

Safety first

The Airbus Safety Magazine

Edition July 2012

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- ▶ Thrust Reverser Selection Means Full-Stop
- ▶ Transient Loss of Communication due to Jammed Push-To-Talk A320 and A330/A340 Families
- ▶ A380: Development of the Flight Controls - Part 2
- ▶ Preventing Fan Cowl Door Loss
- ▶ Do not forget that you are not alone in Maintenance



Issue **14**

 AIRBUS

Safety First

The Airbus Safety Magazine

For the enhancement of safe flight through increased knowledge and communications

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A400M
*Formation of five
 A400M nose to tail
 at Toulouse-Blagnac
 Airport*

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Yannick MALINGE

Chief Product Safety Officer

Editorial

Since our January 2012 issue of this magazine, we held our 18th Annual Safety Conference in March. This took place in Berlin and was attended by more airlines and more delegates than any previous conference. Bearing in mind the general financial situation in our industry at the moment, this provided a pleasing confirmation of our jointly held strong commitment to Safety.

One of the main themes of the conference was Culture. This was examined in both a managerial sense, where the clear commitment of the most senior managers is so vital to support Safety thinking down through all levels within an airline, and also in the Operational area where it is key to getting the best out of the team directly involved with the task.

We also majored on Training. By taking a look at what is trained today and what will be needed tomorrow, we all recognize the need to “close the gap” in this regard. Much good work is being done through the industry Evidenced Based Training initiative. As in-service events hopefully become fewer in number with improved reliability, quality and overall safety, then by definition pilots will experience these events less frequently. Whilst this is of course good, it does mean that pilots will have less and less opportunities to keep their knowledge and skills “sharp”. Indeed, opportunities to maintain “stick and rudder” skills are becoming more and more rare, which is further aggravated by the evolution of the Air Transport System where opportunities for manual flying are decreasing. How we deal with this issue is just one of the challenges we all face.

There is no doubt that this debate is on-going across the whole air transport industry.

In the mean time, you will find in this issue the follow-up of our series of articles on the development of the A380 flight controls, as well as two recurrent topics that deserve a regular reminder in terms of adherence to procedures: fan cowl door loss and use of engine thrust reversers.

Enjoy your reading !

Yannick MALINGE
Chief Product Safety Officer

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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 portal-, 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.

If you do not yet have access rights, please contact your IT administrator.



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News **SAVE THE DATE**

19th Flight safety conference

Bangkok, 18-21 March 2013

We are pleased to announce that the 19th Flight Safety Conference will take place in Bangkok, Thailand, from the 18th to the 21st of March 2013. The formal invitations with information regarding registration and logistics, as well as the preliminary agenda will be sent to our customers in December 2012.

For any information regarding invitations, please contact Mrs. Nuria Soler, email nuria.soler@airbus.com

The Flight Safety Conference provides an excellent forum for the exchange of information between Airbus and its customers. To ensure that we can have an open dialogue to promote flight safety across the fleet, we are unable to accept outside parties.

As always, we welcome presentations from our operators. You can participate as a speaker and share your ideas and experience for improving aviation safety.

If you have something you believe will benefit other operators and/or Airbus and if you are interested in being a speaker, please provide us with a brief abstract and a bio or resume at nuria.soler@airbus.com





Xavier Barriola

Flight Safety

Thrust Reverser Selection Means Full-Stop

1. Introduction

When full forward thrust (TOGA) is applied after thrust reverser selection, there is a risk of non availability of maximum thrust on one or more engines, if the associated reversers do not stow.

This is exactly what happened to an A300-600 equipped with PW4158 engines, which carried out an aborted landing whilst the thrust reversers were still in transit and not fully deployed. As a result of a failure of the electrical restow circuit, the aborted landing was performed with only one engine delivering take-off thrust.

This article will describe the event and review operational recommendations on throttle handling.

This event illustrates the necessity to strictly follow the rule specified in the FCOM: “After reverse thrust is initiated, a full-stop landing must be performed.” This statement is valid for all Airbus aircraft types.

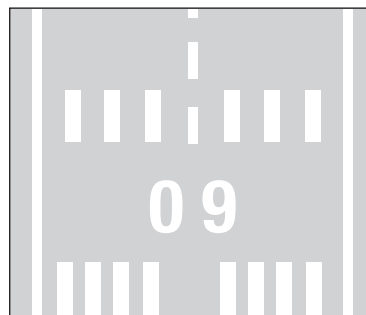
2. Event Description and Analysis

2.1 Approach

The Captain was the pilot flying. The autopilot was not engaged and the approach speed (V_{app}) was 143kt. The weather report indicated rain and cross wind conditions (160°, 20kt gusting at 30kt). The flare was performed at 30ft Above Ground Level (AGL).



160°/20kt
Gusting at 30kt



2.2 Touchdown

The A300-600 touched down with an Indicated Air Speed (IAS) of 138kt and landed hard with a vertical acceleration of 1.82g.

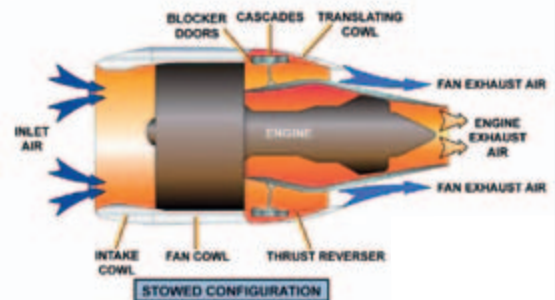
At touchdown the pilot immediately selected the thrust reverser levers to max reverse and the reversers started to deploy (refer to note 1).

The aircraft bounced, and consequently the Captain decided to abort the landing while the thrust reversers were still in transit and therefore not fully deployed.

note 1

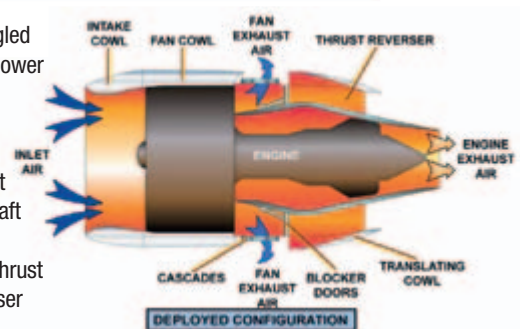
The purpose of the thrust reverser system is to direct fan air forward, to produce reverse thrust and thus to reduce aircraft speed during landing rollout.

“Stowed” is the normal flight position.



“Deployed” is selected after touchdown, producing a forward angled airflow path as engine power is increased.

This redirected airflow creates a rearward or reverse thrust effect that is used to slow the aircraft during landing rollout. The amount of reverse thrust is varied by thrust reverser control lever movement.



2.3 Aborted Landing

While the thrust reversers were still in transit to deploy and the amber REV UNLK lights were ON, they were selected to be stowed, then TOGA was applied on both engines.

On engine 1, the thrust reverser stowed and consequently the FADEC 1 commanded engine 1 at TOGA.

On engine 2, the thrust reverser did not stow and stayed half open due to failure of the electrical restow circuit (refer to note 2).

Consequently, as per design with reverser not stowed, the Auto Idle function of FADEC 2 commanded engine 2 to Idle thrust. A tail strike was experienced during rotation. The liftoff was performed in conf 30/40 (FULL), with an IAS of 125kt .

During liftoff, temporary and intermittent ENG1 REV UNLK (refer to note 3) and permanent ENG2 REV UNLK lights were ON (refer to note 4).

2.4 Diversion

Once airborne, the pilot put the engine 2 thrust lever into the Idle position, then cycled the reverser lever to stow the reverser. The engine 2 thrust reverser remained in the partially deployed position (half open) because:

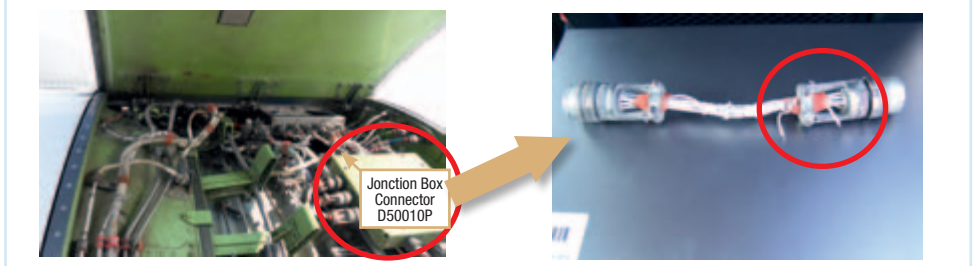
- ▶ The electrical failure of the restow circuit prevented the reverser from stowing correctly
- ▶ A design protection prevents reverser movement in flight.

The pilot then advanced the engine 2 thrust lever to check for thrust response, but the thrust did not increase due to the FADEC's Auto Idle function.

The pilot then shut down engine 2 and diverted to an alternate airport where a single engine landing was performed with engine 1 thrust reverser selected.

note 2

A defective pin at connector level (junction box D5010P) was at the origin of the electrical restow circuit failure.



note 3

Reverse stowed and latched (REV UNLK light OFF) means that it is stowed within 0.125 inch of the full stow stop. At this point, the movement of the thrust reverser sleeve can only be due to vibration, aerodynamic loads (external and in the fan duct), or airplane maneuvers.

Consequently temporary intermittent unlocked indication could be considered to be due to vibration during final transit of the translating sleeve to the full stow stop position.

note 4

The thrust reverser lights indicate the operational status of the thrust reverser systems. When all lights are OFF, the translating sleeves are in the stowed position, the systems are latched.



REV UNLK LIGHTS

A light comes on amber when:

- The related thrust reverser system is unlatched,
- The translating sleeves travel between the status position and 90% of their travel.

REV LIGHTS

A light comes on green when the translating sleeves of the related thrust reverser system are beyond 90% of their travel.

3. Operational Recommendations

3.1 Throttle Handling in Flight

According to the A300-600 FCOM 2.05.70 (ENG REV UNLK procedure), the throttle of the affected engine has to be put and left in the Idle position. No movement of the thrust and reverser levers is authorized while the engine is ON.

3.2 Throttle Handling during Aborted Landing / Touch and Go

a) The A300-600 FCOM 2.03.22 (At TOUCHDOWN) mentions:

► After reverse thrust is initiated, a full-stop landing must be performed.

This statement is valid for all Airbus aircraft types, and is also mentioned in the associated FCOM (Normal Procedure – SOP – Landing).

► Do not move reverse levers towards stow position while reverser are in transit; such action may cause system damage.

b) The A300-600 FCOM 2.02.01 (BOUNCING AT LANDING) has been updated in June 2012 with the following additional statement:

“In any case, if reverse thrust has been selected, a full stop landing must be performed.”

The FCOM of the other Airbus aircraft types will be updated accordingly in the next revisions.

ENG REV UNLK	
THROTTLE (affected engine)	IDLE
DIVERSION	CONSIDER
MAX SPD	300
• IF BUFFET OR BANK:	
FUEL LEVER	OFF
MAX SPD	240
PROC: SINGLE ENG OPERATION (12.08).....	APPLY
ENG AT IDLE	
Displayed only if engine is automatically set at idle by FADEC	

A300-600	STANDARD OPERATING PROCEDURES	2.03.22
	LANDING	PAGE 5
		REV 33 SEQ 070
AT TOUCHDOWN REVERSE LEVERS Pull		
- Immediately after touch-down of main landing gear, pull reverse levers to the idle reverse point, when REV (green) appears, apply max reverse.		
- After reverse thrust is initiated, a full-stop landing must be performed.		
<i>Note 1: Maximum efficiency of the reverse is obtained at high speed</i>		
<i>Note 2: Do not move reverse levers towards stow position while reversers are in transit; such action may cause system damage.</i>		
<i>Note 3: If one or both REV UNLK It remains on, apply reverse normally.</i>		
<i>Note 4: If the use of max reverse is restricted due to noise consideration, maintain reverse idle until taxi speed is reached.</i>		
<i>Note 5: If directional control problems are encountered, reduce thrust to reverse idle until directional control is satisfactory.</i>		
- MAX. REVERSE THRUST		
- N1, EGT and IAS		

A300-600	PROCEDURES AND TECHNIQUES	2.02.01
	GENERAL	PAGE 9
	RECOMMENDATIONS FOR TAKE-OFF AND LANDING	REV 33 SEQ 001
BOUNCING AT LANDING		
In case of light bounce (5 ft or less), maintain pitch attitude and complete the landing. Do not increase pitch attitude, as this could lead to a tailstrike.		
In case of a high bounce (more than 5 ft) maintain pitch attitude and configuration, and initiate a go-around by advancing throttle levers while triggering the go-levers. This will soften the second touchdown that will most probably occur and prevent damage to the aircraft.		
Retract flaps one step and landing gear only when safely established in the go-around and no risk of further touchdown exists.		
A landing should not be attempted after a high bounce, as the remaining runway length might not be enough to stop the aircraft.		
In any case, if reverse thrust has been selected, a full stop landing must be performed.		

4. Conclusion

As a result of the crew’s decision to abort the landing after they had selected reverse thrust, the aircraft took off with one engine on Idle and the aircraft’s tail impacted the runway.

This occurrence illustrates that when TOGA is applied after thrust reverser selection, there is a risk of non availability of maximum thrust on one or more engines if the associated reversers do not stow. This protection is triggered by the Auto Idle function of the FADEC, which maintains the engine thrust at Idle as long as the reversers are not stowed. The consequence could be a loss of control if an aborted landing is initiated at that time.

We therefore strongly encourage all crews to adhere to the following FCOM recommendation, which is common to all Airbus aircraft types:

“After reverse thrust is initiated, a full-stop landing must be performed.”

A previous article published in the first issue of this magazine: “A320 In-Flight Thrust Reverser Deployment”, dated Jan 2005, describes an event where a takeoff was carried despite a REV UNLK warning.

The common key message from these two articles is that it is essential to strictly adhere to any procedure associated with the operation of thrust reversers.



Benoît DUVAL

Safety Enhancement Manager
Aircraft Architecture and Integration

Transient Loss of Communication due to Jammed Push-To-Talk

A320 and A330/A340 Families

1. Introduction

At the end of 2011, the crew of a cruising A320 was unable to transmit on any radio, but reported that it was still possible to receive ATC communications. A few months before, on another A320, the crew reported after landing that it was not possible to contact the tower via either VHF system. Investigations attributed both events to Push-To-Talk (PTT) selectors jammed in the transmit position.

As illustrated by these examples, jammed PTT selectors generate events of transient loss of communication with ATC every year.

This kind of failure might be difficult to identify for the crew, and might lead to the feeling that all communications have been lost with ATC. In reality, a correct identification of the situation and the implementation of a few simple steps will, in most cases, allow the crew to recover full communications.

This article will outline the effects of a jammed PTT and will explain how to restore communications. It will also describe a new ECAM caution and procedure that will be introduced in the next Flight Warning Computer (FWC) standards.

2. Transmitting with VHF or HF

In order to transmit on VHF or HF radio, the flight crew uses one of the Audio Control Panels (ACP) (fig.1).

devices: side stick radio selector, hand mike PTT, or INT/RAD switch on the ACP (fig.2).



In the normal configuration, three ACP are available. They are located on the Captain side (ACP1), on the F/O side (ACP2), and on the overhead panel (ACP3). The ACP3 allows reconfiguration in case of failure of ACP1 or ACP2.

Initially, the pilot has to press one of the ACP transmission keys in order to select a VHF or HF transceiver. Then, in order to actually transmit on the selected radio, he uses one of the Push-To-Talk

3. Impacts of a Jammed Push-To-Talk

3.1 VHF

When a Push-To-Talk device is jammed in the transmit position, the VHF transceiver transmits continuously as soon as it is selected, and no reception is possible on the tuned frequency.

In order to limit such a continuous and unintentional transmission

that could disturb the ATC frequency, an internal protection is implemented inside each VHF, limiting the transmission time to 35s. After 30s of transmission, the crew is warned of this imminent automatic transmission cut-off through an interrupted tone that sounds for 5 seconds (5 audio “beeps”, one per second).

In normal operation, on hearing the 5 audio “beeps” the crew has to release and press again the PTT selector/button to continue the transmission. But if the Push-To-Talk device is jammed the transmission may not be resumed on the selected radio, which will be limited to reception only. In this case, an ECAM COM VHF (1 or 2 or 3) EMITTING caution is also triggered after 60s.

3.2 HF

There is no automatic transmission cut-off after 35s on the HF transceivers, but an ECAM COM HF (1 or 2) EMITTING caution is triggered as well if the HF transmission duration exceeds 60s.

4. VHF/HF Communication Recovery In Case of a Jammed Push-To-Talk

4.1 Typical scenario

Consider, for example, an attempt of VHF1 communication with a side-stick PTT jammed on the Capt side. As soon as the VHF1 transmission key is selected on the Audio Control Panel located on the Capt side (ACP1), a continuous VHF1 transmission is initiated.

The VHF1 transmission will be automatically interrupted after 35s (VHF internal protection). 25s later, the Flight Warning System (FWS) will trigger the ECAM COM VHF1 EMITTING caution.

Figure 2
Push-To-Talk devices



Figure 3
Audio Switching rotary switch



COM VHF 1(2)(3)/HF 1(2) EMITTING

1. If any Push To Talk (PTT) transmission selector (sidestick radio selector, hand mike selector, or PTT switch is jammed in the transmit position, try to release it in order to remove the caution.
2. If unsuccessful, deselect the identified failed VHF/HF transmission keys on the associated Audio Control Panel (ACP) to remove the caution. This ACP should only be used in reception mode. The associated PTT transmission selectors must not be used.

Note : In this case, the ACP of the unaffected side may be used to recover the deselected VHF/HF channel.

3. If no transmission key on the ACP is found in the “transmit” position, pull the affected VHF/HF C/B associated to the ECAM message : COM\HF1 C/B HA 14 on 49 VU, COM NAV\HF2 C/B L13 on 121 VU, COM\VHF\1 C/B G09 on 49 VU, COM NAV\VHF\2 C/B L04 on 121 VU, COM\VHF\3 C/B L05 on 121 VU.

Figure 4
A320 Family FCOM information associated to the COM VHF/HF EMITTING caution

COM VHF 1(2)(3)/HF 1(2) EMITTING

1. If any Push to Talk (PTT) transmission selector (sidestick radio selector, hand mike selector, or PTT switch) is jammed in the transmit position, try to release it in order to remove the caution.
2. If unsuccessful, deselect the identified failed VHF/HF transmission keys on the associated Audio Control Panel (ACP) to remove the caution. This ACP should only be used in reception mode. The associated PTT transmission selectors must not be used.

Note : In this case, the ACP of the unaffected side may be used to recover the deselected VHF/HF channel.

Figure 5
A330/A340 FCOM information associated to the COM VHF/HF EMITTING caution

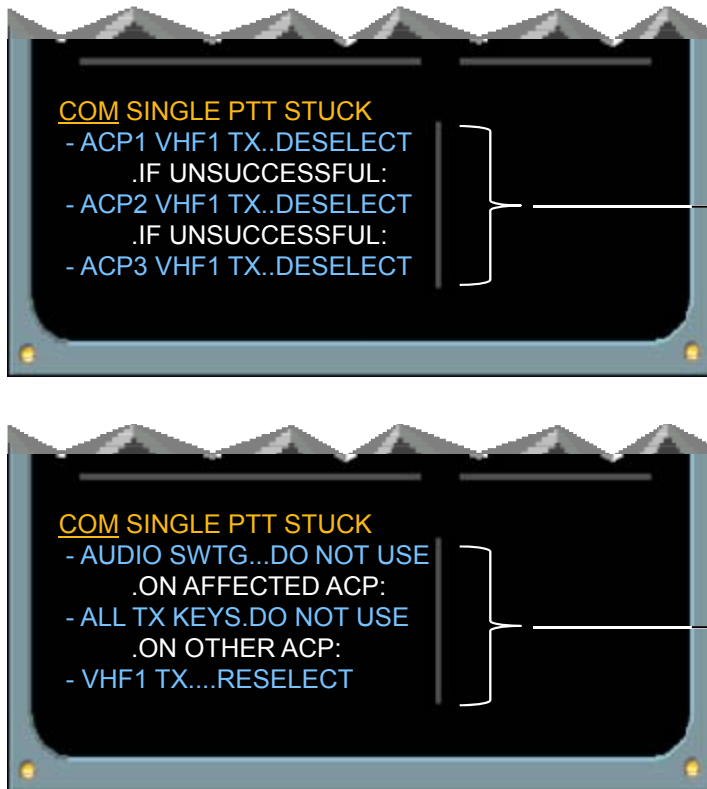
If the crew tries to select another VHF on the same ACP, for example VHF2, the same scenario will occur as the side-stick PTT is still jammed: the VHF2 will be automatically interrupted after 35s and the COM VHF2 EMITTING alert will trigger 25s later.

Selection of “CAPT ON 3” by means of the Audio Switching rotary switch (fig. 3), to use the ACP3 (overhead panel) on the Captain side, will not solve the problem as the jammed PTT will request a permanent transmission through the ACP3.

4.2 Recovery

The way to handle the situation in this case, is to first check the PTT transmission selector and try to release it. Then, if this does not work, isolate the jammed PTT and the associated Audio Control Panel by deselecting all the VHF transmission keys on the ACP1. It is then possible to use the ACP2 and the associated PTT devices, on the F/O side, to establish a new VHF transmission.

Such a procedure is available today in the FCOM, as expanded information associated to the COM VHF/HF EMITTING caution (fig.4 & 5).



Configuration: one PTT jammed, VHF1 transmission, and Audio Switching rotary switch on NORMAL position.

1st part of the procedure: identification of the affected side
These 5 procedure lines disappear as soon as the VHF1 transmission key has been deselected on the affected side (the side where the PTT is jammed).

For example, if the F/O side stick PTT is jammed, these lines will disappear as soon as the VHF1 transmission key has been deselected on the ACP2.

2nd part of the procedure: reconfiguration on the other side
Once the VHF1 has been deselected on all ACPs, the procedure requests the crew to not use the audio switching, nor any transmission keys on the affected ACP. Then, the procedure requests to reselect the VHF1 transmission key on the other ACP.

Figure 6
New ECAM COM SINGLE PTT STUCK caution with associated procedure

5. New ECAM Caution and Procedure in Case of a Jammed Push-To-Talk

5.1 VHF

To assist the crew to recover correct communication in case of a jammed PTT, a new amber COM SINGLE PTT STUCK caution has been developed. This alert will trigger when a PTT is detected continuously activated during 40s and will provide a new procedure to guide the crew through the two following steps :

- Identification of the side affected by the jammed Push-To-Talk.
- Reconfiguration on the non affected side.

An illustration of this procedure for a jammed PTT using a VHF1 radio is given in [fig. 6](#).

In association with the introduction of this new alert, the COM VHF 1 (2) (3) EMITTING alert will be

triggered simultaneously with the audio “beeps”, i.e. 30s after the start of the transmission, to reinforce the awareness that the transmission will be cut-off.

note

The introduction of the COM SINGLE PTT STUCK caution will lead to the downgrading of the COM VHF 1 (2) (3) EMITTING alert from a level 2 to a level 1 caution, which implies that there will be no associated Single Chime nor Master Caution light.

The differences between the present and future ECAM definitions for the VHF radios are summarized in [fig. 7](#).

5.2 HF

The COM SINGLE PTT STUCK caution described above will trigger as well for HF communication. The only difference will lie in the delay of activation: to take into account the longer average length of messages of HF transmissions, the caution will trigger only when a

PTT is detected continuously activated during 180s.

note

As for the VHF associated alert, the COM HF (1 or 2) EMITTING caution (level 2) will likewise be downgraded to a level 1 caution.

The differences between the present and future ECAM definitions for the HF transceivers are summarized in [fig. 8](#).

5.3 Calender

On the A320 Family, these improvements will be implemented on the Flight Warning Computer (FWC) H2-F7 standard (availability planned in December 2012).

On the A330/A340, these improvements will be implemented on the FWC T5 standard (planned in January 2013) for the A330 and A340-500/600, and from the L13 standard (planned in August 2013) for the A340-200/300.

Figure 7
Current and future
ECAM definition in
case of PTT stuck
(example for VHF1)

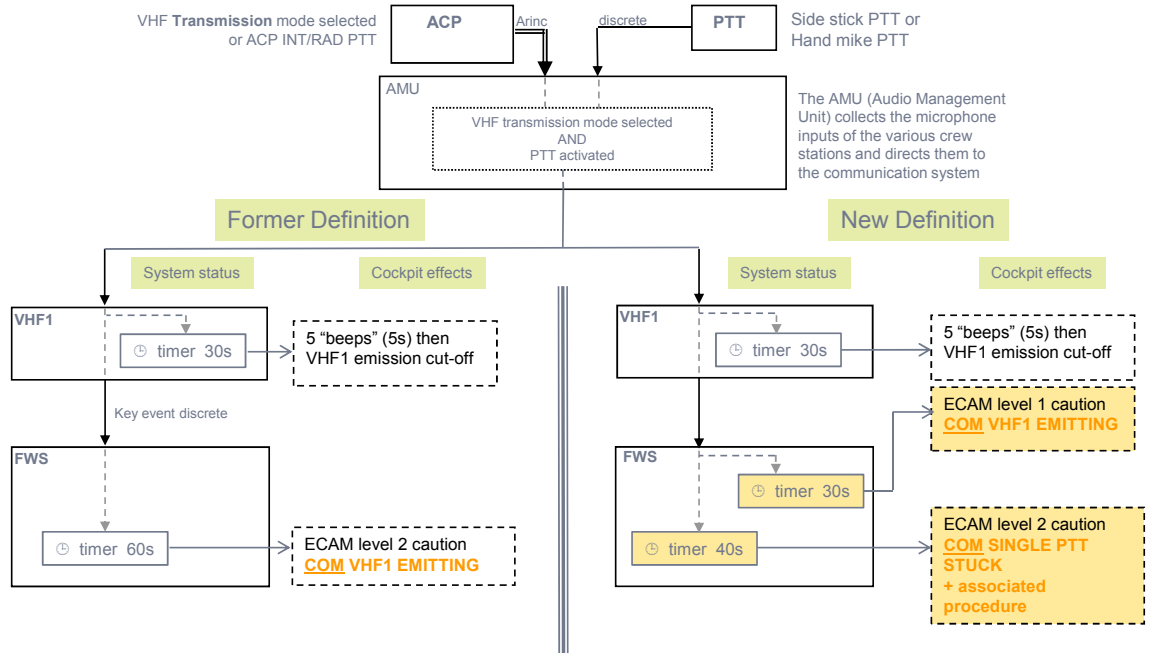
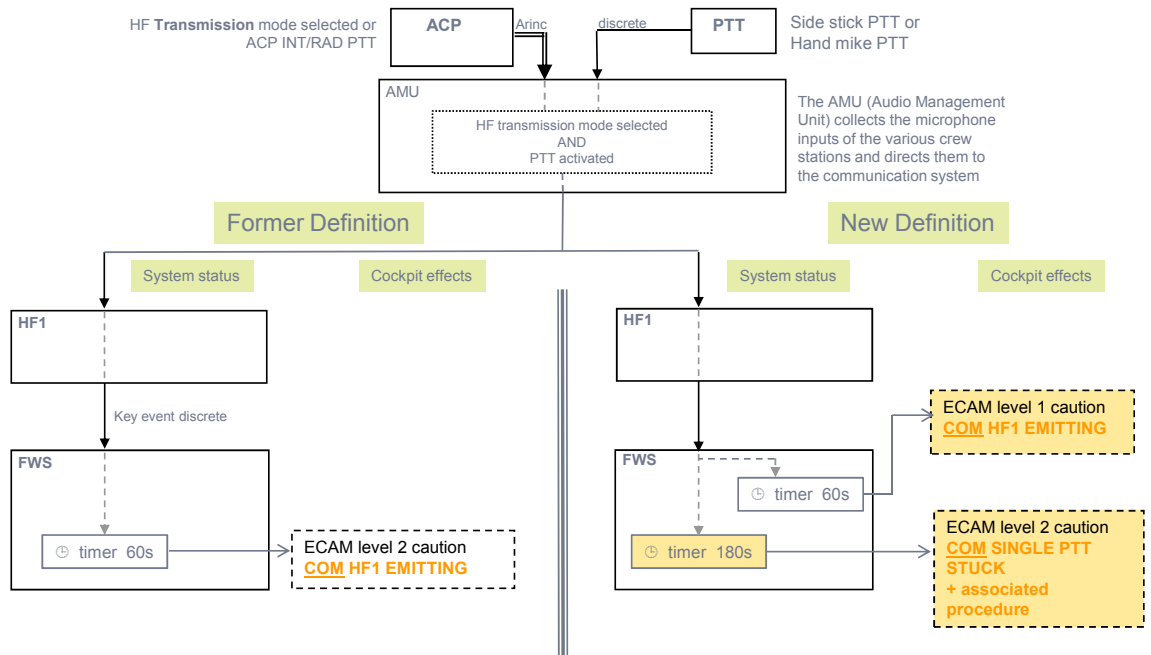


Figure 8
Current and future
ECAM definition in
case of PTT stuck
(example for HF1)



6. Conclusion

On the A320 and A330/A340 families, when a transient loss of VHF communication is experienced in association with the triggering of the alert COM VHF EMITTING, the root cause can almost always be attributed to a jammed PTT device.

In this case, it is necessary to isolate the jammed Push-To-Talk device by deselecting all the transmission keys of the Audio Control Panel on the affected side, then to use a Push-To-Talk device and Audio Control Panel on the other side to recover the transmission.

A new ECAM COM SINGLE PTT STUCK caution and associated procedure will be introduced in the next standards of FWC to assist the crew to recover both ways communications.



Claude LELAIE

Experimental Test Pilot

A380: Development of the Flight Controls

Part 2

The Lateral Flight Control Laws

On July 27th 2005, in Toulouse we had a strong wind from the south, called “vent d’Autan”, giving rise to a lot of turbulence. It was flight 51 of the first A380. We performed several landings and it became apparent that the lateral flight control laws would have to be tuned again: the pilots were very active on the stick, the ailerons were moving a lot and created unpleasant lateral accelerations, mainly at the back of the aircraft. The flight test engineers had several possibilities to adjust the control laws: gains, damping..., but none of them could solve the issue. This typical development flaw had to be corrected, but it was not an easy task.

Mid October, new PRIM flight controls computers were delivered with a new control law for the ailerons that the engineers of the design office called “VDA” or “Valse Des Ailerons” (aileron waltz). As an example, when moving the stick to the left, on the left wing, the internal aileron started to move up immediately. The outer aileron was doing the same, but with a different deflection. Finally, the centre aileron was either initially going down, in opposition to the two others, then taking an upward position, or going

up after a very short delay in a neutral position. Several adjustments were available for the flight engineers, for example, the ratio between the deflection of inner and outer ailerons and the logic of the centre aileron. The target of this strange kinematic was to “break” some wing oscillations as two of them had very close frequencies and, in certain circumstances, they had the possibility to couple together. Looking at the page dedicated to the flight controls on the screen at the disposal of the crew, it was easy to understand why this strange motion of the ailerons received this nickname of “VDA”. A similar differential deflection was also implemented on the two rudders and was called “VDR” or “Valse Des Rudders” (rudders waltz), a typical Airbus “British – French” acronym, as rudder is not a French word! The improvement on comfort was spectacular. However, some tuning was still needed.

In January 2006, we installed a new standard of the computers, with some improvements on the VDA laws. The main one was a reduction in the activity of the ailerons. The adjustments were again performed in flight. The final tuning is such that, for speeds below 300 kts, the deflection of the inner aileron is 2.5 times the value of the outer

one. The centre aileron follows the inner, but with a time delay of 350 milliseconds. Some more modifications were needed at high altitude due to the Mach effect.

But we had another issue: the tuning of the spoilers. At the beginning, they were deflected as soon as there was a command in roll and this created some buffet. Mid February 2006, new settings were proposed by the design office in order to reduce these vibrations, with a limitation of the deflection to 3° as long as there was not a strong demand from the pilot. Without this trick, one of our British test pilots told us that he had the impression of being “punished” by this buffet when entering a standard turn! On top, in the final tuning, when more manoeuvrability was needed, there was a higher deflection of the outer spoilers than of the inner ones, because they were creating less buffet.

For all these flights where it was important to get an idea on the comfort, a qualitative judgement at various locations in the plane was needed. In the cockpit, the pilots gave their impressions, both on the ease of flying and on the comfort in the forward part of the aircraft. The flight test engineers, seating close to the centre of gravity, gave their sensations based on their



feelings and the available traces. At the back, close to the most rear door of the main deck, we installed a seat equipped with an intercom connected to the other crew members. A young flight test engineer was sat there, to give his opinion about his perception of comfort. Taking into account the number of roll manoeuvres we were performing on each flight, we had to hope that he would not become sick! It is true that a choice could have been made based on an analysis of the traces of several parameters of the motion at the various positions in the plane, but we considered that the opinion of a potential “passenger” was fundamental in order to make the final decision. Obviously, all the records of these parameters were used by the design office to make progress in the tuning of the flight controls laws. It is to be noted that, at the beginning of the program, we were concerned by a possible difference of comfort between the two decks. The first flights demonstrated that this was not an issue.

At the opportunity of your next flight on an A380, if you travel in business or economy class, I recommend that you book a “window seat”, close to the wing or at the back of the plane in order to see how the ailerons are working (in first class you

will not have this chance as you will be too far forward!). The effect is best observed just after take-off and during the early climb manoeuvres with the ailerons moving around their neutral position. You will see that when entering into a simple turn or for a unique roll correction, taking as a base the inner aileron, the one closest to you, the outer aileron will move simultaneously but with a smaller deflection. Then with a small time delay, the centre will join the inner. If several corrections are made by the pilot, in one direction then in another, taking into account the different deflections and the time delay, you will see the ailerons in totally different positions, up and down. The nickname “Valse Des Ailerons” is really well chosen and it is efficient.

The High Angle of Attack Protections at Low Mach Number

The tuning of the high angle protections, that prevent loss of control for all types of manoeuvres at low speed, has to be performed on all our new aircraft. The flight test techniques are well known by the test pilots.

We start with some decelerations with the engines at idle, slow manoeuvres at first and then faster, until achieving full back stick. At this stage, we have to check that we have some margin before reaching the stall. These tests are repeated in a stabilized turn and also with full thrust. If all the results are satisfactory, some rapid roll manoeuvres are carried out in one direction then in the other, while maintaining full back stick with various thrusts between idle and take-off power. The conclusion is the “avoidance manoeuvre” where the pilot rapidly puts the stick in the aft corner: a very

rapid turn will commence, the angle of attack will reach its maximum, and the engines will go to full thrust. This is exactly what a pilot would do to avoid another airplane or an obstacle. These tests must be performed for all slats and flaps positions. They must also be carried out for the extreme positions of the centre of gravity and with an aircraft light or heavy, as the reaction will be a function of all these parameters.

During the first flights of the A380, we performed an evaluation of these protections, but in a quasi-static way, with a slow deceleration. The reason was that we had to avoid approaching the stall because of potential high loads on the empennage. The engines were at idle and the target was to get a first idea of the tuning. During flight 7, at aft CG, we carried out some of these decelerations with satisfactory results.

The real tuning started when the slats and flaps deflections were frozen, end of July 2005, and immediately, we had a flight dedicated to these adjustments. We performed the tests at mid and aft CG, as the CG position could be adjusted in flight thanks to the water ballast system and when necessary some fuel transfer. During this flight, we avoided manoeuvres that were too dynamic, as we had still some doubts concerning the loads on some parts of the aircraft. The results were globally good, with the exception of the configurations 3 and Full, where the angle of attack was not properly stabilised when at full back stick, with therefore a risk of reaching the stall. So, for these configurations, we initially decided not to perform the turns with full back stick and maximum thrust.

The tuning continued with various standards of the PRIMs and, very quickly, in October 2005, the tuning of the protections was satisfactory. We proved that

at the Dubai Airshow where we performed the standard flight display, with high angle of attack manoeuvres, similar to the display carried out on all other Airbus types.

The Effect of Icing on the Tuning of Low Speed Protections

However, the tuning of the protections at low speed was not complete. We had to ensure that with some ice on the leading edge of the wing, the protection is still doing its job properly. This is not a critical issue on big transport jets, as due to their rather high speed, it is far more difficult to accumulate a large amount of ice on the wing than on smaller and slower aircraft. But the certification regulations are the same for everybody, and obviously we had to comply.

Some tests are performed in real icing conditions, but it is not possible to accumulate on the leading edge an amount of ice giving a shape representative of the “worst case” required by the regulations. Therefore, the aerodynamicists compute for all flight phases, the ice shapes for the wings and the empennages for the most critical conditions. In order to avoid performing several series of tests with different shapes, only the most critical for all flight conditions is retained.

The ice shapes are then manufactured. They are made of polystyrene with some additional particles glued on in order to simulate the granularity of the ice. These shapes have a thickness of three inches, which is considered to be the maximum that an aircraft will keep on a leading edge. The regulations also consider that the de-icing system may fail. In this failure case, the relevant part of the wing is equipped with a smaller ice shape, as the crew will follow the procedures to leave the icing area, and therefore will accumulate a smaller



Figure 1
*Polystyrene shapes
simulating ice
accretion*

amount of ice. These ice shapes are then glued on the leading edge for the duration of the tests.

With the shapes in place, the tests start with an evaluation of the handling qualities and some stalls in order to check if the margin between the stall and the approach speed remains acceptable or not. If it appears that this margin has become insufficient, it is possible to recommend a small approach speed increase, such as 5 kts in case of severe icing or failure of the de-icing system. On the A380, none of the speeds or procedures needed to be changed in icing conditions.

The second step is to review the high angle of attack protections and adjust them, if necessary. The test techniques are identical to those used without ice shapes.

On the A380, on each wing, the slats are divided in seven sections and only slat 4, close to the outer engine, on the fuselage side, is de-iced. Within the flight test team, we were convinced that this de-icing was not necessary. What could be the effect of a couple of inches of ice on such a huge leading edge? This design change could save around sixty kilograms of weight (about half a passenger!). Therefore we decided to start the tests with a configuration without the de-icing, which means with the three inches leading edge ice shapes on all the wings, including slats 4.

The first flight with ice shapes was performed on June 26th 2006. As mentioned above, we started with the stalls. With flaps retracted, the

results were good. But there was a significant deterioration as the flaps were deflected. For the landing configuration, there was some loss of lift and a pitch up when approaching the stall. Our objective was to keep a safe aircraft, without degradation of the performance. Retaining more or less the same tuning for the angle of attack protections would have been an acceptable solution to save weight and simplify the systems. But, due to the pitch up, it appeared that the maximum angle of attack with the protections, in the landing configuration, would have to be reduced by two degrees, which was really too much. And therefore, we had to keep the de-icing system on slat 4. The flight test team was wrong and the aerodynamicists were right!

The tests continued with the tuning of angle of attack protections. The maximum angle of attack remained unchanged from configuration Clean to 2. Then in configurations 3 and landing, there was a reduction of 0.5 degree, without any consequence on the operation of the aircraft.

The tests were concluded with the validation of the failure case, a small ice shape on slat 4, with no other modification. Considering the previous tests with this slat fully iced, we were anticipating some degradation of the handling qualities. All we found was a slight difficulty to maintain the bank angle precisely with full back stick in the landing configuration. This was found acceptable due to the fact

that this is a situation that will most probably never be found in the life of all A380s: the most severe icing conditions, associated with a failure case and a pilot maintaining the maximum angle of attack during several seconds. And anyway, it is perfectly safe as control is not lost.

In summary, these ice shape tests led only to a very small reduction of the maximum angle of attack in the flight controls protections in configurations 3 and Full.

The High Angle of Attack Protections at High Altitude

The aircraft must also be protected against the loss of control during decelerations and in turns at high and medium altitude with slats and flaps retracted. In these conditions, when the pilot pulls on the stick, without flight controls protections, the classic stall characteristics are not easy to detect as there is no visible stall nose drop compared to low altitude with the flaps extended. On the other hand, the buffeting appears progressively and, if the pilot insists and continues in the manoeuvre, eventually reaches a deterrent level. The angle of attack to get the deterrent level of buffet reduces with the Mach Number and therefore the tuning of the protections has to be done for all Mach Numbers.

For these tests, for each Mach Number, the crew chooses an altitude where he can perform tight turns, without imposing an excessive load factor. An exploration is performed without protection, in direct law, in order to identify the angle of attack of the appearance of the buffeting and of the deterrent buffet. These manoeuvres are difficult to perform, even for well trained test pilots, because, for the measurements, the Mach must be maintained precisely. It is controlled using the bank angle: as an example, decreasing

the bank angle in case of Mach increase (more nose up to decrease the rate of speed acceleration). Then, using these results, a first tuning of the protections is performed immediately and tested, the target is to be at the limiting level of the buffet when full back stick is reached. The tests start with turns where the load factor is very slowly increased. Then turns with fast increase of load factor are carried out. If, with the initial tuning, the buffeting is not found, the engineers will increase the maximum angle of attack by half a degree and re-perform the tests. On the other hand, if there is too much buffeting during all the manoeuvres, the maximum angle of attack must be reduced. As there is some scatter in the results of the manoeuvres, the ideal situation is to be just at the limit of the buffet. This implies having, sometimes no buffeting during smooth manoeuvres but reaching very briefly a strong buffet for aggressive pitch entries.

In summary, for each Mach Number, the tuning is carried out by progressive adjustment. It has to be repeated at various Mach Numbers in order to obtain the curve of maximum angle of attack versus Mach Number. These tests are first performed at forward CG. They must then be repeated at aft CG, which is usually done during the same flight. At aft CG, depending on the characteristics of the flight controls, it may be necessary to reduce very slightly the maximum angle of attack. If everything goes well, at the end of the flight, all the tunings are decided and will be transferred in the next standard of flight controls computers.

On the A380, we started these tests on August 31st 2005. It was flight 78 of aircraft MSN 1. The results were not fully satisfactory for several reasons. The development computers did not allow us the possibility to

insert the right tuning for Mach between 0.6 and 0.7. We also had difficulties in flying the aircraft in roll between Mach 0.80 and 0.84 and therefore, measurements were not very good. Finally, between Mach 0.80 and 0.89, the aircraft exhibited some pitch up (which means that it had a tendency to pitch up without pilot input) and was entering buffet very quickly.

These various problems were progressively solved. It is to be noted that the pitch up phenomenon lead to a very delicate adjustment of the flight controls. When it appears, the flight controls law has to deflect the elevator down smoothly to oppose this immediate and strong motion pitch up effect. Finally, on May 10th 2006, a final revue of the adjustments was performed with very good results.

However, some more flights were needed to validate the behaviour of the protections with the airbrakes out. The issue was that the pitch up, if the pilot insists and continues in the manoeuvre, is a function of the deflection of the spoilers and as their extension is destroying the lift, it also reduces the pitch up. Therefore the "anti pitch up" function of the flight controls laws is adjusted according to the airbrakes position. On the A380, the first tests with airbrakes out demonstrated that the estimations obtained by models and wind tunnel were not correct. To cope with this situation, we performed some identification flights in direct law, with various airbrakes deflections, in order to define the automatic compensation to be introduced in the computers.

Part 3 will include the development of the high speeds protections, the BUSS (Back Up Speed Scale) and the BCM (Back Up Control Module).

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Preventing Fan Cowl Door Loss

1. Introduction

Parts Departing from Aircraft (PDA) have always represented a significant concern in aviation, and as such all events involving PDA need to be reported to Airbus, no matter the shape, material, size or weight.*

PDA may impact the aircraft and lead to structural damage, but they may also represent a danger to people on the ground.

When the part separation occurs close to an airport area, debris may fall on a runway, hence creating a risk for following aircraft.

This is particularly true for lost fan cowl doors, which are among the largest PDA, since more than 80% of the 32 reported events occurred during the take-off phase.

This article covers the published procedures and easy to implement recommendations, for both mechanics and crew members, to avoid fan cowl door losses.

* Ref OIT SE 999.0038/09 & SIL 00-097

2. Potential Heavy Damage To Aircraft

On the A320 Family, each fan cowl weighs about 40 kg, hence it represents a potentially significant amount of energy, which may impact the aircraft when lost at high speed.

A fan cowl loss generally leads to twisted pylon cantilevers and/or minor damages to slats, wing leading edges, horizontal stabilizers and fuselage skins.

But the damage can also extend to

skin panel perforation or serious damage to the vertical or horizontal stabilizers. This type of damage represents a major hazard in terms of handling in flight and also often requires major repair work to rectify on the ground.

Potentially, any part of the aircraft structure located aft of the engines could be affected.

The grounding time for repair can typically last for up to several weeks.

note

On other Airbus programs, occurrences of fan cowl door loss are more limited:

- ▶ 2 cases on the A330
- ▶ 3 cases on the A300/A310 Family.

Although more rare, these events also involve more severe damage, as the impact energy could be higher than for the A320 Family (fuselage puncture leading to cabin decompression, wing skin puncture leading to fuel leak, for instance).

The higher number of occurrences on the A320 Family is mainly attributed to the lower ground clearance of the power plants.



Figure 1
Fan cowl loss event

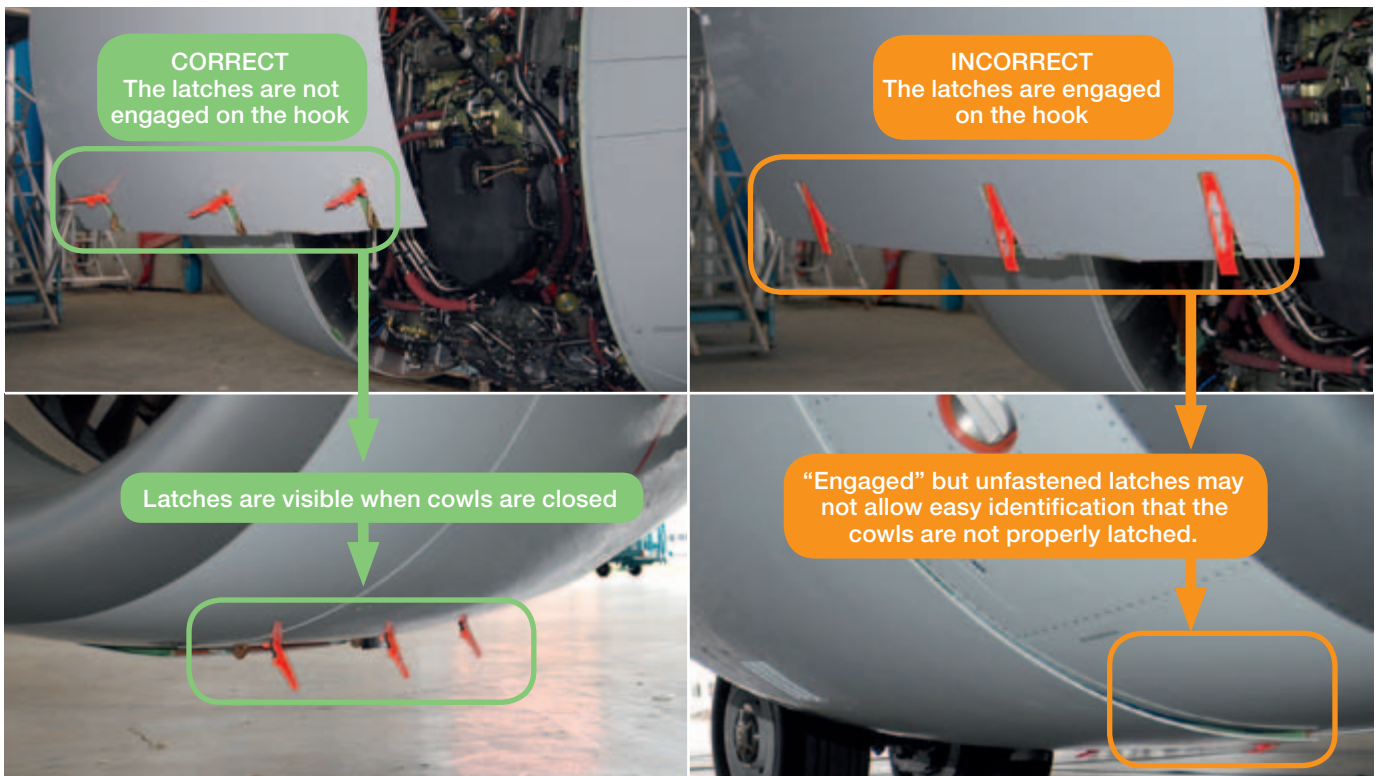


Figure 2
Latches on open doors should be left in the not engaged position

3. Incorrect Latching of Fan Cowl Doors

3.1 Recent Event

A recent fan cowl door loss event highlights some recurring factors associated to such occurrences.

The aircraft originally planned for the flight had to be rescheduled due to a technical issue.

On the day preceding the event, the replacement aircraft had been subject to a weekly IDG oil check, which called for the opening of the engine cowlings. A subsequent daily check was carried out by the same person.

The event flight was the first leg of the day. Less than one hour before the take-off, a transit check was performed. The exterior walk around was performed with time pressure and challenging weather conditions (temperature below 0°C and wind).

The engine fan cowls were lost four minutes after take-off, passing FL110 during climb. The cowls perforated the engine oil tank and the crew shut down the engine.

Post-flight inspection revealed a twisted pylon as well as multiple impacts to slats, horizontal stabilizer and the fuselage. The overall repair required assistance by a working party for three weeks.

The investigation concluded that the aircraft had departed with the fan cowls not properly latched.

3.2 Typical Scenario

For all investigated events, it was established that maintenance actions requiring opening of the fan cowls had taken place prior to the flight, and that the affected fan cowls were incorrectly latched.

Several independent risk factors were identified as the main contributors to fan cowl door losses:

- ▶ First flight of the day
- ▶ Poor weather conditions (low temperature, rain, snow, wind)
- ▶ Time constraints due to a late aircraft change
- ▶ Changes to the routine of the maintenance team during tasks involving opening of the fan cowls.

4. Maintenance Recommendations

In the chain of preventive measures, maintenance is a key factor.

Airbus insists about the need for strict adherence to the AMM 71-13-00 instructions, for proper latching and closing of the fan cowl doors.

Please note the following key recommendations:

- ▶ The fan cowl doors should always be entirely latched when they are being closed. If it is necessary to walk away from the engine prior to completing the latching, the doors should not be left unlatched, or partially unlatched.

If the aircraft walk-around is not performed in an exhaustive manner, the situation may remain unnoticed.

- ▶ Latches on open doors should always be left in a “not engaged” position, which means that they will hang down when the doors are closed and not latched (fig.2).

This ensures easy identification of an unlatched door condition.

note

In the frame of an investigation, the US National Transportation Safety Board (NTSB) has found that Airbus operators who introduced dual inspection sign-offs to their maintenance inspection procedure, to confirm latching of engine fan cowls, were successful in preventing cowl loss events.

The following cautions will be added to AMM 71-13-00 in the August 2012 revision:

CAUTION:

DO NOT LEAVE THIS JOB AFTER JUST CLOSING THE FAN COWLS, CONTINUE ON TO SECURE THE LATCHES. IF YOU ARE CALLED AWAY PRIOR TO LATCHING, THEN EITHER RE-OPEN ONE COWL DOOR OR LATCH THE LATCHES BEFORE WALKING AWAY FROM THIS ENGINE.

CAUTION:

DO NOT ENGAGE THE LATCH HANDLE HOOKS WHEN THE FAN COWL DOOR ARE OPENED

5. A320 Family Design Evolution

A number of modifications were developed to ease the detection of an unlatched cowl condition (ref. 1 & 2). In particular:

- ▶ Fluorescent paint on the latch
- ▶ Hold-Open device (IAE engines) to increase the peripheral gap
- ▶ New latch handle hook springs to ensure handle hanging down when unlatched
- ▶ Caution decal on the cowl.

The latest modification consists of the introduction of red flags, to improve the visibility of an unlatched condition of the cowls:

- ▶ On the IAE engine, a dedicated tool (P/N 98D71103002000) is included in Airbus' Tool and Equipment Manual (TEM). This new tool is called by the AMM at every Fan Cowl Door opening (Fig. 3).

- ▶ On the CFM engine, a similar tool is under development, to be finalized by end of Q4 2012.

6. Importance of the Pre-Flight Check

FCOM Standard Operating Procedures PRO-NOR-SOP-05 provide instructions to the crew to perform the exterior walk-around and ensure that the overall condition of the aircraft and its visible components and equipments are secure for the flight.

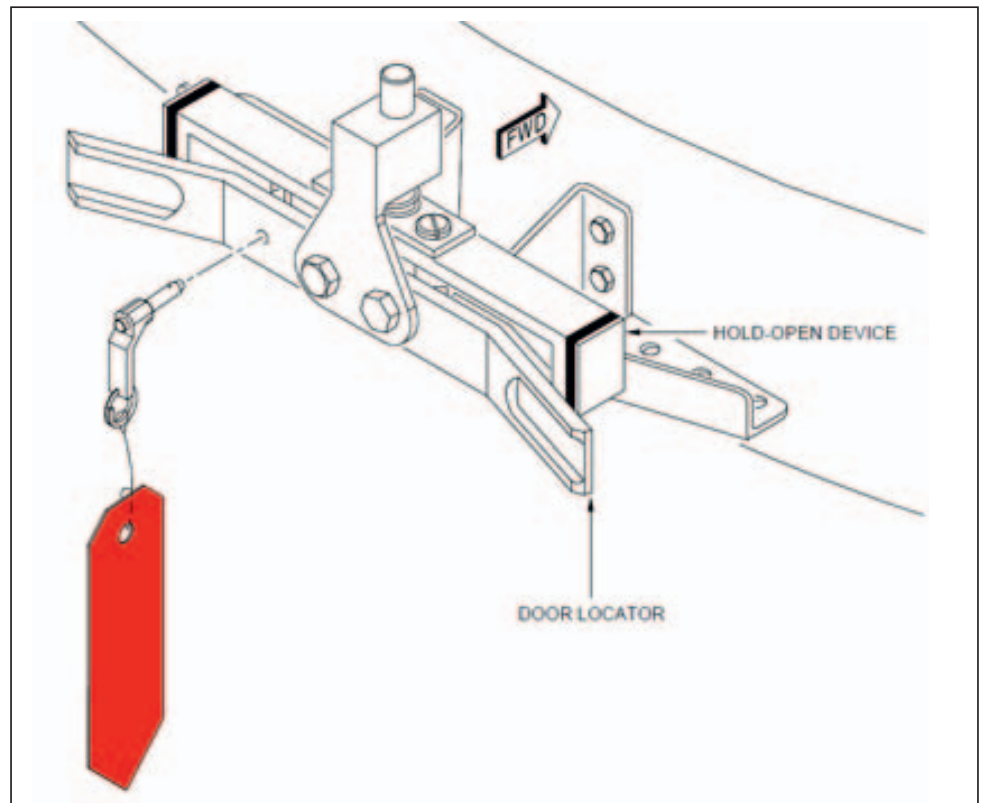


Figure 3
A320 red flag
on the IAE engine
Hold-Open device

As part of this inspection, it is essential that a flight crew member visually inspects the fan cowl doors prior to each flight to ensure that they are closed and latched (ref. 3, fig. 4).

The effectiveness of this check relies on the correct positioning of the flight crew to visually check that all

the handles are flush with the cowls and engaged in their slots.

Indeed, the crew member performing the walk-around needs to position himself **on the side of the engine** and should **crouch** to check that **all** latches are correctly latched and that there is no gap around the cowl (fig. 5).

EXTERIOR WALK-AROUND

Applicable to: ALL

SCHEMATIC

ENG 1 LH SIDE

- Oil fill access door.....CLOSED
- Fan cowl doors CLOSED/LATCHED
- * Drain mast..... Condition/NO LEAK
- * Engine inlet and fan blades.....CHECK



ENG 2 LH SIDE

- Oil fill access door (CFM and IAE only)..... CLOSED
- Master magnetic chip detector access door (IAE only) CLOSED
- * Thrust Recovery Nozzle (PW only)..... CLOSED/LATCHED
- Hydraulic filter visual access door (PW only)..... CLOSED
- * Fan cowl doors CLOSED/LATCHED
- * Drain mast..... Condition/NO LEAK
- * Engine inlet and fan blades..... CHECK

Figure 4
FCOM Exterior walk-around check



* This picture represents the worst case scenario, where the latches are engaged on the hooks, but unfastened

Figure 5
Proper walk-around check for secured fan cowl doors

7. Conclusion

Fan cowl doors that are not properly latched may lead to the in-flight loss of the cowls. This may cause extensive damage to the aircraft structure and result in operational consequences such as in-flight turn back and subsequent long grounding periods for repair. They may also represent a danger to people on ground, as well as a threat to following aircraft when lost at take-off. Specific focus on AMM maintenance instructions and SOPs, are key safety barriers to avoid such events.

The following three recommendations should be followed by maintenance personnel and crew members:

- ▶ Latches on doors in the fully open position should always be left in the horizontal (i.e. not engaged) position.
- ▶ Fan cowl doors should always be entirely latched when the cowls are being closed. Cowls must not be left in the closed position while not properly latched.
- ▶ During the exterior walk-around, the crew member has to visually check the correct closure/latching condition of the fan cowls. To do this correctly, the crew member must be positioned on the side of the engine and crouch.

References:

- ▶ Ref. 1: OIT 999.0057/07: Fan cowl door loss after take-off
- ▶ Ref. 2: Maintenance Briefing Note (MBN): Human factor – error management (case study on fan cowl loss prevention)
- ▶ Ref. 3: OIT/FOT Ref 999.0122/07 Walk-around check.



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Do not forget that you are not alone in Maintenance

1. Introduction

The aim of this article is to highlight the importance of being aware of what other maintenance team co-workers are doing, and where they are working on the aircraft at the same time. The potential consequences can be dramatic when this awareness is lost, as shown by this article.

Maintenance teams are working in an environment where they are faced with ever more complex aircraft systems and the increased interaction of co-workers performing different tasks at the same time on the same aircraft.

Being aware of who is doing what, and understanding the consequences of tasks being performed is essential, to avoid potentially dramatic situations.

2. Maintenance Event Description

Loss of situational awareness in maintenance operations can have serious consequences. In the least it can lead to damage to the aircraft, and in the worst case can result in fatal injuries to maintenance workers involved in the incident, as two recent cases have highlighted.

Case No. 1: Accident with the Krueger flap

During a scheduled maintenance check, an experienced licensed mechanic was cleaning an area between the extended Krueger flap and the structure on an A300-600.

During the performance of this maintenance task, the slats started retracting, causing the head of the mechanic to be impacted by the moving Krueger flap at the end of the slat system retraction cycle.

The investigations performed further to this accident confirmed that the warnings and precautions as per the AMM were clear.

It was also confirmed that head set communication was present between the cockpit operator and the hangar area, and visual alert signs were located around the work areas.

Good standard maintenance practice would require to do a walk-around to be carried out. The person who activated the hydraulic system did not, through such a check, confirm that there was no risk to other personnel prior to energising the hydraulic system.

Case No. 2: Injuries caused by the Nose Landing Door closure

A mechanic was working alone within the landing gear bay on an A320 Family aircraft. For an undetermined reason, the ground door opening handle was in the “closed” position, i.e. not corresponding to the actual position of the nose landing doors (fig. 1).

Another person, not being aware that a mechanic was already working within the landing gear bay, activated the hydraulic system; the doors closed accordingly and trapped the mechanic.

3. The Aircraft Maintenance Manual

The AMM is written with specific warnings and cautions detailing safety procedures and tooling that should be used. These Warning Notices typically ensure that the controls agree with the position of the surfaces they operate, and to operate the controls only when the related hydraulic systems are pressurized.

The use of the correct tooling will prevent the doors from closing, if the hydraulic system is pressurized inadvertently.

The aim of these safety steps is to highlight particular risks, and to reduce the risk of injury to the mechanics.

4. The Lessons Learned

The common factor between the two described accidents was that even though the maintenance documentation provided clear warning advice, fatal injuries were caused to the workers in question.

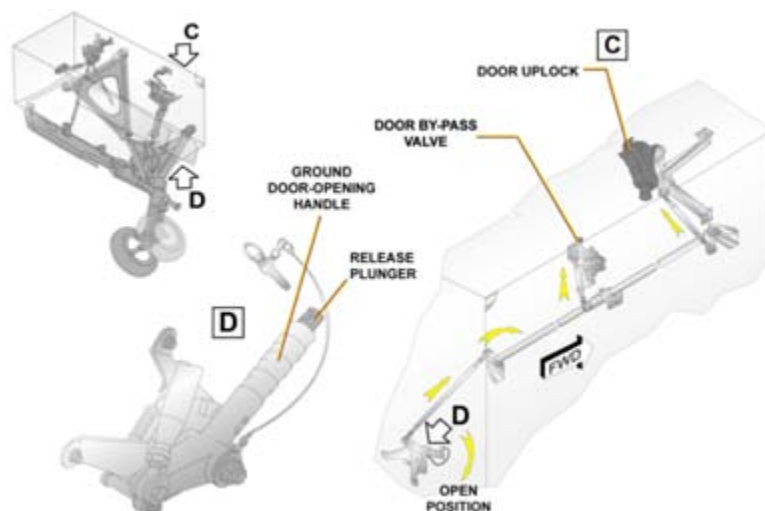
In both events, investigation showed that more than one individual was working on the aircraft at the time, but on different assigned tasks.

None of them had made a maintenance error related to the tasks he was working on. However, a combination of actions taken led to the situation that put one of the workers lives at risk.

All of these difficulties point to a lack of having a clear and up to date understanding of what was going on around the aircraft. It demonstrates the importance of being aware all the time of the state of the aircraft systems, and sub-systems, that may be being working on.

A common situation is that personnel carrying out part of a major maintenance task, without the awareness and knowledge as to how their actions are affecting the overall task, or aircraft technical configuration, i.e. having

Figure 1
A320 Nose Landing Gear operation mechanism



Taking the two examples above, details of the warnings and cautions are as follows:

► MAKE SURE THAT THE CONTROLS AGREE WITH THE POSITION OF THE ITEMS THEY OPERATE BEFORE YOU PRESSURIZE A HYDRAULIC SYSTEM. UNWANTED MOVEMENT OF HYDRAULICALLY OPERATED ITEMS CAN LEAD TO SERIOUS INJURY AND / OR CAUSE DAMAGE.

► ONLY OPERATE CONTROLS WHEN THE RELATED HYDRAULIC SYSTEMS ARE PRESSURIZED.
 ► IF YOU OPERATE A CONTROL WHEN THE RELATED HYDRAULIC SYSTEM IS NOT PRESSURIZED, THERE IS A RISK THAT:
 – THE CONTROL WILL BE IN A POSITION THAT DOES NOT AGREE WITH THE ITEM(S) IT OPERATES.
 – WHEN HYDRAULIC PRESSURE IS RESTORED, UNWANTED MOVEMENT OF THE HYDRAULICALLY OPERATED ITEM(S) MAY OCCUR AND CAUSE SERIOUS INJURY AND / OR CAUSE DAMAGE.

In addition, the “Doors Closing Preparation” of the Technical Training Manual includes a caution, which highlights the following messages:

ON THE GROUND

► MAKE CERTAIN THAT THE GROUND DOOR OPENING CONTROL HANDLE IS LOCKED IN THE OPEN POSITION,
 ► REMOVE THAT THE SAFETY PIN FROM THE DOORS,
 ► MAKE CERTAIN THAT THE DOOR TRAVEL RANGES ARE CLEAR



lost the “big picture”, also commonly known as “tunnel tasking”. Often technicians are given only their piece of the puzzle, for example, being assigned tasks with deadlines without explanation or direction – a “just do it” assignment.

The difficulty in ensuring safety whilst working on aircraft systems is increased by the fact that many different individuals may be working on the aircraft. The presence of multiple individuals increases the need for good and clear communication between them, and clear understanding of responsibilities.

In addition to the awareness of what the different team members within one given team are doing, another important task for maintenance teams is the co-ordination and information transfer across different teams, for example during shift hand-over.

Figure 2
A possible consequence of the lack of awareness in the hangar



5. Conclusion

A recurring source of accidents or incidents during maintenance is caused by loss of situational awareness. Technicians are often made aware of only part of a major maintenance task. Problems can occur when they are not trained or explanations are not provided of how their activities could affect other people working at the same time on the aircraft.

As part of preventive measures, individuals, training organisations, and management should ensure effective shift preparations, communications between all involved working on the aircraft, and avoid being trapped in a “tunnel task” situation, which can have fatal consequences.

Articles Published in Previous Safety First Issues

Issue 13, January 2012

- A320 Family / A330 Prevention and Handling of Dual Bleed Loss
- The Fuel Penalty Factor
- The Airbus TCAS Alert Prevention (TCAP)
- A380: Development of the Flight Controls - Part 1
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