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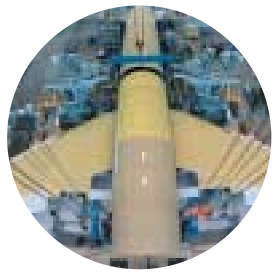
Safety First

The Airbus Safety Magazine



02 | September 2005

AIRBUS

EDITORIAL

02 | September 2005

Yannick MALINGE
Vice President
Flight Safety

The sad events of last August highlight how easily the safety of air transport can become the focus of public attention. These unfortunate accidents only serve to reinforce the need for all of us in the aviation industry to carry on with our work and to maintain the progress of the last few years.

Despite the effects of August, a review of accident statistics for all western built jet aircraft indicates a positive trend: the annual fatal accident rate over the last five years is less than one per million departures. This trend is consistently improving.

Although accident statistics show a consistent improvement, it is probable that the large increase in air travel will bring further accidents in the future. Such occurrences will invariably have a negative impact on our industry. All of us involved in the business of air transport, the stakeholders, must continue to cooperate and work together. By strengthening our efforts we can continue the positive trend of recent years.

Therefore, let's continue working together, to ensure that the cumulative safety experience of other operators and manufacturers benefit to all.

To help in sharing our combined knowledge and experience I encourage you to:

• Offer us safety related articles for publication in this magazine or for presentation at our annual safety conference.

• Use the confidential reporting system to provide information that may lead to further enhancement of flight safety.

I hope you will enjoy reading this second issue of Safety First and would welcome your feedback and inputs to start putting together the next issue.3

Yours sincerely

Yannick MALINGE
Vice President Flight Safety

CONTENT

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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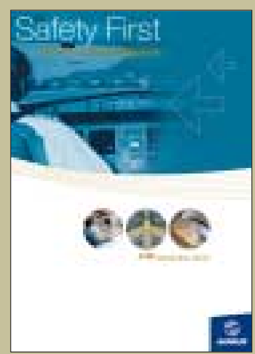

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If you have any questions about the distribution of the magazine either electronically or in hard copy then please contact us.

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Your articles

As already said this magazine is a tool to help share information. Therefore we rely on your inputs. If you have ideas or desires for what is in the magazine please tell us. If you have information that we can share between us then please contact us. We are ready to discuss directly with you.

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Flight Safety Conference

The invitations have been sent to the Airbus operators for the next flight safety conference.

LISBON, Portugal 17th to 20th October 2005

If you have not received one then let us know but please note it is only open to Airbus operators.

Included with the invitation is a draft agenda giving the list of provisional presentations. If anyone has other topics they would like raised then let us know and we will see how we can fit them in.

Note also that we have scheduled the Blood borne pathogen training for the Monday afternoon. This leaves Friday free so giving more flexibility to organise your travel arrangements. The FOMS demonstration was popular last year so it will be run again this year.

We are also very pleased that there is as usual a strong participation from airlines in giving the presentations. Remember that the aim of this conference is for everybody to pass information and experience to all the other participants.

Tail Pipe or Engine Fire

By: Michel PALOMEQUE
Flight Safety Advisor
A318/A319/A320/A321 program

1 Introduction

Fortunately, actual engine fires are a rare occurrence. A fire affecting an engine may be the result of different malfunctions and may have different origins. Thus, a fire affecting the engine should be dealt with according to the origin of this fire.

Two different types of fire may affect the engine and the procedures for fire fighting should be adapted according to each type of fire:
- The engine (or nacelle) fire
- The tail pipe fire

From the cockpit, it is not always obvious for flight crews to differentiate these two kinds of fire. This is particularly true in this unusual and stressing situation with the engine belching smoke and flames.

This is not specific to a given type of engine or even to a type of aircraft, but experience shows that flight crews may tend to discharge the fire extinguisher bottles in case of a reported tail pipe fire.

This article aims at describing the main differences between an engine fire, also called an external fire since it mainly affects the nacelle compartment, and a tail pipe fire, also called an internal fire since the fire is developing within the engine core.

This article also highlights the importance of always applying the relevant strategy for fire fighting depending on each type of fire.

This article is applicable to all Airbus aircraft, whatever the engines and with or without the ECAM system.

2 Engine (nacelle) Fire

2.1.The causes of an engine fire

The nacelle compartment may reach a very high temperature particularly in the HP compressor area or in the combustion chamber area.

Generally, an engine fire is the result of a flammable fluid coming in contact with very hot engine case surfaces.

The nacelle compartment is fitted with many fluid ducts or equipment that contain fuel, oil or hydraulic fluids which are flammable fluids.

Therefore, the source of fire will be due to a malfunction of an external component or a line fitted on the engine core in the nacelle compartment and which contains these flammable fluids.
These fluids have an auto ignition temperature of about:
- 230°C for the fuel
- 260°C for the oil
- 450°C for the hydraulic fluid (between 426°C for Hyjet IV or IV Plus and 507°C for Skydrol 500-B4)

In the event these fluids entering in contact with very hot engine case surface such as the compressor or the combustor, the fire will auto ignite.

The causes of an engine fire will be consequently the result of a malfunction that may be due to different events such as:

- The rupture of a pipe that contains fuel, oil or hydraulic fluid,
- A damage affecting the accessory gearbox. The accessory gearbox fitted on the engine typically contains fuel pumps, hydraulic pumps, oil pumps, starter, IDG,
- The rupture of a rotating part of the engine such as a fan blade or an uncontained compressor blade rupture, which when ejected may damage a pipe,
- The rupture of the combustion chamber leading to fuel leaks

In less frequent occurrences, an internal gaspath abnormality could lead to an engine case penetration resulting in an engine fire.

Consequently, the engine fire will be mainly the result of a fluid leak on the engine core itself. Such a fire will be external to the engine core and will mainly affect the nacelle compartment.

An engine fire may occur during any on-ground or in-flight phase whatever the power is high or low.

This type of fire should not develop inside the engine itself. This is the reason why an engine fire is also named a nacelle fire or an external fire.

2.2.Engine fire protection and detection system

In order to protect the engine and the aircraft against an engine fire (a nacelle fire), fire detectors are fitted in the nacelle compartment.
The detectors are located based on the most sensitive areas of the nacelle considering the temperature of each area but also the presence of flammable fluid and the ventilation of the nacelle.
The location and the number of detectors vary with the engine type and model depending on the engine arrangement and the equipment fitted on the engine.

Whatever the engine type or model, the core element is always protected because of the compressor and the combustion chamber.

These parts of the engine can reach very high temperatures. Additionally, many fluid pipes are fitted all along the engine core and particularly fuel pipes at the level of the combustion chamber.

The pylon area is always fitted with fire detectors. This area is protected in order to detect any torch flame which could result from a rupture of the combustion chamber and which could affect the pylon structure integrity.

The detectors are always installed on the engine core in the nacelle compartment. They are not installed within the engine itself.

Each fire area is always well marked out and protected by fireproof partitions.
The purpose of these partitions is to contain the fire in a given area but also to maintain the agent concentration when the fire-extinguishing agent is discharged.

The turbine area is not fitted with a fire detection system.
This is because this part of the engine is not considered as a sensitive area and does not contain flammable fluid pipes or equipment.

Additionally, the turbines are usually made of highly resistant steel able to sustain extreme temperatures (for instance, combustion chamber exit temperature at HP turbine is between 1000 and 1200°C at max cruise).

2.3.Engine fire procedure

When an engine (a nacelle) fire is detected, the following indications are available to the flight crew:

- The fire warning is triggered. This includes the fire handle illumination, the ECAM activation, the Master Warning and fuel lever illumination accompanied by the continuous chime,
- A rise of nacelle temperature because the fire is affecting the nacelle compartment,
- An engine surge and/or engine performance abnormalities may be noticed if a critical component of the engine is affected.

Then, a fire warning indicates that a fire has been detected in a sensitive area of the engine with possible continuous feeding of fire due to hydraulic fluid, fuel or oil leak. Consequently, this warning requires immediate action from the crew.

3. Tail Pipe Fire

3.1. The causes of a tail pipe fire

Another type of fire that may affect the engine is the tail pipe fire. As presented in this part of the article, this kind of fire has different origins and different consequences compared to a nacelle fire.

Typically, a tail pipe fire occurs during ground engine start or shutdown and results from an excess of fuel in the combustion chamber or in the turbine area. Consequently, this is an event that may occur on ground only during engine start or shutdown sequence. In the engine, the combustion chamber is fitted upstream of the LP and HP turbines.

This excess of fuel in the combustion chamber or in the turbine area may be the result of:

- Engine control unit (MEC, EEC, PMC, FADEC depending on the model and type of engine) overfuelling, or
- Rotating stall with fuel continuing to be supplied to the engine, or
- Malfunction of the ignition system,
  Second engine start attempt with some residual fuel pooled in the turbine area due to the first unsuccessful engine start, or
- Oil leak in the tail pipe, or
- To a lesser extent, severe case of fuel in the oil or fuel nozzle cracking at a lower pressure than the design on a shutdown engine, allowing the fuel to enter a combustion chamber which is still hot.

This excess of fuel ignites in the combustion chamber with the engine not rotating or rotating below idle thrust and incapable of utilizing the energy released in production of thrust.

Contrary to the engine (nacelle) fire, which is an external fire, a tail pipe fire is an internal fire.
The source of the fire is within the engine core, i.e. within the combustion chamber or the turbine area. This fire will develop in the aft turbine race. Such a fire will mainly affect the turbine area which is not considered as a sensitive area since no flammable fluid pipe is present in this area. Additionally, as discussed in the previous chapter of this article, the turbines are made of highly resistant steel.

Consequently, such a fire is normally contained within the engine core and should not damage sensitive parts

3.2. Detection of a tail pipe fire

Such a fire is burning within the engine core, that is the combustion chamber and the turbine race It mainly affects the turbine area which is not a sensitive part of the engine with regards to the fire protection. Thus, the turbine area is not fitted with fire detectors.

Consequently, a tail pipe (an internal) fire will not be detected by the fire detectors fitted in the nacelle compartment (for external fire detection) and will not result in the triggering of the ENGINE FIRE warning.

Therefore, how to detect such a fire?

The main indication that a tail pipe fire occurs is a visual report.

Because this type of fire typically occurs at engine start or shutdown, the crew is mainly made aware of a tail pipe fire by a visual report from either ground crew, cabin crew or tower.

Since the EGT probe is located in the affected area (the turbine area), a rapid EGT rise can also be an indication that a tail pipe fire is developing.
This is one of the reasons why the EGT has to be monitored in accordance with the standard operating procedures during engine start or shutdown.
This should be particularly true in case of a second engine start attempt following an unsuccessful attempt where the risk of some residual fuel pooled in the combustion chamber or the turbine area should not be excluded.

3.3. Tail pipe fire procedure

As discussed previously, a tail pipe fire is mainly due to an excess of fuel or vapour in the combustion chamber or the turbine area during engine start or shutdown.

Because no warning is triggered, no ECAM (when fitted) procedure will be displayed.
The flight crew actions are also described in the QRH.

In accordance with these procedures, the best method of arresting such a fire is:

In case of a reported tail pipe fire, the appropriate procedure is consequently to ventilate the engine in order to blow out the fire and any residual fuel or vapor.

Internal engine damage will normally not occur provided the engine is ventilated within minimum delay. A tail pipe fire should not become an external fire except if ignored and the fuel source was large enough or continual so that the fire became very intense. However, in this case, an external observer will warn that the fire is going on and appropriate actions will be taken.

Contrary to the engine (nacelle) fire, the engine fire extinguishing bottles do not have to be discharged in the event of a tail pipe fire.

The reason is because the fire is internal, it is developing within the engine (the combustion chamber and the turbine race).

A300/ A310	A318/A319/A320/A330/A340
Shutoff fuel supply (fuel HP valve off),	MAN START (if manual start performed)…OFF ENG MASTER (affected)…………………..OFF
Open the crossbleed valve (it has to be opened manually to prevent its closure when the fire handle is pulled),	
Pull the fire handle to shutoff fuel LP valve on A300/A310 only	Note: do not press the ENG FIRE pushbutton, since this will cut off the FADEC power supply which will prevent the motoring sequence
Establish air bleed to supply the affected engine starter using either the opposite engine if still running, or APU bleed or Ground Power Unit if connected	
Crank the engine in order to: inhibit the ignition circuit and dry motor the engine reduce the internal temperature blow out the fire and residual fuel or vapor	

The fire extinguishing system is designed to extinguish a fire in the nacelle compartment where all fluid pipes and various equipment containing flammable fluids are fitted (IDG, accessory gearbox, hydraulic pumps, fuel pumps).

When used, the fire agent is sprayed onto the engine core without penetrating the engine itself.

Consequently, it will not extinguish a fire that is within the combustion chamber and the turbine area. Additionally, the turbine area does not receive extinguishing agent.
The fire extinguishing agent is made of halon gas, a very dry gas, and has no negative impact on the engine. If used, it will not damage the engine parts and will not lead to deposit any residue on the engine. However, since it is designed to extinguish an external fire within the nacelle, it will be of no benefit on an internal fire.
If used, it may even lead to a delay or a no go situation if the bottle that has been discharged cannot be changed or refilled.

In the very worst case where no bleed is available, a ground fire extinguisher can be used as a last resort to extinguish a tail pipe fire if there is no means to ventilate the engine.

The ground fire extinguishers should be used as a last resort since they usually contain dry chemical powder or chemical foam extinguishing agents. These agents are very corrosive agents and may cause serious corrosive damage to the engine.
In accordance with the maintenance practices, the engine must be removed from aircraft for disassembly inspection and cleaning after such an extinguishing agent has been used.

However, if there is no other way to arrest a tail pipe fire or even worse if the fire is developing, there is no doubt that ground fire extinguishers should be used to protect the aircraft.

4. Conclusion

In conclusion, this article highlights the need for a good understanding of the situation for a correct identification of the event that is occurring and for entering the appropriate procedure for fire fighting.

To summarize this article, the main differences between an engine fire and a tail pipe fire are briefly described hereafter:
An engine fire is an external fire. This is a ground or an in-flight event. It is due to a malfunction of an external component with possible continuous feeding of the fire. When occurs the ENGINE FIRE warning is triggered and nacelle temperature rises. The appropriate crew procedure is to shutoff the fuel supply, isolate the engine and, if necessary, discharge the fire extinguishing agent.

A tail pipe fire is an internal fire that is contained within the engine. This is a ground event normally at engine start or shutdown. It is due to an excess of fuel in the combustion chamber or in the turbine. It does not trigger any warning and is visually detected. It is accompanied with a rapid EGT rise. The appropriate crew procedure is to shutoff fuel and ignition and to dry motor the engine for ventilation. The ground fire extinguisher should be used as a last resort.

Managing Severe Turbulence

By: Panxika CHARALAMBIDES
Flight Safety Manager

1 Introduction

Severe turbulence is identified as turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes also large variations in airspeed.

Inadvertent flight into such hazardous weather environment is the leading cause of injuries to passengers and cabin crew in non-fatal airline accidents, and is so a key safety issue for any aircraft.

This kind of events leads rarely to fatal accident but the shake-up triggered by the turbulence can cause serious injuries among non-buckled people but also generate trauma among passengers.
For example a few months ago, an A330 experienced very strong turbulence in early descent leading to more than forty people injured among passengers and cabin crew including one passenger seriously injured.

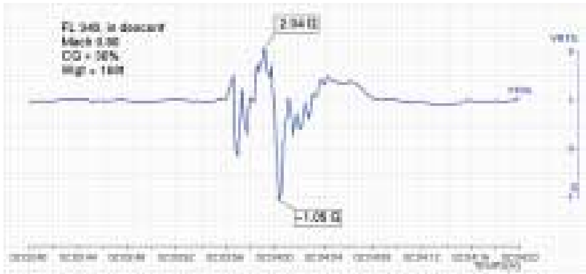
Inadvertent flight into atmospheric turbulence is also an economical issue. Indeed serious turbulence may cause substantial aircraft damage. An AOG situation with associated repair costs may make turbulence very costly.

2 Some figures

Usually only the most severe cases of turbulence are reported to the manufacturer.
Over 3 years, about 20 turbulence events have been annually reported to Airbus. These events have caused injuries for about one third of them.
Generally, during such event, the main vertical longitudinal and lateral acceleration changes are concentrated within a few seconds and injuries concern generally non-buckled passengers and cabin crew when the local vertical load factor decreases under 0g before increasing again (Load factor variations generated by the turbulence are not necessarily the same at any points of the cabin).

To give an order of magnitude of a severe turbulence here are 3 examples:

- The first concerns an A340 in cruise. The maximum and minimum vertical load factor excursions were 2.3g and –0.9g both recorded near the centre of gravity within a few seconds.
- The second concerns an A320. Within 10 seconds the successive up and down vertical load factor excursions were:
  1g/1.4g/ 0.2g/3g/ 0.3g/ +1.6g/-0.8g/+2.6g.
  During the same period of time the lateral load factor varied as follow:
  +0.2g/ -0.08g /+0.06g/ -0.2g/ +0.2g/ -0.22g/ +0.13g
- Eventually here below is the profile of the vertical load factor resulting from a turbulence encountered on an A330.



3 Maintenance actions

Turbulence can be considered as excessive when passengers and crew are moved violently against their seat belts and objects move around the aircraft. In this case, the pilot must make a logbook entry for maintenance action initiation.

Inspection that is recommended after flight in excessive turbulence (or in excess of VMO/MMO) is described in Aircraft Maintenance Manual (AMM) section 05-51-17.
In case of severe turbulence it is also recommended to inform Airbus.Note that in some remote cases we have determined that limit loads have been locally exceeded. In these cases some additional inspections (On top of what is recommended in AMM section 05-51-17) may be required.

4 Managing severe turbulence

Whenever possible, the best solution is to use all the existing means at the pilots' disposal to localise the turbulence as well and as early as possible in order to have enough time to properly avoid it or at least to secure the cabin when it is unavoidable.
But the analysis of several turbulence events has led to the conclusion that, as further developed here below, pilot awareness on the appropriate use of available means could be improved.

4.1 Turbulence detection

Optimum use of weather forecast
Firstly weather forecast information available before taking-off as well as the weather briefing have to be as complete as possible and, depending on the weather context, this information has to be updated in flight as often as necessary. In some severe turbulence events, analysis has shown that an appropriate update of weather information in flight would have very likely allowed the detection and consequently the avoidance of the area of turbulence.

Optimum use of the weather radar
Modern aircraft are equipped with airborne weather radars. The principle of these radars is to detect precipitation such as wet turbulence and wet hail but these radars will not detect wind, ice, fog and Clear Air Turbulence (CAT).
Despite weather radar efficiency to detect convective clouds, in-service events analysis has shown that a large part of turbulence events comes from aircraft incursions into cumulonimbus (CB) that were either not localised by the crew or not avoided with sufficient margin.
Indeed weather radar is only helpful if:

- It is properly tuned (tilt, weather mode and range control on the Navigation Display) to present an optimum weather radar picture
- AND the flight crew performs regularly vertical scan
- AND the flight crew correctly interpretes the screen display.

For this a good knowledge of the radar system itself is essential and allows to optimise the use of the radar that will be tuned using all available information (pre-flight briefing, reported turbulence, updated weather forecast…).
The official investigation launched further to a turbulence event where six cabin crew and three passengers were seriously injured concluded the following:
"It is highly probable that the flight crew were not presented with the optimum weather radar picture that would have enable a full appreciation of the intensity and extend of the weather in the vicinity of the aircraft. As the result the deviation ...was not initiated early enough nor large enough to avoid the weather"

This event is not an isolated case. The analysis of a large percentage of turbulence events in convective environment shows a sudden heading change demand just before encountering the turbulence that has made the radar tuning and picture interpretation questionable.
For example it is important to notice that a tilt setting in cruise too close from horizon (as presented in red in the figure here below) will only scan in a high range of altitude where humidity is in ice shape and so not reflective.

As illustrated with the in service event example here above there is certainly a need to increase pilot knowledge on weather radar.
This is why Airbus Flight Operations Department has issued a Briefing Note dedicated to the Optimum Use of the Weather Radar.

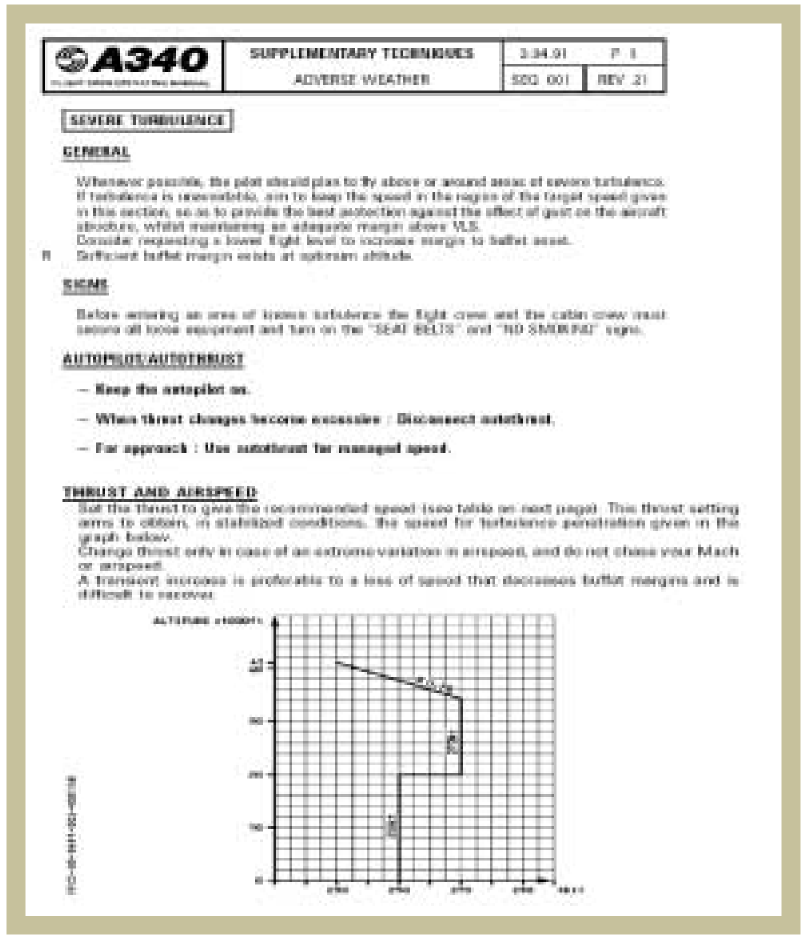
The aim of this brochure is to provide additional information about the capabilities and the limitations of the weather radar. It also presents practical information regarding the weather radar tuning and Navigation Display interpretation that can be used to improve the flight crew's overall understanding of the system.
Alike all other Flight Operations Briefing Note, the "optimum use of weather radar" Briefing Note can be downloaded from the Airbus Safety Library Website:
http:/www.airbus.com/en/corporate/ethics/safety_lib

4.2 Careful turbulence avoidance when detected

Furthermore as explained in the "optimum use of weather radar" Briefing Note and in the FCOM section 3.04.34 of Fly-by-wire aircraft (Weather radar section of the Supplementary techniques dedicated to navigation), turbulence associated with a cumulonimbus is not limited to inside the cloud.

Thus, as current weather radars cannot detect dry turbulence it is essential to take adequate precautionary measures:

- In particular, to minimise the risk of encountering severe turbulence, a cumulonimbus should be cleared by a minimum of 5000 feet vertically and 20NM laterally.
- Furthermore, if the top of cell is at or above 25000 feet, over-flying should be also avoided due to the possibility of encountering turbulence stronger than expected.
- In the same way flight under a thunderstorm should be avoided due to possible wind shears, microburst, severe turbulence or hail.



A340 | SUPPLEMENTARY TECHNIQUES / ADVERSE WEATHER | 3.04.91 P 1 | SEQ 001 REV 21

SEVERE TURBULENCE

GENERAL

Whenever possible, the pilot should plan to fly above or around areas of severe turbulence.
If turbulence is unavoidable, aim to keep the speed in the region of the target speed given in this section, so as to provide the best protection against the effect of gust on the aircraft structure, whilst maintaining an adequate margin above VLS.
Consider requesting a lower flight level to increase margin to buffet onset.
R Sufficient buffet margin exists at optimum altitude.

SIGNS

Before entering an area of known turbulence the flight crew and the cabin crew must secure all loose equipment and turn on the "SEAT BELTS" and "NO SMOKING" signs.

AUTOPILOT/AUTOTHRUST

- **Keep the autopilot on.**
- **When thrust changes become excessive : Disconnect autothrust.**
- **For approach : Use autothrust for managed speed.**

THRUST AND AIRSPEED

Set the thrust to give the recommended speed (see table on next page). This thrust setting aims to obtain, in stabilized conditions, the speed for turbulence penetration given in the graph below.
Change thrust only in case of an extreme variation in airspeed, and do not chase your Mach or airspeed.
A transient increase is preferable to a loss of speed that decreases buffet margins and is difficult to recover.

In this case fasten seat belt sign should be illuminated and cabin crew should closely check passenger seatbelts compliance.
But to be efficient this measure must be used with distinction since a too long or too frequent use will make it counterproductive because not strictly followed.
In the same spirit, advise announcement requiring passengers to keep their seatbelts fastened at all times when seated is also an efficient measure to prevent non-predictive turbulence as CAT.

Flight attendants

Except if this is specifically requested by the flight crew, when the seatbelt sign is illuminated, flight attendants usually continue the cabin service.
In case of specific announcement of turbulence anticipation by the flight crew, flight attendants will secure the trolleys and ensure that all passengers are fastened before sitting down and buckling up themselves. Consequently they secure themselves quite late, which explains that injuries often concern flight attendants.
Graduation in the urgency of the flight crew warning properly perceived by the cabin crew could allow them to better adapt their actions to the situation.

4.3 Secure passengers and cabin crew

Fasten equipment

A part of injuries comes from objects thrown out and coming down on buckled people.
Consequently a prime task of the cabin crew is to secure trolleys and any object that can be harmful.

Passengers

Most of injuries result from non-buckled passengers or crewmembers thrown out during the turbulence.
This could be prevented with seat belts fastened.
Although the ideal situation would be to consider "seat belts fastened" as a full-time countermeasure, the minimum recommendation, which is normally applied, consists in requiring seat belts fastened when moderate or stronger turbulence is anticipated.

4.4 Turbulence crossing

Because some turbulence are not detectable by current onboard weather radar or other cannot be detected early enough to be avoided, aircraft behaviour when crossing a severe turbulence has also to be considered and optimised.
Recommendations depend on the aircraft type.

For A300/A310/A300-600: Disconnect ATHR/ Descent at or below optimum altitude /

Consider Autopilot disconnection if Autopilot does not perform as desired

- Disconnect the ATHR
- Set the target thrust to follow the speed target (that depends on altitude) given in QRH 13.04.
- Descent at or below the optimum altitude given in QRH 17.01. Indeed at the turbulence penetration target speed, this optimum altitude must provide sufficient margin to buffet to face severe turbulence.
- Consider Autopilot disconnection if Autopilot does not perform as desired.

For Fly-by-wire aircraft: Keep Autopilot engaged - Keep ATHR engaged except if thrust changes become excessive

Recent severe turbulence events have clearly illustrated that potential consequences have been minimised thanks to the appropriate use of automation by the crew, mainly in keeping Autopilot engaged instead of possible instinctive reaction, which is to take over manually.

As per FCOM recommendation (section 3.04.91) when encountering a severe turbulence the following procedure has to be applied:

- Follow the speed target (that depends on altitude) given in Section 3.04.91.
- Maintain ATHR engaged (target speed) except if thrust changes become excessive. In this case ATHR will be disconnected and thrust will be set to give the recommended speed (See thrust table versus speed target in the same FCOM section).
- Keep Autopilot engaged. Indeed, detailed studies regarding aircraft behaviour when crossing such external perturbations has shown that the less the aircraft reacts at short term to the turbulence, the better it is. Indeed, the dynamic of such severe turbulence is so, that any additional pitch down reaction to counter the initial up draught will accentuate in most cases the pitch down effect of the down draught usually subsequent to the up draught. This will accentuate the excursion in negative load factor and so increase the risk and number of injuries. To minimise the additional effect of such pitch down order coincident to the down draught, it is recommended to the crew not to react to the turbulence by short term side stick inputs corrections and to keep Autopilot engaged.

Software Flight Control modifications on Fly-by-wire aircraft

A severe turbulence may lead to excessive high speed excursion (beyond VMO/MMO) or to excessive low speed excursion (below 'alpha prot', angle of attack threshold of alpha protection law activation). This will induce Autopilot disconnection and activation of the appropriate manual flight control law (The VMO/MMO protection or the angle of attack protection that will command respectively pitch-up and pitch down movement to reduce these excursions).

In order to keep the Autopilot engaged as long as possible, flight controls software modifications have been developed on fly-by-wire aircraft. They make the Autopilot more robust to disconnection resulting from a transient VMO/MMO or 'alpha prot' exceeding subsequent to a severe turbulence.

Autopilot robustness improvement in case of transient 'alpha prot' angle of attack exceedance has been already implemented on all in-service fly-by-wire aircraft.

Autopilot robustness improvement in case of transient VMO/MMO exceedance has been introduced as shown in various flight control software.

These improvements will be also available at the entry into service of the A380.

> **Software including Autopilot robustness improvement in case of transient VMO/MMO exceedance**
>
> **For the LR aircraft:**
> Standard FCPC L16/M14/P6 respectively for basic A340/A330-300/A330-200
> Standard FCPC L17/M16/P7 respectively for Enhanced A340/A330-300/A330-200
> Standard FCPC W10 for A340-500/-600 (under development).
>
> **For the SA aircraft:**
> Standard ELAC L91 and L83 for A318 and A 321
> Not yet developed on A320 and A319

Managing altitude burst consequent to severe turbulence

Severe turbulence can induce significant altitude excursions because of the severe turbulence itself or as a consequence of the triggering of the VMO/MMO protection or the Angle of Attack protection. Without the pilot in the loop these protections will target respectively speed and incidence decrease rather than maintaining the trajectory.

Indeed, when VMO/MMO protection or Angle of Attack protection has been activated, the Autopilot is automatically disconnected. In these conditions, it is now to the pilot to apply smooth corrections to manage the aircraft trajectory (and to avoid to apply sudden corrections fighting the turbulence). Speed will not be closely targeted. Indeed a number of altitude bursts is the consequence of pilots targeting a large speed margin after recovery from VMO/MMO. Keeping aware of the surrounding traffic, a compromise has to be found since such too large speed margins will be obtained at the detrimental of the trajectory.

5 Areas of improvement

Benefiting of the progress of technology, several areas of improvement are being studied at Airbus in liaison with various partners such as:

Weather forecasting improvement that will make turbulence location more reliable and precise and consequently will allow optimising the route and reducing turbulence hazards.

Enhanced weather radar that will earlier detect turbulence (depending on the aircraft speed, 2 or 3 minutes is foreseen).

Turbulence now-casting that will broadcast pilot's reports of encountered turbulence to surrounding aircraft. Information regarding turbulence (intensity, location) will be sent by an automated turbulence-reporting system and displayed in other airplanes. This system will be particularly helpful to localise CAT.

Cabin safety improvement that will allow to quicker and better secure people and fasten equipment.

Clear Air Turbulence detector that will use optical technology.

6 Conclusion

Flights into severe turbulence are the leading cause of injuries among passengers and cabin crew and may induce also substantial aircraft damage.

Airbus has received a certain number of reports regarding severe turbulence events. All these events have been thoroughly analysed.

In response to these analyses the following can be said:

- Use of existing detection means to avoid encountering turbulence or to allow cabin preparation could be greatly improved.
- In this context Airbus Flight Operations Department has issued a briefing note dedicated to the Optimum Use of the Weather Radar.
- When the turbulence is unavoidable, the consequences of turbulence could be minimised in making appropriate use of operational procedures to better handle the turbulence.
- Airbus has also developed and implemented software flight control modifications on Fly-by-wire aircraft in order to improve Autopilot robustness to severe turbulence.
- Additional ways to mitigate the turbulence are under development. We will let you know when you get mature solutions.

The briefing note dedicated to the optimum use of the weather radar can be downloaded from the Airbus Safety Library website:

http:/www.airbus.com/en/corporate/ethics/safety_lib

APT Airbus Pilot Transition

By: Catherine Neu
Synthetic Flight instructor
Flight Crew Training Policy
Training & Flight Operations Support and Services

This article first appeared in FAST issue 35

The new Airbus Pilot Transition (APT) course is an innovative approach to type rating that trains pilots using the latest interactive learning tools and has been welcomed by airline crews.

With the intensive use very early in the ground course of the Maintenance/Flight Training Device (M/FTD), the first of its kind integrating tutorial mode in a 3D environment with high fidelity simulation software, Airbus again sets training standards for the future through:

- increased training efficiency, quality of the ground school phase
- optimised training time
- greater mobility and flexibility and
- high versatility and fidelity of the selected new training devices.

Training definition. The key elements

APT is based on the following prerequisites

CAPTAIN	FIRST OFFICER
Previous command experience	Previously qualified on JAR/FAR/CS 25
Valid and current Airline Transport Pilot License (ATPL)	Aircraft and commercial operations valid and current CPL (Commercial Pilot License) with instrument rating
Fluency in English. Able to write, read and communicate at an adequately understandable level in English language	Fluency in English. Able to write, read and communicate at an adequately understandable level in English language
200 hours experience as airline, corporate or military transport pilot	
Jet experience	Jet experience
Flight time: • 1,500 hours as pilot • 1,000 hours on JAR/FAR/CS 25 aircraft	Flight time: • 500 hours as pilot • 300 hours on JAR/FAR/CS, 25 aircraft • 200 hours experience as airline, corporate or military transport pilot

APT has been developed by applying the following principles:

Systematic approach to instruction
Airbus training programmes are defined to achieve precise training objectives and to bring flight crew up to proficiency in the most efficient way, in a learning and time sense.

The training objectives are determined through a complete task analysis. The instructional system is approached as a whole, where the training methods, course contents and training equipment are selected for their ability to best fit the required final objectives.

Learning by doing
Practical training is progressively introduced very early in the learning process, with training on Standard Operating Procedures (SOP), crew concept and task sharing.

Computer Based Training (CBT) learning sessions start right from the beginning or the course and are combined daily with realistic hands-on sessions on Airbus's new state-of-the-art training device – The Maintenance/Flight Training Device (M/FTD)

Training to proficiency
At the end of the training programme, each crew member shall be capable of carrying out their tasks safely and efficiently, in accordance with the training objectives. Therefore, the training sequence does not permit a trainee to move up from one phase to the next until they have acquired the skills necessary to complete the objectives of their current phase.

Rigorous definition of the trainee prerequisites
Good definition of the entry level of trainees is a success factor for training programme specification. To be effective, a training programme must start from already acquired knowledge, avoiding creating gaps never filled, or timeless repetition of well known items.

Training curriculum organisation

The training is organised around a two-step learning process – a ground phase enabling learning about systems and operational procedures and a 'handling' phase using a Full-Flight Simulator (FFS).

The ground phase is performed using CBT for system knowledge on a laptop provided to each trainee, it also includes self-paced learning on the M/FTD.
Thanks to the M/FTD, trainees become familiar with operations in the cockpit from the fifth day of training and benefit from an inter-active learning of aircraft procedures. Each crew is supported by a dedicated instructor.
In addition, the M/FTD offers the advantage of being a transportable tool, so the ground phase can be completed at an Airbus training centre or at the operator's home base.
Course breakdown in percentage by type of training devices

Detailed curriculum

CBT in classroom is restricted to systems presentation. Self paced CBT for normal and abnormal operations to prepare the M/FTD sessions.

Use of the M/FTD during ground phase

When working on system operations, an appropriate CBT summary can be displayed on additional screens.

(1) LOFT PHASE

A LOFT (Line Oriented Flight Training) session is defined to summarise all the exercises learned throughout the course and to give the trainee experience in operating the aircraft in real time scenarios.

(2) Aircraft Base Training

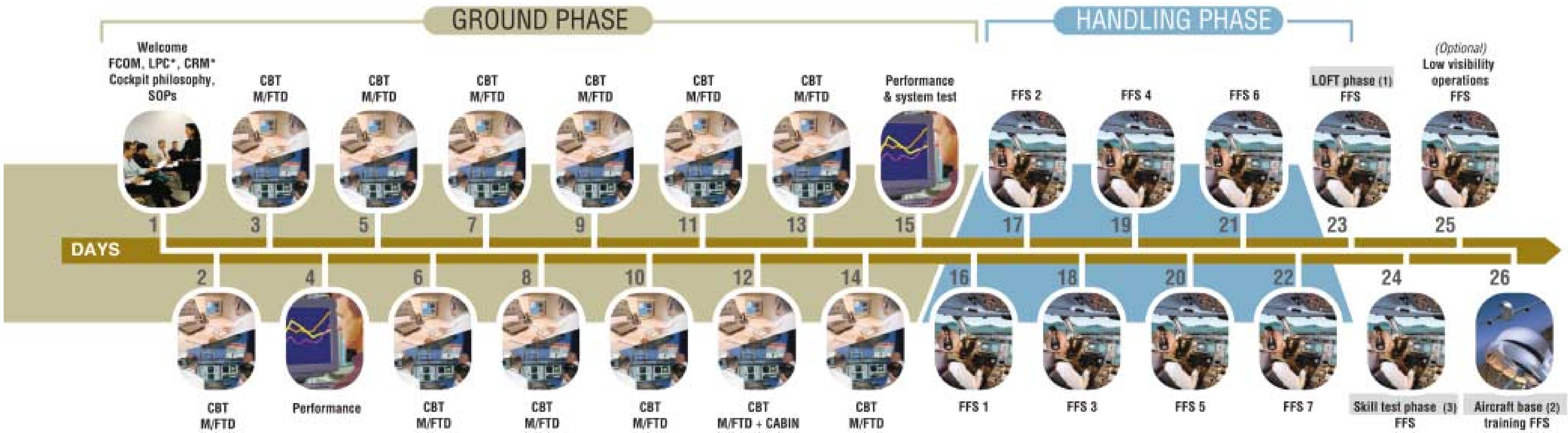
According to regulation requirements and airline request,
two options are provided to the customer:

- either: Aircraft base training – 45 minutes per pilot, or
- Zero Flight Time Training (ZFTT) – 4 hours per crew in the FFS

(3) Skill test phase

According to the JAR – FCL recommendations, the skill test syllabi have been designed in a commercial air transport environment.
They consist of:

- 1st part: a real time sector with some specific events
- 2nd part: additional part to deal with the remaining items to be performed by the trainee in order to fully satisfy the JAR – FCL requirement.



Training is fully integrated

No part task training and progressive introduction of:

- Flight Management System (FMS) functions,
- Systems knowledge
- Standard Operating Procedures (SOP) in normal and abnormal operations
- Crew Resource Management (CRM) including task sharing.

Mode 1

links to CBT summary modules

Mode 2

Tutorial mode

The objective of this mode 2 is to train the procedures:

- sequence of actions
- appropriate call out
- task sharing.

The Tutorial mode included in the M/FTD provides the instructor with the appropriate initialisations when a specific lesson is selected on the M/FTD instructor panel, i.e. the M/FTD is automatically initialised in the correct configuration for the lesson (time saving). The M/FTD also provides some visual materials (drawing on screen).

The tutorial mode is a major contributor to training standardisation, especially for non-Airbus instructors.

Mode 3

Standard free play simulation

In mode 3 trainees can use the M/FTD in the same way and with the same level of system simulation as in a full flight simulator.

Conclusion

The first A320 APT courses were carried out at the Toulouse training centre in mid-September 2004 with crews from two recent Airbus customers. Typical remarks on the course from these customer crews were:

- The M/FTD tutorial sessions are very impressive because we can sequence the entire flight and divide the flight into phases. The instructor can teach us task sharing and the actions to be taken in different flight situations'.
- The structure of the course allowed crews to practice the procedural aspect of their learning on the M/FTD.'

The APT course dramatically enhances the quality and efficiency of flight crew training and has been welcomed by the first crews trained.

Today, all Airbus A320 crews trained in the Toulouse training centre are benefiting from the APT programme. Deployment of A320 APT training in the other Airbus and CAE training centres is scheduled for early in 2005.

APT training will be implemented in March 2005 for type rating on the Airbus A330/A340 aircraft and, later on, on the A380.

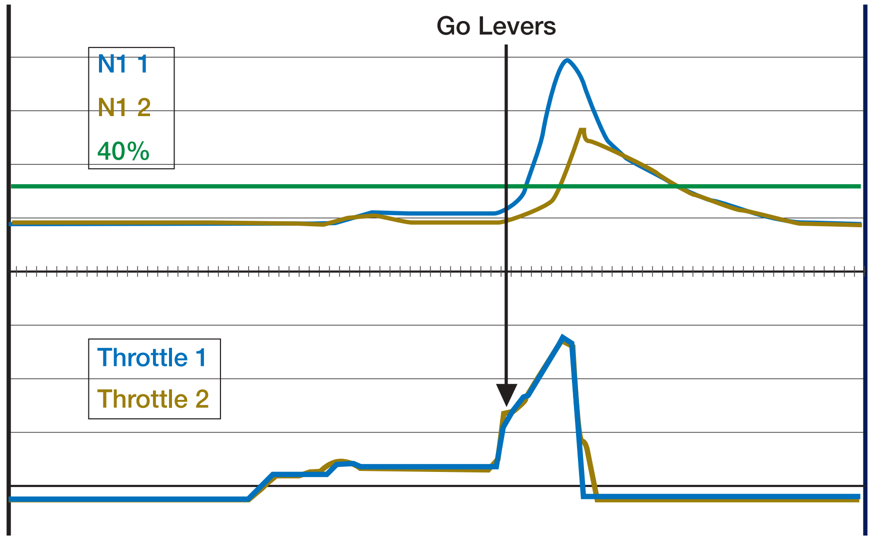
Runway Excursions at Take-off

By: Jean Daney
Director of Flight Safety

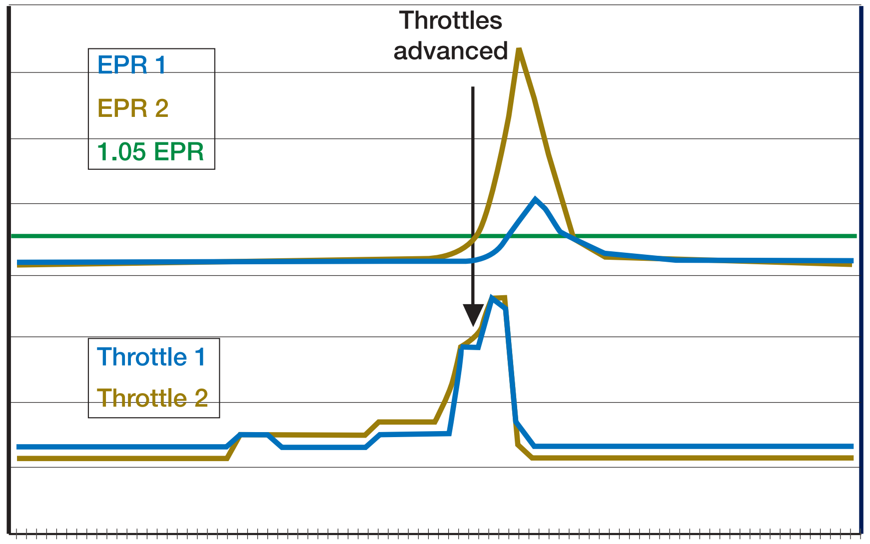
There have been two events involving an A310 and an A320 that resulted in the aircraft exiting the runway during the take-off run. The circumstances that caused these events are very similar:

During the alignment on the runway centreline before take off, one throttle was advanced slightly above the other. This led to a situation where one engine was at idle and the other was slightly above idle. Then, the go-levers were triggered (A310) or the thrust levers were advanced (A320) without prior N1 stabilization. The engine that was above idle accelerated faster than the other, leading to an asymmetrical thrust increase. In both cases, the take off was rejected but the aircraft left the side of the runway at low speed. Here are presented the curves retrieved from the DFDR:

A310



A320



Engine acceleration depends on acceleration schedule (FF vs N2) and throttle movement. There are two types of acceleration:

- Slow throttle movement "behind" the engine acceleration schedule: Thrust is function of the throttle position.
- Fast/normal throttle movement "ahead of" the engine acceleration schedule: Thrust is function of the max acceleration schedule capability

The time to accelerate the engine up to the takeoff power depends on the initial power level: acceleration from min ground idle is slow, while acceleration from intermediate thrust is fast.

At low power setting, engines may have different acceleration profiles while the same acceleration profile for both engines is available from a certain amount of thrust.

As a summary, asymmetrical power increase can occur if the go-levers are triggered (A310) or the thrust levers are advanced (A320) without N1 stabilization while:

- One engine is at idle and the other is slightly above idle
- One engine is slower to accelerate than the other.

FCOM recommendations:

A310:

- Slightly advance throttles and monitor spool-up until both engine are above idle (approx 40% N1) or
- Slightly advance throttles and monitor spool-up until both engine are aligned and stabilized between 1.05 and 1.10 EPR with no more than 0.002 EPR difference between both engines.

A320:

- If the crosswind is at or below 20 knots and there is no tailwind: PF progressively adjust engine thrust in two steps:
- from idle to about 50 % N1 (1.05 EPR).
- from both engines at similar N1 to takeoff thrust.
- In case of tailwind or if crosswind is greater than 20 knots: PF sets 50 % N1 (1.05 EPR) on both engines then rapidly increases thrust to about 70 % N1 (1.15 EPR) then progressively to reach takeoff thrust at 40 knots ground speed

Prevention strategies:

Communication to airlines: Airbus presented these events during the last Safety Committee of IATA and during the last Flight Operation conference and wrote this article in Safety First.

Regular communication to pilots: It is important to emphasize the understanding of engine response at takeoff thrust setting, particularly the requirement of setting a similar N1 (or EPR) on both engines, prior to setting the takeoff thrust during type rating and recurrent training. Airbus encourages airlines to share these lessons-learned through Airline's bulletin to all pilots.

Operational documentation improvements: Airbus will enhance the wording of the FCOM and add a note in the wide body FCOM and single aisle and long range FCTM to emphasize the fact that if this procedure is not properly applied, it may lead to asymmetrical thrust increase and, consequently, to severe directional control problem.

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