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Our Reference: 420.1261/15 Rev01

01 December 2015

USA A320 MSN1141 N113UW flight 1702 - Rejected take-off after rotation at Philadelphia - Airbus submission

On March 13, 2014, about 1830 eastern standard time, US Airways flight 1702, an Airbus A320, N113UW, experienced substantial damage after the captain rejected the takeoff after rotation on runway 27L at Philadelphia International Airport, Philadelphia, Pennsylvania.

The take-off was initiated without performance data set in the FMS. As the aircraft accelerated, take-off data was not displayed and take-off modes did not engage. An ECAM alert indicated that thrust levers were not set to the expected position. As the aircraft reached 80 knots, the audio alert “RETARD” triggered continuously until the take-off was rejected.

On the basis of the information gathered from the Recorders and the Operations Investigation Groups, Airbus supported this investigation by providing technical advisory to NTSB and BEA with the following main deliveries to the Commission of Investigation:

- Sequence of events;
- Assessment of aircraft response (systems, performance, handling qualities);
- Applicable manufacturer’s operational procedures;
- Focus on Flight Warning Computer behavior and reason for triggering the audio-alert “RETARD” during take-off;
- In-service experience reported to Airbus;
- Product enhancement with regards to “RETARD” inhibition at take-off.

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ABBREVIATIONS

ATC	Air Traffic Control
BEA	Bureau d'Enquête et d'Analyse
E/WD	Engine Warning Display
ECAM	
FADEC	Full Authority Digital Engine Control
FCOM	Flight Crew Operating Manual
FLX	Flexible (temperature and thrust levers setting)
FMA	Flight Mode Annunciator
FMS	Flight Management System
FOBN	Flight Operations Briefing Note
ft	feet
FWC	Flight Warning Computer
kt	knots
MCDU	Multipurpose Control & Display Unit
MOD	Modification
NLG	Nose Landing Gear
NTSB	National Transportation Safety Board
PFD	Primary Flight Display
QRH	Quick Reference Handbook
SOP	Standard Operating Procedures
SRS	Speed Reference System

PREAMBLE

NTSB and BEA authorized Airbus to share the lessons learnt from this occurrence with Operators during the yearly Airbus Flight Safety Conference in March 2015. The presentation and the messages passed during the conference have been the basis of this document. Presentation is attached in appendix 1.

1. SYNOPSIS

Refer to appendix 1, background.

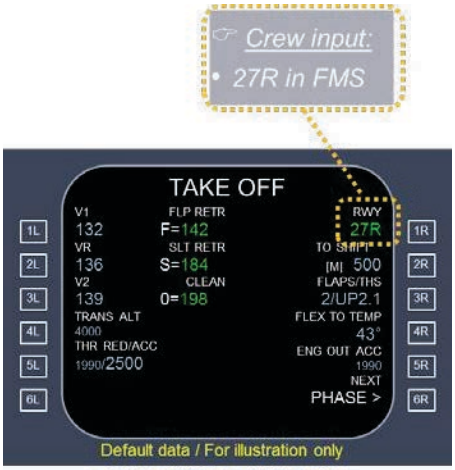
On March 13, 2014, about 1830 eastern standard time, US Airways flight 1702, an Airbus A320, N113UW, experienced substantial damage after the captain rejected the takeoff after rotation on runway 27L at Philadelphia International Airport, Philadelphia, Pennsylvania.

The aircraft became temporarily airborne before it was flown back to the runway. When it touched down dynamically and first (175kt, 3.76g recorded), the nose landing gear sustained overload damage. The aircraft bounced and experienced a tailstrike at second and final landing. The nose landing gear collapsed before the aircraft came to a final stop. The aircraft sustained further damage as the forward lower fuselage and engines contacted the ground. The tail, forward lower fuselage, nose landing gear, and engine damage was beyond economical repair.

An emergency evacuation was completed during which emergency systems operated nominally. There were no injuries.

2. BEFORE TAKE-OFF

Refer to appendix 1, event description.

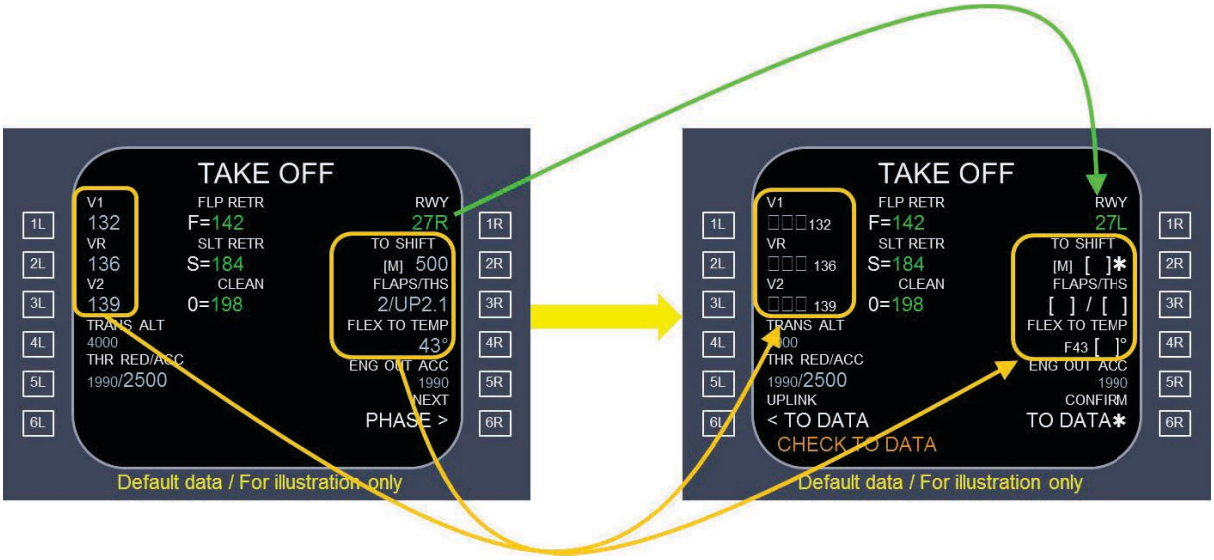


At the time of the accident, the aircraft had been assigned runway 27L by ATC. However the crew entered the data for runway 27R during FMS preparation. Relevant performance take-off data was inserted, which included the V-speeds (V1, VR, V2) and the flexible temperature (FLEX TO TEMP) since the take-off was to be performed at reduced thrust.

The discrepancy in FMS entry remained unnoticed during briefings and checks. The aircraft was taxied towards the assigned runway 27L. Taxi was performed with one engine shut down.

As the aircraft was in the queue, ATC informed that flight 1702, previously number 6, had become number 2. Consequently there was a change in the take-off sequence while a number of tasks were still to be carried out, including starting the second engine and performing the take-off briefing. At this stage, the FMS runway discrepancy, 27R instead of 27L was still unnoticed.

The discrepancy was noticed eventually and the runway loaded in the FMS was revised whilst entering the runway. The assigned runway 27L was entered in place of discrepant 27R.



When doing so, FMS performance data was deselected and moved to the adjacent boxes. The amber message CHECK TO DATA was displayed. Data was not reentered. The aircraft was aligned for take-off without V-speeds and without FLX TO TEMP selected in the FMS.

3. TAKE-OFF

3.1 Sequence of events

Refer to appendix 1, event description.

As planned during flight preparation, thrust was set by positioning the thrust levers at position MCT/FLX. Without FLX TO TEMP selected in the FMS, this position of thrust levers did not correspond to a take-off one so the take-off modes did not engage as indicated at the FMA. In particular the FMA did not display SRS/RWY guidance modes and MAN FLX thrust mode with associated FLX TO TEMP.

The red memo SPD SEL was displayed at the top of the speed scale of the PFD. It indicated the non-availability of V-speeds (V1, VR, V2). This was noticed by the crew who elected to continue with the V-speeds in mind.

Within 3 seconds, at an airspeed below 50kt, ECAM alert ENG THR LVRS NOT SET triggered with associated action to be carried out THR LEVERS…..TO/GA. Instead of being set to TOGA, thrust levers were pulled back and returned to FLX/MCT. This action did not engage the take-off modes.

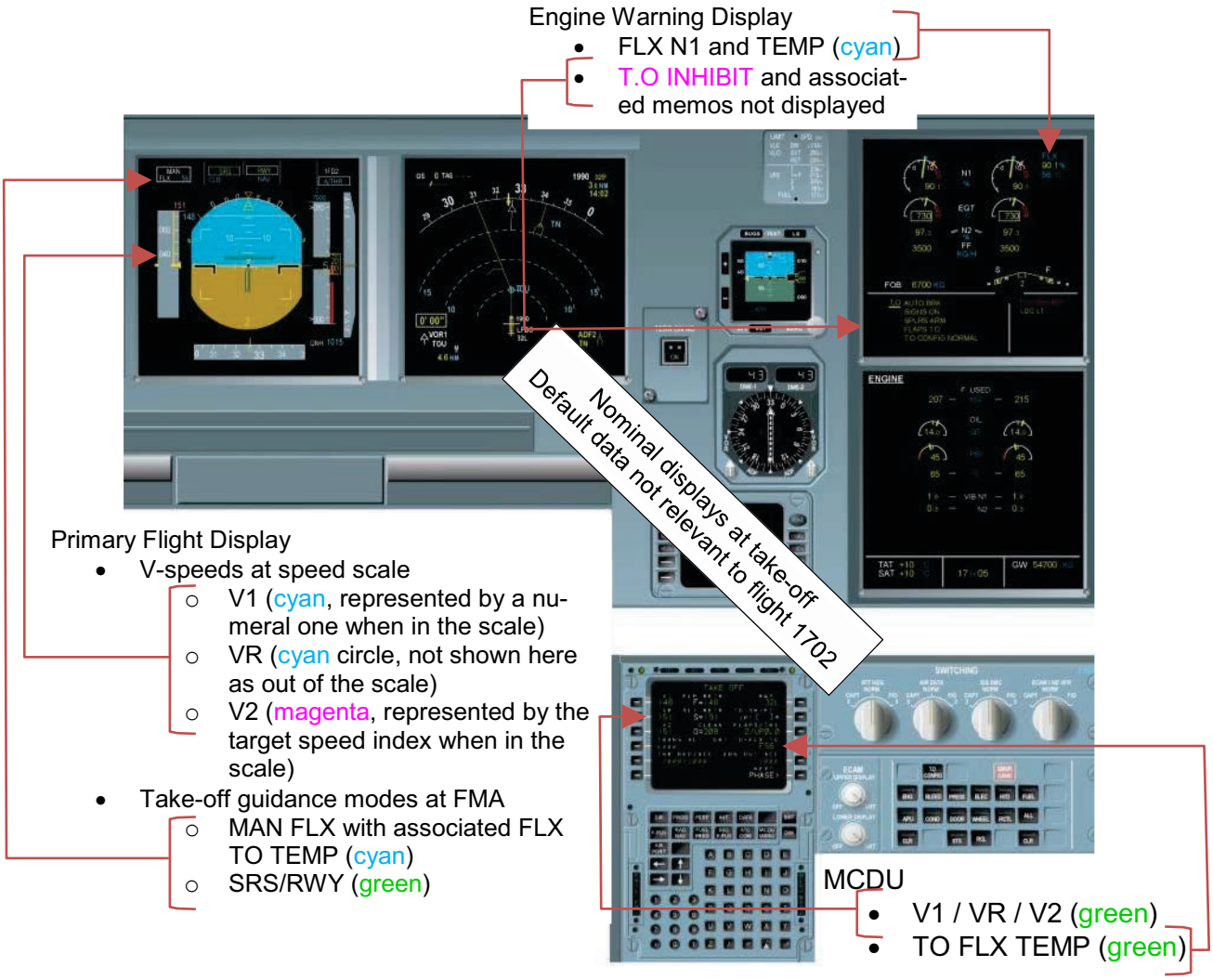
5 seconds later (8 seconds after initial thrust setting), FADEC set TOGA thrust. This automatic function, available on some engine types (refer to §8), provides maximum take-off thrust however does not engage the take-off modes. The crew confirmed that take-off thrust was available and continued.

When reaching 80kt, audio-alert “RETARD” triggered continuously until lift-off for a reason explained in §6. Take-off was continued with nominal acceleration, passing V1 and VR by memory at which moment rotation was initiated.

Immediately after rotation, the take-off was rejected. The next sequence of action was described in §1, with first touchdown on nose landing gear, a bounce, a second touchdown during which tailstrike and damage resulting from nose landing gear collapse were experienced.

3.2 Cockpit effects

Nominal displays in case of a flexible take-off are illustrated here after. They are to be compared with the illustrations of §3.1. Only left hand and center displays are shown, right hand ones would be similar to the left ones.



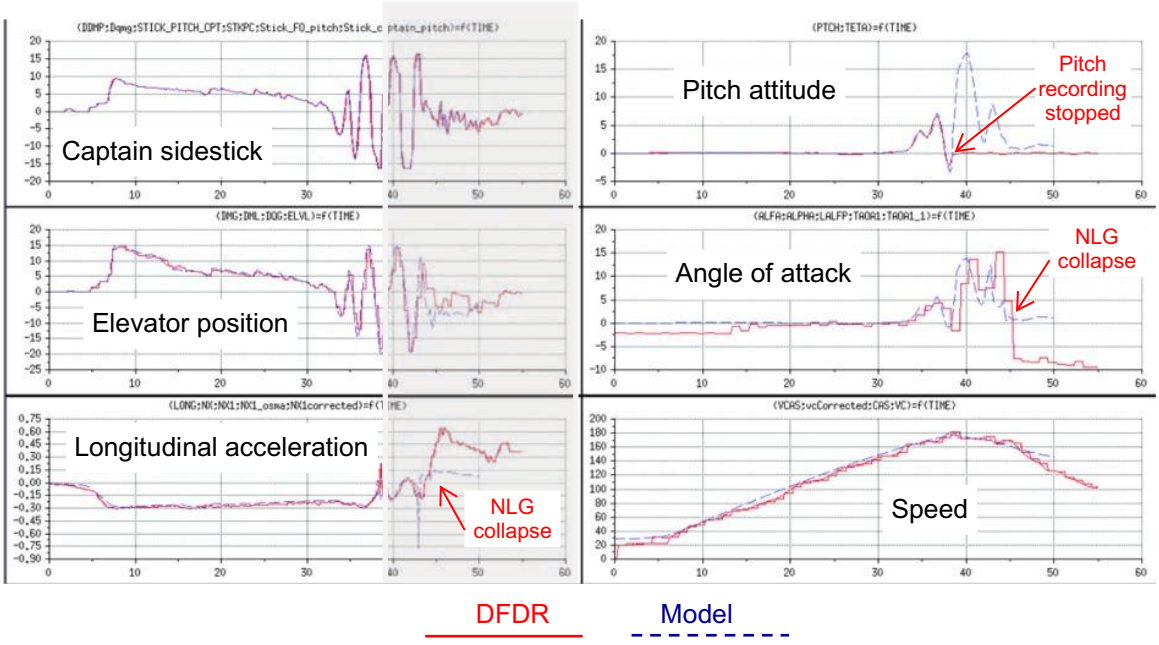
During flight 1702, there were salient cues that FMS was not configured properly and that the take-off modes did not engage. These were mainly:

- At the MCDU, active boxes were empty, data was in the adjacent ones, and the amber memo CHECK TO DATA was displayed;
- At the speed scale, V-speeds were replaced by the red memo SPD SEL;
- At the FMA, take-off guidance modes and FLX MAN thrust mode were not displayed;
- At the Engine section of the E/WD, TOGA was displayed in place of FLX and FLX TEMP (after automatic thrust setting by FADEC);
- At the ECAM section of the E/WD, T.O INHIBIT and take-off memos were not displayed. Instead, LDG INHIBIT appeared as airspeed reached 80kt.

4. AIRCRAFT RESPONSE

Analysis of the flight data recordings for flight 1702 indicated nominal systems, performance, and handling qualities response of the aircraft.

The investigation involved engineering handling qualities analysis. The flight data recordings were reviewed against the certified model. Responses were identical until second touchdown.



The difference with the model appeared after first impact:

- DFDR stopped recording the pitch attitude, still available with the model;
- After second touchdown, the model did not simulate the nose landing gear collapse.

The flight was repeated in the integration simulator with NTSB and BEA participation. The simulator was configured equivalent to the accident aircraft with regards to systems and powerplant:

- Simulator was fitted with most of USA1702's computer standards:
  - FADECs+EIU#2, FMs, FWCs, FAC, SEC: same part numbers
  - EIU#1, FGs, ELACs: similar computers, HW difference but no functional impact foreseen
- Electronic Instrument System
  - EIS2 instead of EIS1 : no functional impact foreseen on FMA, RWY display, EWD and speed indications
  - SDAC simulated : no model issue/lack of representativeness foreseen

Computer	USA1702	Simulator
FADEC	5BS2 (rating 5B4)	5BS2 (rating 5B4)
EIU	v14	EIU#1:v15 EIU#2:v14
FMGC (FG/FM)	C12/S6	C12A/S6
FWC	H2-F5	H2-F5
FAC	B0513	B0513
ELAC (HW-SW)	A'-L81	B-L81
SEC	B-104	B-104
DMC	EIS1 v60	EIS2 s12
SDAC	H2-D2	Simulated

It was demonstrated that take-off may have been continued after rotation with nominal handling qualities and with the performance provided by MCT thrust corresponding to the thrust levers position.

It was also demonstrated that adhering to SOP for the ECAM alert ENG THR LVRS NOT SET, i.e. by advancing the levers towards TO/GA, the audio-alert "RETARD" would have been inhibited.

5. OPERATIONAL CONSIDERATIONS

Refer to attachment 1, operational considerations

5.1 Flight preparation

Whatever the circumstances leading to discrepant data being entered into the FMS, Standard Operating Procedures define several stages (FMGS preparation, take-off briefing, before start clearance) when data should be checked and rechecked by the 2 cockpit crewmembers.

During March 2015 Flight Safety Conference, Airbus highlighted the importance of adherence to these SOP.

5.2 Late changes before take-off

SOP consider the case of FMS data revision.

When runway was revised and that the data inserted during initial FMS preparation was deselected, the previously-entered values remained valid and may have been re-selected by pressing the CONFIRM TO DATA* key on [6R] of the MCDU.

The aircraft take-off sequence changed from 6th to 2nd with still the second engine to start and the final pre-take-off actions and briefing to carry out. FMS data was not revised despite the amber message CHECK TO DATA and the capability to fast recover previous data.

During March 2015 Flight Safety Conference, Airbus highlighted the hazard associated with late changes before take-off, a contributory factor observed previously in take-off incidents and accidents.

5.3 Decision to reject

The decision to continue or reject should depend on the speed regime:

- Low speed regime;
- High speed regime below V1;
- Above V1.

5.3.1 Low speed regime

At low speed, i.e. below 100kt according to Airbus SOP, 80kt according to the involved Operator SOP, any ECAM warning or caution should be seriously considered for rejecting the take-off.
There were a number of systems events that occurred early in the take-off and that may have triggered the crew to reject in the low speed regime:

- Salient cues of improper configuration triggered early in the take-off (refer to §3.2)
- ECAM alert ENG THR LVRS NOT SET
    - Note: Rejecting in accordance with guidance "*seriously consider discontinuing the takeoff, if any ECAM warning/caution is activated*" was one of the 2 options to positively respond to this alert. The second one was pushing the thrust levers fully forward as instructed by the memo THR LEVERS…..TO/GA.

5.3.2 High speed regime below V1

When entering the high speed regime (passing 80kt according to the Operator SOP), the audio-alert "RETARD" activated. In this regime still below V1, Airbus SOP indicate that "*the Captain should be "go-minded" and very few situations should lead to the decision to reject the takeoff*". These are:

1. Fire warning or severe damage,
2. Sudden loss of engine thrust,
3. Malfunctions or conditions that give unambiguous indications that the aircraft will not fly safely,
4. Any red ECAM warning,
5. A few amber ECAM cautions, none relevant to this accident.

The unexpected audio-alert "RETARD" was not considered to be an unambiguous indication that the aircraft was not going to fly safely, so take off was continued.

Note: Considering that the audio-alert was spurious, the crew may have stopped it by the EMER CANC pushbutton (emergency cancel) of the ECAM control panel. Refer to §6.3.

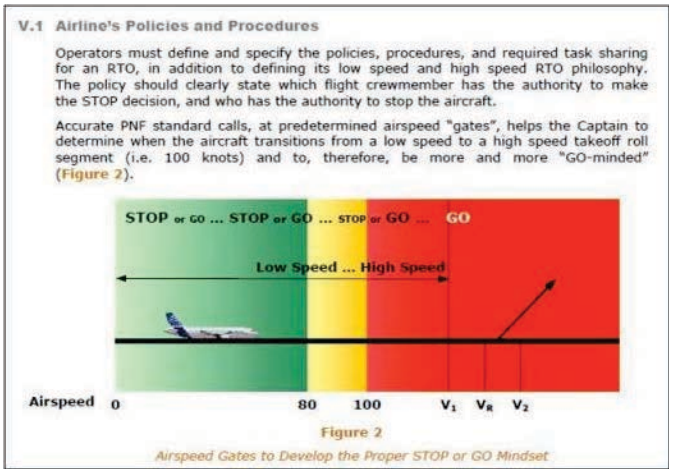
5.3.3 Above V1

Above V1, Airbus SOP indicate that "*take-off must be continued, because it may not be possible to stop the aircraft on the remaining runway*". Rejecting the take-off was no longer an option.

5.4 High speed regime policy

Airbus SOP define 100kt as the high speed policy threshold. The Operators policy defined 80kt.

The 100kt is not critical but result from a choice essentially based on the aircraft energy. Therefore 100kt is the recommended line; however adopted policies and procedures are an Operators' decision.



Information was provided to all Operators by means of Flight Operations Briefing Note "Takeoff and Departure Operations - Revisiting the "Stop or Go" Decision" which included the attached extract. The 80kt policy in place at the Operator at the date of flight 1702 matched the figure 2 of the FOBN. It was a valid option.

6. FLIGHT WARNING COMPUTER BEHAVIOR

6.1 Nominal flight phase increment

The flight phase increment by FWC for take-off is based on:

- Ground signal,
- Thrust levers position,
- Aircraft speed.

After engine start, FWC computes flight phase 3 when at least one thrust lever is set to the take-off position corresponding to FMS thrust configuration, i.e.:

- Thrust lever at FLX detent if a FLX TO TEMP has been entered (reduced take-off thrust);
- Thrust lever at TOGA detent if no FLX TO TEMP has been entered (maximum take-off thrust).

When the aircraft accelerates and reaches a speed of 80kt, FWC computes flight phase 4 until lift-off, when flight phase 5 is set.

Before landing below 800ft, FWC computes flight phase 7. At touchdown, ground condition sets flight phase 8. When aircraft decelerates below 80kt, FWC computes flight phase 9.

	Take-off		Landing	
	Flight phase 3	Flight phase 4	Flight phase 8	Flight phase 9
FWC conditions	GROUND 1st ENG TO PWR SPEED < 80kt	GROUND 1st ENG TO PWR SPEED > 80kt	GROUND NO ENG TO PWR SPEED > 80kt	GROUND NO ENG TO PWR SPEED < 80kt

ENG TO PWR = engine at take-off power

6.2 If thrust levers are not set for take-off

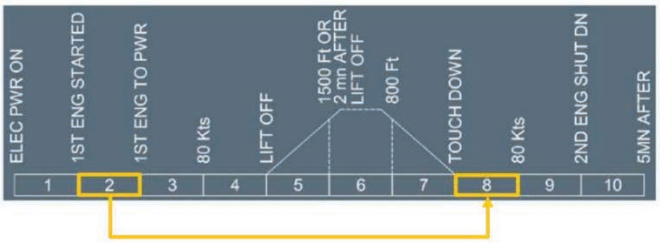
The condition 1st ENG TO PWR is not set when thrust levers are not advanced sufficiently to reach the take-off position corresponding to FMS thrust configuration, i.e.:

- Thrust levers below FLX detent if a FLX TO TEMP has been entered,
- Thrust levers below TOGA detent if no FLX TO TEMP has been entered.

As the aircraft accelerates during the take-off run, FWC does not compute flight phase 3 but stays in phase 2 in absence of corresponding thrust condition (1st ENG TO PWR not met). When aircraft reaches 80kt, FWC computes flight phase 8 on the basis of the 3 conditions:

- GROUND
- NO ENG TO PWR
- SPEED > 80kt.

Accordingly, the aircraft is declared in landing phase whereas it is taking off.



1st ENG TO PWR: Information taken from thrust lever position

6.3 Audio-alert RETARD during take-off

Audio-alert “RETARD” has been designed in order to remind the pilot to retard the thrust levers for landing.

When the aircraft accelerated beyond 80kt, the conditions for triggering the “RETARD” were met:

- LANDING (flight phase 8, refer to §6.2)
- THRUST LEVERS ABOVE IDLE (thrust levers were set to FLX/MCT).

The audio-alert, if considered spurious by the crew, may be stopped by pressing the EMER CANC pushbutton at the ECAM control panel.

6.4 Introduction of ECAM alert ENG THR LVRS NOT SET

ECAM alert ENG THR LVRS NOT SET triggering early at take-off was designed in order to crew to correct the thrust levers setting when they have not been advanced sufficiently to reach the position corresponding to FMS thrust configuration.

- Thrust levers below FLX detent if a FLX TO TEMP has been entered (reduced take-off thrust expected)
  - Associated action THR LEVERS…..MCT/FLX
- Thrust levers below TOGA detent if no FLX TO TEMP has been entered (maximum take-off thrust expected)
  - Associated action THR LEVERS…..TO/GA

This action restores the expected take-off performance, engages the take-off thrust mode (FLX MAN or TOGA).and the guidance modes (provided data has been entered in the FMS), and prevents unexpected audio-alert "RETARD" by setting the FWC condition "1st ENG TO PWR". FWC computes the corresponding take-off flight phases 3 and 4. Audio-alert "RETARD" is inhibited.

Note: In a scenario like flight 1702 when V-speeds are not entered in the FMS, setting take-off thrust does not engage the guidance modes due to absence of V2 to compute the SRS mode.

ECAM alert ENG THR LVRS NOT SET has been introduced since 2006 with FWC standard H2-F3. Later FWC standards H2-F5 and H2-F7 have been rendered mandatory and FWC have been subject to a retrofit monitored by Airbus. The vast majority of the fleet, over 94%, has embodied H2-F5 or H2-F7 standard therefore FWC providing subject alert. References are:

- FWC H2-F3 desirable SB A320-31-1267 dated Nov/06
- FWC H2-F5 mandatory SB A320-31-1334 dated July/09, EUAD-2011-0001, AD-2012-04-11
- FWC H2-F7 mandatory SB A320-31-1414 dated Dec/12, EUAD-2011-0001R1

As mentioned in §5.3.1, crews' response may be either to set the levers at the appropriate position or to reject the take-off since the alert triggers in the low speed regime. In the first case, flight phase is incremented and audio-alert "RETARD" inhibited.

This operational scenario and the dedicated ECAM alert ENG THR LVRS NOT SET were discussed with Airbus Operators during Flight Operations Conferences. They were also subject to written communication with In Service Information reference 31.50.00046. Refer to appendices 2 and 3.

7. IN-SERVICE EXPERIENCE

In order to support the investigation into flight 1702, Airbus ran a review of in-service experience of audio-alert "RETARD" experienced at take-off due to thrust levers not sufficiently advanced to reach the take-off position corresponding to FMS thrust configuration. It covered the period from beginning of year 2000 to mid-2014. The review is summarized in the following table:

In order to preserve confidentiality, Operators have been identified with a number (Op#). The number appearing several times indicates that the Operator has experienced several occurrences.

20 occurrences were reported to Airbus.

In all cases a rejected take-off was performed before V1.

The second column indicates what policy was in place within the involved Operator with regards to the high speed regime. Four Operators had the 80kt policy in place, 10 implemented the 100kt.

Three events occurred with aircraft having embodied the ECAM alert ENG THR LVRS NOT SET.

Year	Operator	80kt / 100kt	THR LVR NOT SET
2000	Op2	100kt	N
2000	Op5	80kt	N
2002	Op13	80kt	N
2006	Op1	no feedback	N
2006	Op3	no feedback	N
2006	Op4	100kt	N
2006	Op7	100kt	N
2006	Op13	80kt	N
2007	Op2	100kt	N
2007	Op6	100kt	N
2007	Op9	100kt	N
2008	Op3	no feedback	N
2008	Op11	no feedback	N
2008	Op14	80kt	N
2009	Op14	80kt	N
2010	Op6	100kt	N
2010	Op10	80kt	Y
2010	Op12	no feedback	Y
2012	Op5	80kt	N
2013	Op8	100kt	Y

8. PRODUCT ENHANCEMENTS

8.1 Prevent RETARD during take-off run: Flight Warning Computer

Refer to appendix 1, design enhancement.

Further to flight 1702, Airbus has investigated the possibility to introduce additional safety nets against the audio-alert “RETARD” triggering during take-off. Two options have been considered, both modifying the flight phase computation by FWC:

1. Getting benefit of the FADEC logic that automatically triggers TOGA within 8 seconds after setting thrust levers above climb position (logic called Auto-TOGA in this slide);
2. Reviewing the flight phase computation logic in order to match the take-off flight phase autonomously.

8.1.1 FWC acquiring Auto-TOGA signal

The first option is being implemented in service on aircraft fitted with FADEC standards that elaborate the Auto-TOGA function:

- It is not available on A318 fitted with PW6000 engines, on A330 fitted with TRENT700 engines, and on A380;
- It is basic on A350 and will be basic on A320NEO at entry into service;
- Availability for the rest of the fleet requires the combination of the following FWC and FADEC standards
    - A320 family fitted with FWC standard H2F8 and CFM56 FADEC standard 58T or V2500FADEC standard SCN22
    - A340-200/300 fitted with FWC standard L13 with CFM56 FADEC standard C3N
    - A330 fitted with FWC standard T5 and PW4000 FADEC standard SCN11 or CF6 FADEC standard E.1.P
    - A340-500/600 fitted with FWC standard T5 and TRENT500 FADEC standard L6

If the FWC sets the condition “NO ENG TO PWR” but the FADEC triggers the Auto-TOGA function, FWC will increment the flight phase to take-off, i.e. flight phases 3 or 4 depending on speed. Audio-alert “RETARD” will be inhibited.

8.1.2 Without Auto-TOGA signal

The modification of the logic has not been defined yet. Engineering studies are still going on in order to make sure that the modification of the logic does not impact other functionalities in a negative manner. The modification will be proposed after the consolidation phase has been completed.

8.2 Prevent taking-off with incomplete take-off data: Take-Off Securing Function

Take-Off Securing function (TOS) has been developed in order to check the consistency of data entered in the FMS automatically. A status on this system and on future evolutions was presented to Airbus Operators during March 2015 Flight Safety conference. The presentation is attached in appendix 4.

Among the functionalities provided by TOS, the one aiming at checking take-off speeds availability is relevant to flight 1702. If take-off speeds are not inserted, ECAM alert T.O SPEEDS NOT INSERTED

triggers, associated with a Master Caution and a Single Chime audio-alert in addition to message CHECK TO DATA displayed at MCDU in order to increase crew's awareness.

This function has been available since entry into service of the A350 and has been introduced with FMS L2 and FWS L52 on A380. It is under development for the A320 family, A330, and A340 fleets.

9. SUMMARY

9.1 Sequence of events - Systems

- Take-off was initiated without V-speeds (V1/VR/V2) and without FLX TO TEMP entered in the FMS.
- As a consequence, systems did not configure to take-off mode when thrust levers were set to FLX/MCT.
- There were salient cues that FMS was not configured for take-off and that the take-off modes did not engage:
    - At MCDU, no take-off data active and amber message CHECK TO DATA
    - At speed scale, no V-speeds, replaced by the red memo SPD SEL
    - At engine display, FLX and FLX TEMP not displayed
    - At FMA, non-engagement of take-off modes
    - At ECAM warning display, T.O INHIBIT and associated memos not displayed.
- Within 3 seconds in the take-off run, ECAM alert ENG THR LVRS NOT SET triggered with associated action THR LEVERS.....TO/GA.
- Within 8 seconds, TOGA thrust was set by the FADEC automatically.
- Thrust levers were moved back and repositioned in the FLX detent.
    - Not setting TO/GA prevented FWC computing take-off flight phases.
- At 80kt, FWC computed landing flight phase and triggered the audio-alert "RETARD".
    - Consistent with conditions (GROUND and NO ENG TO PWR and SPEED > 80kt)
- Take-off was continued.
    - The alert was not considered to unambiguously indicate that the aircraft will not fly safely.
    - The alert was not cancelled via the EMER CANC pushbutton.
- Decision speed V1 was passed.
- Rotation was performed at VR.
- Take-off was rejected.
- Investigation confirmed the nominal systems, performance, and handling qualities response of the aircraft.

9.2 Audio-alert "RETARD" during take-off

In order to prevent the unexpected triggering of the audio-alert "RETARD" during the take-off run, Airbus has designed an enhanced flight phase computation for aircraft fitted with FADEC that involve the automatic setting of take-off thrust. Embodiment requires the combination of FADEC and FWC by Operators as per the table shown in §8.

In order to optimize the flight phase computation when FADEC do not provide this automatic function, a FWC flight phase computation independent of FADEC is being investigated.

9.3 Take-off with no V-speeds at FMS

Take-Off Securing (TOS) introduces ECAM alert T.O SPEEDS NOT INSERTED in addition to message CHECK TO DATA displayed at MCDU in order to increase crew's awareness. This function, available on A350 and A380, is being developed for the rest of the fly-by-wire fleet.

10. PRIMARY SAFETY NETS WITH STANDARD OPERATING PROCEDURES

The design enhancements (refer to §8 and §9) are to be considered as additional safety nets; however prevention primarily relies on adherence to SOP, in particular:

- Checking and crosschecking the data entered in the FMS;
- Ensuring that late changes are fully assessed and completed;
- Processing the ECAM;
- Adhering to safety rules for continuing or rejecting the take-off.

APPENDICES

1. 2015 Airbus Flight Safety Conference: Rejected take-off above VR
2. 2012 Operational Liaison Meeting: Securing the Flexible Takeoff
3. 2013 In Service Information 31.50.00046 – RETARD call-out during T.O. acceleration
4. 2015 Airbus Flight Safety Conference: Future System Evolution – TOS/TOM extracts

21st Flight Safety Conference
Paris, 23-26 March 2015

Rejected Take-Off above VR

Event update

Presented by Albert Urdiroz

AIRBUS

Preliminary

- This event is being investigated in accordance with ICAO Annex 13
  - NTSB Investigator In Charge
  - BEA Accredited Representative
  - Airbus Technical Advisor
- The content of this presentation has been approved for release by the NTSB and BEA
- NTSB accident ID DCA14MA081

Content

- Background
- Event description
- Operational considerations
- Design enhancement

Background

- A320
- CPT PF / F/O PM
- 3200m / 10506ft long runway
- Take-off run
- V1, VR
- Rejected take-off
- Nose landing gear collapse
- Final stop at the edge of the runway
- Emergency evacuation
- No injuries
- Damaged beyond economical repair

Content

- Background
- Event description
- Operational considerations
- Design enhancement

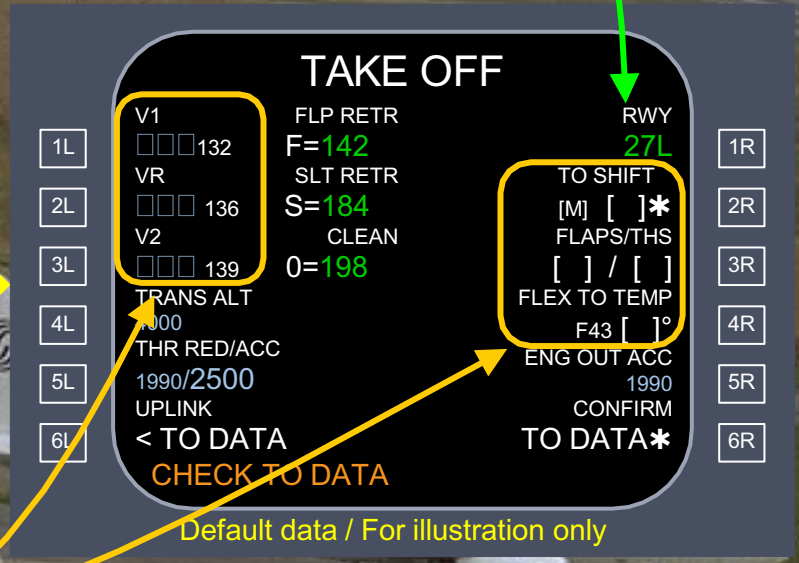
Runway data entered in FMS

Change in take-off sequence

FMS runway revised whilst entering the runway

☞ *Crew input:*

· *Late runway change at MCDU (27R ⇨ 27L)*



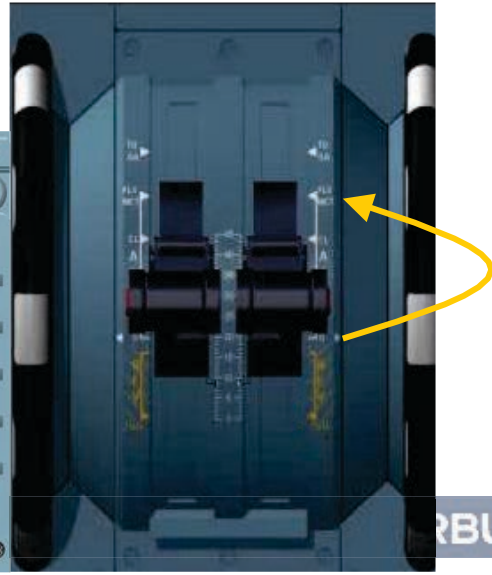
· TO DATA not re-entered

AIRBUS

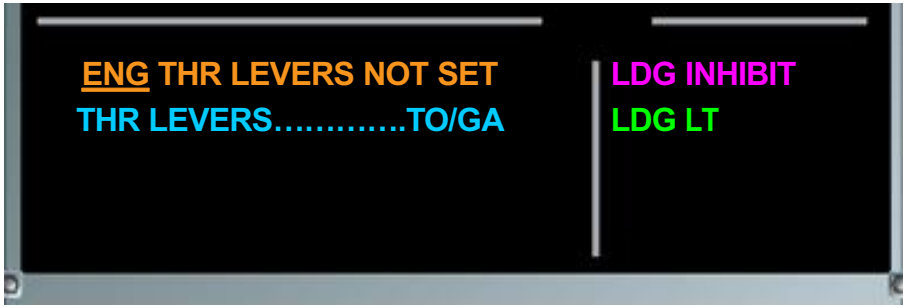
Sequence of events – Thrust levers

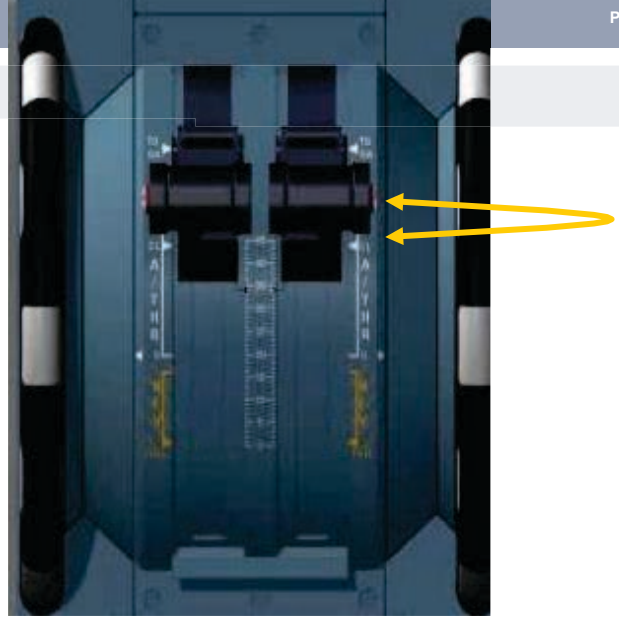
☞ *Crew input:*

- *Thrust levers set to FLX*
  - Without FLX TEMP entered in the FMS, TO modes did not engage
  - Crew noticed V-Speeds were not displayed
  - T/O was continued with the V-Speeds in mind



Sequence of events – Thrust levers





☞ *Crew input:*

- *Levers pulled back and then returned to FLX*

- FADEC automatically set TOGA
  - TO mode not engaged due to thrust levers setting
- *Crew action:*
- *Crew confirmed TOGA thrust values*

Sequence of events – Above 80kt

- Continuous audio alert “RETARD”

☞ *Crew action:*

- *Take-off continued*
- *V1 and VR from memory*
- *Aircraft rotated*
- *T/O rejected*

AIRBUS

Content

- Background
- Event description
- Operational considerations
- Design enhancement

Operational considerations - Flight and cockpit preparation according to SOP

- *FMGS Preparation*

  F-PLN A page.....COMPLETE AND CHECK

  FMS PREPARATION..... CHECK

- *Take-off briefing*

  TAKEOFF BRIEFING.....PERFORM

- *Before Start Clearance*

  FMS T.O DATA..... CHECK/REVISE AS RQRD

Extracts from FCOM PRO-NOR-SOP-06/07

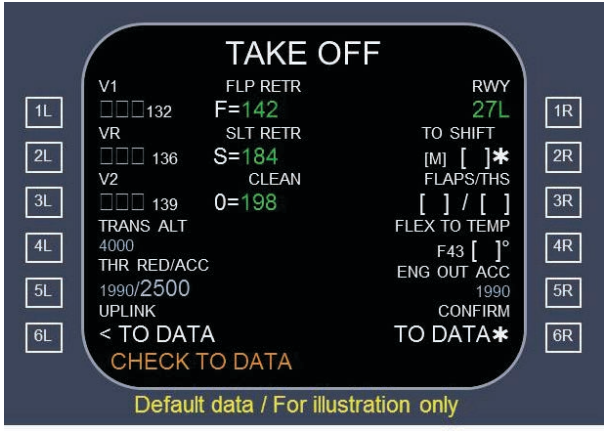
Check / Crosscheck

AIRBUS

Operational considerations - Late changes before take-off

- *Taxi*

If takeoff data has changed, or in case of a runway change, prepare updated takeoff data, as appropriate



F-PLN (Runway)..... REVISE

FLAPS lever .....AS APPROPRIATE

Select takeoff position

V1, VR, V2.....REINSERT

FLX TO temperature.....REINSERT

Be aware of pre-take-off pressure

Extract from FCOM
PRO-NOR-SOP-10

Operational considerations - Reject or continue?

- In the low speed regime (below 100kt per Airbus SOP / 80kt per this Airline SOP)
  - Seriously consider discontinuing the takeoff, if any ECAM warning/caution is activated
- In the high speed regime and below V1
  - Be more “go-minded”
  - Very few situations should lead to the decision to reject the takeoff
- Above V1
  - Takeoff must be continued

Content

- Background
- Event description
- Operational considerations
- Design enhancement

Why the continuous “RETARD”?

Without take-off thrust setting, FWC did not compute T/O phases (3, 4) but switched from phase (2) to landing phase (8)

1st ENG TO PWR: Information taken from thrust lever position

FWC enhancements considered versus FADEC standards

		Auto-TOGA available							Other aircraft			
A/C		A318/A319/A320/A321			A340 200/300	A330		A340 500/600	A350	Combination of FADEC and FWC not embodied	A318	A330	A380
		CEO		NEO									
ENG		CFM56	V2500	ALL	CFM56	PW4000	CF6	T 500	T XWB		PW6000	T 700	ALL
MOD1	FADEC	5BT	SCN22	Basic	C3N	SCN11	E.1.P	L6	Basic	N/A			
	FWC	H2F8 Oct/15		Basic	L13	T5			Basic				
	Principle	FWC to acquire AUTOTOGA condition from FADEC in order to increment Flight Phase: FP 2 → FP 3 or 4 (depending on speed)											
MOD 2		Under review: FWC Flight Phase process without FADEC information											

AIRBUS

Operational Liaison Meeting 2012

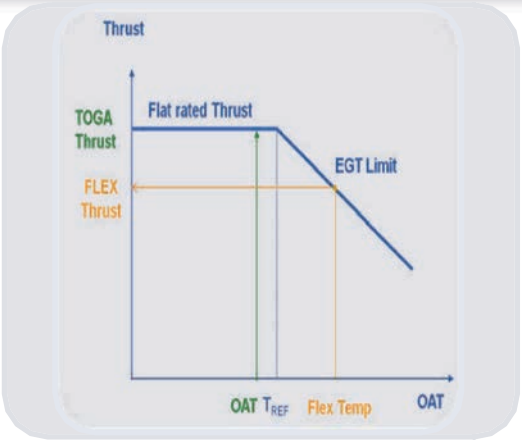
Securing the Flexible Takeoff

AIRBUS

Contents

Contents

FLEX Takeoff mode arming



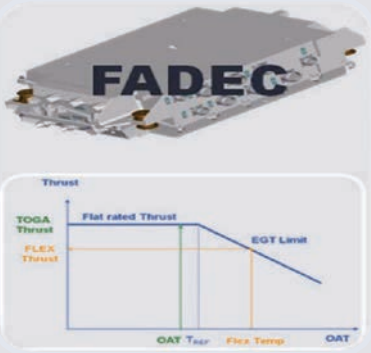
FLEX Temp. above OAT

Thrust levers at or above IDLE position

FLEX Temp. entered in the MCDU

Cockpit preparation | Engines start | Taxi | Takeoff

FLEX Takeoff mode armed engagement



FLEX takeoff mode armed

ENGINES RUNNING
TAT aircraft (ADIRU1/ADIRU2)
TAT engines (engine probes)

Thrust Levers in FLX/MCT position

TFLEX higher than OAT

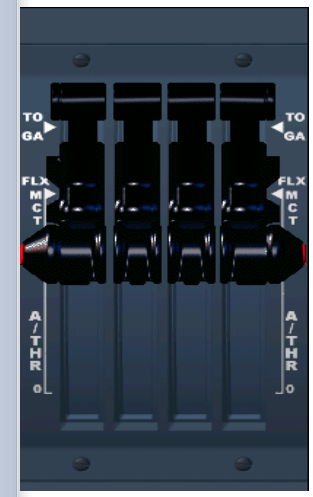
Cockpit preparation → Engines start → Taxi → Takeoff

Contents

ENG THR LEVERS NOT SET

Thrust Levers not in the appropriate detent for takeoff

- *The ENG THR LEVERS NOT SET triggers when thrust levers are not in the appropriate detent for takeoff*



ENG THR LEVERS NOT SET

Note: 1. *The takeoff thrust mode is engaged when the flight crew sets the thrust levers above the CL position.*

2. *The flex thrust mode is armed only if the flight crew entered a FLEX TO TEMP on the MCDU that is above the OAT.*

If the flex mode is not armed, and the flight crew sets the thrust levers below or at the MCT/FLX position:

THR LEVERS ..... TOGA

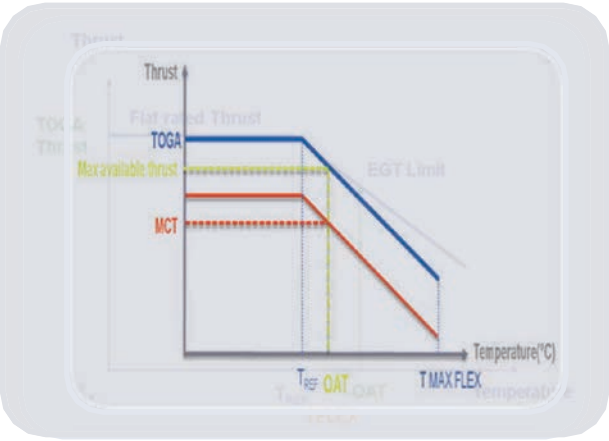
If the flex mode is armed, and the flight crew sets the thrust levers below the MCT/FLX position:

THR LEVERS ..... MCT/FLEX

// END

Contents

a. In-Service Occurrences - *Increase of OAT during taxi-out*



TFLEX entered in the MCDU

Thrust levers in FLX/MCT position

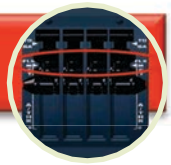
Takeoff at MCT Thrust

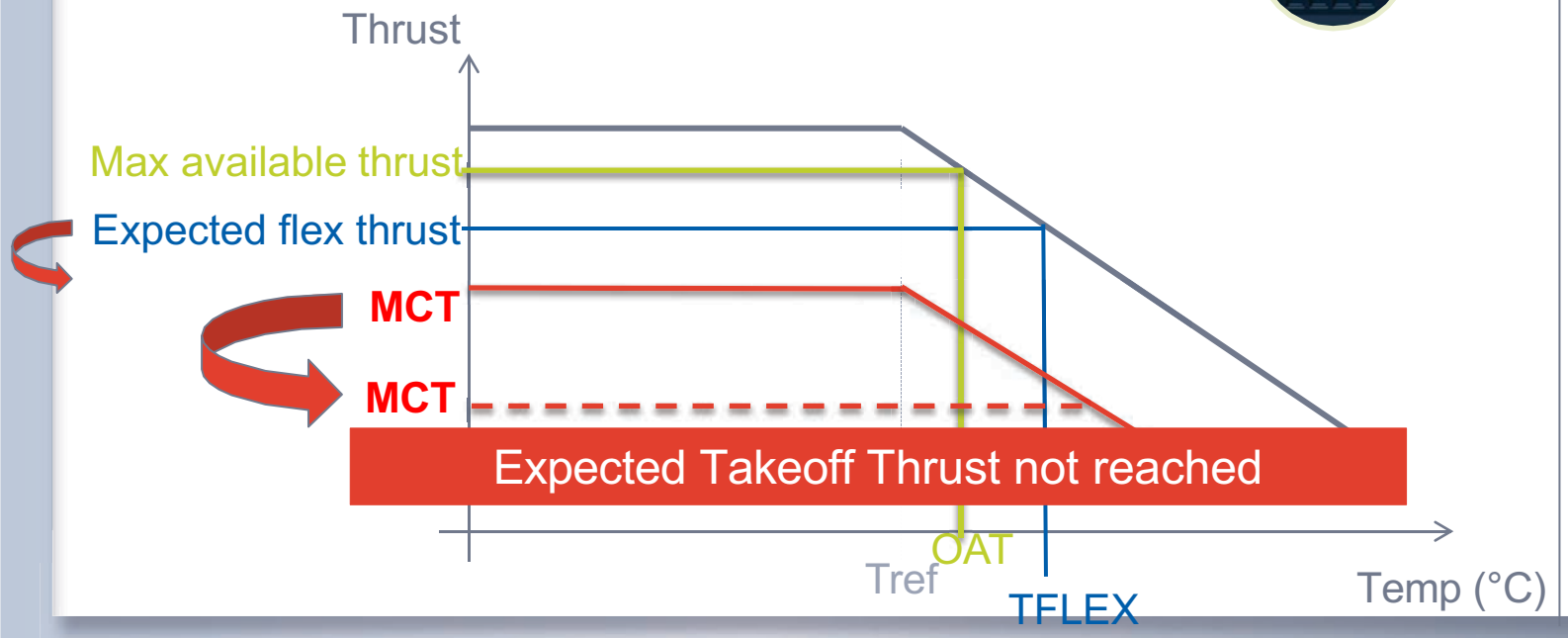
Cockpit preparation → Engines start → Taxi → Takeoff

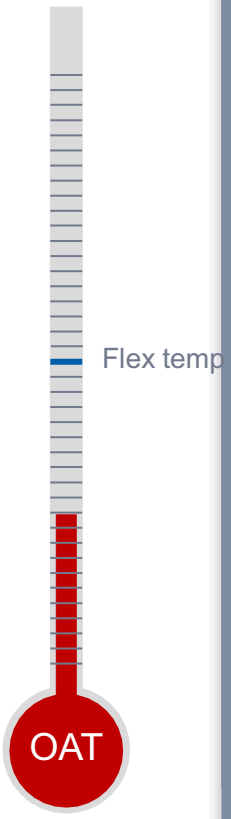
a. In-Service Occurrences - *Increase of OAT during taxi-out*

- FLEX takeoff disengaged
- Thrust levers in FLX/MCT detent
- ENG THR LEVERS NOT SET triggered

Takeoff at MCT thrust



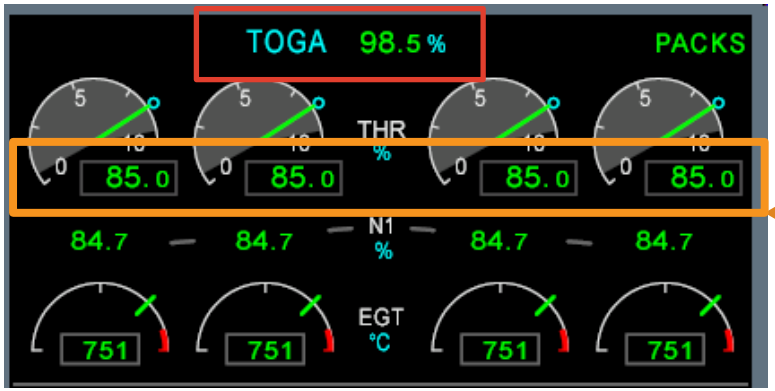




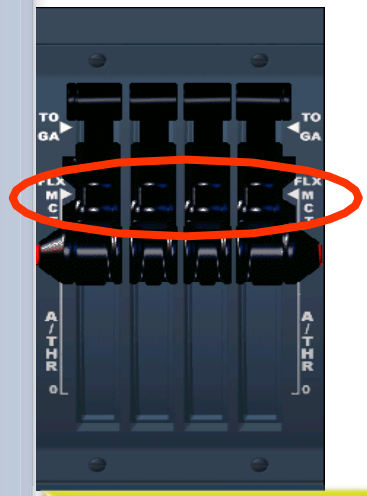
a. In-Service Occurrences – *Cockpit effects*

ENG THR LEVERS NOT SET

- *The FLEX takeoff mode disengages when OAT is higher than TFLEX*
- *The ENG THR LEVERS NOT SET triggers when thrust levers are not in the appropriate detent for takeoff*



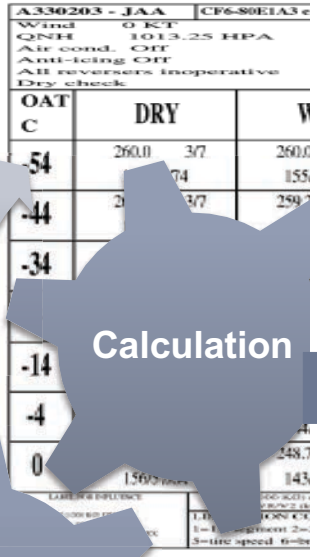
MCT



Cockpit preparation → Taxi → Before Takeoff → Monitor → Takeoff

b. Operational Recommendations - *SOPs*

- Pilots' Responsibility – Takeoff data



Calculation

Check

Con

BEFORE START

BEFORE TAKEOFF

PROCEDURES — **NCL.C3** — 30 MAY 12

BEFORE START	
COCKPIT PREP	COMPLETED (BOTH)
GEAR PINS and COVERS	REMOVED
SIGNS	ON/AUTO
ADIRS	NAV
FUEL QUANTITY	____KG LB
TO DATA	SET
BARO REF	____SET (BOTH)
WINDOWS/DOORS	CLOSED (BOTH)
BEACON	ON
THR LEVERS	IDLE
PARKING BRAKE	AS RQRD

AFTER START	
ANTI ICE	AS RQRD

BEFORE TAKEOFF	
FLIGHT CONTROLS	CHECKED (BOTH)
FLT INST	CHECKED (BOTH)
BRIEFING	CONFIRMED
FLAP SETTING	CONF____ (BOTH)
V1. VR. V2/FLX TEMP	____ (BOTH)
ATC	SET
ECAM MEMO	TO NO BLUE
- *SIGNS ON*	- *AUTO BRK MAX*
- *CABIN READY*	- *TO CONFIG NORM*
- *SPLRS ARMED*	
- *FLAPS TO*	
TAKEOFF RWY	____CONFIRM (BOTH)
CABIN CREW	ADVISED
TCAS	TA OR TA/RA
ENGINE START SEL	AS RQRD
PACKS	AS RQRD

AFTER TAKEOFF / CLIMB	
LDG GEAR	UP
FLAPS	RETRACTED
PACKS	ON
BARO REF	____SET (BOTH)

APPROACH	
BRIEFING	CONFIRMED
ECAM STATUS	CHECKED
SEAT BELTS	ON
BARO REF	____SET (BOTH)
MINIMUM	____SET (BOTH)
ENG START SEL	AS RQRD

LANDING	
CABIN CREW	ADVISED
A/THR	SPEED/OFF
AUTOBRAKE	AS RQRD
ECAM MEMO	LDG NO BLUE
- *SIGNS ON*	- *FLAPS LDG*
- *CABIN READY*	- *SPLRS ARMED*
DG GEAR DN	

AFTER LANDING	
FLAPS	RETRACTED
SPOILERS	DISARMED
APU	START
RADAR	OFF/STBY
PREDICTIVE WINDSHEAR SYSTEM	OFF

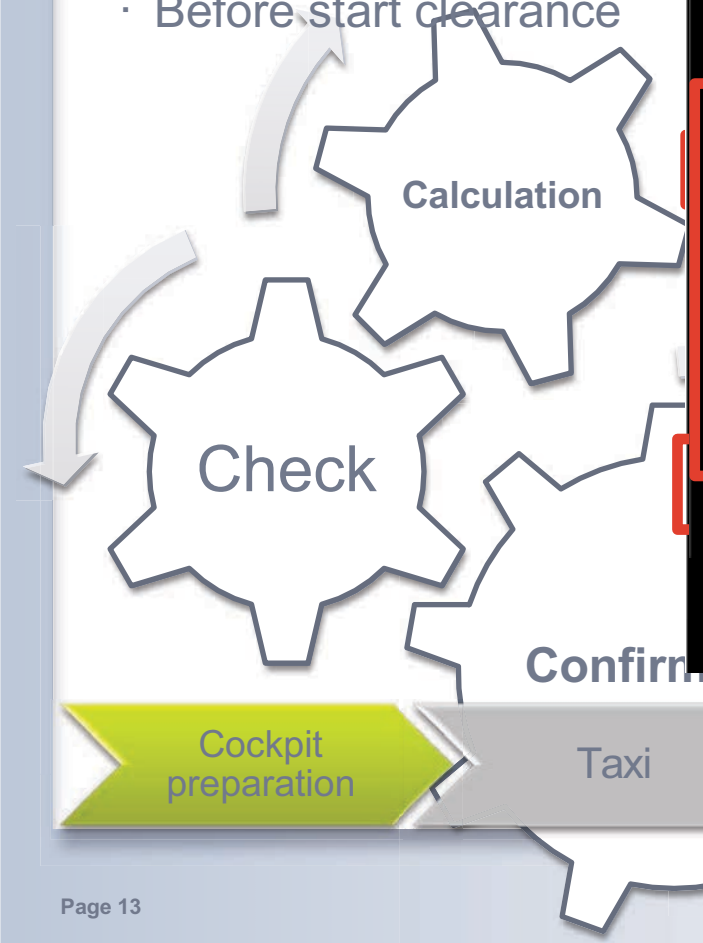
PARKING	
APU BLEED	ON
ENGINES	OFF
SEAT BELTS	OFF
EXT LT	AS RQRD
FUEL PUMPS	OFF
PARK BRK AND CHOCKS	AS RQRD

SECURING THE AIRCRAFT	
ADIRS	OFF
OXYGEN	OFF
APU BLEED	OFF
EMER EXIT LT	OFF
SIGNS	OFF
APU AND BAT	OFF

b. Operational Recommendations - *SOPs*

BEFORE START

- FMGS data Insertion
- FMGS data confirmation
- Before start clearance



Cockpit preparation | Taxi | Before Takeoff

AIRBUS
A330/A340
QUICK REFERENCE HAND BOOK

NORMAL PROCEDURES

NCL.C3
30 MAY 12

BEFORE START

COCKPIT PREP	COMPLETED (BOTH)
GEAR PINS and COVERS	REMOVED
SIGNS	ON/AUTO
ADIRS	NAV
FUEL QUANTITY	KG LB
TO DATA	SET
BARO REF	____SET (BOTH)
WINDOWS/DOORS	CLOSED (BOTH)
BEACON	ON
THR LEVERS	IDLE
PARKING BRAKE	AS RQRD

TAKEOFF D
Once the k
- The PN
flexible
- The PF
flexible
Take pa
Confirm
- The PF
PERF pa

*F-PLN A page
- Select the EFIS CSTR
accuracy.

- SIGNS ON
- CABIN READY
- SPLRS ARMED
- FLAPS TO
- AUTO BRK MAX
- TO CONFIG NORM

TAKEOFF RWY	____CONFIRM (BOTH)
CABIN CREW	ADVISED
TCAS	TA OR TA/RA
ENGINE START SEL	AS RQRD
PACKS	AS RQRD

AFTER TAKEOFF / CLIMB

LDG GEAR	UP
FLAPS	RETRACTED
PACKS	ON
BARO REF	____SET (BOTH)

EXT LT	AS RQRD
FUEL PUMPS	OFF
PARK BRK AND CHOCKS	AS RQRD

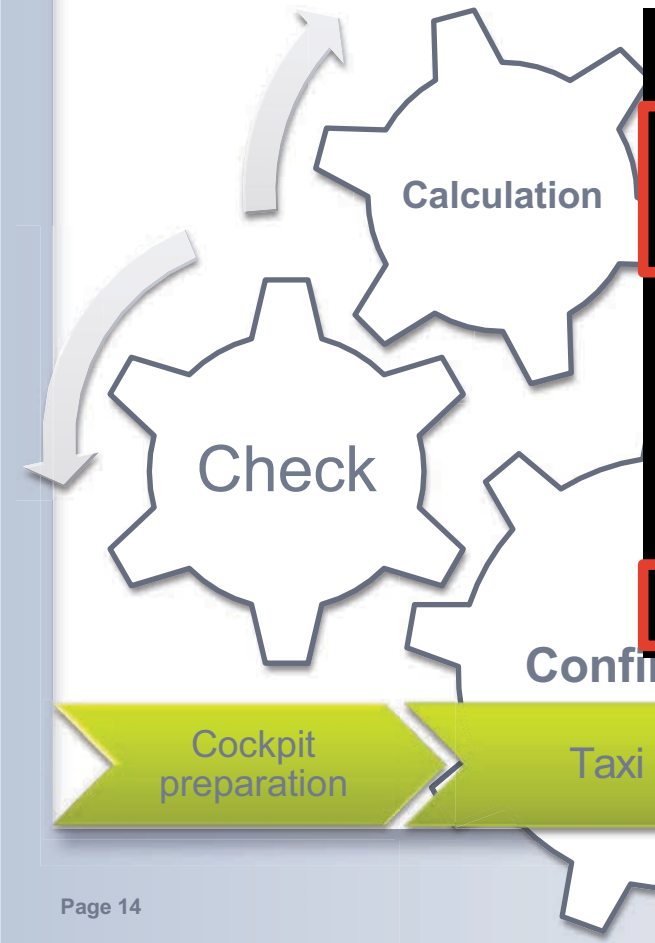
SECURING THE AIRCRAFT

ADIRS	OFF
OXYGEN	OFF
APU BLEED	OFF
EMER EXIT LT	OFF
SIGNS	OFF
APU AND BAT	OFF

b. Operational Recommendations - *SOPs*

BEFORE TAKEOFF

- TAXI
- *Note :Takeoff data change includes OAT changes*



TAXI - TAKEOFF DATA/CONDITIONS

TAKEOFF DATA/CONDITIONS

If the takeoff data has changed, or in the case of a runway change, prepare updated takeoff data and, as appropriate :

F-PLN (Runway) ..... REVISED

FLAP lever ..... AS APPROPRIATE
Select takeoff position.

V1, VR, V2 ..... REINSERT

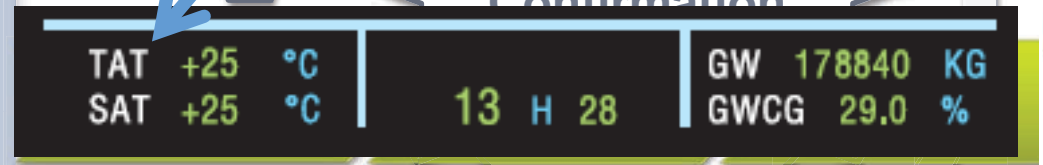
FLEX TO temperature ..... REINSERT

Cockpit preparation | Taxi | Before Takeoff | Monitor | Takeoff

b. Operational Recommendations - *SOPs*

BEFORE TAKEOFF

- Check **TFLEX on E/WD**
- Check that **FLEX Takeoff mode is still arm**
- If **TFLEX close to OAT**, check **TFLEX vs C**



AIRBUS A330/A340 QUICK REFERENCE HAND BOOK | NORMAL PROCEDURES | NCL.C3 | 30 MAY 12

BEFORE TAKEOFF

FLIGHT CONTROLS	CHECKED (BOTH)
FLT INST	CHECKED (BOTH)
BRIEFING	CONFIRMED
FLAP SETTING	CONF (BOTH)
V1. VR. V2/FLX TEMP	_____ (BOTH)
ATC	SET
ECAM MEMO	TO NO BLUE

- *SIGNS ON*
- *CABIN READY*
- *SPLRS ARMED*
- *FLAPS TO*
- *AUTO BRK MAX*
- *TO CONFIG NORM*

TAKEOFF RWY	_____ CONFIRM (BOTH)
CABIN CREW	ADVISED
TCAS	TA OR TA/RA
ENGINE START SEL	AS RQRD
PACKS	AS RQRD

LDG GEAR	UP
FLAPS	RETRACTED
PACKS	ON
BARO REF	____ SET (BOTH)

APU AND BAT ..... OFF

b. Operational Recommendations - *SOPs*

Prior to LINE-UP

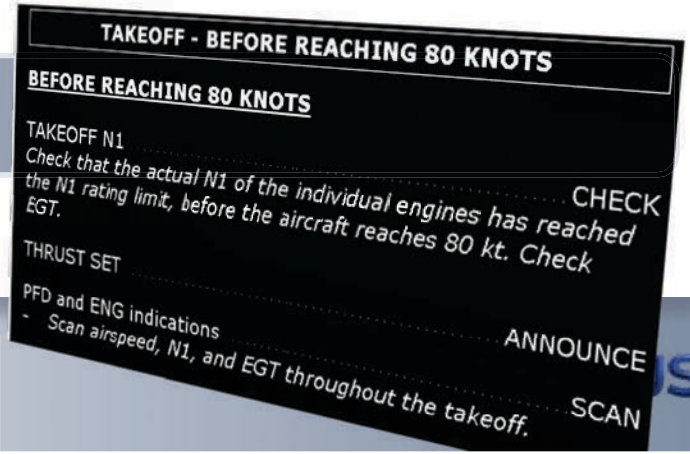
- **Monitor TFLEX** and **FLEX takeoff mode** arming
- **Anticipate** any increase of OAT above TFLEX and/or FLE disengagements
  - ❖ *Steady OAT increase*
  - ❖ *Transient OAT increases can be experienced (Dark t… pavement, exhaust from preceding aircraft, Bad probe ventilation...)*

FMA callout

- **Announce** FMA thrust mode: *MAN TOGA or MAN FLX*

Thrust set

- **Check** thrust rating limit versus actual thrust of



b. Operational Recommendations - *Summary*

Performance

- Performance calculation for the actual takeoff conditions
- Pilot's responsibility : computation/checks/confirmation

Anticipate an OAT increase

- Pavement, shadow, other aircraft exhaust
- Desertic/Mountainous area with rising sun, time of the day, weather

TFLEX checks

- **TFLEX** higher than **OAT**
- **TFLEX** higher than **TREF**
- **TFLEX** below or equal to **TMAX FLEX**

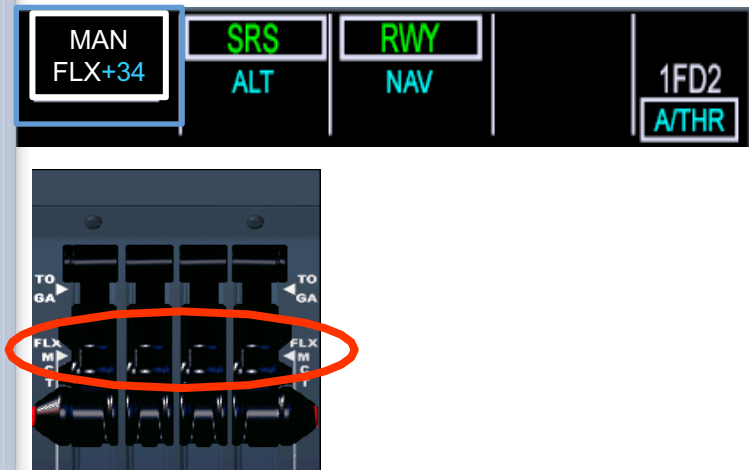
TFLEX margin

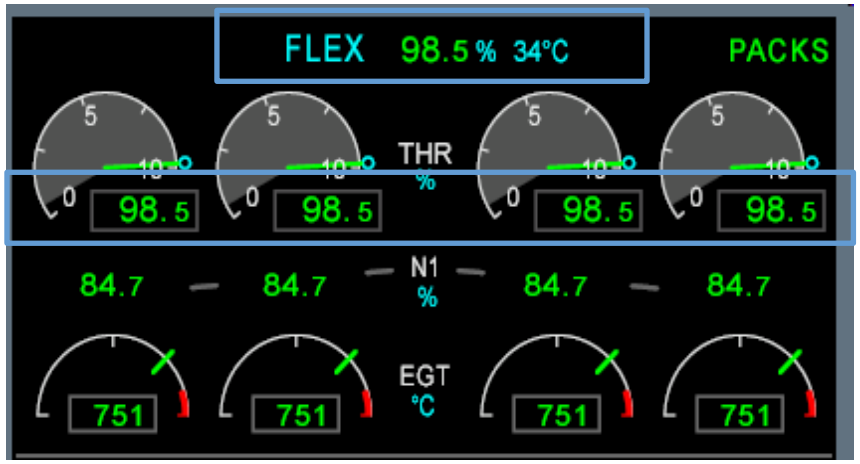
- No additional margin on the performance computation
- Operators policy for OAT increase anticipation

c. Systems Logics

New FADEC logic

- *The FLEX takeoff mode remains engaged when OAT is higher than TFLEX in order to cover small OAT variations during takeoff.*
- *The FADEC will provide the maximum thrust available for actual conditions instead of reverting to MCT thrust (previous FADEC) up to TFLEX+10°C.*





Cockpit preparation | Taxi | Before Takeoff | Monitor | Takeoff

c. Systems Logics

New FADEC logic

- *The FADEC checks TFLEX versus ADIRUs TAT parameters*

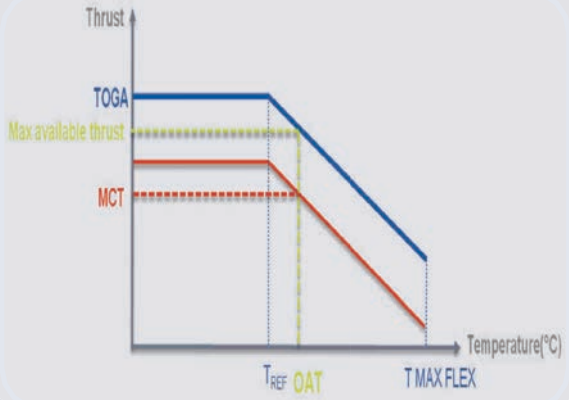
TAT aircraft
(ADIRU1/ADIRU2)

New FADEC and FWC logic

- *In case of erroneous TFLEX entry, the new ENG SAT ABV FLEX TEMP ECAM caution triggers during taxi .*
- *The ECAM caution requires to check the takeoff data*

Contents

a. In-Service Occurrences



No TFLEX entered in the MCDU

Thrust levers in FLX/MCT position

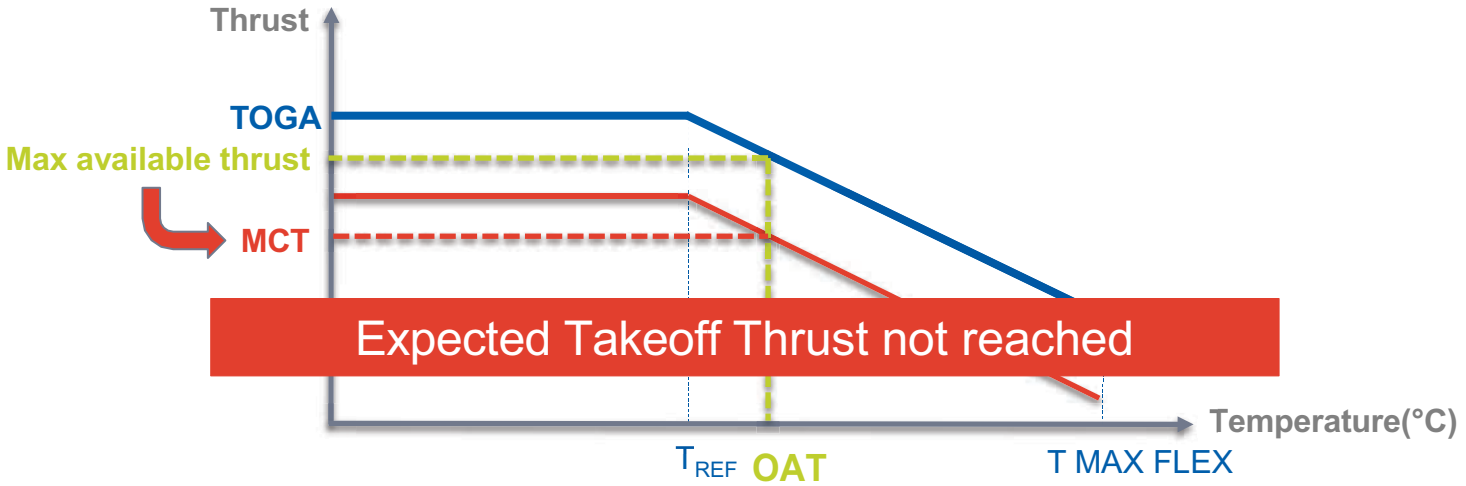
Takeoff at MCT Thrust

Cockpit preparation → Engines start → Taxi → Takeoff

a. In-Service Occurrences

- FLEX takeoff mode not armed
- Thrust Levers in FLX/MCT detent
- ENG THR LEVERS NOT SET triggered

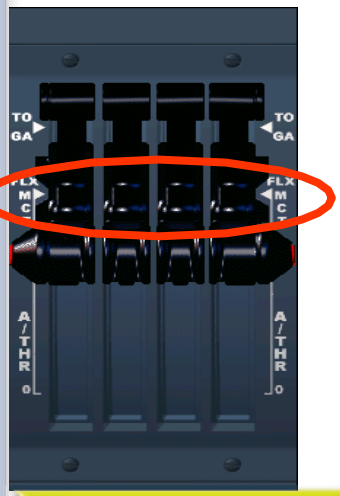
Takeoff at MCT Thrust

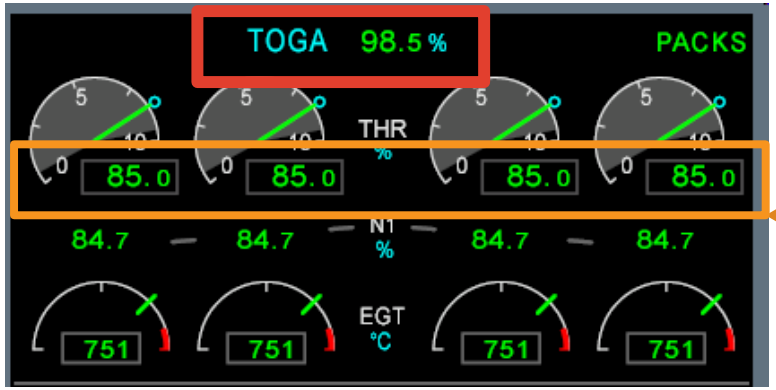


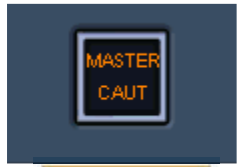
a. In-Service Occurrences – *Cockpit effects*

Thrust Levers not in the appropriate detent for takeoff

- *The ENG THR LEVERS NOT SET triggers when thrust levers are not in the appropriate detent for takeoff*
- *No FLEX Temp. entered in MCDU. FLEX takeoff mode not armed*







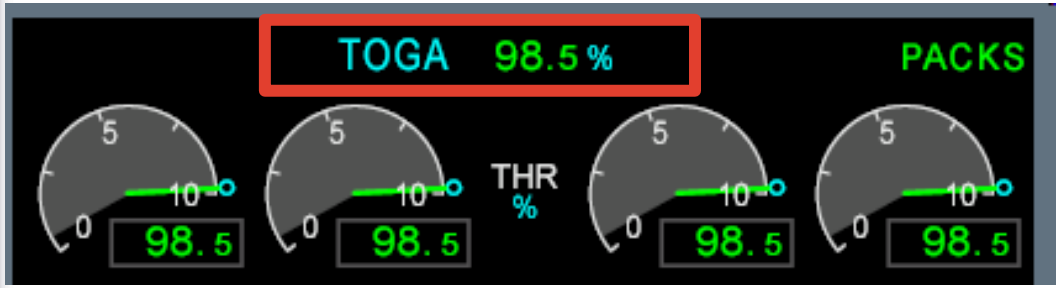
MCT

Cockpit preparation → Taxi → Before Takeoff → Monitor → Takeoff

b. Operational Recommendations - *SOPs*

Takeoff briefing

- Highlight the takeoff thrust setting



AIRBUS | NORMAL PROCEDURES | NCL.C3

BEFORE START | APPROACH

BEFORE TAKEOFF

FLIGHT CONTROLS	CHECKED (BOTH)
FLT INST	CHECKED (BOTH)
BRIEFING	CONFIRMED
FLAP SETTING	CONF ____ (BOTH)
V1. VR. V2/FLX TEMP	____ (BOTH)
ATC	SET
ECAM MEMO	TO NO BLUE

- *AUTO BRK MAX*
- *SIGNS ON*
- *CABIN READY ( )*
- *SPLRS ARM*
- *FLAPS TO*
- *TO CONFIG NORM*

TAKEOFF RWY	____ CONFIRM (BOTH)
CABIN CREW	ADVISED
TCAS	TA OR TA/RA
ENG MODE SEL	AS RQRD
PACKS	AS RQRD

Cockpit preparation | Taxi | Before Takeoff | Monitor | Takeoff

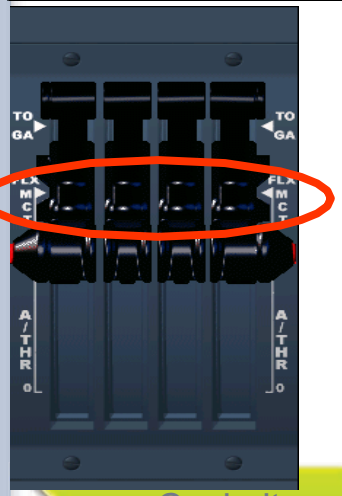
c. Systems Logics

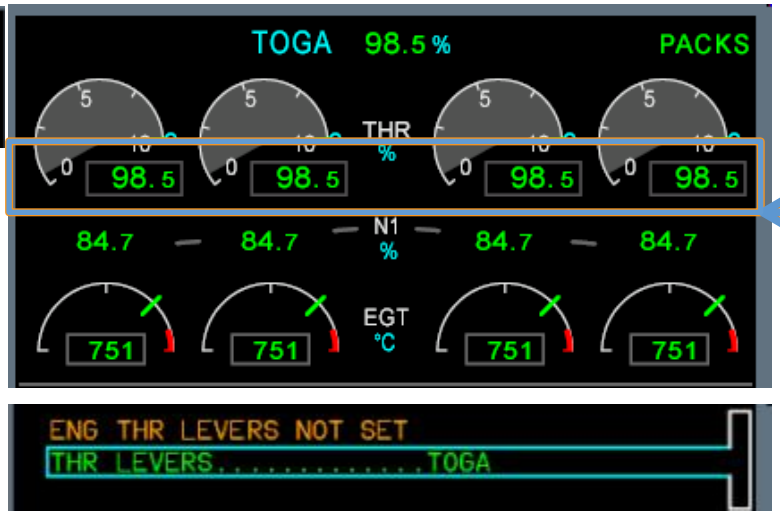
New FADEC logic

- *In order to avoid takeoff at Maximum Continuous thrust (MCT), if pilot s do not move thrust levers, the FADEC will **automatically select TOGA thrust after 8 seconds**.*

New FG and EIS standard

- ***LVR TOGA** flashes on the FMA*

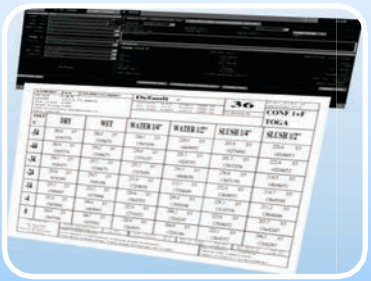




After 8s TOGA

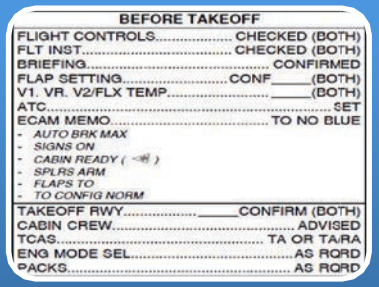
Cockpit preparation → Taxi → Before Takeoff → Monitor → Takeoff

Conclusion



Performance Computation

- Flight crew responsibility
- Check that the conditions for which the performance calculations have been performed are still valid



Operational Recommendations - SOPs

- Anticipate outside conditions variations
- When TFLEX close to OAT: check TFLEX vs. OAT up to the line-up

New systems logics

- To prevent takeoff at Maximum Continuous Thrust (MCT)

Appendix - New systems logics standard

FADEC / FWC standard

· *The new FADEC logics are implemented with the latest FADEC standard*

Engines	FADEC	FWC	availability
CFM56-5A/5B (SA)	5BS	H2F6	Q1 2012
IAE V2500 (SA)	SCN22	H2F6	Q4 2013
PW6000 (A318)	Post A.10.0	H2F6	-
GE (A330)	E1P	T4	Q1 2012
TRENT 700 (A330)	Post A14.1	T4	-
PW4000 (A330)	SCN11	T4	Q1 2012
TRENT 500 (A3456)	L6	T4	Q4 2013
CFM56-5C (A3423)	Post C3-M	L12	-

ENG SAT ABOVE FLEX TEMP

· *The ECAM caution is implemented with the combination of both FADEC and FWC latest standard*

Appendix - New systems logics standard

LVR TOGA flashes on FMA

- *The LVR TOGA is implemented with both FG and EIS 2 standard*

Engines	FG	EIS 2	availability
A330 PW/RR	T4HJ2	L8	Q4 2013
A330 GE	T4G2	L8	Q3 2014
A3456	T4K3	L8	-

Flight Warning Computer (FWC) - RETARD call-out during T.O. acceleration

Reference: **31.50.00046** First Issue Date: **14-AUG-2008** Last Publication Date: **28-DEC-2013**

ATA: **31-50** A/C Type : **A318 ; A319 ; A320 ; A321**

Old Wise Ref:
engsup-1686

Engineering Support

First Issue Date: **14-AUG-2008** Last Publication Date: **28-DEC-2013**

Description

Several operators performed Rejected Take-Off due to "RETARD" call-out during acceleration.

Solution

The auto call out "RETARD" is normally triggered on landing phase (flight phase 8) when the following conditions are gathered:

- aircraft speed is above 80kts,
- AND both thrust levers are not set to idle,
- AND TOGA or FLEX MODE not engaged (GO AROUND operation).

However, a call out "RETARD" may be unduly generated during TO roll due to a wrong flight phase computation by the FWC. Wrong flight phase computation may be due to an abnormal thrust setting (i.e. no engines recognized at TO power by the FWC).

Flight phase 2 is computed as soon as one engine is started.
Flight phase 3 is calculated whether one or another TLA is at "TO POWER" condition
Flight phase 4 is calculated if A/C speed is > 80 kts.

Logics for triggering "TO POWER" condition of the engines depend on the type of TO realised:

- for a normal TO: Thrust Lever Angle (TLA) is at TOGA position (i.e. above 43.3 degrees) OR N1 is above 95%
- for a FLEX or DERATED TO: TLA is at MCT position (i.e. from 33.33 to 36.67 degrees)

So, if the take-off is initiated with an abnormal thrust setting (i.e. no engines at TO power), during the acceleration phase, FWC stay in flight phase 2 and does not enter into flight phase 3 because of too low TLA and too low N1. When over 80 kts, the FWC leaves the flight phase 2 for excessive speed and computes the flight phase 8 corresponding to a landing roll.

The "RETARD" call out is therefore triggered at around 80 kts. Please note that the "RETARD" call out is NOT associated with Master Caution or Master Warning lights. This scenario can be confirmed by DFDR data analysis with N1 and thrust lever position parameters. Similar events were confirmed by other operators through data analysis.

Hence the "RETARD" call out experienced during TO roll is supposed to be linked to a wrong aircraft flight phase computation by FWCs due to throttles position not set in TO POWER condition (TO/GA or FLX/MCT TLA positions). Finally, if confirmed, this FWC behavior does not correspond to a failure

but is a normal operation due to the TLA configuration. So, there is no troubleshooting procedure to be applied at FWC level.

In order to confirm above scenario, Airbus would like to be provided with the following additional data:

- DFDR or DAR or QAR data (format as specified in SIL 00-086 enclosed)
- LRU ident of FWS as per AMM 31-50-00
- TSDs (TroubleShooting Data) of FWS as per AMM 31-50-00
- PFR of the RTO

In addition, please check calibration of the Throttle Control by performing a parameter ALPHA call-up of the TLA (label 133 of the ECU) in order to confirm the throttle position with the input sent to ECU.

EQ SYS LAB SDI:
TLA1 7C 1 133 01 - DEG TLA (THROTTLE RESOLVER ANGLE) SYS.1
TLA2 7C 2 133 10 - DEG TLA (THROTTLE RESOLVER ANGLE) SYS.2

Expected angular values are provided below in degrees:

Idle -> 0
MCL -> 25
MCT -> 35
TO -> 45

These values will then be analysed by Airbus to assess that calibration is good or not based on resolvers measurement tolerances.

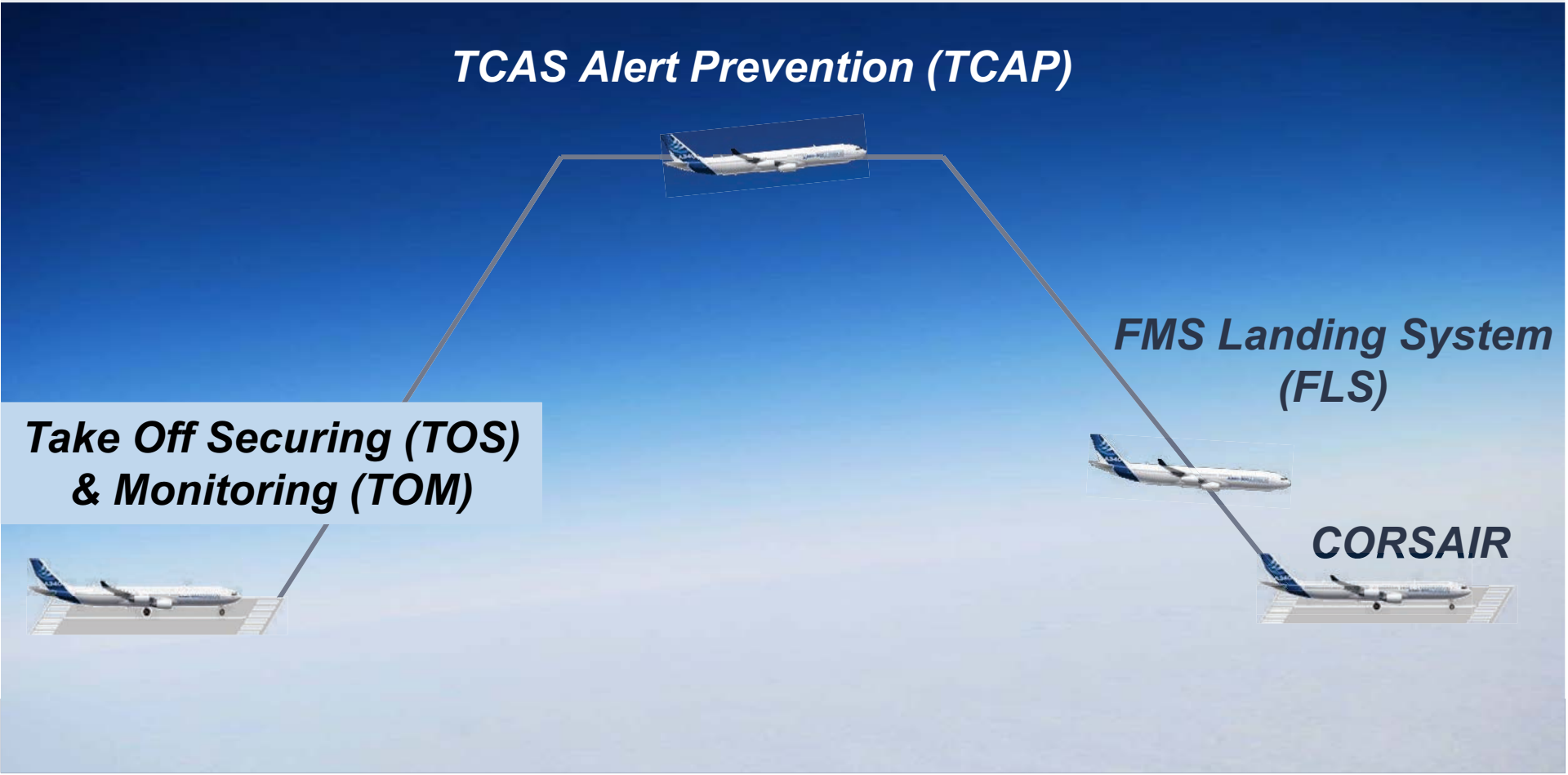
In FWC standards prior to H2-F3, the alert "*ENG THR LEVERS NOT SET*" (triggered if the Thrust Levers position is not correct during Take-Off) was displayed only if the Derated Take-Off option was installed. Note that since the H2-F3 standard (available through SB 31-1267), this alert is triggered whatever the Derated Take-Off option is installed or not. Derated Take-Off option is activated through pin-programming at FMCG level and requires minimum standards of FADEC, FMCG and FWC. Since H2-F3P standard, this type of event described would results in "*ENG THR LEVERS NOT SET*" ECAM alert triggering.

21st Flight Safety Conference
Paris, 23-26 March 2015

Future System Evolution

Presented by Eric JEANPIERRE

Future System Evolution



TOS (Take Off Securing)

Detect gross inconsistency between take-off parameters inserted in FMS
To reduce risks of tail strike and runway overrun

- ✓ Check to catch entry errors on **ZFW range**
- ✓ Checks to catch entry errors on **TO speeds**

AUDIO

T.O SPEEDS TOO LOW
TOW AND T.O DATA……CHECK

ECAM

AIRBUS

TOS (Take Off Securing)

Detect gross inconsistency between take-off parameters inserted in FMS
To reduce risks of tail strike and runway overrun

- ✓ Check to catch entry errors on **ZFW range**
- ✓ Checks to catch entry errors on **TO speeds**
- ✓ Check to detect **TO speeds not inserted**

AUDIO

T.O SPEEDS NOT INSERTED

ECAM

AIRBUS

TOS (Take Off Securing)

To reduce risks of tail strike and runway overrun

✓ Check to detect inappropriate **trim setting or high lift configuration setting**

+

AUDIO

F/CTL PITCH TRIM/MCDU/CG DISAGREE

ECAM

TOS (Take Off Securing)

To reduce risks of tail strike and runway overrun

✓ Check to detect inappropriate **trim setting or high lift configuration setting**

+

AUDIO

F/CTL FLAP/MCDU DISAGREE

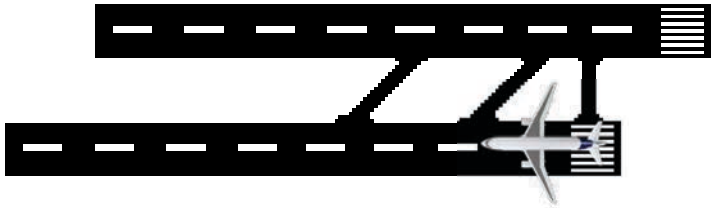
ECAM

Next evolutions of TOS function

To minimize risks of take-off from wrong runway or from taxiway

✓ **A/C position check** performed at take-off power setting

1) A/C on a runway ≠ FMS departure runway



FMS departure runway

NAV NOT ON FMS RUNWAY

ECAM

2) A/C not on runway

NAV ON TAXIWAY

ECAM

Next evolutions of TOS function

To minimize risks of runway overrun

✓ **Take off distance check** to ensure A/C has sufficient runway to perform a safe take-off

Lift-off distance > Runway length available

PREFLIGHT

TAKE-OFF CONFIG TEST

T.O RWY TOO SHORT

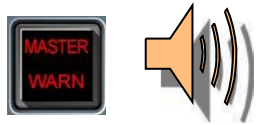
TOW AND T.O DATA.....CHECK

ECAM

TAKE-OFF POWER SETTING

T.O RWY TOO SHORT

ECAM



AIRBUS

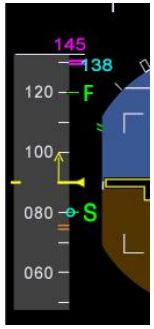
TOM (Take Off Monitoring)

To minimize risks of runway overrun or tailstrike due to:

- Degraded aircraft performance (Low thrust, residual braking, aero degradation, wrong TO weight)
- Unusual level of contamination on the runway

✓ Monitoring **aircraft acceleration** during take off

TAKE-OFF POWER SETTING



CAS 90kt

T.O ACCELERATION DEGRADED

ECAM

AIRBUS