrust was sometimes used to control roll, due to the reduced roll induced by the rudder. The speed had to be maintained with a good precision with the thrust lever. One of the key difficulties was that any action on the thrust gave a pitching moment that had to be compensated with the trim wheel. One of the pilots was in charge of maintaining the trajectory: altitude and heading and the other one was keeping the speed. Obviously a good coordination was needed.

The crews were concerned about their ability to maintain the flight parameters very precisely due to the large inertias of the A380. Each test point lasted for 3 minutes and had to be performed with an electric trim and no trim wheel. Finally, the Design Office prepared a specific direct flight control law such that the test conditions could still be maintained by action on the stick. Everything then became straightforward.

Progression in speed (CAS) is generally slow, by step of 15 kts. In parallel, for each speed, the Mach Number has to be increased progressively as the relationship between Mach and CAS is a function of altitude.

For high Mach Numbers, it is not always possible to maintain the altitude during 3 minutes because drag increases rapidly with Mach. In this case, tests are performed in descent and, as variable frequency oscillations could not be used, it is replaced by what we call "pulses", which are abrupt impulses sent by computers to the flight controls. Above MMO , it is quite frequent

to find buffeting of various levels. This buffeting generally reduces the risk of flutter as it disorganizes the potential oscillations of the different modes.

The final test is the dive at VD / MD. It is necessary to start at the ceiling of the aircraft. Then, with full thrust, the crew begins the dive until reaching MD in descent. MD is kept with a speed increasing up to VD. At the conjunction of MD / VD, the test is over and the pilots can throttle back and pull gently on the stick. During all the tests, pulses are sent to the flight controls on the various axes. The flight test engineers must act quickly as for some aircraft, the drag is such that the rate of descent is high.

4. History of the A380 flutter tests

On the A380, the envelope opening at VMO / MMO was performed at flight n°5 without specific flutter test due to the good results obtained after analysis of the ground tests.

The first real flutter flight was flight n°21, on June 9th 2005, about one and a half months after the beginning of the flight tests. Take-off weight was 533 tons and landing weight 485 tons (normal MLW is 386 tons). During this flight, with maximum fuel in all tanks, the speed has been increased up to VD (375 kt) at a low Mach Number.

The following flutter tests were performed during flight n°51, at the beginning of August 2005. Why such a delay between these two flights? The reason is that priority had been given to other activities, mainly the validation of the final aerodynamic configuration: slats and flaps deflections... During this second flutter flight, the envelope has been opened up to the conjunction VD and MMO, without any abnormal finding in flight. However, when on ground, it appeared that there were serious damages on the belly fair-

ings. Clearly, reinforcements were necessary before the next flutter flights.

At the end of August, a new flutter flight was performed with modified belly fairings. The target was to open the flight envelope up to the conjunction of VMO / MD. It was the first opportunity to fly above MMO. This has been done by step, but when the aircraft reached a value slightly above 0.95, the Mach Number suddenly jumped up to 0.98. The reason was a shock wave crossing the static pressure sensor and it was not possible to stabilize precisely MD = 0.96.

Starting from mid September, one or two flutter flights were performed every week. It was not possible to do more as some time was needed for data analysis and on top, as the aircraft was well shaken during each flight, there was a need for a thorough inspection. For all these flights, the amount of fuel in the tanks was adjusted to cover all the situations, one of the key issues being the fuel quantity in the trim tanks.

The campaign was interrupted for some weeks due to a commercial campaign. Then, on the 1st of December 2005, the dive at VD / MD was performed. We were aware of the difficulty to stabilize precisely MD due to this shock wave influencing the measurement. The test was repeated several times, reaching an indication of 0.988. Finally the flutter specialists agreed that this was sufficient to certify the aircraft.

After the flutter tests came the time of the tuning of the flight control laws, as it is necessary to demonstrate that with the protections, it is not possible to exceed the cleared flight envelope. This will be the subject of another article.

Figure 3
A380 over Switzerland





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A380 Operational Performance



Robert LIGNEE

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Operational Landing Distances

A new standard for in-flight landing distance assessment

1. Introduction

A third of major accidents of large commercial transport aircraft are runway excursions. Many involve difficulties by the crew to realistically assess the available landing distance margins at time of arrival.

This is to some extent explained by three contributing factors:

- ▶ The multitude of methods and formats for assessing and reporting the runway surface condition
- ▶ The lack of explicit regulation regarding the in-flight landing distance assessment
- ▶ The variety of landing performance data formats published by manufacturers or operators for in-flight use.

Following a runway overrun in winter conditions, the FAA launched a full review of American operators landing distance assessment policies. This review led the FAA to recommend guidelines and best practices to the airlines by the Safety Alert for Operators

(SAFO) 06012, followed up by Advisory Circular (AC) 91-79. It then created the Takeoff and Landing Performance Assessment Aviation Rulemaking Committee (TALPA ARC). This group of representatives from the FAA and other regulators, airlines, airport operators, pilot associations and most manufacturers, including Airbus, finalized its proposal for new regulation of in-flight landing distance assessment in July 2009.

This article briefly describes the current regulations covering the landing distance assessment, restricted to the FAA and EASA for simplification purposes, and the options Airbus has chosen to follow. It will then outline the main concepts of the proposed TALPA ARC rules for landing.

2. Current situation

2.1. Runway condition assessment and reporting

There is currently not a unique standard for runway condition assessment and reporting:

- ▶ Most frequently the contaminant type and depth is reported, with variation in the measurement means and terminology
- ▶ When runway friction measurement vehicles are available, friction values may be reported, although there is no correlation available for a runway friction measured by a vehicle with aircraft performance on the same surface
- ▶ After landing, it is common practice for North American pilots used to winter conditions to report their assessment of braking action to the tower, and thus to following aircraft. The assessment is based on a scale ranging from GOOD to POOR.

2.2. In-flight assessment operational rules

Current FAA and EASA rules make a generic statement regarding the need to assess landing performance

in flight: “The commander must satisfy himself/herself that, according to the information available to him/her, the weather at the aerodrome and the condition of the runway intended to be used should not prevent a safe approach and landing”. No guidance is given on the criteria and factors to be taken into account for the determination of a safe landing distance.

2.3. Landing performance computation and publication

2.3.1. Actual Landing Distances (ALD)

The data published in the Airbus operational documentation for in-flight reference are labeled as Actual Landing Distance (ALD). They are defined by regulations for publication in the Flight Manual for dry (FAA and EASA) and contaminated (EASA only) runways. There is no such a regulation for wet runways.

The ALD are the basis upon which margins are added for the regulatory dispatch requirements.

They are not a valid reference data for making in-flight performance assessments when used as published, with no additional margin (fig. 1 & 2).

The ALD are published for sea level, a reference temperature and no wind. Corrections for pressure altitude, longitudinal wind, reverse thrust use, planned approach speed, automatic landing and auto brake use are provided, but not for runway slope or temperature. A runway down slope or higher than reference temperature will thus make the achievable landing distance longer than the published one.

Airbus ALD computation method

Air distance:

- For dry and wet runways, it is derived from flight tests conditions.
- For contaminated runways, EASA has defined the air distance as 7 seconds at the equivalent ground speed of V_{ref} , with a 7% speed decay between threshold and touchdown.

Ground roll wheel to ground frictions:

- For dry runways, it is derived from flight tests.
- For wet runways, Airbus uses the regulatory smooth runway friction approved for rejected take-off.
- For contaminated runways, they are defined by EASA regulations.

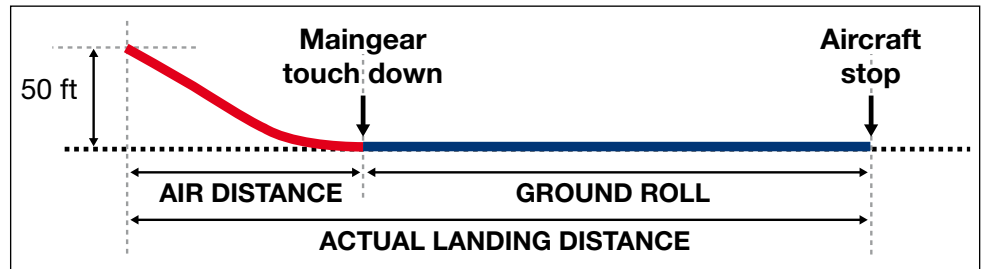


Figure 1
Regulations breakdown of ALD into air distance and ground roll

Runway condition	Airbus ALD computation		Regulatory basis
	Air distance	Ground roll wheel to ground frictions	
DRY	Flight tests	Flight tests	FAA and EASA
WET	Flight tests	FAA/EASA model with WET anti-skid efficiency from flight tests	FAA and EASA Rejected take-off
CONTAMINATED	7 sec with 7% speed decay	EASA CS25.1591	EASA only

Figure 2
Main characteristics of the ALD published by Airbus

2.3.2. Landing distance requirements for dispatch

The Required Landing Distances for dispatch are defined by regulations as factored ALD and are labeled as RLD (fig. 3). They must be shorter than the declared Landing Distance Available (LDA) of the intended runway, and vary with:

- Runway condition, and
- The approach type (for EASA only: dispatch requirement with AUTOLAND planned at arrival).

No RLD corrections are published for runway slopes or temperatures above the reference temperature:

- For dry runways, the effects of slope and temperature are covered by the large regulatory margin.
- For wet and contaminated runways the margins are comparatively small, particularly when taking into account that the recommended approach speed is $V_{ref}+5$, which increases the landing distance significantly.

Figure 3
Main characteristics of the RLD

Runway condition	RLD computation	Regulatory basis	Reverse credit
DRY	1,67 x ALD DRY	FAA and EASA	No
WET	1,15 x RLD DRY = 1,92 x ALD DRY	FAA and EASA	The 15% margin implies use of max reverse thrust
CONTAMINATED	1,15 x ALD CONTAMINATED	EASA only	Allowed

3. FAA TALPA ARC proposals

The TALPA ARC proposals consist of three intensely related packages of:

- ▶ **Airports** standards for runway condition reporting (FAR139)
- ▶ **Aircraft** operational landing performance computation (FAR25/26)
- ▶ **Operators** operational rules (FAR121) and training.

3.1. Runway condition assessment and reporting

The centerpiece of the proposals is the runway condition “Matrix” hereafter, that associates:

- ▶ 7 runway condition codes, built on the existing ICAO runway friction codes, to
- ▶ 6 aircraft performance levels defined in § 3.2.1. No performance level is provided for the code 0 as operations in these conditions are prohibited.

Provisions of specific landing and rejected take-off performance credit for wet grooved or PFC runways have been made. However no specific runway code was assigned to such runways.

The following reports are used as entry points:

- ▶ Contaminant type and depth
- ▶ Pilot braking action (PiREP)
- ▶ Runway friction measurement (Mu (μ)).

The latter two report types should be used exclusively to downgrade a runway assessed by means of contaminant type and depth (primary columns).

Fluid contaminants (snow, water, slush) generate an extra drag, function of their depth:

- ▶ TALPA ARC proposals limit this credit at landing (to half of the reported depth)

Airbus has elected to take no credit for this fluid contaminant drag at landing, enabling one unique aircraft landing performance level associated with each code.

The “Matrix” has been already extensively tested in Alaska and other US airports in real conditions during the 2008-2009 and 2009-2010 winters. The runway condition classification made in the “Matrix” will also be the basis of the digital NOTAM system currently being developed in the US.

The information to be transmitted to the flight crew includes:

- ▶ The runway code for each third of the runway
- ▶ The type and depth of the contaminant and percentage of coverage in 25% increments
- ▶ The PiREPS when available.

Airport Estimated Runway Condition Assessment				Pilot Reports (PIREPs) Provided To ATC And Flight Dispatch
Runway Condition Assessment – Reported		Downgrade Assessment Criteria		
Code	Runway Contaminant	Mu (μ)	Deceleration And Directional Control Observation	PIREP
6	• Dry			Dry
5	• Wet (Smooth, Grooved or PFC) • Frost 1/8" or less of: • Water, Slush, Dry or Wet Snow	40μ or higher	Braking deceleration is normal for the wheel braking effort applied. Directional control is normal.	Good
4	At or below -13°C: • Compacted Snow	39-35μ	Brake deceleration and controllability is between Good and Medium.	Good to Medium
3	• Wet (Slippery) At or below -3 C: • Dry or Wet Snow greater than 1/8" Above -13°C and at or below -3°C: • Compacted Snow	34-30μ	Braking deceleration is noticeably reduced for the wheel braking effort applied. Directional control may be slightly reduced.	Medium
2	Greater than 1/8" of: • Water or Slush Above -3 C: • Dry or Wet Snow greater than 1/8" • Compacted Snow	29-25μ	Brake deceleration and controllability is between Medium and Poor. Potential for hydroplaning exists.	Medium to Poor
1	At or below -3°C: • Ice	24-21μ	Braking deceleration is significantly reduced for the wheel braking effort applied. Directional control may be significantly reduced.	Poor
0	• Water on top of Compacted Snow • Wet Ice, Dry or Wet Snow over Ice Above -3°C: • Ice	20μ or lower	Braking deceleration is minimal to non-existent for the wheel braking effort applied. Directional control may be uncertain.	Nil

Primary columns

Downgrade columns

note
Code 2 - Water depth greater than 1/8" (3 mm) - may not be detected by airports, and may therefore not be reported.

TALPA ARC main rules associated to the "Matrix"

- Pilot reports (PIREPs) of braking action might provide insight that the friction level fell since the last airport evaluation. With existing technology, these reports reflect a purely subjective pilot evaluation, presently only in North America and from pilots used to such a difficult evaluation. They rarely apply to the full length of the runway. The airport should exercise prudent judgment, prompt a new evaluation, and if warranted, report a lower runway condition code than the "Matrix" would indicate for the contaminant type.
- Friction values from measurement vehicles in winter conditions will no longer be transmitted to pilots, but restricted for the airport authorities use in consolidating or downgrading a runway code. The "Matrix" area shown in blue above is therefore meant for airport use only.
- All ambiguous airport reporting terms will be eliminated (such as "patchy", "thin", etc).
- A damp runway must be considered wet.
- Wet runways failing maintenance friction survey as defined in AC 150-5320 (e.g., heavy rubber deposits) will be reported as "Slippery" until brought back into required friction standards.

3.2. Landing performance computation and publication

3.2.1. Operational Landing Distance (OLD)

The TALPA proposal defines the Operational Landing Distance (OLD) as the maximum landing performance realistically achievable by a line pilot adhering to standard techniques (fig. 4).

OLD computation method

Air distance:

The length of the air distance is the distance covered in 7 seconds at the ground speed corresponding to the approach speed (including temperature and conventional wind effect), with speed decay during the flare set at 4%.

Ground roll wheel to ground frictions:

Deceleration means are considered as per their prescribed use in the Standard Operating Procedures (SOP):
 - For landing in manual braking, maximum pedal braking is assumed to be initiated, if allowed by SOP, at main gear touchdown with reversers deployed shortly after.
 -For landing with auto brake, the automatic sequence is followed.

Runway condition code	Braking action	Main contaminant description	OLD computation		Regulatory basis	Reverse credit
			Air distance	Ground roll wheel to ground frictions		
6	/	DRY	7 sec, with 4% speed decay	Flight tests with abatement for rubber contamination	FAA	Allowed
5	GOOD	WET		Unchanged FAA/EASA model with wet anti-skid efficiency		
4	GOOD TO MEDIUM	Compact Snow		Consistent in essence with EASA CS25.1591 (*)		
3	MEDIUM	Loose Snow				
2	MEDIUM TO POOR	Standing Water, Slush				
1	POOR	ICE				

Figure 4
Main characteristics of the OLD

(*) The over-conservative ICE value built for dispatch requirements is changed to a more realistic friction coefficient.

3.2.2. Landing distance requirements for dispatch

TALPA ARC was not mandated to review current dispatch rules, therefore the existing rules continue to apply. However for the long term, the need to review dispatch landing distances for consistency with the time of arrival requirements, was acknowledged by TALPA ARC in its submission to the FAA.

3.3. In-flight assessment operational rules

The FAR 121 operational rules will mandate an in-flight landing distance assessment based on 115% of the Operational Landing Distance published for prevailing conditions (FOLD or Factored OLD) (fig. 5).

With the current dispatch requirements, it will be permitted to omit the in-flight assessment for landing on the runway planned at dispatch only if:

- Dispatch was performed for DRY and if, at the time of the approach preparation, a dry runway and no worse conditions than the standard ones considered for dispatch are reported
- Dispatch was performed for WET and if, at the time of the approach preparation, a wet runway and no worse conditions than those considered for the dispatch are reported and the runway is maintained to the standards defining grooved or PFC runways in AC 150-5320.

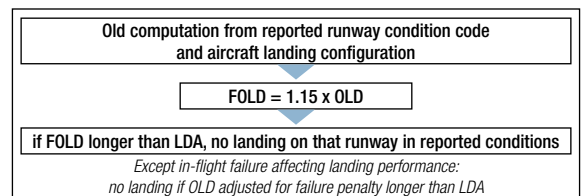


Figure 5
In-flight assessment prior to initiating an approach

4. Conclusion

The FAA TALPA ARC proposal for regulatory changes is made up of three intensely related packages of:

- **Airport** runway condition reporting standards
- **Aircraft** performance computation and publication standards
- **Operators** operational rules and training.

The resulting FAA regulation will become applicable to all new aircraft, and be made retroactive for all existing aircraft.

Airbus supports the new methods for assessing Operational Landing Distances as part of the Industry efforts to help further reducing the runway overruns at landing.

note

The Runway Overrun Prevention System (ROPS), described in Safety First Issue 8 dated July 2009, is consistent with the TALPA ARC proposals. The system was certified in October 2009 on the A380. A future article will detail how the ROPS integrates the new in-flight landing distance assessment rules.

Airbus will provide Operational Landing Distance data in the documentation by mid-2011, and has anticipated by issuing recommendations for interim measures since May 2009.



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Training Policy and Development – In Service Fleet

Go Around handling

1. Introduction

Recent serious incidents involved improperly conducted Go Around maneuvers. This article will briefly describe two of these occurrences. It will then make a short number of simple and important recommendations to help avoid the re-occurrence of this critical type of events.

2. Description of incidents

2.1. First event

On a hazy morning with low patches of cloud (Vis 3000m, SCT002, BKN003), the crew conducted a manual (flight and thrust) ILS approach. The crew had no visual contact at MDA (200 ft AAL). The Captain (PF), considering a low missed approach altitude of 170ft AAL, advanced the thrust levers progressively (within 5 seconds) but stopped the action when in the FLX/MCT notch. He increased the pitch to about 6° Aircraft Nose Up. The aircraft stopped descent at 150ft RA and CONF3 was selected. 4 seconds after setting the levers in the FLEX/MCT detent, the Autopilot (A/P) was engaged and the landing gear retracted. The aircraft – still in LAND mode, due to the lack of TOGA selection – immediately conducted a rapid pitch down to regain the glide slope. PF moved the thrust levers to the CLB detent. At 127ft RA and a pitch of 3.9° Nose Down, the EGPWS audio “SINK RATE” sounded. The PF disconnected the Auto Pilot and pulled almost full back on the stick. The aircraft had reached a minimum height of 76ft RA at an airspeed of 182kts, in CONF3, gears up.

2.2. Second event

On a foggy day the crew conducted an ILS approach A/P and ATHR on. There was no contact at the minimum. The crew initiated a Go Around at a Radio Altitude of 185ft, but the thrust levers were momentarily moved only to a position just forward of, before being retarded to the FLX/MCT detent. Three seconds later the Flaps were retracted to CONF3. The Captain disconnected the Autopilot at 57ft simultaneously EGPWS “DON’T SINK” alert sounded. The aircraft reached its lowest RA of 38ft.

3. Technical considerations

On the Airbus Fly By Wire (FBW) aircraft, the common Go Around flight guidance modes of the Auto Flight System (AFS) are triggered by setting the thrust levers to TOGA. If the crew decides to go around and fails to set TOGA, the AFS status will depend on the type of approach:

- For an **ILS approach**, the A/P remains engaged in the currently selected AFS mode
- For a **managed Non Precision Approach (FINAL APP)**, the AFS remains in FINAL APP mode. Disengage the Autopilot 50 ft below minimum and revert to the basic modes (depending on Mod Status)
- For a **fully or partially selected NPA**, the A/P remains engaged in the selected mode.



Figure 1
PFD (at 140ft and 80ft) after setting MCT instead of TOGA at 200ft during an ILS approach, (symbolic graphic – no direct reproduction of the described events)

4. Recommendations

4.1. Applying TOGA in the proper way

Setting TOGA in Go Around (and in any other maneuver where maximum thrust is required instantly) should be a one-step intuitive action i.e. pushing the thrust levers rapidly up to the full forward mechanical stop. Pilots must not count the mechanical detents (clicks), like in setting thrust on Take-Off. Instructors in pilot training could emphasize this movement by the description of “firewalling it”, a term well known to most pilots from their early days of basic training. (fig. 2)

4.2. Monitoring the basic flying parameters, pitch/thrust

Airbus Golden Rule N°2 “Fly, navigate ...” applies also to the G/A phase :

Initiation of a rotation to get a positive rate of climb has priority (on the A320 for example, this translates to 15° of pitch with all engines and approximately 12,5° if one engine is out). Only then follow SRS Flight Director pitch bars orders if consistent with the intended flight path, and if the FMA has been checked.

4.3. Checking and announcing the FMA

Airbus Golden Rule N°5 requires: “Know your FMA at all times”. For the GA it means to verify that the expected mode (MAN TOGA/SRS/GA TRK or MAN TOGA/SRS/NAV) is displayed and announced immediately after the flap have been retracted one step and the flight path has been confirmed using raw data (see § 4.2).

4.4. Connecting the AP only when the FD shows the intended flight path

Before engaging the Autopilot (AP), the Flight Crew should follow the recommended practice: Fly the aircraft on the intended path, check on the FMA that the Flight Director is engaged with the appropriate modes.

4.5. Training recommendations

Academic training should ensure that crews understand that thrust levers in Airbus FBW have more than just the thrust function. They are not only used to control thrust in Manual or Auto mode, but serve also as “Mode Selectors” in certain stages of flight. The multiple additional functions of the thrust levers are for example the:

- ▶ Engaging of common modes when TOGA or FLEX (for T/O only) is set
- ▶ Sequencing of the FMS flight plan into the missed approach procedure when TOGA is set
- ▶ Retracting of the speed brakes, if extended when setting TOGA (fig. 3).



Figure 2
Thrust levers in TOGA position

“Firewall it”

Thrust Levers
are also
Mode selectors



Figure 3
Airbus FBW thrust levers are also “Mode Selectors”



Christopher MCGREGOR

Director, Flight Safety

A320 landing gear downlock

1. Introduction

A prelude to two runway excursions was a spurious landing gear not downlocked indication on the landing gear indication panel. The spurious indication led to unnecessary application of the LDG WITH ABNORMAL L/G QRH procedure.

This article summarizes the correct interpretation of landing gear downlock indications to prevent re-occurrence.

2. Landing gear position status

2.1. Landing gear control and indication architecture

The Airbus A320 utilise two Landing Gear Control and Indication Units (LGCIU1 and LGCIU2). The LGCIUs provide the inputs and feedback necessary to control the landing gear. In addition to the control inputs, the LGCIUs provide the system parameters for the flight deck display and fault annunciation. System redundancy is reflected by LGCIU1 and LGCIU2 (fig1).

LDG GEAR CTL panel receives landing gear position feedback from LGCIU1 ONLY

LGCIU1

LGCIU2

ECAM WHEEL Systems Display (SD) page displays the landing gear position feedback from both LGCIU1 and LGCIU2



Figure 1
Landing gear control and indication architecture

This article will utilise the EIS 1 display for the illustrations. However the article is applicable to both EIS 1 and EIS 2 displays.

Figure 2
EIS 1 versus EIS 2 WHEEL Systems Display Page



2.2. Gear selected DOWN / No sensor failure / Normal landing gear downlocked indications

Following gear selection and downlock, the flight crew will observe the green downlock lights on the landing gear panel and two green triangles per landing gear position on the ECAM WHEEL Systems Display (SD) page. This provides confirmation that the gear is properly downlocked (fig 3).



Figure 3
Normal landing gear panel and WHEEL Systems Display landing gear downlocked indications following gear down selection

2.3. Gear selected DOWN / Sensor failure / Spurious landing gear not downlocked indications

The LGCIU1 proximity sensors located on the each landing gear strut provides the lock/unlock signal to the landing gear indication panel. Failure of one of these sensors could generate a spurious main landing gear not downlocked (“UNLK”) red light and a single red triangle on the SD WHEEL page (fig 4).

note

In the event of a genuine landing gear strut detected as not downlocked by both LGCIU1 and LGCIU2 sensors, the “L/G GEAR NOT DOWNLOCKED” ECAM warning will be triggered, along with associated warnings:

- ▶ Continuous Repetitive Chime audio warning, and MASTER WARN light
- ▶ UNLK red light on the LDG GEAR CTL panel
- ▶ On the ECAM WHEEL SD page, both red lights are displayed on the affected landing gear strut
- ▶ RED ARROW on the LDG CTL lever panel
- ▶ ECAM memo “LDG LDG GEAR DN” (blue).

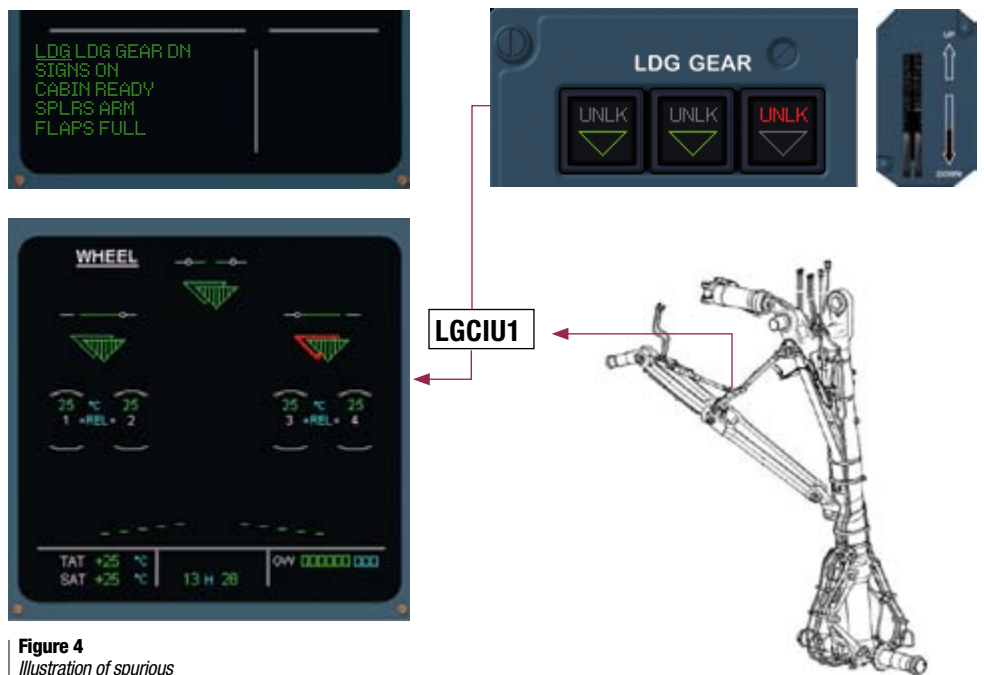


Figure 4
Illustration of spurious landing gear not downlocked indication

On gear selection, one green triangle on the ECAM SD WHEEL page and the green “LDG LDG GEAR DN” memo on the E/WD is sufficient to confirm the landing gear is down and locked.

2.4. At 750 ft RA, gear not selected DOWN / No sensor failure/ Normal landing gear indications

The “L/G GEAR NOT DOWN” ECAM warning is triggered passing 750 ft RA in approach to warn the flight crew that the landing gear is not set to DOWN while the aircraft is in the landing configuration. This alert must not be confused with the “L/G GEAR NOT DOWNLOCKED” ECAM warning that indicates that the landing gear is detected as not downlocked by both LGCIUs (fig 5).



Figure 5
Illustration of “L/G GEAR NOT DOWN” ECAM warning display – landing gear lever not selected but aircraft in landing configuration passing 750ft RA

2.5. At 750 ft RA, gear selected DOWN / Sensor failure / Spurious landing gear not down indications

However, on the A320 Family, this warning could also be triggered when the landing gear is detected as not downlocked by one LGCIU. In this case, check that at least one green triangle is displayed on each landing gear strut on the ECAM WHEEL page. This confirms that the landing gear is downlocked. Rely also on the “LDG LDG GEAR DN” green LDG memo message to confirm that the landing gear is downlocked (fig 6).



Figure 6
Illustration of spurious “L/G GEAR NOT DOWN” indication

As per SOP, following gear selection down, the PNF has to check for three landing gear indications on the ECAM WHEEL page: at least one green triangle on each landing gear strut is sufficient to indicate that the landing gear is downlocked. In addition, the E/W D “LDG LDG GEAR DN” green memo on the ECAM (before landing checklist) also confirms the landing gear is down and locked.

Selection	Landing Gear Selector down			
Gear Position	Downlocked	Downlocked	Downlocked (Passing 750ft)	Not Downlocked
Indication	Sensor failure	Sensor failure	Sensor failure	Confirmed failure
Landing gear panel				
UPPER ECAM	No ECAM warning			
ECAM WHEEL page				
Approp crew response	Continue normal descent and landing	Continue normal descent and landing	Continue normal descent and landing	Gravity extension & landing with abnormal landing gear procedures

3. In-service events

To help distinguish between a genuine and a spurious landing gear not downlocked position indication, the following in-service events are summarized (fig 7).

In the cases of spurious landing gear not downlocked indication illustrated in fig 7, the flight crew applied the L/G gear gravity extension and LDG with abnormal landing gear QRH procedures.

- As per procedure the application of these paper checklists disables:
- ▶ Anti-skid
 - ▶ Ground spoilers
 - ▶ Nose-wheel steering
 - ▶ Auto-brake

The increased workload can be appreciated, hence the need to avoid applying these procedures unless necessary.

Distinguish between L/G GEAR NOT DOWN and L/G GEAR NOT DOWNLOCKED.

4. Ongoing Development

The FCOM and QRH procedures have been enhanced to prevent unnecessary application of the L/G GRAVITY EXTENSION and LDG WITH ABNORMAL L/G procedures (A320 Family FCOM/QRH June 2010 general revision).

The revised procedures include the following caution:

Caution :
Do not apply this procedure if at least one green triangle is displayed on each landing gear strut on the ECAM SD WHEEL page. This is sufficient to confirm that the landing gear is downlocked. Disregard any possible L/G GEAR NOT DOWN ECAM warning at 750 feet RA.

As previously discussed , on A320 Family aircraft the “L/G GEAR NOT DOWN” warning may also appear at 750ft RA when the landing gear is confirmed down by only one LGCIU. Under these conditions the new Flight Warning Computer development FWC (F6) will inhibit the spurious “L/G GEAR NOT DOWN” message.

Figure 7
Summary of
in-service events

5. Conclusion

Flight crews have entered unnecessarily into the L/G GRAVITY EXTENSION and LDG WITH ABNORMAL L/G QRH procedures, whereas the landing gear was actually downlocked. This has created significant additional workload during the landing phase. To prevent re-occurrence, in all cases (and as per SOP) refer to the ECAM WHEEL SD page to check that the landing gear is downlocked. Rely also on the “LDG LDG GEAR DN” green LDG memo message during the LANDING CHECKLIST.

Do not confuse “L/G GEAR NOT DOWN” with “L/G GEAR NOT DOWNLOCKED” ECAM warning. In the case of a genuine unlocked landing gear, the ECAM will alert the flight crew and trigger a “L/G GEAR NOT DOWNLOCKED” ECAM warning after gear selection down.

On landing gear down selection, the key message is

One green triangle on the ECAM WHEEL SD page and a “LDG LDG GEAR DN” green memo on the E/WD (Before Landing Checklist) confirms the landing gear is down and locked.



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Situation awareness and decision making

1. Introduction

An A320 crew reported an in-flight problem with the elevators and decided to divert. The ensuing captain's report described precisely their analysis of the situation, decision process, actions, and how the decision to divert was ultimately reached.

Surprisingly, however, subsequent read-out of the Post Flight Report and decoding of the DFDR contradicted the crew and indicated that the ECAM had displayed an aileron fault warning and nothing about the elevators.

In this event, the crew wrongly interpreted the ECAM message for some reason that may be explained by a lapse of attention and/or by the fact that they had perceived a slight nose-down tendency during the take-off phase of the flight.

The important point is that, as a consequence of this misperception, the crew's awareness of the situation was flawed and the ensuing decision process was based on incorrect assumptions. This illustrates how perception is critical in the situation assessment process and thus in decision making.

This article will describe why, when faced with a challenge, situation awareness is crucial in implementing the appropriate actions. It will as well explain how situation awareness may lead to either the application of an "off the shelf" solution (referred to as mental template) or to a decision making process. The last part of the article will identify some of the main obstructions to sound decision making.

2. Situation awareness

Situation awareness implies a clear and up to date understanding of what is going on around us. To help us do so we use mental templates that are the product of our experience and which will be triggered in specific situations.

Pilots are educated and trained to use their experience to recognize the situation as an instance of a familiar type (a "typical situation"). Once it has been recognized as 'that' type of situation, the pilots can trigger the corresponding mental template.

The chosen mental template incorporates goals and intentions, typical actions, expectations and relevant cues. It pinpoints as well how to monitor the typical expected actions. For example, while "ready for take-off", the crew's template contains key parameters and a selected number of potential failures, which are crucial for this phase like:

- ▶ Tower clearance, runway length, wind, engine power...
- ▶ Engine failure, runway incursion, wheel bursts...

In the elevators/ ailerons confusion case described in the introduction, the main problem was with the assessment of the situation. This illustrates the importance of gathering the information to properly assess the situation, and represents where the crew should put its initial mental effort. The relevant clues should not be missed. An evalua-

tion of the situation should be done to ensure a proper diagnosis.

To ensure a good assessment of the situation, try to think about the situation changing the point of view: "can it be something else?", "are we missing something?"

If the pilot does not recognize a "typical situation", he will not be able to trigger the appropriate mental template and suitable actions, but will have to make a decision. The decision is defined with reference to situation awareness. Situation awareness is necessary in maintaining control of the situation and managing the risk assessment.

3. Decision making

3.1. The decision process

We all take many decisions every day. Decision making is the process of selecting a course of action among one or several alternative(s).

Before deciding we should assess the situation, analyze the problem, and then collect the information that will be used in our decision making. The problem must be precisely identified and assessed in the context of a specific situation. The decision should include:

- ▶ Clear and organized objectives
- ▶ Considered alternative actions
- ▶ Anticipated potential consequences

If the solution is not reached, the loop starts again.

How safety is taken into account in the decision making process depends on the situation (e.g. flight phases) and the ability to anticipate potential consequences.

To put it simply, the pilot are trained to:

- ▶ Perceive the critical information in the environment
- ▶ Understand and assess the relevance and the importance of these informations in accordance with his/her own objectives
- ▶ Predict what will happen next
- ▶ Adjust accordingly if possible.

In the cockpit, decisions have the following characteristics:

- ▶ They are intimately related to the evaluation of the situation
- ▶ They are “good” only if they may be applied with the appropriate knowledge and skills
- ▶ They have a limited life span: due to the dynamics of the situation, a decision is “good” only for a defined amount of time
- ▶ They cannot always be split from actions. Sometimes it is the possible actions which lead and orient the decision (e.g. Go Around, TCAS...).

In aviation, every decision may have a major impact due to:

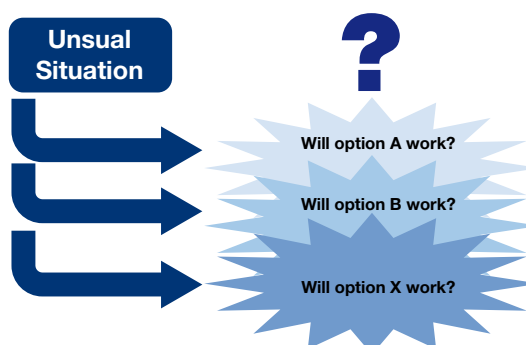
- ▶ The dynamics of the situation
- ▶ The interconnection of information
- ▶ The irreversibility of some crew actions (no “undo”!).

3.2. Mental simulation

Mental simulation is a conscious process that will allow choosing one option by evaluating consequences.

In case of a diversion (i.e. pax medical emergency or engine problems), the crew needs to decide if it is best to return to the original airport, to continue as planned, to land at the nearest suitable airport...? In this case there is no doubt on what has happened. The situation is clearly identified and assessed. Here the crew really needs to

Decisions based on mental simulation



mentally consider each option and its feasibility (safety but also operational and commercial consequences, such as: how much fuel ? what weather, what about the passengers, the maintenance ? etc...). In dynamic situations, once the decision is taken, it becomes most of the time irreversible due to the evolution of the situation.

The following traps may seriously impair this mental simulation:

- ▶ The crew can choose an option that is poor or inappropriate: for example the crew can decide something, which is perceived as a “best solution” and then realize that they cannot implement it
- ▶ The crew can choose and accept the first alternative that might work without going through the complete mental simulation process and this may lead to a premature termination of evidence search.

Not only is the decision important, but the decision follow-up as well because sometimes the situation may evolve quickly and differently from what was expected.

Tips to improve the mental simulation:

- ▶ Try to widen the range of options
- ▶ Question the capabilities (can you make it, individually and as a crew)
- ▶ Look for negative evidence: “Is there anything telling us we are wrong?”
- ▶ Decision follow up: watch how the situation evolves and be ready to adapt your decision or strategy accordingly.

3.3. Time pressure

When assessing the situation, time pressure is important, as flying is a dynamic process. A trap when attention is focused is to lose time consciousness: thus pilots may believe they have plenty of time to think and evaluate the situation.

Under pressure, fewer options are envisaged and the evaluation of each option is limited. It is why often the first acceptable solution is taken.

Example of the Hudson accident: (extract from the NTSB report)

“About one minute after the bird strike, it was evident to the flight crew that landing at an airport may not be an option. The captain indicated that, because of time constraints, they could not discuss every part of the decision process; therefore they had to listen to and observe each other. The captain further stated that they did not have time to consult all written guidance or complete the appropriate check-list, so he and the first officer had to work almost intuitively in a very closed-knit fashion.”

In this event, the crew had to take an irreversible decision. In similar circumstances, some pilots may have been paralyzed or blocked by the analysis and the important stress experienced at that time.

Tips to manage the time pressure:

- ▶ Fix a decision deadline
- ▶ Stabilize the situation
- ▶ Assess time factors (fuel!), be aware of the available time
- ▶ Prioritize
- ▶ Manage workload and use all resources
- ▶ Do not forget to fly the aircraft.

3.4. Decision aids

Procedures are tools to support decision making because they provide to the crew:

- ▶ Element of diagnosis
- ▶ Actions to perform
- ▶ Elements/ conditions to control.

Aircraft systems also support decision making by giving information for situation assessment and decision. The ECAM for example, which is based on a need to see concept, will provide the check lists and status of the aircraft for all anomalies detected by the aircraft systems.

4. Constraints to decision making

4.1. Level of fatigue, stress, workload and distraction

When pilots are tired, the tendency will be to ignore some information (fixation on a specific item).

Stress will favor “short term” decisions (short benefit decisions) and may be detrimental to the decision process.

When workload is too high, the quality of decision making process deteriorates.

In the Hudson accident, the crew was able to manage their level of stress (resulting from high workload and time pressure) and they avoided the “tunnel vision” created by stress, which narrows the attention. They were also able to face series of aural alerts and many ATC communications, which did not distract them from their action plan.

4.2. Personality type

Personality may also impair the decision:

- ▶ Invulnerability: it won't happen to me!
- ▶ Impulsivity: I have to act, to do something!
- ▶ Macho: I can do it!
- ▶ Anti-authority: don't tell me!
- ▶ Resignation: what will be the interest of doing this?

Even if people cannot change personality, pilots should be aware of their natural trend in order to know their weaknesses and thus manage the decision process accordingly.

4.3. Expertise/ Experience

Experience plays an important role in situation awareness and in the management of stress:

- ▶ An experienced pilot may take inappropriate shortcuts in the decision process
- ▶ A less experienced pilot may miss important points and priorities when taking his decision.

4.4. Risk perception

Too deep analysis may be a trap for decision making, for example when the two pilots are head down trying to analyse a situation, thereby forgetting to fly the aircraft.

Pilots tend to favor decisions, which will reduce their perception of risk. The main risk is the feeling of “not being able to do in the available time”. Risk may be underestimated, possibly because a previous similar situation was successfully managed.

4.5. Individual biases

Let's look at some bias (not an exhaustive list!) which may impact decision making in flight:

- ▶ Frequency bias : tendency to over or underestimate the probability of occurrence of a particular event, because our evaluation is based solely on our personal experience
- ▶ Conformity bias: tendency to look for data (instrument values, events, etc) that support and confirm our decision rather than information that would contradict it. The confusion between elevators/ ailerons is a typical example
- ▶ Familiarity bias: tendency to choose the most familiar solution (linked to our preconceived ideas or to our experience)
- ▶ Recency : tendency to pay more attention on the most recent information and ignore the more distant one
- ▶ Illusion of control : We tend to believe we have more control on events than we really do. Thus we tend to underestimate future uncertainty. We believe we have control to minimize potential problems in our decisions.

4.6. Group thinking biases

Each member may affect the collective decision making process. The crew should have the same information to build collective situational awareness and check for a common understanding and agree on goals:

- ▶ Authority bias: tendency to agree with the opinion held by the captain because of rank; and for the captain not to listen to the copilot's inputs (thinking he/she is the boss)
- ▶ Group conformity or group think bias: tendency to agree with opinions held by the majority. In a two crewmembers cockpit, this will be similar to the authority bias.
- ▶ Source credibility bias: tendency to reject something from a person that we do not like or on whose abilities we have preconceived ideas.

5. Conclusion

Situation awareness is key to implementing the appropriate action plan. It calls for the performance of a real, timely and complete assessment of the environment. It then serves as the basis either for the application of a mental template or for the launching of a decision making process.

A decision should include:

- ▶ Clear and organized objectives
- ▶ Considered alternative actions
- ▶ Anticipated potential consequences.

Reaching a good decision is critical but may be a difficult exercise, especially in a dynamic situation. It is therefore important to bear in mind the following two common pitfalls to reaching a sound decision: time pressure and human biases.

When taking a decision:

- ▶ Manage the time stress and do not rush into action
- ▶ Know yourself and beware of the obstructions to effective decision making.

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