The Airbus safety magazine

#29

Safety first

AIRBUS

Safety first, #29 January, 2020. Safety first is published by Airbus S.A.S. - 1, rond point Maurice Bellonte - 31707 Blagnac Cedex/France.
Publisher and Editor: Yannick Malinge,
Chief Product Safety Officer.
Concept Design by Airbus MultiMedia Studio 20192534. Reference: X00D16031905 Issue 29.
Photos by Airbus, S. Ramadier, BlackJack3D, P. Masclet, C. Koshorst, J. Cahill, P. Pigeyre, Mirko Macari / EyeEm, A. Tchaikovski, H. Goussé.
Computer rendergins by Fixion.

This brochure is printed on Symbol Tatami White. This paper is produced in factories that are accredited EMAS and certi ed ISO 9001-14001, PEFC and FSC CoC. It is produced using pulp that has been whitened without either chlorine or acid. The paper is entirely recyclable and is produced from trees grown in sustainable forest resources.
The printing inks use organic pigments or minerals. There is no use of basic dyes or dangerous metals from the cadmium, lead, mercury or hexavalent chromium group.
The printer, Art & Caractère (France 81500), is engaged in a waste management and recycling programme for all resulting by-products.

Editorial Team

Guillaume ESTRAGNAT	Timothy ROACH
	

Safety first

The Airbus magazine contributing to the enhancement of the safety of aircraft operations by increasing knowledge and communication on safety related topics.

Safety first is published by the Product Safety department. It is a source of specialist safety information for the use of airlines who fly and maintain Airbus aircraft. It is also distributed to other selected organizations and is available on digital devices.

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

All articles in Safety first are presented for information only and are not intended to replace ICAO guidelines, standards or recommended practices, operator-mandated requirements or technical orders. The contents do not supersede any requirements mandated by the State of Registry of the Operator’s aircraft or supersede or amend any Airbus type-specific AFM, AMM, FCOM, MMEL documentation or any other approved documentation.

Articles may be reprinted without permission, except where copyright source is indicated, but with acknowledgement to Airbus. Where Airbus is not the author, the contents of the article do not necessarily reflect the views of Airbus, neither do they indicate Company policy.

Contributions, comment and feedback are welcome. Enquiries related to this publication should be addressed to:

Airbus
Product Safety department (GS)
1, rond point Maurice Bellonte
31707 Blagnac Cedex - France
Fax: +33(0)5 61 93 44 29

safetycommunication@airbus.com

Visit us at safetyfirst.airbus.com or install the Safety first app:

editorial

YANNICK MALINGE

SVP & Chief
Product Safety Officer

Dear Aviation colleagues,

As we begin a new decade, we can reflect on the last 10 years that show the continually decreasing accident rates decade upon decade. Flying is safer today than ever before, even when faced with the constant growth of our industry. Unlike some of the commentary about aviation safety issues, which may present differing perspectives, the facts show that the most significant improvements in the safety of flight are evident over the last 20 years. However this does not mean we can be complacent as it is clear that society expects zero accidents, and this must be our goal.

Prevention of aviation accidents is a long journey that we started many years ago and together with all key actors. Sustaining aircraft and technological evolutions towards safer operations, strengthening competencies with innovative training solutions, fostering a speak-up culture, and sharing safety strategies are our key enablers. By applying a proactive risk management mindset, implementing safety enhancements as appropriate and in a pragmatic way, we are reinforcing the trust of the flying public by making air travel even safer again in the next decade.

Through sharing safety information in this issue of the Safety first magazine, we begin 2020 as we mean to go on - always keeping safety as our priority.

I extend my best wishes to all of you for a happy and safe New Year in 2020 and beyond.

Safety first

The Airbus Safety magazine

Also available in app and website versions

Visit us at safetyfirst.airbus.com

NEWS

The 26th Airbus Flight Safety Conference will be held in Singapore from 23-26 March 2020

This event provides the opportunity for Airbus to exchange with its customers on how to reinforce resilience in our Air Transport System.

With this objective forming the theme of our next conference, we will address the topics of safety at the interface of maintenance and flight operations and revisit the visual challenge. To prepare the future, we will share initiatives for reinforcing pilot skills and review the subject “Resilience and Autonomy - At the Service of the Pilot” focusing on the foreseeable evolution of aircraft functions and flight operations.

ATTENDANCE & INVITATIONS

Invitations for this event were sent to all our customer airlines and operators in January. Please contact Airbus if you need to update your information.

Safety first #29

Flight Operations

Cabin Operations

Ground Operations

Maintenance

GNSS Interference

Signals from the Global Navigation Satellite System (GNSS) are one of the main inputs used for aircraft positioning or time reference for Communication, Navigation and Surveillance functions on-board most of the Airbus aircraft.

Operators report an increasing number of events related to the loss of GNSS signals due to Radio Frequency Interference (RFI) during operations in some areas of the world.

This article explains the causes of RFI, the effects on the aircraft systems and provides recommendations for flight and maintenance crews.

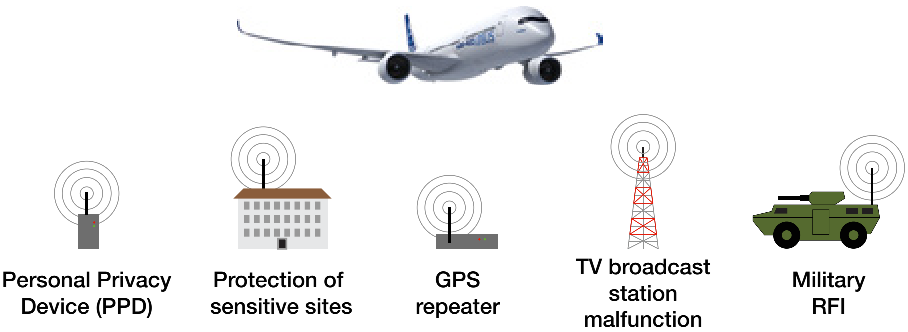
The Global Navigation Satellite System (GNSS) began in 1978 when the first satellite of the Global Positioning System (GPS) constellation was launched. The full operational capability of GPS was declared in 1995. In 2000 the full availability was granted to provide improved performance of the GPS position for civilians. The number of users and uses consequently increased, especially in civil aviation.

RADIO FREQUENCY INTERFERENCE (RFI)

A low power signal sent from space

The GPS signal is a low power signal. It is comparable to the power emitted by a 60W light-bulb located more than 20,000 km away from the surface of the earth. This means that the signal could easily be disturbed by any ground source located near an aircraft and emitting in the GPS L1 frequency band (1575.42 MHz +/-10 MHz), leading to the loss of GPS data **(fig.1)**.

Main known sources of RFI



(fig.1)
Main sources of RFI

Personal Privacy Devices (PPD)

Some of the reported disturbances were caused by portable Personal Privacy Devices that jam a GPS signal in the immediate area to avoid tracking. Operational disruptions at airports due to a loss of the GPS signal in the area around the airports have been caused when these devices were activated in the vicinity of an airport.

Protection of sensitive sites and VIPs

Certain sensitive sites may be protected using GNSS RFI for security reasons, such as correctional facilities or sites where dignitaries or political figures are living or visiting. Aircraft operating in the vicinity of these sites may be affected by interference with the GPS signal.

GPS repeater

GPS repeaters are used to make a GPS signal available inside a hangar during aircraft maintenance. GPS repeater signals have caused interference with actual GPS signal in some reported events, causing reception issues on aircraft located close to the hangar.

TV broadcast station malfunction

A TV broadcast station malfunction reportedly disturbed the GPS signal and affected aircraft operations.

Military GPS RFI in conflict zones

GPS RFI can also cause loss of the GPS signal in flight if too close to areas of military conflict. These areas are often known and NOTAMs inform flight crews that they may encounter interference close to these areas. It can be the case that military RFI activity is not known in advance or communicated leading to loss of GPS signal without prior notice.

GNSS spoofing

Some of the known RFI sources are reportedly capable of emitting signals that mimic GNSS signals.

Objectives for such spoofing include providing GNSS positioning service within hangar with repeaters, preventing GNSS receivers to compute position over prohibited area or triggering geo-fencing responses as part of anti-drone measures.

There are no reported events of GNSS spoofing leading to wrong aircraft position and timing on any Airbus aircraft to-date. However, Airbus constantly monitors the emerging threats and launched investigations to further evaluate GNSS spoofing threat and its possible consequences.

EFFECTS ON AIRCRAFT SYSTEMS AND ASSOCIATED COCKPIT EFFECTS

> “Airbus aircraft are designed to be robust to GNSS signal loss”

Impact on the aircraft position computation

GNSS RFI can cause the loss of GNSS position and timing. Even if GNSS plays a major role in the aircraft positioning system, Airbus aircraft are designed to be robust to GNSS signal loss. The use of other sources of data (IRS, VOR and DME) enables the aircraft systems to maintain a position computation capability. A loss of GNSS inputs does not lead to a map shift or to an erroneous position computation by the Flight Management Systems (FMS). In the case of a loss of GPS signal, the FMS switches from the mixed GPS/IRS position to an IRS-DME/DME position or IRS-VOR/DME or pure IRS in order of priority. Refer to the FCOM description of the FMS position computation for more detail.

Potential loss of some navigation and surveillance functions as well as of certain operational capabilities

Certain navigation and surveillance functions or operational capabilities may be lost if there is a loss of the GPS signal **(fig.2).** This is because the need for high accuracy and integrity of GPS position data is not met (e.g. for RNP AR, SLS, GLS, etc.) or when functions rely only on available GPS data for position or time reference. All, or some of the cockpit effects listed in **(fig.2)** may be triggered in an order that depends on the confirmation time of each system's monitoring function and how long the GPS signal is lost.

GPS signal loss and its associated effects were temporary in most of the reported events. The lost functions and capabilities were recovered immediately after aircraft moved out of range from the source of the radio-frequency interference.

(fig.2)

Potential effects of the loss of the GNSS signal on systems/functions with their associated cockpit effects

<table>
<tr><th rowspan="2"></th><th rowspan="2">Potential effect on systems/functions/ operations</th><th colspan="6">Main Cockpit effects</th></tr>
<tr><th>A300/A310</th><th>A220</th><th>A320</th><th>A330/A340</th><th>A380</th><th>A350</th></tr>
<tr><td rowspan="8">Navigation</td><td>Downgraded aircraft position computation</td><td rowspan="3">NAV GPS x FAULT
GPS PRIMARY LOST on ND and CDU</td><td>GNSS NOT AVAIL on EICAS</td><td colspan="4" rowspan="3">NAV GPS x FAULT
GPS PRIMARY LOST on ND</td><td rowspan="3">NAV GNSS x FAULT
NAV PRIMARY LOST on ND</td></tr>
<tr><td>Impact on RNP operations (RNP4, RNP 2, RNP 1)</td><td>UNABLE RNP on EICAS</td></tr>
<tr><td>Loss of RNAV (GNSS) capability</td><td rowspan="2">APPROACH NOT AVAIL on EICAS</td></tr>
<tr><td>Loss of RNP AR capability</td><td>N/A</td><td colspan="2">GPS PRIMARY LOST on ND</td><td>N/A</td><td>NAV RNP AR CAPABILITY DOWNGRADED
NAV RNP AR CAPABILITY LOST</td></tr>
<tr><td>Loss of the GLS function (No GLS approach)</td><td>N/A</td><td>N/A</td><td colspan="4">NAV GLS x FAULT</td></tr>
<tr><td>Loss of the SLS function (No LPV approach)</td><td>N/A</td><td>LPV NOT AVAIL on EICAS</td><td>N/A</td><td>N/A</td><td>N/A</td><td>NAV SLS x FAULT</td></tr>
<tr><td>Limited FLS function (only available for VOR or NDB approaches)</td><td>N/A</td><td>N/A</td><td colspan="4">FLS LIMITED TO F-APP+RAW on ECAM STATUS
F-APP+RAW on FMA</td></tr>
<tr><td>Loss of OANS/ANF function</td><td>N/A</td><td>SMS FAIL on EICAS</td><td>N/A</td><td colspan="3">ARPT NAV POS LOST on ND</td></tr>
<tr><td rowspan="4">Surveillance</td><td>Loss of the Predictive TAWS functions</td><td>TERR MODE "FAULT" light</td><td>TAWS MAP FAIL on EICAS</td><td colspan="2">NAV GPWS TERR DET FAULT</td><td colspan="2">SURV TERR SYS x FAULT</td></tr>
<tr><td>Loss of ADS-B out reporting</td><td>No alerting system</td><td>ADS-B OUT FAIL on EICAS</td><td colspan="2">NAV ADS-B RPTG x FAULT</td><td colspan="2">ADS-B POS RPTG LOST Memo</td></tr>
<tr><td>Loss of the ADS-B IN (ATSAW) function</td><td>N/A</td><td>N/A</td><td colspan="2">NAV ADS-B TRAF FAULT or NAV ADS-B FAULT</td><td>N/A</td><td>SURV ADS-B TRAFFIC x FAULT</td></tr>
<tr><td>Loss of ROW/ROPS</td><td>N/A</td><td>N/A</td><td colspan="4">SURV ROW/ROP LOST</td></tr>
</table>

"It is not necessary to deselect GPS in the case of RFI as this would prevent the aircraft from recovering its full capabilities when the GPS signal is restored"

OPERATIONAL CONSIDERATIONS

During Flight Preparation

Check RFI NOTAMs

Operators should consider the NOTAM related to known or expected areas with GNSS RFI when planning flights. If a NOTAM is applicable to the flight, then the availability of non GNSS-Based routes, procedures and approaches (such as ILS, VOR and DME) must be checked for the affected area.

During Flight

Application of ECAM/FCOM procedures

Flight crews must follow the associated ECAM or FCOM procedures if a loss of GNSS signal occurs during flight with a cockpit effect described in **(fig.2)**.

Recovery of the signal

Loss of GPS information is usually temporary and the normal navigation mode based on GPS data ("GPS PRIMARY" or "NAV PRIMARY"), as well as the communication and surveillance functions, are recovered as soon as the aircraft leaves the area affected by RFI. It is therefore not necessary to deselect GPS in the case of RFI as this would prevent the aircraft from recovering its full capabilities when the GPS signal is restored.

Zones with ADS-B OUT required

If the GNSS loss occurs in an area where ADS-B OUT is required per regulation, the flight crew should notify ATC of the loss of ADS-B OUT and report that this is due the loss of the GNSS signal.

After a flight with suspected loss of GNSS signals

Report to Maintenance

At the end of a flight where the effects of a loss of GNSS signal were experienced, the flight crew should report the event and cockpit effects to the Maintenance to investigate and confirm if the event was due to RFI or a result of a system or equipment malfunction.

Share information

Operators should report any identified suspected GNSS RFI events to regional (e.g. ANSPs) and international organizations, such as EUROCONTROL's Voluntary ATM Incident Reporting (EVAIR). This will facilitate and accelerate GNSS RFI event confirmation or resolution, and enable the publication of a NOTAM to share information to all other operators flying near the affected area.

MAINTENANCE CONSIDERATIONS

At the end of a flight impacted by a transient loss of GNSS, a confirmation should be done to make sure that the effects encountered were due to RFI and not to a system or equipment malfunction.

Transient loss of GNSS in an area with known RFI

At the end of a flight affected by transient GNSS loss within an area with known RFI, Airbus recommends that maintenance personnel reset the system and test both Multi-Mode Receivers (MMR).

To ensure that there was no system failures, Airbus also recommends a system test of any equipment affected by a loss of GNSS signal based on the cockpit effects observed during the flight. Should any system test fail, maintenance personnel must perform troubleshooting in accordance with the associated Trouble-Shooting Manual (TSM) task.

Refer to the "GNSS loss and GNSS interference on Airbus aircraft" ISI article ref 34.36.00049 available on the Airbus World portal for more details and a list of the related AMM/MP tasks for system tests.

What if the interference is still present on ground?

It the GNSS is still impacted by RFI on ground, the aircraft should be moved out of the RFI area. A dispatch under MEL conditions should be considered if this is not possible to do so.

Transient loss of GNSS in areas not known for RFI

At the end of a flight affected with transient GNSS loss within an area without known RFI issues, Airbus recommends that maintenance personnel confirm the root cause of the GNSS loss by studying all potential sources: aircraft system failure, GNSS constellation anomaly, environment masking, multipath or space weather events such as ionospheric scintillation. When all these potential causes are eliminated, RFI can be suspected. In this case, aircraft data should be sent to Airbus for further investigation. A list of the information items to report is provided in the "GNSS loss and GNSS interference on Airbus aircraft" ISI article ref 34.36.00049, available on the Airbus World portal.

CONTRIBUTORS:

Julien FRARD
Flight Operations
Support Engineer
Customer Support

Laura MARTIN SACRISTAN
Radio Navigation &
Surveillance Systems
Engineer
Customer Support

Diane RAMBACH
Avionics System
Engineering
Design Office

François TRANCHET
GNSS Expert
Design Office

Timo WARNS
Aircraft Information
Security Expert

With thanks to Pierre DUHAMEL from the A220 In-service Engineering-Avionics and Marc LE-LOUER from the Flight Operations Support

The number of reported transient GNSS loss due to radio-frequency interference is increasing. The loss of GPS signal can cause a downgrade of the aircraft position computation capabilities. However, Airbus aircraft are designed to maintain position computation capability without a GPS signal by using IRS or ground Navaids data.

Certain navigation and surveillance functions may be lost temporarily. When radio-frequency interference is encountered during flight, the flight crew will be alerted to any loss of function or capability. The flight crew must then use the relevant ECAM/FCOM procedure associated to these cockpit effects.

In most reported cases of radio-frequency interference, there is a return to normal operations immediately after the aircraft has moved away from the affected area.

During flight preparation, precautions should be taken when flying to or above known area of RFI to avoid operational burdens.

When it is confirmed by the maintenance that RFI is suspected in an area not know to be impacted, the information should be shared with the aviation community.

Takeoff Surveillance & Monitoring Functions

Airbus has continuously improved takeoff safety since the "TO CONFIG TEST" pushbutton was first introduced on A300 and A310 aircraft, and with the development of the Takeoff Surveillance (TOS1 & TOS2) and Takeoff Monitoring (TOM) functions.

The TOS2 package that was initially developed for the A350 is now available for A320 family and A330 aircraft. This is an opportunity to review the checks that are performed by each function, from cockpit preparation to takeoff.

This article supersedes "The Takeoff Securing function" article published in the Safety first issue #8 (July 2009).

SECURING THE TAKEOFF

There have been several events during takeoff over this last decade. In certain cases, the aircraft took off with incorrect trim or flaps settings, which increases the risk of runway overrun or tail strike event. Erroneous parameters were sometimes used for the performance calculation, leading to incorrect takeoff speeds or Flex thrust computation. On other occasions takeoff data was not updated in the FMS following a late runway change, leading to takeoff without the correct performance data in the FMS. A number of aircraft started takeoff from a taxiway intersection when the computed performance was for the entire length of runway. There were also takeoffs starting on a taxiway or from the opposite QFU. Finally, few cases of residual braking leading to an abnormal aircraft acceleration were reported during takeoff roll.

Most of these events can be avoided by complying with the FCOM Standard Operating Procedures (SOP). Indeed, several crosschecks enable the flight crew to identify discrepancies. These examples however show that errors can still be made, which typically occur when there are stressful situations, high crew workload, last minute changes or demanding ATC requests.

Airbus developed Takeoff Surveillance and Monitoring functions to provide additional safety-nets to support the flight crew during takeoff preparation and takeoff roll.

Evolution of the Takeoff Surveillance & Monitoring functions on Airbus aircraft

The "TO CONFIG TEST" pushbutton was first introduced on A300/A310 aircraft. When pressed, it checks the correct aircraft configuration for takeoff. If the aircraft configuration is not correct, the CONFIG light comes on the Master Warning Panel (A300) or an ECAM alert triggers (A300-600/A310).

Airbus introduced the first step of the Takeoff Surveillance functions (TOS1) on A320 family aircraft in 2009 and then on A330/A340 aircraft in 2013. TOS1 improves the checks performed on flaps and trim settings and adds a check of the performance parameters entered in the FMS (aircraft weight and takeoff speeds).

The second step of the Takeoff Surveillance functions (TOS2) was introduced on A350 aircraft in 2018 and is now available on A320 family and A330 aircraft. TOS2 checks that the aircraft is positioned on the intended runway and that the expected takeoff performance – based on data entered in the FMS by the crew – is compatible with the runway distance available.

The Takeoff Monitoring function (TOM) was first developed on A380 in 2018 and is now also available on A350. TOM monitors the acceleration of the aircraft during the takeoff phase and warns the flight crew if a lower-than-expected acceleration is detected. ■

TOS CHECKS DURING COCKPIT PREPARATION

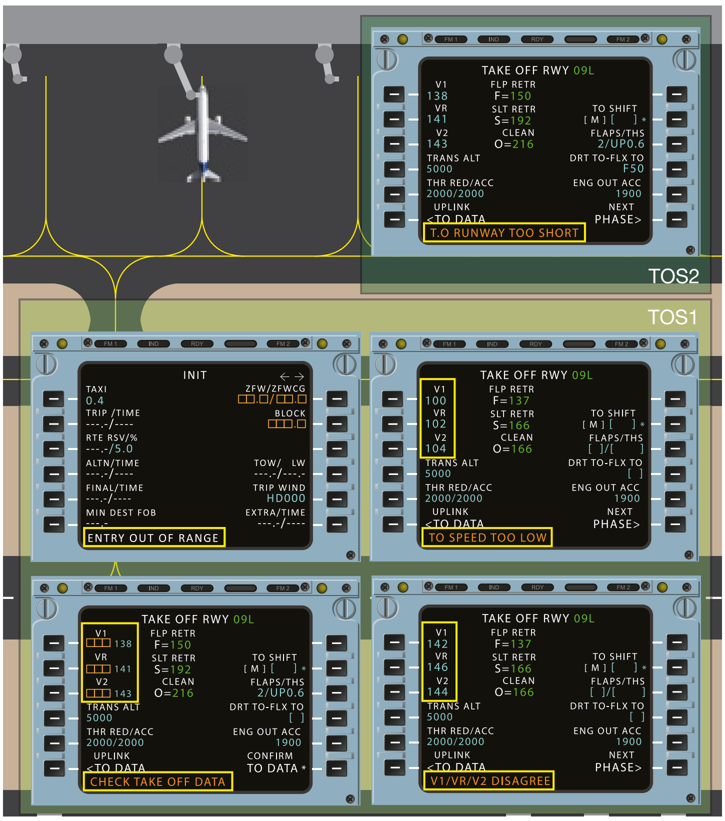
ZFW and takeoff speeds check (TOS1)

During the cockpit preparation, TOS1 checks for gross errors on weight or takeoff speeds inserted into the FMS. The MCDU/MFD can display the below scratchpad messages **(fig.1)**.

- ENTRY OUT OF RANGE: Inserted Zero Fuel Weight value is outside of the correct range.
- TO SPEED TOO LOW (A320/A330) or T.O SPEED TOO LOW CHECK TOW AND T.O DATA (A380/A350): Inserted takeoff speeds do not respect the required margins with minimum control (VMCG, VMCA) or stall (VS1G) speeds.
- V1/VR/V2 DISAGREE: Inserted takeoff speeds do not respect the rule V1 ≤ VR ≤ V2.
- CHECK TAKE OFF DATA: The flight crew changed the takeoff runway but takeoff speeds that were entered are applicable for another runway. The takeoff speeds are therefore invalidated and must be either re-entered or re-validated.

Lift-off distance check (TOS2)

TOS2 computes the Lift Off Distance (LOD) expected with the performance dataset entered by the crew (weight, thrust, Flaps, OAT and VR/V2) and compares it with the available runway length of the takeoff runway selected in the FMS. The LOD computation takes into account any takeoff shift entered in the MCDU/MFD. If the available runway length is lower than the LOD, the MCDU/MFD scratchpad displays a T.O RWY TOO SHORT message **(fig.1)**.

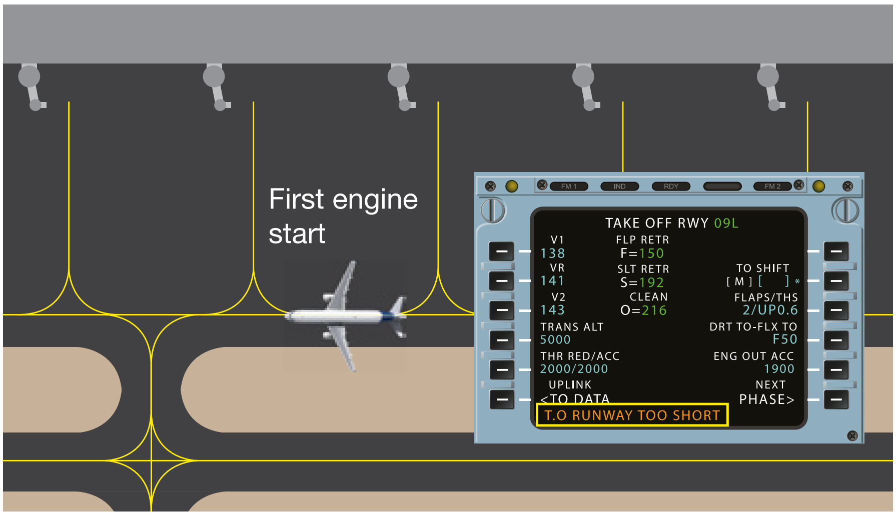


(fig.1)
TOS1 and TOS2 potential scratchpad messages during cockpit preparation

TOS CHECKS AT ENGINE START

Lift-off distance check (TOS2)

TOS2 re-performs a LOD check at engine start, using actual fuel quantity data now available from the fuel system. If the available runway length is lower than the LOD, the MCDU/MFD scratchpad displays a T.O RWY TOO SHORT message **(fig.2)**.



(fig.2)
TOS2 potential alert at first engine start

TOS CHECKS DURING TAXI PHASE (T.O CONFIG PUSHBUTTON PRESSED)

During taxi, the SOP request the flight crew to press the T.O CONFIG pushbutton. TOS functions then perform the following checks:

Flaps check (TOS1)

TOS1 checks consistency between the Flaps setting inserted by the crew in the Takeoff PERF page and the actual flaps setting. If there is an inconsistency, this will trigger the F/CTL FLAP/MCDU DISAGREE (A320/A330/A340) **(fig.3)** or F/CTL FLAP/FMS DISAGREE (A350/A380) ECAM message.

Trim Check (TOS1)

TOS1 also compares the trim setting entered by the crew into the Takeoff PERF page with the actual Trimmable Horizontal Stabilizer (THS) position and with the trim computed by the FAC/FMGEC/FE based on the CG value provided by the fuel management system. If an inconsistency is detected, this will trigger the F/CTL PITCH TRIM/MCDU/CG DISAGREE (A320/A330/A340) **(fig.3)** or F/CTL PITCH TRIM/FMS/CG DISAGREE (A350/A380) ECAM message.

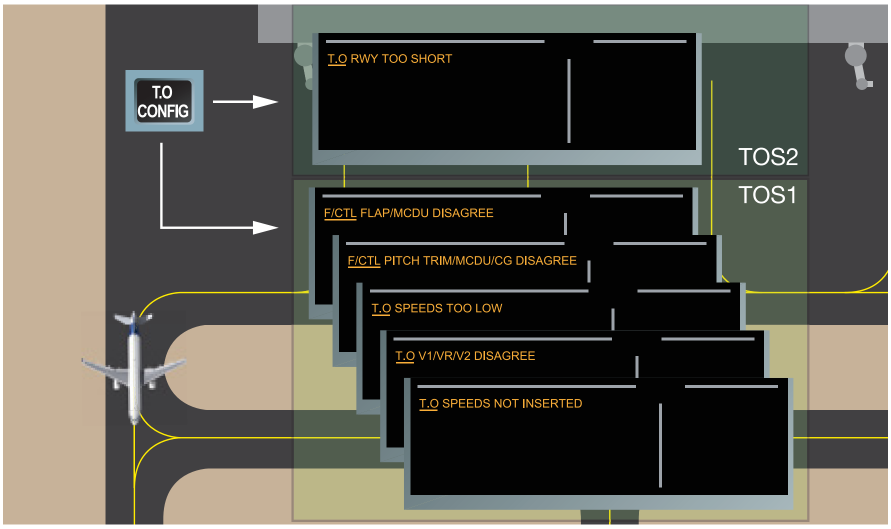
Takeoff speeds check (TOS1)

TOS1 performs an additional takeoff speeds check in the same way as it was done during the cockpit preparation phase. If one of the checks fails, the Flight Warning System triggers an ECAM alert and displays the associated MCDU/MFD scratchpad message **(fig.3)**:

- T.O SPEEDS TOO LOW
- T.O V1/VR/V2 DISAGREE
- T.O SPEEDS NOT INSERTED

Lift-off distance check (TOS2)

TOS2 performs an additional LOD check. If the available runway length is lower than LOD, the Flight Warning System triggers the ECAM alert T.O RWY TOO SHORT **(fig.3)** and displays the associated scratchpad message.



(fig.3)
TOS1 and TOS2 potential alerts when the T.O CONFIG pushbutton is pressed

TOS CHECKS AT TAKEOFF THRUST APPLICATION

When the flight crew initiates the takeoff roll by setting the thrust levers to takeoff thrust, TOS2 provides additional safety nets by checking that the aircraft is on the intended runway and that the required liftoff distance is compatible with the available runway distance, taking into account the real aircraft position on the runway.

Check of takeoff start position (TOS2)

When the crew applies takeoff thrust, TOS2 checks if the aircraft is positioned within an area that contains the takeoff runway entered in the FMS **(fig.4)**.

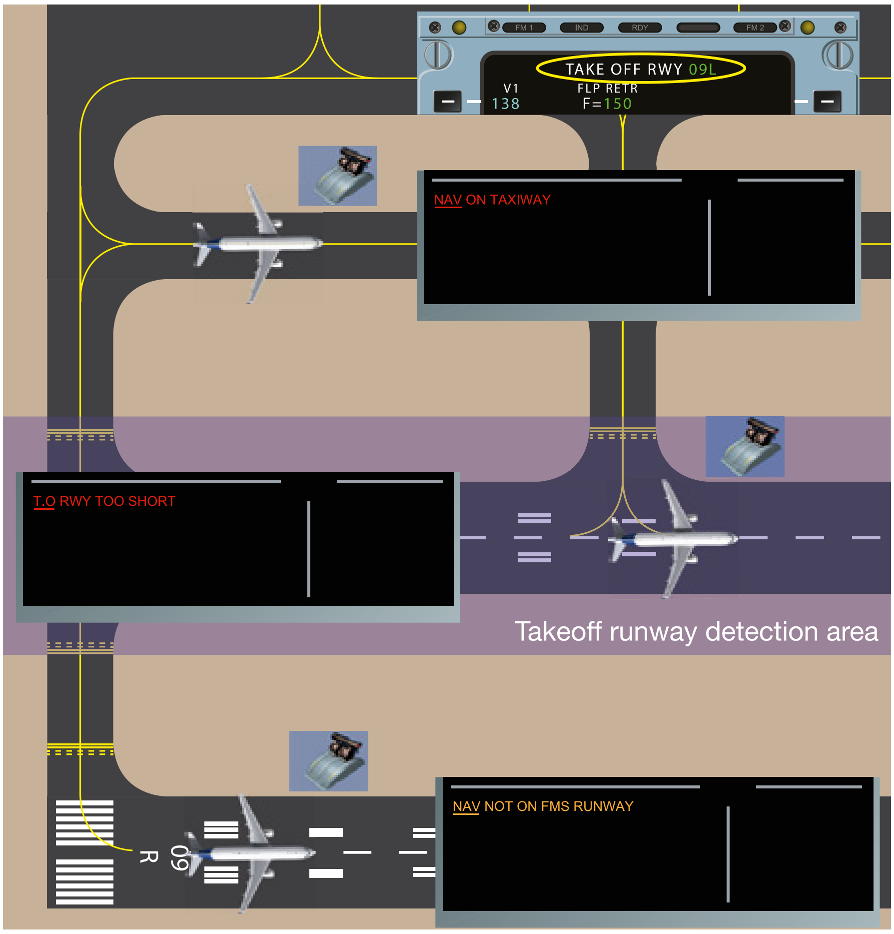
If the flight crew applies takeoff thrust when the aircraft is still on a taxiway and outside the runway area, this will trigger the red ECAM warning NAV ON TAXIWAY.

The alert can also be an amber caution depending on the FWS standard.

If the flight crew applies takeoff thrust while the aircraft is positioned on a different runway from the one entered into the FMS, this will trigger the ECAM caution NAV NOT ON FMS RUNWAY.

Lift-off distance check (TOS2)

When the flight crew applies takeoff thrust, TOS2 performs a final LOD check based on the real aircraft position. If the runway distance available in front of the aircraft is lower than the computed LOD (e.g. an aircraft commencing takeoff from a wrong runway intersection or from an incorrect runway with an insufficient length), this will trigger the red ECAM warning T.O RWY TOO SHORT **(fig.4)**.



(fig.4)
TOS2 potential alerts at takeoff thrust application

De-activation of TOS 2 function

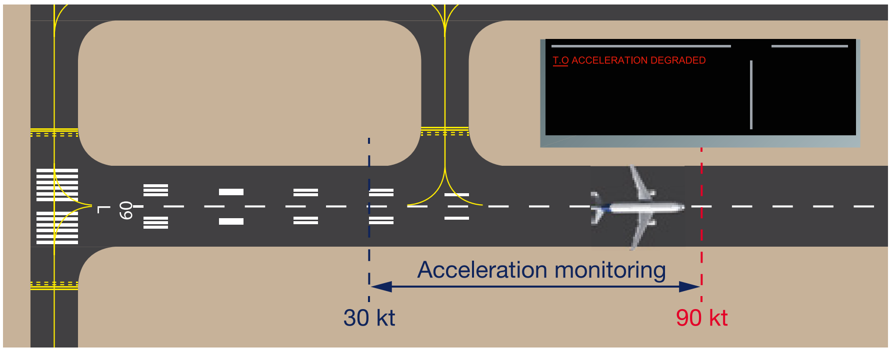
The T.O SURV pushbutton switch de-activates TOS2 function to avoid spurious alerts if the Navigation/Airport database information for a particular airport is not up-to-date. This pushbutton switch is installed on A320/A330 aircraft equipped with the TOS2 and can be installed on A350 as an option.

(fig.5)
Example of the T.O SURV pushbutton switch on A320 aircraft

TAKEOFF MONITORING (TOM)

TOM provides an additional safety-net during the takeoff roll. From 30 kt, it compares the expected acceleration with the real acceleration of the aircraft. If the difference between the real aircraft acceleration and its expected acceleration is more than 15 % when the aircraft reaches 90 kt, TOM will trigger the red ECAM warning T.O ACCELERATION DEGRADED.

TOM can be de-activated on A350 aircraft using the T.O SURV pushbutton switch (if installed).



(fig.6)
TOM alert displayed if the difference between the aircraft's actual acceleration and its expected acceleration is more than 15 % when the aircraft reaches 90 kt

OPERATIONAL CONSIDERATIONS

SOP ensure correct takeoff preparation and request checks for error identification

Adherence to SOP ensures takeoff preparation is completed correctly regardless of whether an aircraft is equipped with the Takeoff Surveillance and Monitoring functions. Correct takeoff preparation by the crew is ensured by promoting the following:

- A takeoff briefing should be relevant, concise and chronological
- The takeoff performance computation should be independently performed by both flight crew members and crosschecked
- Ensure accurate aircraft positioning data by systematically inserting T.O SHIFT during the departure phase when the takeoff will start from an intersection.

The Takeoff Surveillance and Monitoring functions must be considered as a safety net and are not replacements for full application of SOP actions.

An up-to-date Navigation/Airport database is key

TOS2 function relies on the FMS Navigation Database (for A320/A330/A380) and on the Airport database (for A350). Therefore the database must be up-to-date to fully take advantage of the TOS2 function. An outdated database may lead to spurious TOS2 ECAM alerts or non-triggering of an alert.

NOTAMs impacting the TOS2 function

NOTAMs that modify the runway length available may not always be incorporated into the Navigation/Airport database. Airbus recommends that Operators evaluate the impact on TOS2 of these NOTAMs and request that their flight crew deactivates the function to avoid spurious alerts if necessary **(fig.5)**.

Takeoff Surveillance alerts and RTO

Airbus recommends to reject the takeoff if TOS2 ECAM alerts are triggered at takeoff thrust application – including:

- NAV ON TAXIWAY
- NAV NOT ON FMS RUNWAY
- T.O RWY TOO SHORT

Takeoff Monitoring alert and RTO

Many ECAM alerts are inhibited between 80 kt and 400 ft (takeoff inhibition phase). Any warning received during this period must be considered as significant. For this reason, Airbus recommends to reject the takeoff if the T.O ACCELERATION DEGRADED warning is triggered. The TOM function is designed so that if this warning appears when the aircraft reaches 90 kt, the flight crew can safely perform a rejected takeoff before V1. ■

SUMMARY & AVAILABILITY OF TOS AND TOM FUNCTIONS

Focusing on the types of event that were reported to Airbus in the last ten years shows that the takeoff surveillance and monitoring functions would detect the majority of them and alert the flight crew.

(fig.7)
Summary of the potential occurrences addressed by TOS and TOM functions

Design Mitigation / Potential Occurrences	T.O Configuration P/B	TOS1	TOS2	TOM
Wrong CG/trim setting	**Yes** (Trim inside green band)	**Yes** (check of Trim vs FMS and computed CG)		
Wrong flaps setting	**Yes** (Flap not in CLEAN or FULL)	**Yes** (Actual Flaps vs FMS Flaps)		
Erroneous FMS Takeoff Speeds		**Yes**		
Runway too short for takeoff			**Yes**	
Incorrect aircraft position at takeoff			**Yes**	
Degraded acceleration at takeoff				**Yes**

The table below summarizes the availability of the TOS and TOM functions on the various aircraft types. The availability for retrofit depends on the exact aircraft configuration (FMS, EIS, ADIRU, and FWS standards). For more details on the system pre-requisites, operators are invited to contact Airbus customer support.

Aircraft Type	T.O CONFIG P/B	TOS1	TOS2	TOM
A300	Basic	No	No	No
A310	Basic	No	No	No
A300-600	Basic	No	No	No
A320	Basic	FMS R1A*	Option	Under feasibility study
A330	Basic	FMS R1A*	Option	Under feasibility study
A340	Basic	FMS R1A*	No	No
A350	Basic	Basic	Basic	Basic**
A380	Basic	Basic	Under feasibility study	Basic
* TOS1 is basically activated on all aircraft fitted with FMS2 release 1a and later standards (see below table for availability) **Available on A350-1000 in 2020				

(fig.8)
Availability of the Takeoff Surveillance and Monitoring functions

Aircraft Types & Engines	HONEYWELL FMS		THALES FMS	
	MSN*	Delivery Date	MSN*	Delivery Date
A320 CFM56	4379	Aug-10	4030	Sep-09
A320 IAE	4066	Oct-09	4110	Dec-09
A320neo	All aircraft			
A330 GE	1458	Nov-13	1276	Jan-12
A330 PW/RR	1425	Jun-13	1627	May-15
A330neo	All aircraft			
A340	Retrofit only			
* Manufacturer Serial Number: first aircraft with FMS release 1a or later standard installed in production line				

(fig.9)
Availability of the TOS1 (Release 1A FMS standard or later standards) for A320/A330/A340 aircraft

CONTRIBUTORS:

Daniel LOPEZ FERNANDEZ
Director Product Safety Enhancement
Product Safety

Marie PALARIC
TOS/TOM Product Leader
Engineering Aircraft Performance

Annabelle BLUSSON
Flight Operations Support

Airbus developed the Takeoff Surveillance TOS 1 & TOS 2 and Takeoff Monitoring (TOM) functions to provide an additional safety-net against the risks of runway overrun or tailstrike at takeoff that may occur due to:

- Errors in takeoff performance computation, or errors when entering takeoff data
- Takeoff starting from an incorrect position
- A degraded acceleration condition, where the aircraft's actual acceleration is lower than the expected acceleration during the takeoff roll.

The TOS2 was initially developed for the A350 aircraft and it is now available for the A320 family and on A330 aircraft.

It is important to remember that these Takeoff Surveillance functions are enhancements that act as an additional safety-net. They do not replace the correct application of SOP by the flight crew.

Managing Severe Turbulence

Severe turbulence encounters may cause injuries to passengers and cabin crew. If turbulence is unavoidable, using best practices, applying recommended techniques and following procedures will help to reduce the risk of injuries.

This article is about turbulence encounters, their risks and tips for how to avoid them. It provides references and links to the relevant publications. It also highlights how communication between the flight crew and cabin crew can be most effective to manage the risks and recalls procedures and best practices to apply in the case of severe turbulence.

ANALYSIS OF AN EVENT

Severe turbulence during approach

An A320 aircraft was facing severe thunderstorms on approach into its destination airport. Trying to find their way to the final approach path, the crew passed the boundary of one of the thunderstorms by approximately 4 NM. The aircraft was suddenly caught by a significant updraft followed by a downdraft, resulting in a g-load close to zero and the disconnection of the autopilot. Both pilots were surprised by the shift of the g-loads but they did not react on the sidestick. Assessing and accepting the minor altitude deviations, the flight crew then reengaged the autopilot and landed safely. There were no injuries to any passengers or crew.

Event analysis

The flight crew actions were in accordance with the FCTM recommended techniques when encountering turbulence. After the initial updraft and AP disconnection the flight crew resisted the potential instinctive reaction to use manual inputs on their sidesticks to fight against the turbulence. This limited the risk of over-control on the sidestick, allowing the A320's flight control laws to cope with the effects of the turbulence.

The cabin was already secured for landing with everybody seated and seatbelts fastened, which was a key factor in the prevention of injuries to passengers and cabin crew.

WHAT CAUSES TURBULENCE AND HOW TO AVOID IT?

Several phenomenons create turbulence. Here is a list of the main contributors and how to anticipate, detect and avoid them when possible.

Convective weather

The first and most obvious is the convective weather where air is heated by the earth's surface. Hot air rises and causes strong air displacements. Convection associated with high humidity leads to the formation of thunderstorms that can cause turbulence.

Using weather forecasts to predict convective weather

Flight crew must anticipate any potential route deviation and plan extra fuel to avoid any expected storms shown on the weather forecast analysis during their pre-flight preparation. The weather forecast should be regularly updated, especially during long haul flights, because meteorological conditions can be changeable.

NOTE

For more information about the use of the on-board weather radar, refer to:

- FCOM AIRCRAFT SYSTEMS – SURVEILLANCE - Weather radar
- FCTM AIRCRAFT SYSTEMS – WEATHER RADAR
- Pilot's guide from the radar manufacturer
- *"Optimum use of weather radar"* article published in Safety first #22" in july 2016
- "Getting to grips with surveillance" brochure issue 2 (2018)
- *"RDR-4000 IntuVue™ Weather Radar Pilot Training for Airbus Aircraft"* video from HONEYWELL.

Using the weather radar to detect and avoid convective weather

Storms contain a large quantity of liquid water that can be detected with the on-board weather radar . Knowing the capabilities and limitations of the weather radar installed on the aircraft is essential as well as being familiar with the techniques for using the weather radar to optimize the chance to detect convective weather.

Avoiding Storms

Severe turbulence can be met inside a cumulonimbus cloud. However, it can also be met outside of the cloud as we have seen in the event described above where the aircraft was 4 NM outside the boundary of the storm. As a rule of thumb, storm cells should be avoided by 20 NM laterally and preferably upwind to avoid risk of encountering hail. A storm cell must not be overflown by less than 5000ft separation. Avoiding the storm cell by flying around it is preferred because turbulence can extend well above the visible top of a cumulonimbus. High vertical expansion cells with top over 25,000 ft should not be overflown due to potential of strong turbulence.

NOTE

For more information on avoidance of convective weather, refer to the *"Avoidance of convective threats"* video from the Airbus Destination 10X sharing platform.

Clear Air Turbulence

Clear Air Turbulence (CAT) is due to the difference of speed of air masses at high altitude. Severe turbulence is generally encountered at altitudes higher than 15,000ft when flying across the boundary between the two masses.

Using weather forecast and pilot reports

The on-board weather radar cannot detect CAT as it does not contain water droplets. Using the weather forecast is the main method to predict when CAT may be encountered during a flight. Flight crews may also be informed of the potential to encounter CAT from pilot reports sent from aircraft that have previously flown through the affected areas to ATC and to the Operators' operations control centre. There are turbulence information sharing platforms that have been developed by airlines or third parties to share turbulence data and provide real time information to flight crews about the locations of turbulence.

(fig.1)
Lenticular clouds indicating the presence of mountain waves

Mountain waves

Windy conditions in mountainous areas can cause air to be directed upwards by the face of the mountain that causes a wave effect downwind of the mountain range. Severe turbulence may be encountered when flying through theses waves. The effects of mountain waves can be felt up to 100 NM downwind of the mountain range and up to the cruise altitude of airliners.

Anticipating mountain waves

Mountain waves are predictable in certain mountainous areas when there are specific meteorological conditions. it is important that operators inform flight crews when the conditions are likely to cause mountain waves on the planned flight path. Pilot reports are also invaluable to help inform other aircraft that may be approaching an area where there are mountain waves.

Lenticular clouds observed downwind of a mountain range is a good indicator that mountain waves may be encountered in the area.

Wake vortices

The pressure difference between the upper and the lower side of an aircraft's wing creates a wake vortex at its wing tips. Wake vortex may cause severe turbulence depending on the weight of the aircraft generating the vortices and the distance from it. The typical signature of a severe wake vortex encounter is a small roll initiated in one direction followed by a much more significant roll in the opposite direction.

To reduce the risk of a wake turbulence encounter, the flight crew must comply with the aircraft separation minima.

An upwind lateral offset can be used to avoid entering wake turbulence if the flight crew suspects that the aircraft may encounter it.

NOTE

For more information on wake vortices, refer to:

- FCTM PROCEDURES-NORMAL PROCEDURES-Supplementary Procedures-Adverse weather-Wake Turbulence
- *"Wake vortices"* article published in Safety first #21 in january 2016.
- *"Wake vortices"* briefing on the Airbus Worldwide Instructor News (WIN) website.

Perturbation due to ground obstacles and boundary layer effect

Ground obstacles such as mountains or buildings can create turbulence that can affect aircraft trajectory at lower altitudes in windy conditions during takeoff and landing phases.

Some airports are known to be susceptible to turbulence in certain wind conditions due to its surrounding infrastructure, hills or mountain ranges in close proximity . Operators should ensure that their pilots are kept informed when turbulent conditions are expected at the departure and/or arrival airports.

EFFICIENT COMMUNICATION BETWEEN THE COCKPIT AND THE CABIN IS KEY

Efficient coordination and communication between flight crew and cabin crew is essential to safely manage turbulence. It begins with using common terminology in precise and specific communication, both before and during the flight.

The Turbulence Scale

Turbulence is classified into three categories. To ease identification, each category is based on the impact to the aircraft's trajectory and the effects felt in the cabin. Using common terminology ensures that the flight crew and the cabin crew share the same understanding of the level of turbulence expected. This enables the cabin crew to perform the appropriate duties in order to effectively manage the cabin during turbulence.

Light Turbulence	Moderate Turbulence	Severe Turbulence
Light turbulence momentarily causes slight, rapid, and rhythmic bumpiness without noticeable changes in aircraft altitude or attitude.	Moderate turbulence causes rapid bumps or jolts.	Severe turbulence causes large abrupt changes in aircraft altitude and attitude with large variations in airspeed.
Cabin Condition		
• Liquids shake but do not splash out of cups • Trolleys can still be maneuvered with little difficulty • Passengers may intermittently feel a slight strain against their seat belts.	• Liquids splash out of cups • Trolleys difficult to manoeuvre • Difficulty walking in the cabin • Difficulty standing without holding onto something • Passengers feel definite strain against their seat belts.	• Items fall or lift off the floor • Loose items are tossed about the cabin • Impossible to walk • Passengers are forced violently against their seat belts.

Preflight briefing

The preflight briefing is the opportunity for flight and cabin crews to discuss the forecasted weather and the possible effects on flight conditions together.

The flight crew will inform the cabin crew of any expected turbulence events and provide the estimated flight times and locations of possible turbulence.

Anticipated severe turbulence

When approaching an anticipated area of turbulence:

- The flight crew should advise the cabin crew on how much time is available to secure the cabin and galleys, as well as informing them of the level and expected duration of the turbulence encounter.
- A Passenger Address announcement requesting the passengers to return to their seat and fasten their seatbelt should be made.
- The cabin crew should ensure they inform the flight crew when the cabin is secured.

Unanticipated severe turbulence

When entering an unexpected area of turbulence, the flight crew must switch the seatbelt sign ON and make an announcement to the cabin requesting passengers and crew to fasten seatbelts immediately using the Passenger Address system.

After a severe turbulence encounter

It is important that the flight crew informs the cabin crew when the aircraft is clear of the severe turbulence so that cabin crew can check for passenger injuries, give first aid if necessary, calm and reassure passengers and check for any cabin damage. The purser should then provide a cabin status to the flight crew detailing the number of injuries and any cabin damage.

MANAGING SEVERE TURBULENCE FROM THE COCKPIT

"Autopilot is designed to cope with turbulence"

Flying through turbulence is sometimes unavoidable despite the best efforts to prevent this. The flight crew must use the recommended procedure to limit the impact of the turbulence on the aircraft's trajectory and limit the risk of injury to passengers and cabin crew.

Prepare the cockpit before entering an anticipated severe turbulence area

Any loose objects in the cockpit must be cleared or secured before entering an area where turbulence is expected. Shoulder harnesses should be firmly fastened and locked.

Keep autopilot ON

Autopilot is designed to cope with turbulence and will keep the aircraft close to the intended flight path without the risk of overcorrection. The recommendation is to keep autopilot ON during a turbulence encounter. A pilot may be tempted to "fight against turbulence" when manually flying the aircraft and may overreact to sudden changes in the trajectory in some cases.

The flight crew should consider autopilot disconnection if autopilot does not perform as desired.

Keep autothrust ON (except A300/A310) and use the QRH turbulence penetration speed if turbulence is severe

The turbulence penetration speed/Mach, also known as Rough Air speed/Mach (V_{RA}/M_{RA}), can be found in the QRH. This speed provides the best protection against reaching structural limits due to gust effect whilst maintaining a sufficient margin above V_{LS}.

V_{RA}/M_{RA} should be used in severe turbulence. Managed speed can be kept when in light or moderate turbulence.

On A300/A310 aircraft, the flight crew should disconnect the autothrust and set the target thrust to maintain V_{RA}/M_{RA}.

On fly-by-wire aircraft, use manual thrust when autothrust variations become excessive

If the autothrust variations become excessive on fly-by-wire aircraft, the flight crew should disconnect autothrust and manually adjust thrust to the value provided in the QRH.

In cruise, consider descent to a lower Flight Level

Choosing a lower FL enables the flight crew to increase the aircraft's margins before buffet onset.

“the pilot should only make careful and considered corrections to counter any significant deviation from the intended flight path”

Advantage of the fly-by-wire technology in manual flight

If the autopilot disconnects on a fly-by-wire aircraft, the flight crew can still utilize the advantages of the fly-by-wire technology to cope with turbulence. If the sidestick remains in its neutral position, the aircraft's flight control system will compensate for turbulence effects by aiming for a 1g flight path and a constant roll attitude. Therefore, if the pilot is only making careful and considered corrections to counter any significant deviation from the intended flight path, this will allow the flight controls to stabilize the aircraft, whereas continuous pilot sidestick inputs could induce further destabilization.

Do not “fight the turbulence”

The pilot must not “fight the turbulence” in manual flight to maintain the aircraft's trajectory or altitude. Only applying smooth sidestick/control column inputs and allowing some reasonable variations from the intended flight path will reduce the risk of overcorrection that can cause unnecessary accelerations, which may increase the risk of injury to passengers and cabin crew.

NOTE

For more information on the handling of turbulence, refer to the FCTM *“PROCEDURES - NORMAL PROCEDURES - Supplementary Procedures - Adverse weather - Weather Turbulence”*

NOTE

For more details on the handling of overspeed in cruise, refer to:

- FCTM PROCEDURES - ABNORMAL AND EMERGENCY PROCEDURES - Miscellaneous - Overspeed
- *“Management of Overspeed events in cruise”* article published in Safety first #28 in July 2019
- *"What About Overspeed Prevention and Recovery?"* briefing from the Airbus Worldwide Instructor News (WIN) website.

NOTE

For more information on the Ground Speed Mini function, refer to the *“Control your speed during descent, approach and landing”* article published in Safety first #24 in July 2017.

NOTE

For more information on turbulence event reporting, refer to the *“High Load Event Reporting”* article published in Safety first #26 in July 2018.

Do not use rudder

Do not use rudder to counter the turbulence if in manual flight. Violent rudder inputs can cause additional aircraft trajectory destabilization and stress on the aircraft structure.

Don’t overreact to temporary overspeed excursion

The flight crew may observe temporary overspeed situations when encountering severe turbulence due to the changes in wind intensity or direction. The flight crew must not overreact to temporary overspeed excursion since the use of VRA/MRA ensures sufficient margins to structural limits. The recommendation is to keep the autopilot ON and autothrust ON and accept the temporary overspeed excursion.

In final approach, use autothrust

The use of autothrust and managed speed in final approach enables the aircraft to benefit from the Ground Speed Mini function that will adapt the managed target speed to the wind variation close to the ground.

Severe turbulence reporting

The flight crew must make a logbook entry to report any severe turbulence encounter so that maintenance crew are alerted to perform the necessary inspections of the aircraft before the next flight.

It is also recommended to report severe turbulence events to Airbus to assess the effects of the high loads on the aircraft and assess what checks may be necessary before commencing the next flight.

MANAGING SEVERE TURBULENCE FROM THE CABIN

Anticipated severe turbulence: a prioritized preparation

Once advised by the flight crew of an anticipated turbulence, the cabin crew should prioritize their duties based on the time available before the turbulence encounter in order to best prepare the cabin, as per CCOM recommended procedure:

- First, they must stow and secure large items such as trolleys and remove bottles from the cabin and galley surfaces. Any hot liquid must be safely disposed of
- The cabin crew must then secure the cabin and ensure all lavatories are unoccupied
- Once the cabin is secured, the cabin crew must secure the galleys
- Cabin crew must then return to their station, fasten their seatbelt and inform the purser that the passengers and themselves are secured
- Then the purser must inform the flight crew that the cabin is secured.

Unanticipated severe turbulence: ensure personal safety first

Most injuries in the cabin happened to passengers or crew members not seated with their seatbelt fastened during severe turbulence. Cabin crews are more exposed to risk of injury due to sudden turbulence because they are often standing during service. The cabin crew must ensure their own personal safety first if sudden severe turbulence is encountered. The cabin crew must take the nearest available seat and securely fasten the seat belt. The nearest seat may be a passenger seat.

"The cabin crew must ensure their own personal safety first if sudden severe turbulence is encountered."

BEST PRACTICE

Tidy cabin and galleys for safe flights

Any loose object in the cabin can become a projectile during turbulence. Keeping the cabin and galley tidy throughout the flight reduces the risk of injuries and damage to the cabin should an unexpected turbulence event occur.

Passenger awareness on the use of seatbelt

The most effective way to prevent injuries during turbulence is to keep seatbelts fastened. It is therefore key that passengers are aware of this and are encouraged to keep their seatbelt fastened at all times.

"It is key that passengers are encouraged to keep their seatbelt fastened at all times."

Passengers must be made aware that they are obliged to comply with the FASTEN SEATBELT sign at all times when set to ON.

NOTE

For more information on the handling of turbulence in the cabin, refer to:

- CCOM:
  - *ABNORMAL/EMERGENCY PROCEDURES – TURBULENCE MANAGEMENT*
  - *ABNORMAL/EMERGENCY PROCEDURES – SAFETY OPERATIONAL AWARENESS*
  - *TURBULENCE THREAT AWARENESS*
- *"TURBULENCE MANAGEMENT"* Chapter of the *"Getting to Grips with Cabin safety"* brochure published in 2015 by the Airbus Flight Operations Support department.

An Analysis of Reported Severe Turbulence

240 severe turbulence events were reported to Airbus between 2014 and 2018.

Injuries to passengers and cabin crew occurred on:

- 30 % of long haul flights where severe turbulence events were reported
- 12 % of short haul flights where severe turbulence events were reported.

Passengers tend to unfasten their seatbelt during long haul flights to move around the cabin and use the lavatories more during long haul flights and this is likely to be the reason for the higher rate of injuries when compared to the figures for short haul flights. Furthermore, the majority of the injuries that are reported on short haul flights mainly affects cabin crew whereas both cabin crew and passenger injuries are reported for long haul flight severe turbulence events.

It is further evidence of the need to inform passengers on the importance of having their seatbelts fastened during the flight and for the crew to manage the cabin and secure themselves appropriately in anticipation of severe turbulence and during the event.

Post turbulence cabin duties

When the flight crew confirms that the aircraft is clear of the turbulence, the cabin crew can leave their seat, check with passengers for any reports of injury, provide first aid if necessary and reassure other passengers. The cabin should then be checked for damage.

Once the situation assessment is done, the purser must report any injury or damage to the flight crew.

CONTRIBUTORS:

Robert GRAEF
Expert pilot
Flight Operations Support

Jean Paul VIEU
Cabin Operations
Engineer - Cabin Safety
Enhancement
Flight Operations Support

With thanks to Domenico SPATARO from the Product Safety Enhancement Department

Severe turbulence can cause injuries to passengers and cabin crew as well as damage to the cabin. Flight crew must ensure they are aware of and use all available means to prevent flying through areas where turbulence will be encountered. If turbulence is unavoidable then FCOM procedures and recommended techniques must be applied to limit risks of injury to passengers or cabin crew and damage to the cabin:

- Keep autopilot ON
- Keep autothrust ON and use the QRH turbulence penetration speed if turbulence is severe
- If the autopilot is disconnected, only use careful and considered inputs on the sidestick and take advantage of the fly-by-wire capability to cope with turbulence.
- Do not use rudder to counter turbulence
- Use manual thrust when autothrust variations become excessive
- In cruise, consider descent to a lower Flight Level and don't overreact to temporary overspeed excursion.
- In final approach, use autothrust to benefit from the ground speed mini function
- Report any severe turbulence encounter to the Maintenance at the end of the flight with a logbook entry.

Communication between the flight crew and the cabin crew enables safe and efficient management of the cabin before and during turbulence events.

Cabin crew should remember that they must first ensure their own safety by immediately seating in the closest available seat and securely fasten their seatbelt in the case of sudden severe turbulence. Assisting other cabin crew or passengers should only be resumed when the flight crew confirms that the aircraft is clear of turbulence.

Encouraging the passengers to keep their seat belts fastened at all times when they are seated and ensuring that the cabin and galleys remain tidy during the flight is the most effective means to limit the risk of injury to passengers and cabin crew in the case of unexpected turbulence.

Safe Aircraft Parking

Incorrect or incomplete application of the parking procedures at the end of a flight can lead to unexpected aircraft movement potentially resulting in injuries or significant damage from a collision with ground obstacles. Several cases of this type of event during maintenance are reported to Airbus each year.

This article provides an overview of the parking brake architecture and explains the importance of checking accumulator pressure before applying the park brake, and then confirming there is sufficient hydraulic pressure at the brake unit. It also describes the safety enhancement available on A320 family and A330/A340 aircraft and gives recommendations for chock design and placement.

This article applies to A300/A310/A320/A330/A340/A350/A380 aircraft. It does not apply to A220 aircraft as they are equipped with electric brakes.

ANALYSIS OF AN EVENT

After landing and taxi in, the A319 was approaching the parking position at the gate. The pilot applied pedal braking and checked the accumulator pressure value on the BRAKES and ACCU PRESS indicator. The accumulator pressure indication was in the green zone as expected. The pilot set the parking brake handle to ON but did not confirm that there was sufficient brake pressure showing on the indicator. He released the brake pedals and switched off both engines. The aircraft began to roll forward and it collided with the airbridge. After the collision, the flight crew checked the BRAKES and ACCU PRESS pressure indicator. It was now showing that there was sufficient pressure at the brakes. If the accumulator pressure indication was green and the indicator was showing sufficient pressure at the brakes after the collision occurred, then why did the aircraft roll forward after the brake pedals were released with the parking brake on?

Investigation

The crew correctly checked the accumulator pressure indication before setting the park brake to ON but they forgot to confirm the brake pressure indication before releasing the brake pedals and switching off the engines. Decoding the DFDR and troubleshooting identified there was a problem with the Parking Brake Selector Valve (PBSELV) causing it to open very slowly. Even though the park brake handle was set to ON, when the pilot took his feet off the pedals, the parking brake pressure was not yet sufficient and this allowed the aircraft to roll forward. When the Parking Brake Selector Valve finally rotated to its open position the brake pressure indicator was finally showing sufficient pressure at the brake, but it was too late.

The SOP recommends checking the brake pressure on the triple indicator after the parking brake handle is set to ON and before releasing the brake pedals. This would have informed the pilot that the hydraulic pressure at the brake unit was too low to hold the aircraft in its parked position with only the park brake.

THE PARKING BRAKE ARCHITECTURE

The parking brake application relies on the hydraulic pressure provided by one or two hydraulic pressure accumulator(s) (depending on the aircraft type) when the engines are not running. The accumulator(s) provide sufficient hydraulic pressure for the parking brake over a 12 hour period without repressurizing.

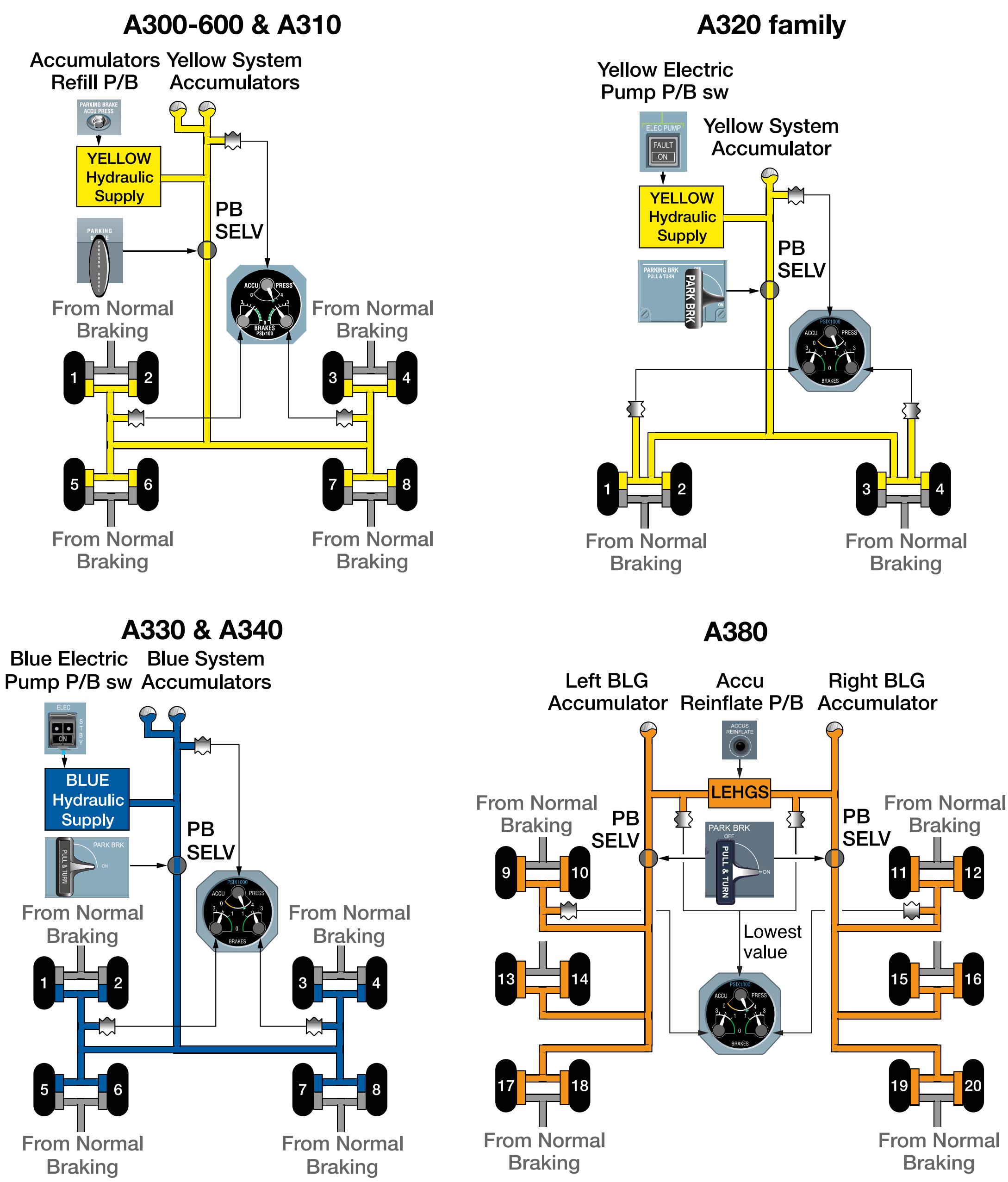
When the parking brake handle is set to ON, the Parking Brake Selector Valve (PBSELV) opens, allowing hydraulic pressure to apply the brakes and hold the aircraft in its parked position.

Accumulator(s) pressurization

Accumulators are units that are automatically pressurized by their associated hydraulic system when the aircraft's engines are running. They can also be manually repressurized (or refilled) by pressing the Accu refill/reinflate pushbutton (A300-600/A310/A350/A380) or by switching the yellow (A300/A320) or blue (A330/A340) electrical pump to ON on the overhead panel.

The BRAKES and ACCU pressure indicator: An essential indication of a safe parking configuration

On A300-600, A310, A320 family, A330, A340 and A380 aircraft, the BRAKES and ACCU pressure indicator located on the center instrument panel enables the flight crew to quickly check the available accumulator pressure on its upper part and the actual pressure applied to the brakes on its lower part **(fig.1)**.

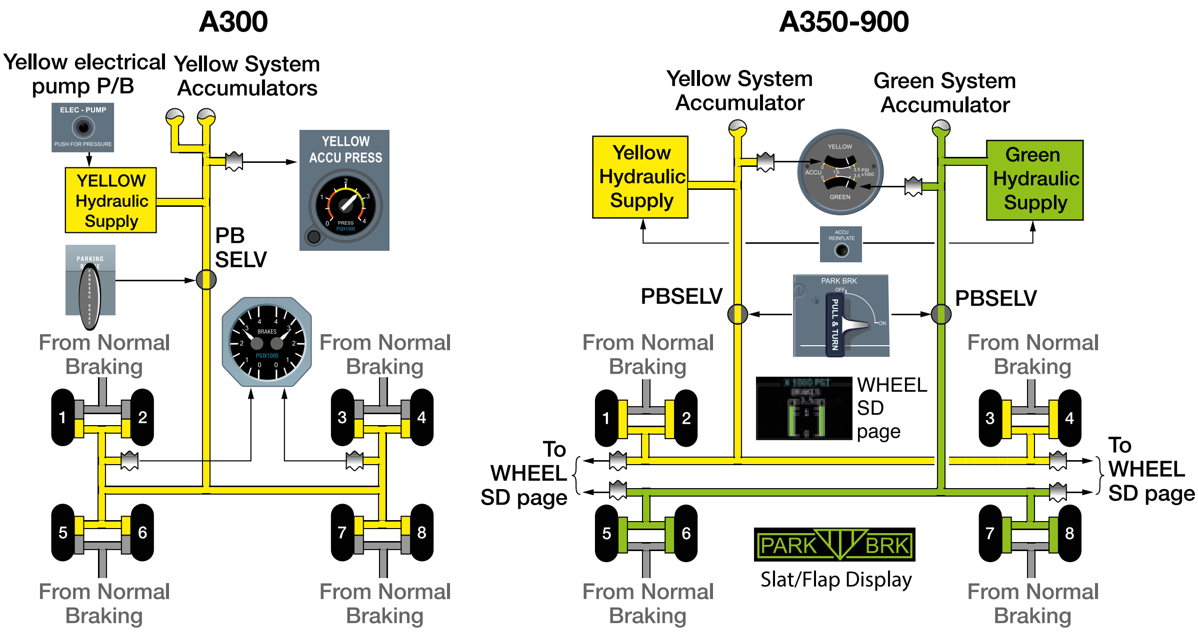


(fig.1)
Functional schematics of the parking brake system

On A300 aircraft, the YELLOW ACCU PRESS indicator located on the overhead panel provides yellow accumulator pressure indication to the flight crew. The brake pressure indicator located on the center instrument panel provides measurement of the actual pressure applied to the brakes **(fig.2)**.

On A350 aircraft, the ACCU pressure indicator provides pressure indication from both green and yellow accumulators. The flight crew can check the pressure applied to the brakes on the SD WHEEL page or check that the PBSELV is open and that sufficient pressure is applied to the brakes when the Slat/Flap display shows the green PARK BRK indication **(fig.2)**.

(fig.2)
Functional schematics of the parking brake system for A300 and A350 aircraft (A350-1000 not represented)



Cases of incorrect application of the parking brake reported in service

There are two reasons that were identified as root causes of the incorrect application of the parking brake reported in service:

Incorrect opening of the Parking Brake Selector Valve (PBSELV)

The incorrect opening of the PBSELV does not enable the hydraulic pressure to reach the brakes as expected as it was the case in the event described above.

Insufficient accumulator pressure

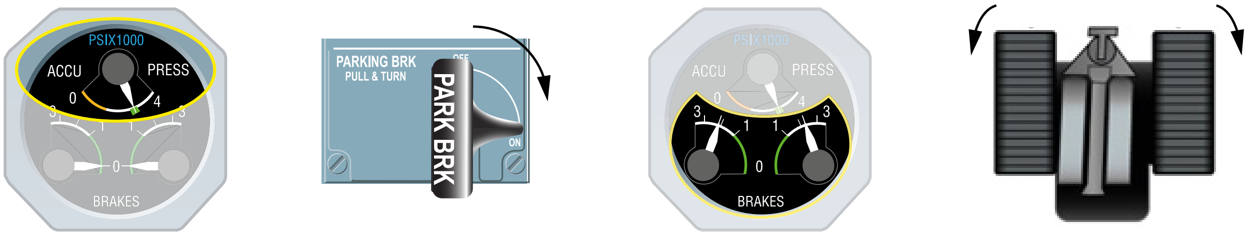
Insufficient accumulator pressure limits the friction applied on the brake discs and may lead to unwanted aircraft movement.

The insufficient pressure may be due to a leak in the hydraulic system or in the brake system itself. It can also be due to a long aircraft stay on ground (more than 12 hours) or following numerous parking brake application and release without accumulator repressurization.

RECALL OF THE PARKING PROCEDURE

The correct application of the FCOM parking procedure enables the flight crew to detect if there is a defect that could cause incorrect application of the parking brake.

1. Check that the accumulator pressure is in the green band
2. Set parking brake selector to ON
3. Check that sufficient pressure applies to the brakes
4. Release brake pedals and shutdown engines



(fig.3)
Example of the parking procedure on A320 aircraft

Step 1: Accumulator pressure check (Engines running and brake pedals pressed)

The first step is to check the accumulator pressure on the BRAKES and ACCU PRESS indicator (ACCU Pressure indicator on A350) before applying the parking brake. The accumulator(s) pressure must be in the green band **(fig.3)**.

If the pressure is not sufficient, the flight crew must keep the brake pedals pressed and contact the ground operator to put chocks in place before switching off the engines and make a logbook entry once the aircraft is parked to alert Maintenance.

Step 2: Parking brake application (Engines running and brake pedals still pressed)

If accumulator pressure is sufficient, the parking brake selector can be set to ON.

Step 3 & 4: Check of the brake pressure, pedal brake release and engine shutdown

To ensure that the PBSELV opened correctly and that sufficient hydraulic pressure is provided to the brakes, it is essential to check the left and right brake pressure on the BRAKES and ACCU pressure indicator (or that the green PARK BRK indicator is displayed on the Slat/Flap display on A350). If the indicators show insufficient parking brake pressure, the flight crew must keep the brake pedals pressed and contact the ground operator to put chocks in place before switching off the engines and then make a logbook entry to alert Maintenance.

NOTE

What if the aircraft starts to move after parking brake application?
On A300 and A310 aircraft, the parking brake handle must be set back to OFF to recover normal pedal braking to stop the aircraft.
On A320 Family/A330/A340/A350 and A380 aircraft, normal pedal braking has priority over parking brake, so pedal braking can be directly used to stop the aircraft.

NOTE

Why is it not recommended to leave the parking brake ON with hot brakes?
The SOP recommends to set the parking brake brake back to OFF once the chocks are in place when the brakes are hot (refer to FCOM for temperature values). This is to prevent transmitting heat to the brake pistons potentially causing seal degradation, hydraulic fluid overheating and generation of a black aggregate, that can reduce the piston running clearance and then lead to brake dragging.

ALSO BEWARE DURING MAINTENANCE!

An illustrative event reported to Airbus recently involved an A319 aircraft, which was being towed to the gate to resume operations after maintenance activities. The operator on the ground requested the person seated in the cockpit to set the parking brake to ON before disconnecting the towbar from the nose landing gear. They turned the parking brake handle to the ON position without checking the accumulator pressure on the BRAKES and ACCU pressure indicator or confirming the brake pressure. The ground operator disconnected the towbar and the aircraft began to roll backwards and away from the tow tractor. The person in the cockpit attempted to stop the aircraft by pressing down on the brake pedals but the aircraft continued to roll because there was no hydraulic pressure present in the normal braking system. The aircraft eventually came to rest after colliding with ground obstacles.

This example shows why it is essential to check the braking pressure indications and/or that chocks are in place before disconnecting the towbar or the towing truck. Inflation of the accumulator(s) using the Accu reinflate pushbutton or the appropriate electrical pump pushbutton (depending on the aircraft type) will provide sufficient accumulator pressure for parking brake application for up to 12 hours.

"It is essential to check the braking pressure indications and/or that chocks are in place before disconnecting the towbar or the towing truck."

AVAILABLE SAFETY ENHANCEMENT: THE PARKING BRAKE MONITORING FUNCTION

Airbus introduced the parking brake monitoring function on A320 Family/A330/A350 aircraft. This function detects any discrepancy between the parking brake handle position and the PBSELV. The BRAKES PARK BRK FAULT ECAM warning **(fig.4)** triggers if the PBSELV does not open when the parking brake handle is set to ON, and reminds the flight crew to consider requesting ground personnel place chocks at the wheels before shutting down the engines.

BRAKES PARK BRK FAULT
PARK BRK.............................OFF
. BEFORE ENG SHUTDOWN
CHOCKS..................CONSIDER

(fig.4)
Example of an ECAM alert provided by the Parking Brake monitoring function

This modification is installed on A320 family aircraft built from October 2010 (serial number 4468 onward), on A330 aircraft built from January 2011 (serial number 1187 onward) and on all A350.

This parking brake monitoring function modification can be retrofitted on earlier A320 Family/A330/A340 aircraft by the following Service Bulletins:

- SB A320-32-1381
- SB A320-31-1353
- SB A330-32-3244
- SB A340-32-4285
- SB A340-32-5105

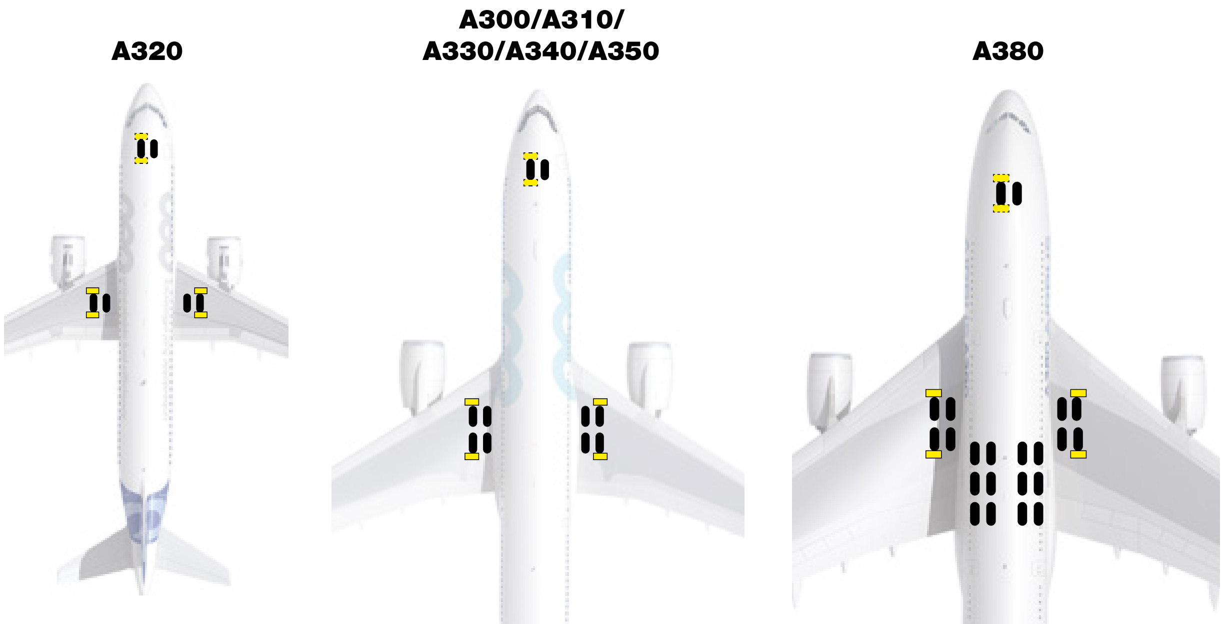
GROUND OPERATION RECOMMENDATIONS

Chocks Placement

At the gate (transit)

Airbus recommends to first place a set of chocks on one wheel of the nose landing gear as soon as the aircraft comes to a stop. Then two sets of chocks should be placed on the outboard wheels of the main landing gear only when the engines are switched off and spooling down. Chocks on the NLG can now be removed if it is required **(fig.5)**. The ground operator must notify the flight crew that the chocks are in place.

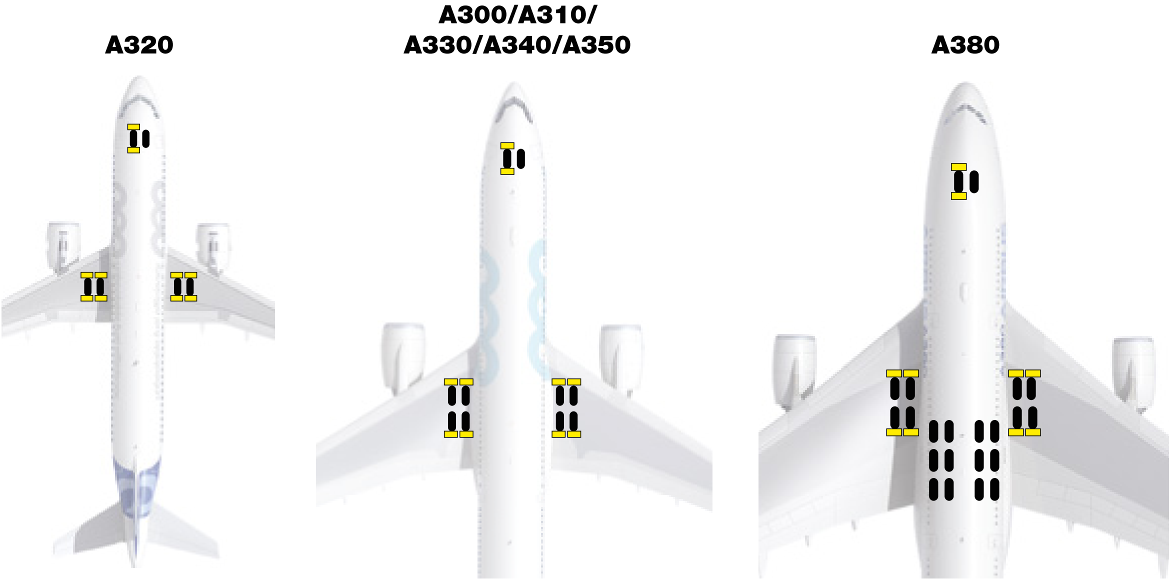
(fig.5)
Recommended location of chocks during transit



Night stop, long stay or windy conditions

For a night stop, a long stay or in the case of strong wind, Airbus recommends to keep the nose landing gear chocks in place and also secure the inboard wheels of the main landing gear with additional sets of chocks **(fig.6)**.

(fig.6)
Recommended location of chocks during night stop, long stay or in strong wind conditions



During Maintenance

Specific chocks placements may be required for a maintenance task. The chocks placement guidance in the Aircraft Maintenance Manual (AMM) should be followed.

Chocks design

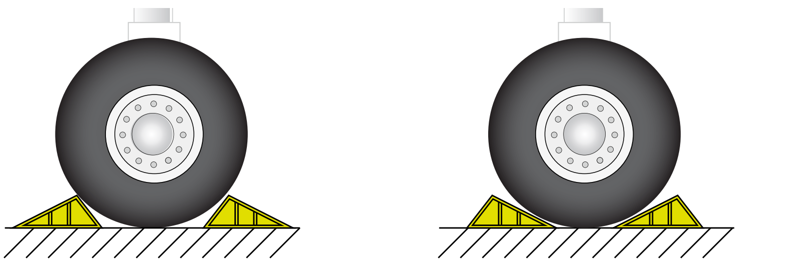
Many different types of chocks are used by ground operators throughout the world. Airbus participated in a study to define an optimum design for chocks that can solve recurrent issues faced in operation such as:

- Chocks durability
- High weight with associated handling difficulties
- Reduced efficiency on wet and contaminated aprons
- Difficulties to remove chocks before pushback with risk of delay

The recommended chocks are made of urethane type material and have an asymmetric design enabling optimum efficiency depending on if the apron is dry or wet/contaminated **(fig.7)**.

For more information, refer to the AIR4905 revA document published by SAE international that provides general considerations for the design and use of aircraft wheel chocks.

(fig.7)
Example of chocks with asymmetric design adapted to apron state



Dry ground surface (limited weight applied on the chocks for easy removal)

Wet or contaminated ground surface (increased weight on the chocks to increase friction on the ground)

CONTRIBUTORS:

Laurent COUTURET
Product Leader
A380/A300 Braking
and steering -
Engineering
Customer Services

Willy-Pierre DUPONT
Senior Expert
Airport Operations

Didier GENDRE
Ground Operations
Engineer
Airport Operations

David PIERRE-ANTOINE
HO Braking and
Steering Systems
Engineering
Support
Customer Services

Peimann TOFIGHI-NIAKI
Flight Operations
Support Engineer
Flight Operations
Support

To ensure that an aircraft remains safe and stationary when using the parking brake, flight crew or maintenance personnel must first ensure that sufficient accumulator pressure is available using the BRAKES and ACCU pressure indicator before setting the brake handle to ON. If the indicator is in the green band, they can set the parking brake to ON and confirm using the pressure indicator that sufficient pressure is applied to the brakes. If not, they must wait until chocks are correctly placed at the wheels before releasing the brake pedals and switching off the engines or disconnecting from the towing vehicle. Maintenance must be alerted about the issue to troubleshoot and rectify.

When chocks are required for ground operations or when the parking brake pressure is insufficient, chocks must be correctly placed at the aircraft's wheels. Airbus recommends chocks made of urethane type material with an asymmetric design that allows them to be orientated for the most efficient holding friction on wet or dry apron surfaces.


NO
TOW
NO STEP
NO STEP

ARTICLES PUBLISHED IN PREVIOUS 'SAFETY FIRST' ISSUES

Available in the Safety first app and website: **safetyfirst.airbus.com**

Issue 28

July, 2019

- Overspeed Event with Crew Take-over and OEB49 Application
- Management of Overspeed Event in Cruise
- The Adverse Effects of Unrealistic Simulator Scenarios
- Preventing Fan Cowl Door Loss
- Correct Escape Slides Maintenance for Successful Slides Deployment

Issue 27

January, 2019

- Engine Thrust Management - Thrust Setting at Takeoff
- Prenventing Inadvertent Slide Deployments
- Preventing Violent Door Opening due to Residual Cabin Pressure
- Lessons Learned About the Teach-In Function

Issue 26

July 2018

- Look out for Ice Ridges on the Lower Nose Fuselage
- High Load Event Reporting
- Using Aircraft as a Sensor on Contaminated Runways
- Thrust Reverser Deployment in Fight

Issue 25

January 2018

- Are You Properly Seated?
- A Recall of the Correct Use of the MEL
- Protecting Aircraft and Passengers from Cargo Fire

Issue 24

July 2017

- Control your Speed... During Descent, Approach and Landing
- Troubleshooting Airframe Vibrations
- Preventing Falls from Height
- Progress to Pinpoint anAircraft's Position

Issue 23

January 2017

- Safely Flying Non-Precision Instrument Approaches
- Introduction to the Soft Go-Around Function
- Preparing Flight Crews to Face Unexpected Events
- Safety, Our Shared Destination

Issue 22

July 2016

- Pitot Probe Performance Covered On the Ground
- 180° turns on runway
- Optimum use of weather radar

Issue 21

January 2016

- Control your speed... in cruise
- Lithium batteries: safe to fly?
- Wake vortices
- A320 Family Aircraft configuration

Issue 20

July 2015

- Control your speed... during climb
- Lateral runway excursions upon landing
- Fuel monitoring on A320 Family aircraft
- Hight-altitude manual flying

Issue 19

January 2015

- Tidy cockpit for safe flight
- Landing on contaminated runways
- Understanding weight & balance
- Wind shear: an invisible enemy to pilots?

Issue 18

July 2014

- Control your speed... at take-off
- Safe operations with composite aircraft
- Learning from the evidence
- A320 Family cargo Containers/ pallets movement
- Parts Departing from Aircraft (PDA)

Issue 17

January 2014

- Airbus Brake Testing
- Hard Landing, a Case Study for Crews and Maintenance Personnel
- Aircraft Protection during Washing and Painting
- Flight Data Analysis (FDA), a Predictive Tool for Safety Management System (SMS)
- Flying a Go-Around, Managing Energy

Issue 16

July 2013

- **Performance Based Navigation:** RNP and RNP AR Approaches
- **Atlantic Airways:** Introduction of RNP AR 0.1 Operations
- Flight Crews and De-Icing Personnel – Working together in Temporary Teamwork for safe Skies
- Low Speed Rejected Take-Off upon Engine Failure
- Late Changes before Departure

Issue 15

January 2013

- The Golden Rules for Pilots moving from PNF to PM
- Airbus Crosswind Development and Certification
- The SMOKE/FUMES/AVNCS SMOKE Procedure
- Post-Maintenance Foreign Objects Damage (FOD) Prevention
- **Corrosion:** A Potential Safety Issue

Issue 14

July 2012

- 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 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
- Facing the Reality of everyday Maintenance Operations

Issue 12

July 2011

- Airbus New Operational Landing Distances
- The Go Around Procedure
- The Circling Approach
- VMU Tests on A380
- Automatic Landings in Daily Operation

Issue 11

January 2011

- What is Stall? How a Pilot Should React in Front of a Stall Situation
- Minimum Control Speed Tests on A380
- Radio Altimeter Erroneous Values
- Automatic NAV Engagement at Go Around

ARTICLES PUBLISHED IN PREVIOUS 'SAFETY FIRST' ISSUES

Available in the Safety first app and website: **safetyfirst.airbus.com**