



The Airbus safety magazine

July 2016

#22

Safety first



AIRBUS

Safety first

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

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editorial



YANNICK MALINGE

SVP & Chief
Product Safety Officer

2015 is the safest year ever by number of fatal accidents: this is the positive achievement that we highlighted in our last Commercial Aviation Accidents Statistics brochure. But is this the signal that our long and complex journey with safety enhancement has reached an end? We believe that it is just the beginning of something new.

There is no room for complacency in safety; instead good results should force us to become even more creative and innovative. This ambition is what drove the introduction of our new collaborative project 'Air Transport Safety: Destination 10x Together'. We are hopeful that this initiative will bring a new impetus to collaboration across our industry. It will first aim to form a diagnosis of safety at the Air Transport System level today, and then define together not only what the current and emerging safety threats and challenges are, but also opportunities to further reduce the accident rate.

In the frame of this project, a first survey was made during the last Flight Safety conference and it highlighted areas and safety threats that will need focus. Traffic and fleets growth implying increased congestion and recruiting & training needs, security and weather information were amongst the most cited.

We will continue to welcome your feedbacks and suggestions, and we will make sure these are heard and properly communicated to the benefit of all stakeholders across our industry.

Together, we must perpetuate our commitment to safety and strive to continue to improve collectively. The articles published in this new issue of our magazine have been written in this regard.

I hope that you will enjoy reading this new Safety first issue!

A handwritten signature in black ink, appearing to read 'Y. Malinge'.



NEWS

A statistical Analysis on Commercial Aviation Accidents: check the 2016 edition!

The new edition of our yearly brochure on commercial aviation accidents statistics is now available.

This statistical analysis examines the evolution of hull-loss and fatal accidents during revenue flights from 1958 to 2015. A particular focus is made on a breakdown of statistics by generations of aircraft and main accident categories, namely Controlled Flight Into terrain (CFIT), Loss Of Control In-flight (LOC-I) and Runway Excursion (RE).



Visit our airbus.com website (keyword "safety") or find it on our tablet application.

SAVE THE DATE



NEWS

23rd FLIGHT SAFETY CONFERENCE – 2017

We are pleased to announce that the 23rd Flight Safety Conference will take place in Santiago, Republic of Chile, from the 20th to the 23rd of March 2017. A preliminary conference agenda will be announced in September and the formal invitations will be sent to our customers in January 2017 to register. For any information regarding invitations, please contact Mrs. Nuria Soler, email nuria.soler@airbus.com.

The annual Airbus Flight Safety Conference has proven to be an excellent forum for the exchange of information between Airbus and its customers. To ensure that we continue to have an open dialogue that

promotes flight safety across the fleets of all our operators, we are unable to accept requests to attend from outside parties.

We welcome presentations from our customers and encourage your participation as a speaker to share experiences and ideas and experience for improving aviation safety.

If you believe there is a topic that will benefit other operators and/or Airbus, and you are interested in being a speaker at this conference, please send a brief abstract and a bio or resume to nuria.soler@airbus.com

23rd Flight Safety Conference

Santiago, Republic of Chile
20-23 March 2017







Safety first #22

-  Flight operations
-  Maintenance
-  Engineering
-  Ground operations

■ PROCEDURES

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180° turns on runway

■ OPERATIONS

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Optimum use of weather radar

■ PROCEDURES

Pitot Probe Performance Covered On the Ground



Pitot Probe Performance Covered On the Ground

Pitot probes inlet obstruction will affect accuracy of the air data parameters calculated from its measurements such as the aircraft airspeed and Mach number. Pitot probes inlet obstruction on the ground can be caused by unexpected sources such as sand, dirt, dust or insect nesting activity. This is why it is important to think about when to install Pitot probe covers for an aircraft on the ground to protect its air data system performance.



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AN OBSTRUCTED PITOT PROBE MAY OCCUR IN LESS TIME THAN YOU THINK

In-service experience: impacts of a blocked Pitot probe in a context of dispatch under MEL

In a recent incident, the captain of an A330 rejected the take-off attempt after noticing an airspeed indication failure. Troubleshooting conducted subsequently led to swap two of the Air Data Inertial Reference Units (ADIRU) and the aircraft was dispatched with ADIRU 2 inoperative as allowed by the Minimum Equipment List (MEL). A second take-off passed the critical V_1 speed when an airspeed discrepancy was noticed again on the captain's PFD. The take-off had to be continued but a wrong captain airspeed associated with ADIRU 2 inoperative caused the A330's auto-thrust and flight directors to disengage, the flight controls mode

reverted from normal to alternate law and the autopilot became unavailable. The crew performed an immediate in-flight turn-back. After the uneventful landing, a detailed ground inspection found conclusive evidence that the cause of the indicated airspeed discrepancy was due to a Pitot probe partially blocked in less than two hours by nesting wasps.

An investigation of another in-flight turn-back (from a non-Airbus aircraft type) at the same airport also showed that the inlet of the captain's Pitot probe was partly obstructed by material consistent with a mud-dauber wasp nest.

Main reasons for Pitot obstruction: insects but not only...

Insects can cause rejected take-off or in-flight turn-back events and there are other potential sources of Pitot obstruction.

"A mud dauber wasp can build a significant nest capable of completely blocking a Pitot probe, vent, or drain in around 20 minutes" according to a recent airworthiness bulletin

issued by the Australian Civil Aviation Safety Authority (CASA) following an investigation of an in-service occurrence. But it is not only insect activity that can be the cause of Pitot blockage. Pitot probe inlet obstruction by insect, dust, dirt or any materials (sand) is the main root cause of rejected take-off or in-flight turn-back events due to airspeed discrepancy below FL 250. ■

“ The cause of the indicated airspeed discrepancy was due to a Pitot probe partially blocked in less than two hours by nesting wasps. **”**

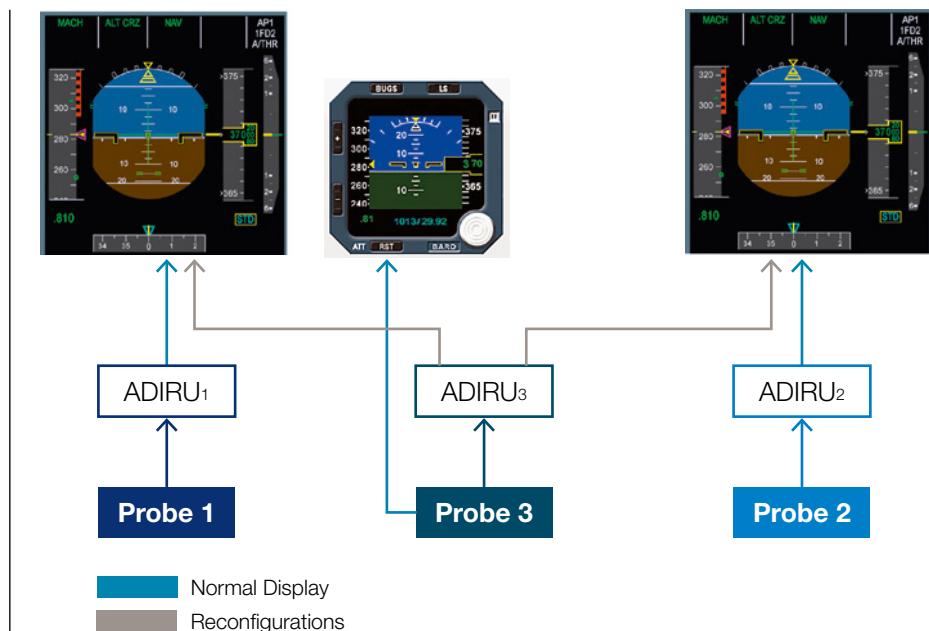
“ The main cause of airspeed discrepancy below FL250 was Pitot obstruction by sand, dust, dirt or insects. **”**

PROCEDURES

Pitot Probe Performance Covered On the Ground

(fig.1)

Pitot probe simplified schematic (applicable for A320, A330 and A340 aircraft)



A PRECISION INSTRUMENT FOR MEASURING AIRSPEED

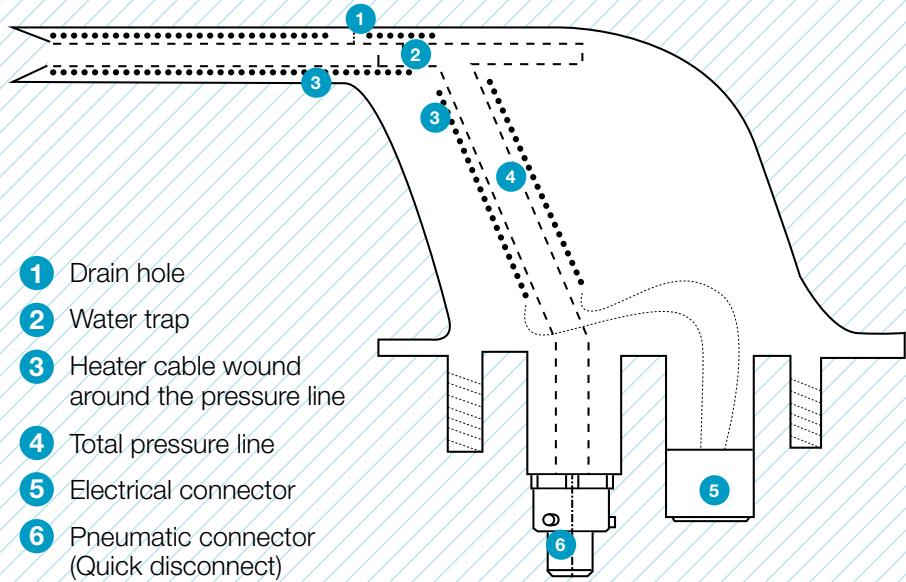
The Pitot probe consists of a tube pointing directly into the air flow (fig.2) and measuring the stagnation pressure called total pressure or Pitot pressure.

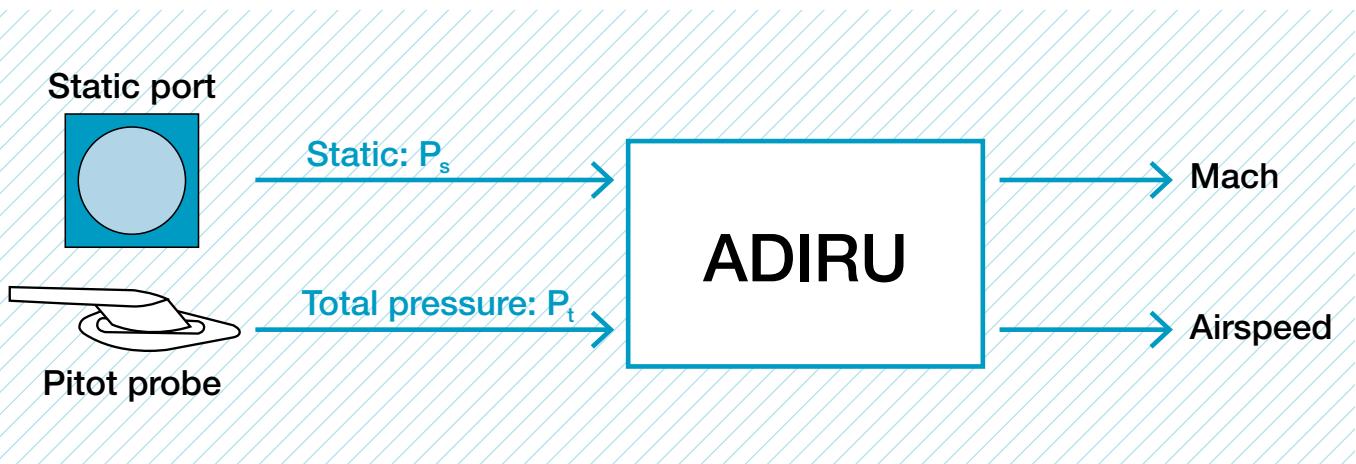
This total pressure information and the static pressure delivered by static ports on the fuselage are used to compute the indicated airspeed and Mach number provided by the ADIRU (fig.3).

Like any precision instrument, Pitot probes need to be protected on ground to provide correct airspeed and Mach number measurements in flight in order to fly the aircraft safely.

(fig.2)

Design principle of a Pitot probe (applicable for A320, A330 and A340 aircraft)





PREVENTING PITOT PROBE OBSTRUCTION ON GROUND

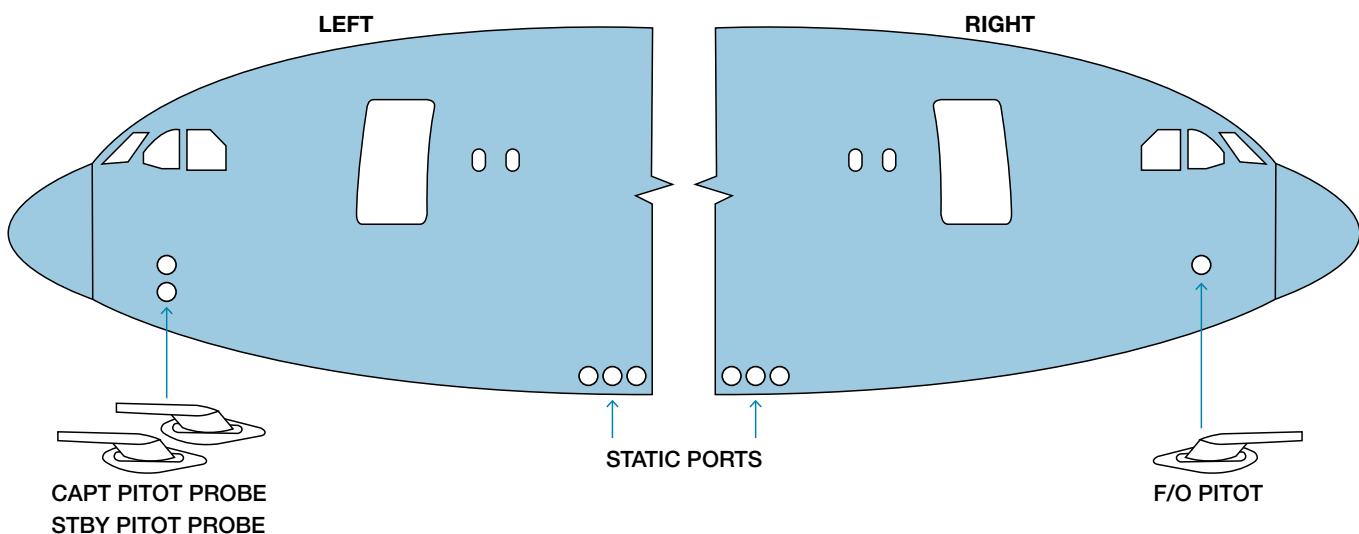
Aircraft Maintenance Manual parking procedure

Parking procedures available in the Aircraft Maintenance Manual (AMM section 10-11-00) will request that approved protective covers are installed on each of the air data probes or

devices, including Pitot probes (fig.4). But many operators will not apply the AMM parking procedure if the aircraft only has a short turn-around time or remains on the flight line.

(fig.3)
Pitot probe principle

(fig.4)
Pitot probe locations on an Airbus A330 or A340 aircraft



■ PROCEDURES

Pitot Probe Performance Covered On the Ground

(fig.5)

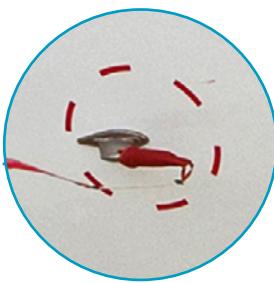
Aircraft Pitot probe protective cover (applicable for A320, A330 and A340 aircraft)



The proper protection for Pitot probes

Using the approved Pitot probe covers **(fig.5)** is important as the covers for other manufacturer's aircraft may not be the correct fit or offer complete protection for the Pitot probes of Airbus aircraft. The same Pitot probe cover can be used on

Airbus A310, A320, A330, and A340 aircraft families. Airbus A380 and A350 aircraft have Multi-Function Probes (MFP) and a standby Pitot probe that use two different covers. Pitot probe and MFP covers are part of the flight kit for each aircraft.



When is Pitot probe too hot to handle on ground?

Protective covers can be installed 30 minutes after engines shut down as the probe heating is deactivated when engines are turned off. After a

period of 15 minutes for the probe tip to cool to 70°C, it can take an additional 15 minutes to reach ambient temperature. ■

AIRLINE ASSESSMENT – FROM OPERATIONAL BASES TO DESTINATION AIRPORTS

Is the Pitot probe protection a priority for ground handlers and maintenance teams?

With the recent finding from the example incident where a Pitot probe obstruction occurred in less than two hours, it is important to know if Pitot probe protection is a priority in local airport ground handling or turn-around procedures. The aircraft operator should collaborate with the local airport authorities to assess the risk of Pitot probes being blocked by sand, dust, dirt or insects activity at their operational base or destination airports.

For example, check if a wildlife management plan is part of the airport's hazard management strategy and what mitigations are in place to detect or manage insect activity. Confirm how each airport will alert airlines or operators where there is evidence that local conditions may contribute to an increased risk of Pitot blockage to aircraft on the ground.

Depending on the outcomes of this risk assessment, the operator should consider implementing a specific policy on the use of Pitot covers even for a short turn-around time. Some airlines already have policies in place for certain airports that require Pitot covers to be used for all aircraft on the ground regardless of turn-around times.

Airlines or operators should also report any in-service incidents of Pitot probe obstruction to the local airport authority and to Airbus. This will help to determine root causes, prevent further occurrences and track any trends of obstructions of Pitot probes on ground. ■

“ Some airlines already have policies in place for certain airports that require Pitot covers to be used for all aircraft on the ground regardless of turn-around times. ”

AIRPORT PROACTIVE PREVENTION STRATEGIES

The airports can also implement preventive actions following an assessment of the locally occurring risks such as regularly inspecting for wasps or other insects at their sites. It is important to continuously monitor and communicate with all airlines and aircraft operators about any seasonal increased insect activity, especially by wasps, and where there are local conditions causing accumulations of sand, dirt or fine particle dust. This will

alert aircraft operators and their ground handlers to consider applying additional preventive measures to protect Pitot probes with the approved covers, even for short aircraft turn-around times. If there is a persisting problem, it may be necessary to issue a Notice to Airmen (NOTAM) making the pilots aware of the risk (fig.6) and alert them to pay particular attention when checking their aircraft's Pitot probes for any risk of obstruction. ■

(fig.6)

Example extract from NOTAM with item [3.] warning of mud wasp activity and the recommendation to install Pitot tube covers - Courtesy of Brisbane Airport Corporation

AIP Australia

26 MAY 2016

FAC YBBN - 7

- b. Australian White Ibis flocking on airfield HJ, increased numbers expected February-June.
- c. Straw Necked Ibis present on airfield HJ, increased numbers expected July-October.
- d. Flying Fox HN only.
- e. Cattle Egret present on airfield HJ, increased numbers expected NOV-MAR.
- f. Increased pelican and cormorant in VCY of AD.
- 3. Significant mud wasp ACT WI AD VCY affecting pitot tubes. Pitot tube covers recommended.
- 4. Fuel/Oil clean-up/disposal are chargeable and must meet Governmental Environmental standards.
- 5. Due to local effects from structural and topographical features the ground winds advised on the ATIS may vary to the wind aloft. Where there is a significant variation reported in these winds, ATC will advise a reported 500FT wind in addition to the aerodrome wind.



CHARTS RELATED TO THE AERODROME

1. WAC 3340.
2. Aerodrome Obstruction Chart Type A Charts: RWY 14/32 - 11th Edition (MAR, 2014); RWY 01/19 - 10th Edition (MAR 2014).
3. Also refer to AIP Departure & Approach Procedures.

PROCEDURES

Pitot Probe Performance Covered On the Ground

(fig.7)

Mud wasp awareness poster -
Courtesy of Brisbane Airport Corporation



(fig.8)

Array of 3D printed Pitot probes of various designs (A330, B737-400, B737-800, Dash-8, B747 and E190) used for monitoring wasp activity and ecology study at Brisbane airport. - Courtesy of Brisbane Airport Corporation



ADDITIONAL AIRPORT MEASURES – UPPING THE ANTE

An example of where collaboration between Airlines and Airports can enhance the operational safety of aircraft

Like many other airports around the world, being located in a sub-tropical environment means Brisbane Airport (BNE) is ever vigilant about the presence of mud wasps on site. While the airport has always maintained a stringent monitoring and control regime for these pests, following an incident whereby a mud wasp nest blocked the air data instruments of an Airbus aircraft during a standard turn-around at Brisbane Airport, the Brisbane Airport Corporation (BAC) upped the ante by introducing additional measures to mitigate the ongoing risk of Pitot blockage on ground.

Airport to Airline Communication

BAC recommends the use of Pitot probe covers on aircraft at BNE to prevent possible obstructions from mud wasp activity. Results from pest inspections carried out by pest management professionals are emailed out weekly to all airlines and stakeholders. The notifications include the location and number of nests found and treated. Their "Watch out for the Mud Wasp" awareness poster **(fig.7)** is a quick reference guide to the conditions to observe when the wasps are likely to be more active at BNE and details what information to report to the BAC wildlife coordinator via email or at the Brisbane Airport Wildlife Working Group.

Preventative pest control

BAC initiated a wasp ecology study consisting of an array of 3D printed Pitot probes of various designs (A330, B737-400, B737-800, Dash-8, B747 and E190), which are secured to sheets of metal to resemble the aircraft's fuselage, and they are mounted in different parking positions around the airfield **(fig.8)**. Each location is inspected regularly for evidence of mud wasp activity and when there are nests found in any of the 3D printed Pitot tube arrays the contents are hatched and examined by an ecologist. Results from the study are expected in February 2017. This will help BAC achieve a better understanding of the species of mud wasp present at Brisbane, the impacts that they can have on aircraft operations and any further measures that can be taken to mitigate the risk.

FLIGHT CREW FOCUS ON PITOT PROBES

Additional safety barriers, embedded in Airbus Standard Operating Procedures (SOP), are available to flight crews in order to avoid taking-off with obstructed Pitot probes.

SOP Exterior Walk Around (FCOM section PRO-NOR-SOP-05)

Always look at the Pitot probes carefully during the pre-flight exterior inspection and check that all of the covers are removed before flight. Ensure there is no damage to the Pitot

probe and that the general condition is good. This will give confidence that the correct airspeed readouts will be available on all of the instruments in all flight phases.

SOP Take-off (FCOM section PRO-NOR-SOP-12)

During the take-off phase, a partially or totally obstructed Pitot probe may lead to an underestimated, fluctuating or “flagged” airspeed information on the Primary Flight Display (PFD) or standby instrument for the affected Pitot probe. In this case, there is likely to be an indicated airspeed discrepancy

which should be detected when cross checked with the other PFD. Standard Operating Procedures for Airbus aircraft require the flight crew to scan airspeeds shown on the PFD throughout the take-off and the Pilot Flying shall cross check and confirm the airspeed indicated on reaching 100 knots. ■

Pitot probe protection using the Airbus approved covers is the most effective way to prevent Pitot obstruction on ground.

Airlines and operators should assess and monitor the risk of any obstruction to their aircraft's Pitot probes at the airports where they are based or operating to. Airports can also play an active role by collaborating with their operators to manage airport hazards and communicate on any of the mitigations in place.

Where there is an identified risk of Pitot obstruction due to sand, dirt, dust or insect nesting activity, the operator should consider applying a specific policy to use Pitot covers for aircraft on the ground regardless of turn-around times.

Reporting any occurrences of Pitot probe obstruction to the local airport authorities and Airbus will help to monitor for adverse trends, put specific measures in place and communicate this information to the benefit of all airlines and operators.



180° turns on runway

Performing a 180° turn or U-turn on a runway may seem an ordinary maneuver compared to other phases of the flight. However, operational experience over the past 10 years shows that unintentionally leaving the runway while completing a U-turn can happen, even to experienced pilots, in any conditions, even on dry runway, on any aircraft type including the A320 family aircraft. A specific technique exists for such U-turns to avoid runway excursions.



**STÉPHANE
BRIZAY**

Flight Operations
Engineer



**XAVIER
JOLIVET**

Director Flight Safety
Enhancement

U-TURNS ON RUNWAY: A SIGNIFICANT CONTRIBUTOR TO RUNWAY EXCURSIONS

Who would naturally think about U-turns on runways when referring to aviation accidents? Although not intuitive, this relationship does exist. Indeed, operational experience shows that a number of runway excursions resulted from a failure to manage such a maneuver correctly. In less than 10 years, more than 20 runway excursions with some incidents leading to an ICAO Annex 13 investigation have been reported to Airbus.

Beyond the potential for significant aircraft damage or time for inspection and repairs, the consequences of such events translate mainly into operational disturbance. They lead to flight cancellation, the need to off-

load and defuel the aircraft when it has to be returned to the pavement, not to mention the impact on airport operations with the potential closure of the runway and its associated safety implications. The airline involved is often put in an embarrassing position from a brand point of view due to the speed of modern visual communications.

The number of recent events may be growing due to a reporting bias, but the issue has now drawn attention from a safety vantage point.

Thanks to the reported events, Airbus was able to analyze and understand the conditions of occurrence.

Lessons from in-service events

Some possible preconceived ideas are dismissed by facts especially concerning the runway contamination, the pilot's

experience or the type of aircraft. Let's review the 21 events reported to Airbus over the past 10 years in figures:

Aircraft type Runway state	A320 family	A330 family	A300/A310 family	A350	Total
Contaminated	5	4	0	1	10
Dry	2	6	0	0	8
No information	0	1	2	0	3
Total	7	11	2	1	21

■ PROCEDURES

180° turns on runway

“ Any runway excursion, as smooth as it may seem, requires the aircraft to be checked prior to the next flight. ”

“ To ensure the aircraft integrity for the next flight, to allow safety lessons to be learnt and to be able to take appropriate mitigation measures from analyzing all events of similar nature, all runway excursion events need to be reported. ”

Beyond these two dimensions, a thorough analysis of the events shows that the runway surface quality is also an important parameter. Indeed, a degraded or damaged runway surface may have as much influence on the performance of a U-turn as a contaminated runway.

As for the pilot's background, it turns out that it was extremely variable from one event to the other. In other words, a runway excursion when performing a U-turn on a runway is not the preserve of the least experienced pilots...

Reporting: the most precious input to enhancing safety

In one surprising event, although the crew had experienced a runway excursion, they realigned the aircraft and took off. Damage on the gear was observed at arrival. Even at low speed, a runway excursion can damage the aircraft in a way that can affect the safety of the following flights. Any runway excursion, as smooth as it may seem, requires the aircraft to be checked prior to the next flight in accordance with the AMM guidelines.

Moreover, to ensure the aircraft integrity for the next flight, to allow safety lessons to be learnt and to be able to take appropriate mitigation measures from analyzing all events of similar nature, all runway excursion events need to be reported.

As of today, the analysis of the events made available to Airbus through reporting allowed us to dismiss possible preconceived ideas, such as: it only occurs to the least experienced pilots or only on contaminated runways or with large aircraft. It also allows us to highlight the key points or parameters that need to be checked before initiating the turn and executing the maneuver, as well as to emphasize the best technique and tips to perform such turns safely.

Eventually, thanks to airlines reporting, the technique available today in the FCOM is going to be revisited and improved as part of the FCTM. Key values relating to the recommended runway width will be kept in the FCOM. These updates will be available by the end of 2016. ■



TECHNIQUE AND TIPS TO PERFORM A SAFE U-TURN ON THE RUNWAY

The analysis of in-service events allowed the technique for U-turns in the FCOM to be revisited. The philosophy of the new revision will align with the existing content and emphasize the key steps of the technique for performing successful and safe U-turns. The technique was initially developed for U-turns on a runway, where there are standard markings at the borders of the runway.

As far as possible, a U-turn on the runway needs to be prepared before arriving on the runway. The preparation includes a discussion on who will be PF and in which direction should the turn be performed in accordance with the airline policy.

Performing a safe U-turn on a runway is not just a matter of managing the turn itself. It starts before initiating the turn...

“ Performing a safe U-turn on a runway is not just a matter of managing the turn itself. It starts before initiating the turn... **”**

Before initiating the turn

Initiating the turn in good conditions relies on a number of complementary

aspects beyond the ones mentioned before.

Suitability of runway width with the conditions of the day

Performing a safe U-turn on a runway requires anticipating the space required for the safe completion of the maneuver. The minimum runway width for a given aircraft type is provided in the FCOM. However, it is important to keep in mind that this value is based on the following assumptions: the runway is dry, the runway surface quality is good and the technique recommended by Airbus is

used. Therefore, it may be necessary to add some margins if these conditions are not met (e.g. contaminated runway).

In summary, before considering a U-turn on a runway, check that the runway width is sufficient with respect to the minimum published in the FCOM possibly adjusted to the anticipated conditions of the day.

“ The minimum required runway width to carry out a U-turn is based on the following assumptions: a dry runway, a good runway surface and the application of the correct technique. **”**

Consider the actual runway surface quality

As previously mentioned, the state of the runway may require the margins provided by the FCOM to be adapted. The maneuver is to be performed with the maximum available steering of the nose wheels and in such a configuration, a poor surface may make the wheels slip and increase the turn radius.

surface. In other instances, pieces of multiple layers of painted surface became detached over time, thus generating depressions likely to retain rain water even though the remainder of the runway had already dried up.

It is important to keep in mind that painted areas such as runway threshold markings can be significantly more slippery than the rest of the runway. Indeed, some investigations highlighted that the repainting of the white strips tended to fill the runway's textured

As a consequence, special care must be taken when the trajectory requires taxiing the aircraft over a painted surface. A good friction coefficient experienced while still on the unpainted area is not necessarily representative of the one when on the painted marks. The crew must be ready to reassess the situation if any unexpected skidding during the turn is experienced.

PROCEDURES

180° turns on runway

Control the ground speed and adapt it to the conditions of the day

Remaining on the runway while performing a U-turn requires control of the trajectory at all times. This involves before initiating the turn:

» Stabilizing the trajectory

Stabilizing the initial trajectory before the turn is key in many respects. It allows for:

- optimization of the point of initiation of the turn
- compliancy with the assumptions used to determine the minimum runway width required, i.e. the maneuver is properly performed (initial recommended divergence angle)
- reduction of the number of parameters to be managed during the turn itself.

In order to optimize the turn initiation point and the distance required to complete the turn, it is recommended to adopt a divergence angle from the runway axis. The advisable divergence angle varies depending on the aircraft type but it typically ranges between 15° and 25°.

As illustrated in **Figure 1**, increasing the divergence angle leads to an increase in the turn radius. For example, adopting a divergence angle of 40° instead of the recommended 20° for an A330-300 leads to an increase of about 2 meters. Decreasing the divergence angle by too large an amount would result in the main landing gear possibly exiting the runway at initiation of the turn.

A330-300	Divergence angle	Measure of necessary width Nose Wheel Steering Angle (NWSA) 95% (m)	Difference compared with FCOM recommended value of 20° (m)	Measure of necessary width NWSA 80% (m)	Difference between 80 and 95% NWSA (m)
	10°	56.2	-0.17	65.6	9.4
	Recommended 20°	56.4	0	65.7	9.3
	40°	58.1	1.7	67.4	9.3

» Stabilizing the ground speed

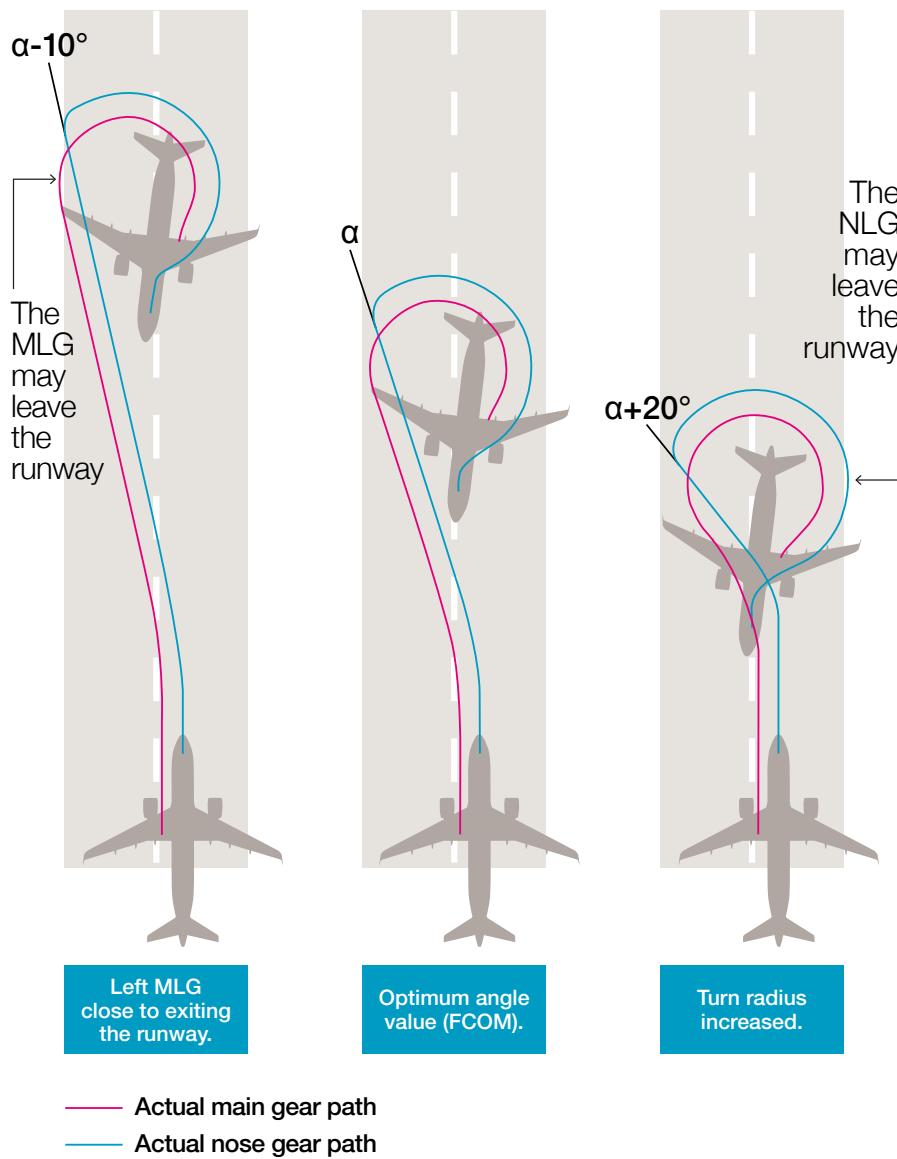
The recommended ground speed for the 180° maneuver should be between 5 and 10 kt on most aircraft. If the speed is not stabilized before the turn, larger thrust adjustments may be needed during the turn. However, these adjustments can lead to an increase beyond the recommended speed, and may be a contributor to a runway excursion.

As mentioned earlier, any degradation of the runway state either due to runway surface condition or contamination requires additional precautions and margins. In terms of speed, it is safer to target the lower boundary of the recommended speed window, namely 5 kt, to perform a U-turn on a degraded runway.



BEST PRACTICE

On A300/A310, A330/A340 and A350 families, on dry runways, the use of differential braking to stop one gear (Braked Pivot Turn technique) may induce stress on this gear and could have fatigue effects over time on the gear. Such a technique is therefore not recommended. However, on a wet or contaminated runway, the lower friction coefficient reduces the induced stresses and differential braking, whilst avoiding pivot braking, could help to manage the turn. This recommendation does not apply to A320 family and A380 aircraft, for which the Braked Pivot Turn technique is usually used without adverse effect on the gears.

**(fig.1)**

Turn radius evolution as a function of the divergence angle α

Performing the turn

During the maneuver, the ground speed is a key parameter to manage: the objective is to maintain a low (5 to 10 kt) but steady ground speed. If too much speed is lost, turning the aircraft will become more difficult to manage and it may eventually come to a complete

stop. To avoid stopping, applying some additional thrust may be necessary. However, gaining too much speed could increase the chances of the aircraft exiting the runway. Maintaining a continuous speed before and during the turn is therefore of paramount importance.

Initiating the turn

For field of view reasons, the turn is recommended to be performed by the crew member sitting on the seat opposite to the direction of the U-turn. This means that to turn right, the flight crew member on the left hand side of the cockpit is PF; respectively to turn left, the flight crew

member on the right hand side is PF.

The visual reference to initiate the turn depends on the aircraft type. On most Airbus aircraft, the turn is to be initiated when the PF assesses that he/she is physically directly over the runway edge.

■ PROCEDURES

180° turns on runway

Once the PF reaches the appropriate initiation point, he/she needs to progressively use up to full tiller deflection to turn the aircraft.

During this initial maneuver, due to the aircraft inertia the nose wheels are not fully aligned with the aircraft trajectory. This misalignment reduces the grip of the nose wheels onto the runway and may lead the aircraft to skid if the nose wheels are not turned smoothly and

progressively. This is why an aggressive application of full nose wheel steering should not be done.

The speed can be maintained by applying small amounts of asymmetric thrust and keeping idle thrust on the engine on the inside of the turn. As explained before, maintaining a continuous speed is key and after any adjustment to the thrust, the speed must be carefully monitored.

During the turn

As shown in **Figure 1**, if the divergence angle affects the required turning distance, then the steering value is a parameter even more significant. The minimum distance published in the operation documentation considers a full steering order throughout the whole maneuver.

Throughout the turn, the PF is focused on the dynamics of the maneuver. He/she is looking outside in the direction of the expected aircraft trajectory, and adjusting the aircraft speed accordingly.

The role of the PM is at all times to monitor not only the aircraft trajectory but also the aircraft ground speed and to call out any deviation. The PM can monitor the heading, the ground speed indication as well as the ETACS when available. Indeed, by focusing on the outside, the PF cannot closely monitor these parameters and especially the aircraft ground speed to detect any excursion outside the recommended speed range; therefore, the role of the PM is essential.

Finishing the turn

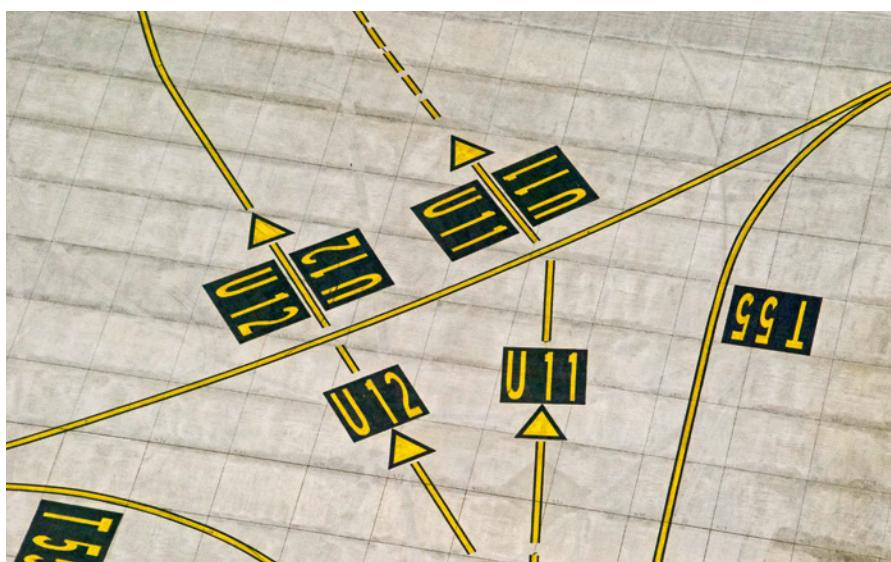
In this phase of the turn, the main challenge is to get the aircraft aligned on the centre of the runway without jeopardizing the remaining runway length or the planned take-off distance available.

When the aircraft is aligned with the runway, the tiller is to be released smoothly before stopping the aircraft to make sure that the nose wheel is aligned

with the aircraft and therefore ready to initiate the take-off roll in good conditions.

At any stage before or during the maneuver, should any problem arise, stop and call the tower to get support from a tug. Keep in mind that it is most preferable to call a tractor to finish the maneuver, rather than to recover the aircraft with a landing gear off of the runway. ■

“ At any stage before or during the maneuver, should any problem arise, stop and call the tower to get support from a tug. ”





Performing a U-turn on a runway is not an insignificant maneuver. Safely performing it starts with good preparation and a precise initiation of the turn as well as implementing the technique properly at the right speed. Whether it has to be performed before taking-off or at the end of the flight, some key aspects are to be kept in mind:

- Carefully check the minimum distance published in the operational manual versus the available runway width, keeping in mind that the minimum 180° turning distance published values correspond to a dry runway
- Pay attention to the runway condition, both surface quality and contamination, as they may induce skid and may increase the turn width. Add reasonable margins accordingly
- Adapt the speed to the runway condition (within the recommended speed range)
- In case of a problem at any stage of the overall maneuver, stop the aircraft and call for support
- Should the crew become aware that the aircraft has left the runway surface, even slightly, report the occurrence and inspect the aircraft before taking-off

Some simple advice to avoid big problems!

OPERATIONS

Optimum use of weather radar



Optimum use of weather radar

In recent years, there have been a number of flights where passengers or crew suffered injuries due to severe turbulence. In some other instances, the aircraft structure was substantially damaged following a hailstorm encounter. Clearly adverse weather can pose a threat to the safe and comfortable completion of a flight, thus it needs to be detected and avoided in a timely manner.



**DAVID
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The airborne weather radar system is an essential tool for pilots to assess the intensity of convective weather ahead of the aircraft. In this respect, it enables the strategic and tactical planning of a safe flight trajectory.

Weather radar technology has evolved significantly in the last few years and a range of enhanced products is now available. If properly used, they permit pilots workload to be significantly reduced while substantially reducing encounters with adverse weather.

This article offers an overview of the existing weather radar technologies, and provides information and tips on how to tune the system and correctly interpret the available displays.

WEATHER RADAR PRINCIPLE AND OPERATION

The weather radar system installed on-board aircraft provides the pilot with the necessary information to avoid - not penetrate - adverse weather. To obtain the maximum benefit from the weather radar system requires

the crew to carefully optimize its use. This relies primarily on a good meteorological knowledge of weather phenomena, along with a good understanding of the available radar functions.

Flying in adverse weather: lessons learned

The aviation industry experience shows that although aircraft are equipped with airborne weather radars, incursions into very active convective cells still occur, resulting in injuries or substantial

aircraft damage (**fig. 1**). These events have led us to wonder why such encounters happen, and clearly show that prevention through anticipation is essential.



When it comes to understanding why aircraft fitted with technologically advanced weather radars can end up flying in such unfavorable weather patterns, we have to consider that getting the best out of technology onboard is just a part of the answer. A key element of adverse weather avoidance strategies



is the active monitoring of the overall meteorological situation by the crew, in addition to the optimum use of the weather radar and correct understanding of the information displayed. We must not forget that weather radar is of help, but the crew overall assessment of the weather situation plays the central role.

“ Prevention through anticipation is essential. **”**

(fig.1)

Radome and windshield after hail encounter

“ Weather radar is of help, but the crew overall assessment of the weather situation plays the central role. **”**

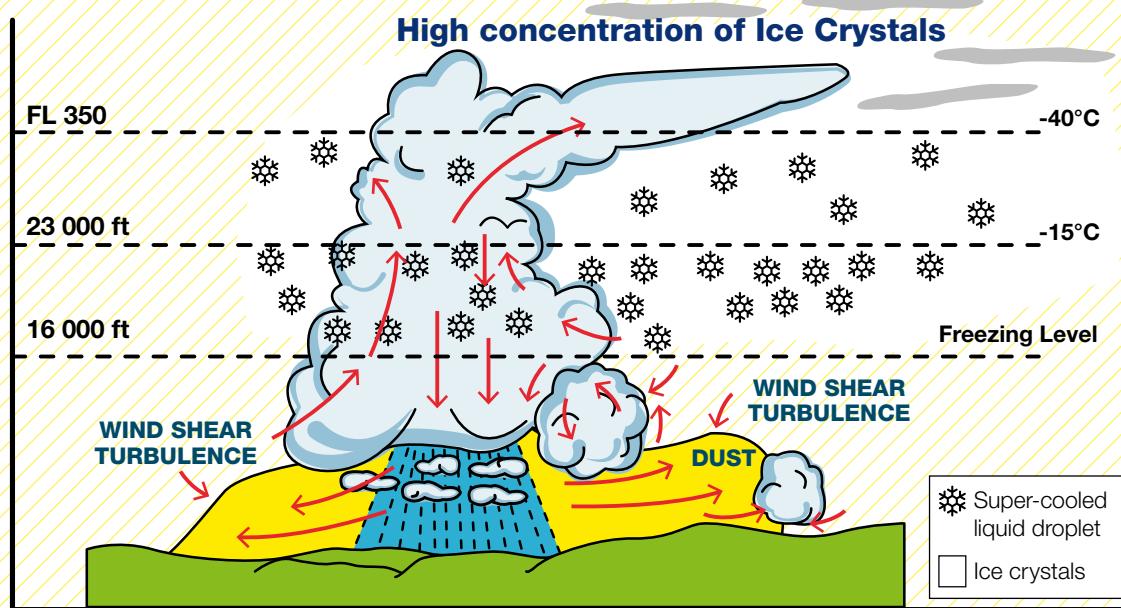
OPERATIONS

Optimum use of weather radar

HOW IS A CUMULONIMBUS, OFTEN CALLED "THUNDERSTORM", STRUCTURED?

Three common threats to aircraft are turbulence (which is caused when two masses of air collide at different speeds), hail and windshear. All three of these are by-products of thunderstorms.

Understanding how a cumulonimbus cloud is structured and evolves is key in dodging the associated weather disturbances.



Turbulence:

Turbulence associated with a cumulonimbus is not limited to inside the cloud. Therefore, when flying in an area where cumulonimbus clouds have developed,

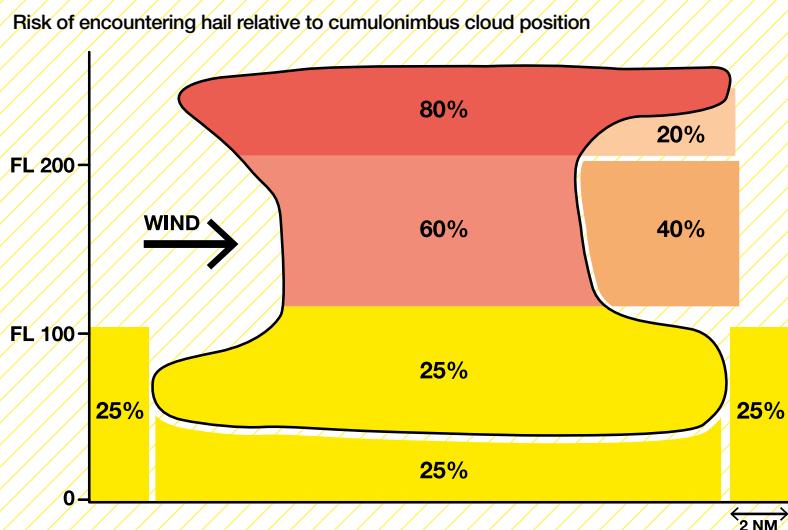
it is necessary to apply recommendations for weather avoidance as summarized in this article.

Hail:

The presence of hail within a cumulonimbus varies with altitude and wind:

- Below FL 100, hail is equally likely to be encountered under the storm, in the cloud or around it (up to 2 NM).
- Between FL 100 and FL 200, approximately 60 percent of hail is encountered in the cumulonimbus and 40 percent is encountered outside the cloud, under the anvil.
- Above FL 200, hail is most likely to be encountered inside the cloud.

When hail is encountered outside the cloud, usually the threat of hail is greater downwind of the cumulonimbus because moisture is



driven upward within the cloud by strong drafts. It then freezes and is transformed into hail before being blown downwind. Paradoxically, there

is less risk of hail in humid air than in dry air. In fact, moisture in the air behaves as a heat conductor, and helps to melt the hail.

Weather radar principle

A knowledge of the radar principle is paramount in order to accurately

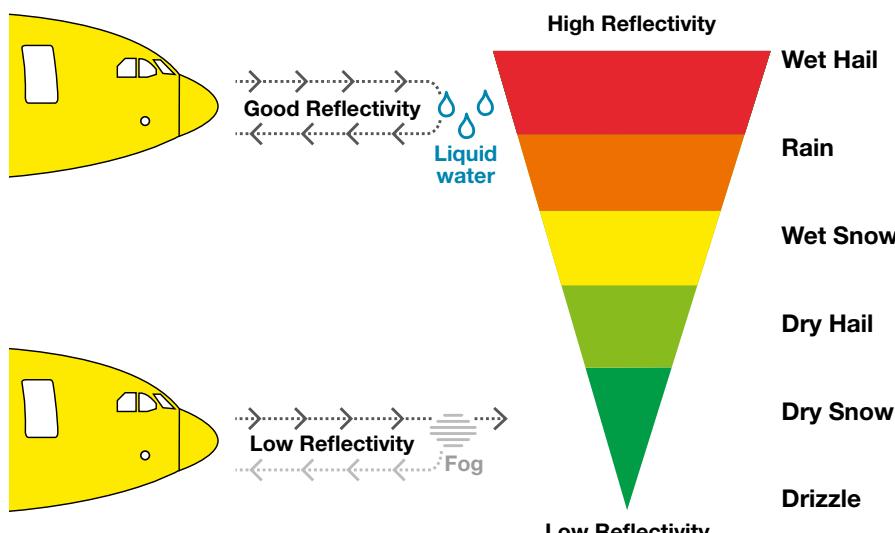
tune this system and interpret the weather radar display correctly.

Reflectivity

Weather detection is based on the reflectivity of water droplets (fig.2). The weather echo appears on the Navigation Display (ND) with a color scale that goes from red (high reflectivity) to green (low reflectivity).

The weather radar echo returns vary in intensity as a function of the droplet size, composition and quantity. For example, a water particle is five times more reflective than an ice particle of the same size.

“ On the Airbus fleet, all weather radars have full capability to allow wet turbulence detection. ”



Some weather radars are fitted with a turbulence display mode. This function (the TURB function) is based on the Doppler effect and is sensitive to precipitation movement. Like the weather radar, the TURB function needs a minimum amount of precipitation to be effective. An area

of light rainfall, depicted in green in normal mode, is shown in magenta when there is high turbulence activity. The TURB function is on most weather radars only active within a range of 40 NM (Doppler measurement capability) and should only be used in wet turbulence.

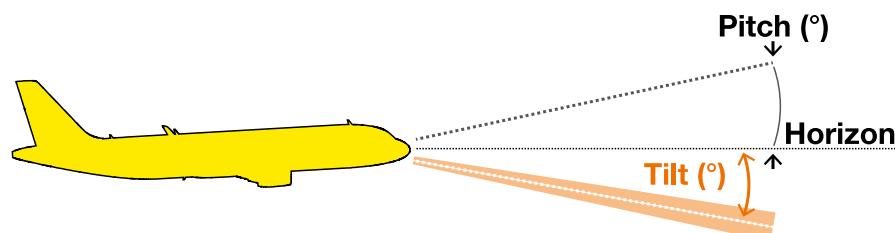
Weather radar operation

The flight crew uses four features to operate the radar:

- **Antenna tilt:** this is the angle between the centre of the beam and the horizon (fig.3).
- **Range control of the ND:** this

has an essential influence on the optimum tilt setting.

- **Gain control:** this adjusts the sensitivity of the receiver.
- **Radar modes:** weather (WX) or weather + turbulence (WX + T).



(fig.2)
Weather radar principle



Each type of weather radar has its own particularities. To get all the information on the characteristics, limitations and operational recommendations of each weather radar model, the user guide of the radar manufacturer needs to be studied.

(fig.3)
Definition of the TILT

“ Reflectivity is not directly proportional to the level of risk that may be encountered. ”

Weather radar limitations

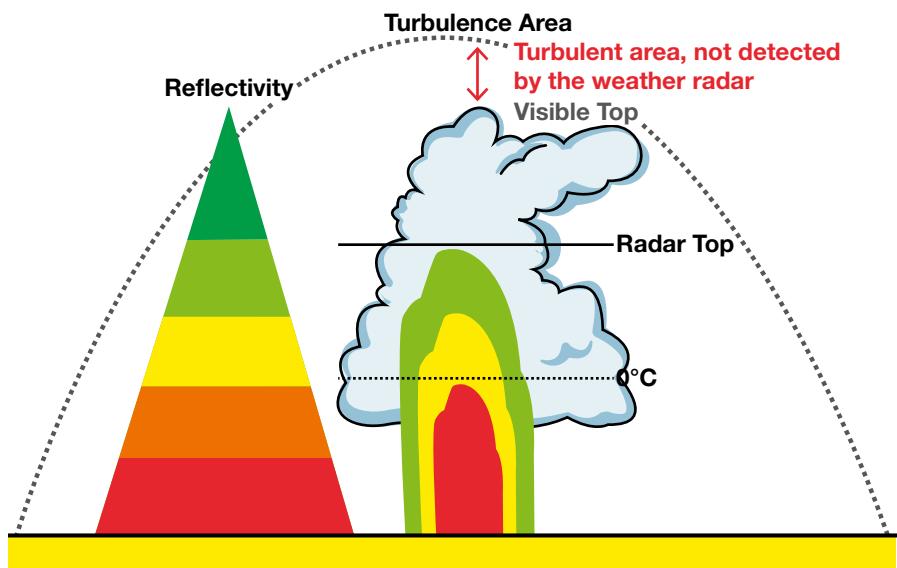
Weather radar detection capability

One of the weather radar limitations is that it indicates only the presence of liquid water. The consequence is that a thunderstorm does not have the same reflectivity over its altitude range because the quantity of liquid water in the atmosphere decreases with the altitude (fig.4). Yet, the convective cloud and associated threats may extend significantly above the upper detection limit of the weather radar (called ‘radar top’). This means that reflectivity is not directly proportional to the level of risk that may be encountered: a convective cloud may be dangerous, even if the radar echo is weak.

This is particularly true for equatorial overland regions where converging

winds produce large scale uplifts of dry air. The resulting weather cells have much less reflectivity than mid-latitude convective cells. However, turbulence in or above such clouds may have a higher intensity than indicated by the image on the weather radar display. On the other hand, air close to the sea can be very humid. In this case, thermal convection will produce clouds that are full of water: these clouds will have a high reflectivity, but may not necessarily be a high threat.

Consequently, limitations of weather radars must be well understood and complemented by basic meteorological knowledge of the crew and, where possible, visual observation.



(fig.4)

Reflective image of a cumulonimbus

The weather radar detects:	The weather radar does not detect:
<ul style="list-style-type: none">- Rainfall- Wet hail and wet turbulence- Windshear	<ul style="list-style-type: none">- Ice crystals, dry hail* and snow- Clear air turbulence- Sandstorms (solid particles are almost transparent to the radar beam)- Lightning*

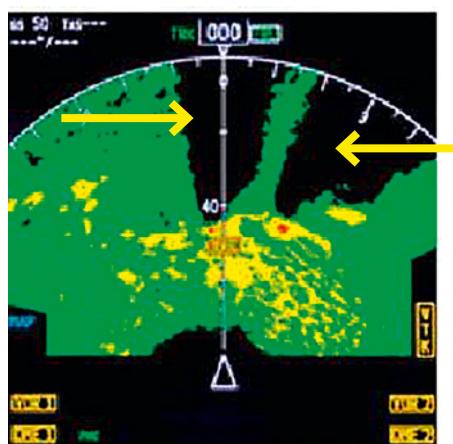
* The latest generations of weather radars offer hail and lightning prediction functions (see the following sections).

The beam attenuation phenomenon

Another limitation of the weather radar is called 'shadowing' or 'attenuation'. The weather radar display depends on signal returns: the more intense the precipitation, the less distance the radar can see through. Therefore when the radar echo is unable to make the two way trip through heavy precipitation, a 'shadowing' effect occurs.

The result is twofold. First, the size, shape

and intensity of that weather may not be accurately displayed to the pilot. What appears to be a thin or nonexistent band of precipitation **(fig.5)** could in fact be the leading edge of a much larger area of precipitation. Secondly, any weather behind such strong shadowing cells will not be detected. This can result in unexpected weather unfolding only after the cell has been circumnavigated. ■



“ A black hole behind a red area on a weather radar display should always be considered as a zone that is potentially very active and shadows weather further down the scanned path. ”

(fig.5)

Attenuation caused by moderate to extreme precipitation

WEATHER RADAR TECHNOLOGY: THE DIFFERENT TYPES OF WEATHER RADAR

In cooperation with its suppliers, Airbus has continuously and proactively supported weather radar technology evolution over the years.

These continuous improvements have allowed the crew to be provided with optimized observation features and weather threat assessment functions.

Radars with manual controls

Full manual control radars

Early generations of radars are not equipped with an automatic tilt function; therefore the antenna tilt needs to be manually adjusted up and down as the flight progresses according to the aircraft's altitude,

the expected weather on path and the ND range selection. Then the pilot needs to analyze and understand the individual radar slices of weather displayed in order to get an overall picture.



NOTE

Early generation of full manual controlled radars without auto tilt are: Rockwell Collins WXR-701X family up to weather radar transceiver Part Number 622-5132-624 and Honeywell RDR-4B family up to weather radar transceiver Part Number 066-50008-0407.

OPERATIONS

Optimum use of weather radar

Autotilt radar (Honeywell RDR-4B family PN 066-50008-0409)

Honeywell introduced the first weather radar featuring an automatic tilt computation named "Autotilt". When in Autotilt mode, the radar uses

the EGPWS terrain database and automatically adjusts the antenna tilt based on the aircraft position, altitude, and the selected ND range **(fig.6)**.

(fig.6)

Honeywell Autotilt



“ Automatic radars optimize weather detection and decrease significantly the pilots' workload. ”

Fully automatic radars

The next generation of radars included automatic functions, which:

- Scan airspace ahead of the aircraft with multiple beams
- Feature a three dimensional (3D) buffer to store weather data
- Automatically compute and adjust the antenna tilt

- Offer independent pilot control and display selection.

These new radars optimize weather detection and decrease significantly the pilots' workload necessary to understand the complete picture of the weather ahead.

A320 & A330 families:

Multiscan radar (Rockwell Collins WXR-2100 family)

The WXR-2100 Multiscan weather radar is part of this new generation of weather radars that offers an automatic computation of tilt and gain control at all ranges, all altitudes and all times **(fig.7)**.

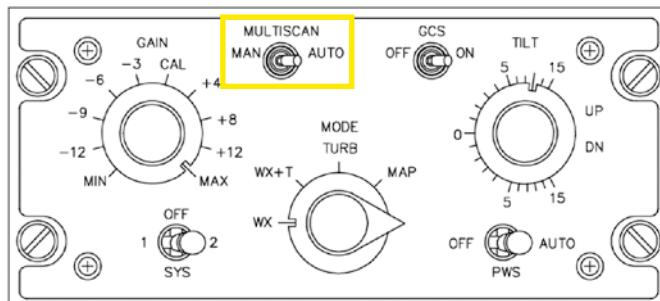
This weather radar is designed to work in Multiscan automatic mode. Pilots select only the desired range for the display and the radar alternatively scans at two

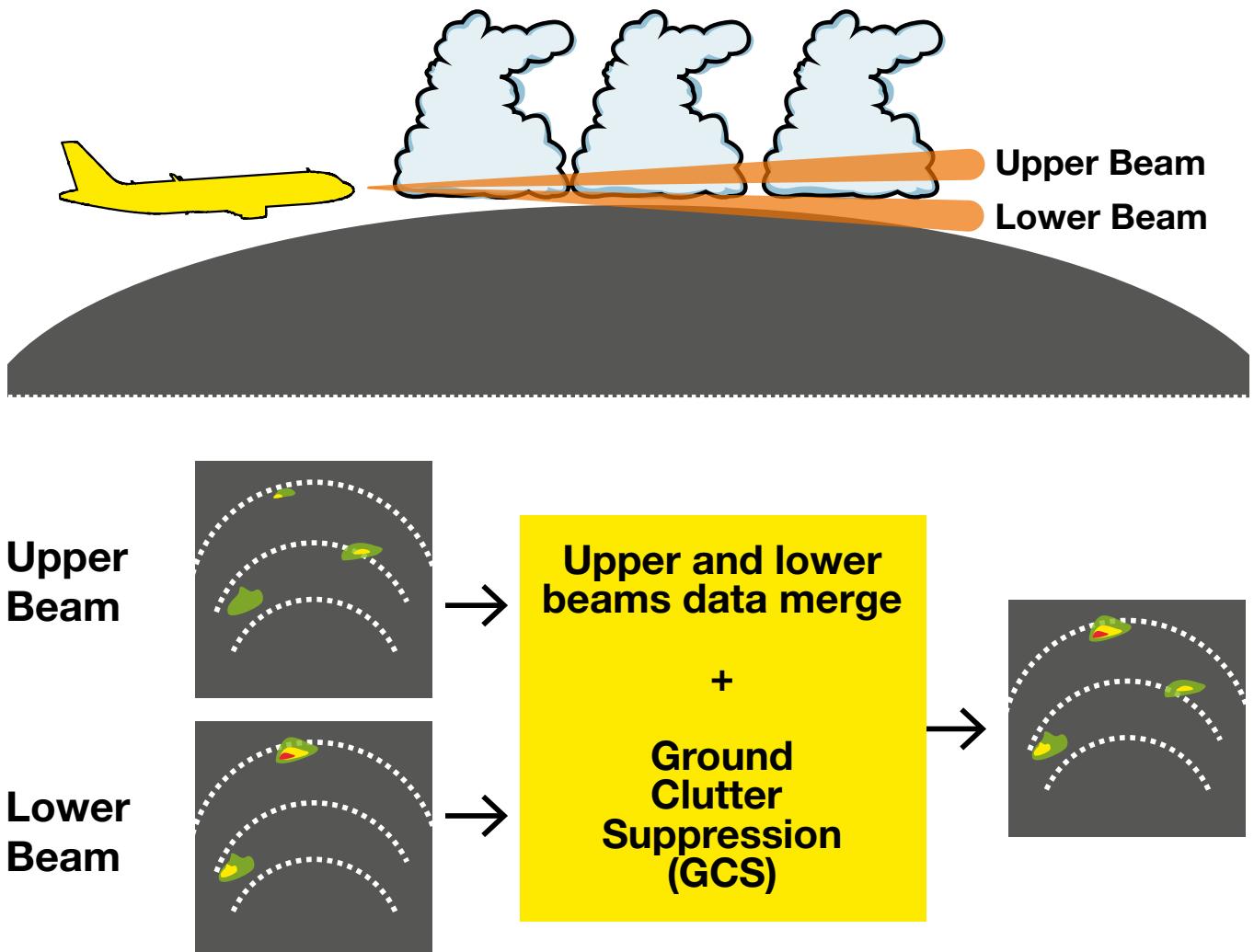
antenna tilt settings. The image that is displayed on the ND is the result of the stored and combined information from each beam.

The radar automatically adjusts the gain and tilt based on various parameters (aircraft altitude, geographical area, season, time of the day) to obtain the best weather display in each geographic region.

(fig.7)

Rockwell Collins Multiscan





A320 & A330 & A350 & A380 families: Honeywell RDR-4000

The Honeywell RDR-4000 model is part of the new generation of weather radars including a 3D volumetric buffer.

It can probe hundreds of miles ahead (up to 320 NM on A320 & A330 families and up to 640 NM on A350 and

A380) to show the en route weather picture, as well as automatically scan from the ground up to 60 000 feet to provide information targeted at various altitudes. The required display data are then accessed from the 3D buffer **(fig.8 and 9)**.



(fig.8)

Honeywell RDR-4000 control panel on A320 & A330 families

OPERATIONS

Optimum use of weather radar

(fig.9)

Honeywell RDR-4000 control panel on A350 & A380

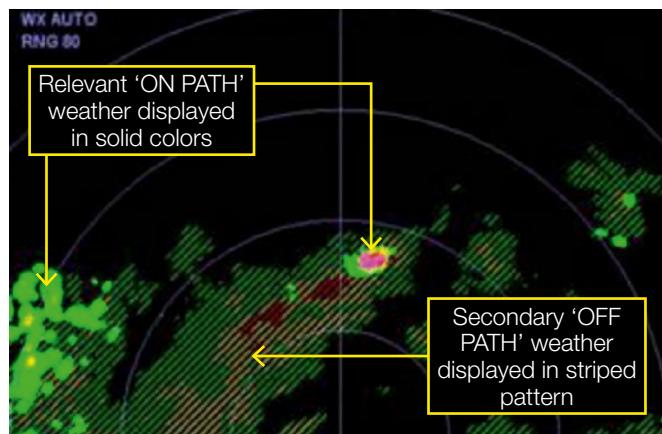


When it is activated in the automatic mode, the radar RDR-4000 takes into account a vertical trajectory envelope (nominally +/- 4000 ft) along the vertical flight path of the aircraft based on the flight path angle. It then defines if the weather echo is inside this envelope (relevant 'ON PATH') or not (secondary

'OFF PATH') depending on the flight profile. Weather conditions along the plane's trajectory are displayed in solid colors, while more distant vertical echoes are shown in striped pattern to help pilots determine whether weather avoidance maneuver or rerouting is necessary **(fig.10)**.

(fig.10)

Honeywell RDR-4000 display



NOTE

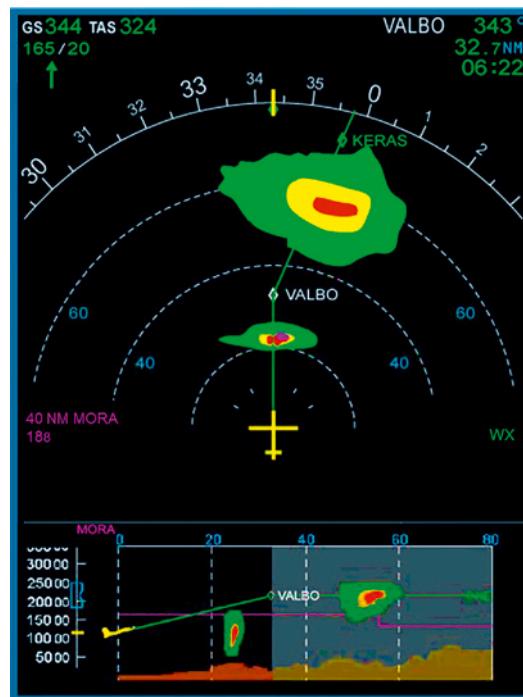
These enhanced weather radars are provided at Entry Into Service for new programmes (A380, A350) and as a retrofit option for A320 and A330 families.

The RDR-4000 can also be used in manual mode (elevation mode) as a tool for analyzing weather at user-selected altitudes and thus, assess the vertical expansion and structure of convective clouds.

This system is available on the A380 and also on the A350 with an additional 'weather ahead' alerting function. On these aircraft, the weather displayed is a computed image on:

- the ND, for views along the vertical flight path (in AUTO mode) or along the selected altitude (in ELEVN mode) or along the selected tilt angle (in TILT mode)

- as well as on the Vertical Display (VD) for views along the lateral flight path (in AUTO mode) or along the selected azimuth (in AZIM mode) **(fig.11)**.

**(fig.11)**

Weather information displayed on the Vertical Display

Hail and lightning prediction: the new functions introduced by 'step 2' automatic radars

In continuity of RDR-4000 and Multiscan WXR-2100, a new step of development recently introduced:

- Hail and lightning prediction
- Improved weather information.

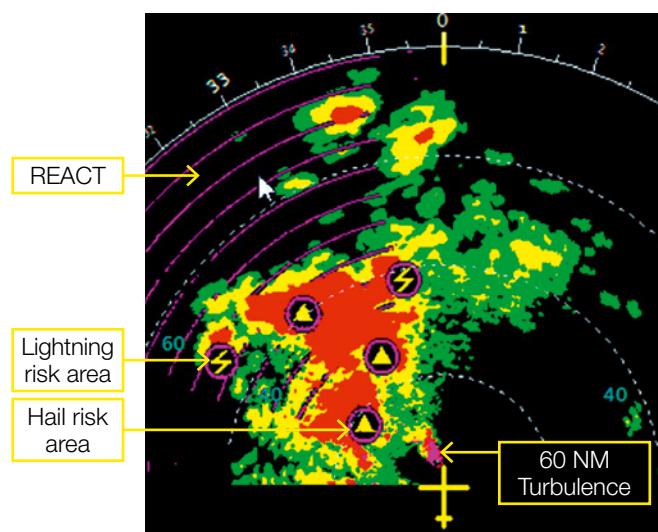
» **Honeywell RDR-4000 (V2)** includes new features to improve weather hazard assessment by automatically providing the following additional information **(fig.12)**:

- Weather alerting ('WEATHER

AHEAD') to alert the crew when the ND is not in weather mode

- **Hazard functions** offering:

- Lightning and hail prediction
- Rain Echo Attenuation Compensation Technique (REACT): this function indicates areas where the intensity of the radar echo has been attenuated by intervening weather.
- Extended turbulence detection (up to 60 NM instead of 40).

**(fig.12)**

Honeywell RDR-4000 V2 display

OPERATIONS

Optimum use of weather radar

» **Rockwell Collins Multiscan WXR-2100 (V2)** includes an automatic

WX1200 (V2) includes an automatic weather threat assessment ("Track While Scan" function). In continuity of the Multiscan, the aim of this version is to provide not only a depiction of the reflectivity of surrounding weather cells, but also a threat assessment for each cell detected.

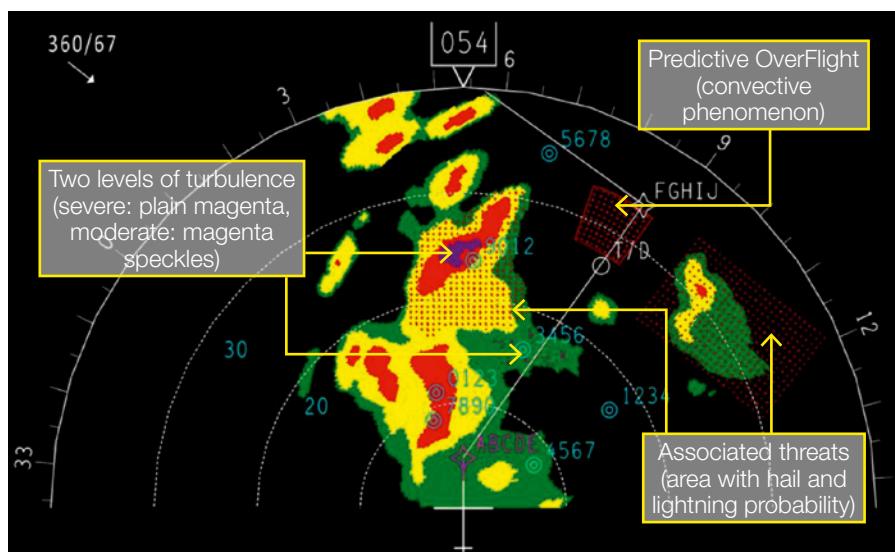
Weather cells are first tracked and then, additional vertical scans are performed automatically to assess

the corresponding threat based on reflectivity characteristics (**fig.13**). This new radar also provides **hazard functions**, namely:

- Lightning and hail prediction
- Predictive OverFlight (this function alerts the crew to growing cells that are potentially on the aircraft trajectory)
- Improved turbulence detection able to display an additional level of moderate turbulence.

(fig.13)

Rockwell Collins Multiscan V2 threat detection and analysis



NOTE

Honeywell RDR-4000 V2 and Rockwell Collins Multiscan WXR-2100 V2 weather radars were certified in July 2015 for A320 and A330/A340 families and are available as retrofit options.



Coming next... the future evolution of weather information

Airbus in cooperation with weather radars suppliers, maintain their efforts in designing and producing new weather surveillance functions. Today, at a research level, a strong focus is placed on three main dimensions with the aim to improve pilots' awareness of the weather ahead.

1. High Altitude Ice Crystal (HAIC) detection to avoid flying in ice crystals areas.

There are multiple threats attributed to ice crystals; for example, engine vibrations, engine power loss, engine damage or icing of air data probes. In fact, the formation of ice crystals at high altitude and their effect on aircraft performance is recognized as an industry wide issue. Airbus in particular is leading the HAIC research project with several partners. This project aims to characterize and identify the environmental conditions of ice crystals, to improve aircraft operations through the development of appropriate detection and awareness technologies to be fitted

on aircraft. The next generation of weather radars is expected to benefit from this research work and enable the detection of ice crystals to avoid convective weather linked to ice crystal icing.

2. Weather display fusion to offer a single display of weather data covering all weather threats.

The feasibility of collecting all "weather on board" information together with weather information collected by the radar (reflectivity, turbulence and hazards) and merging them in a single display is currently being studied.

3. 3D weather analysis: automatic re-routing

Work is also being carried out to allow the automatic computation of an optimized deviation route based on: the actual weather (weather on board and radar data), the ongoing traffic and the stored flight plan. Such a function is expected to facilitate pilot's decision making and re-routing planning if needed. Additionally it improves comfort. ■

PUTTING THEORY INTO PRACTICE: HOW TO MAKE AN OPTIMUM USE OF THE AIRBORNE WEATHER RADAR

The weather radar is a tool for detecting, analyzing and avoiding adverse weather and turbulence. As with any other tool, adequate skills and the crew's involvement are needed in order to use it efficiently. In fact, the management of adverse weather still relies primarily on the crew to actively monitor the meteorological situation throughout the flight, and make a full use of the available technology thanks to:

- Awareness of weather radar capabilities and limitations, according to the specificities outlined in the FCOM and the manufacturer's user guide.
- Preflight briefing (knowledge of the route climatology and weather forecast –

charts and online simulation) and during flight (update on weather information)

- Adapted use of the weather radar, with the crew regularly assessing the range, gain and tilt, and making use of weather threat assessment functions when available in order to display an optimum weather radar picture on the ND.
- Regular manual vertical and horizontal scanning by the crew to increase situation awareness.
- Correct understanding of the radar image displayed.
- Adequate strategic (mid-term) and tactical (short term) decision making for trajectory planning.

How to optimally tune the weather radar and manage flights in convective weather?

Flight planning: the importance of weather briefing and weather reports

Weather avoidance already starts in the briefing room before commencing the flight, with a thorough assessment of en-route weather and decisions on possible mitigation means.

Before boarding, a weather briefing should reveal areas of predicted significant weather activity. Equally, this briefing should include the assessment of typical weather patterns in the area. For example in the tropics, cumulonimbus intensity and development is greater at certain times of the day. The crew have the opportunity at this stage to plan a route to avoid active weather based

on both the weather briefing and their knowledge of local climatology. Changing the flight route could be an option as well as taking additional fuel for enhanced strategic and tactical options in flight.

Once airborne, the weather radar should be used and tuned regularly in combination with all available information, e.g. pre-flight briefing, pilot's knowledge and experience of the area's typicality, reported turbulence, updated weather reports... If possible, the weather information should be updated in flight regularly. Information sought by ATC of turbulence encounters are an additional means.

Once airborne, the weather radar should be used and tuned regularly in combination with all available weather information.

INFORMATION

Safe operation in convective weather requires good theoretical knowledge of meteorology, particularly on the formation, development and characteristics of convective clouds in different regions of the world. This knowledge is usually provided in pilot licencing and operational training and is not covered by aircraft documentation (FCOM and FCTM).

Weather radar antenna tilt

Effective management of the antenna tilt along with an appropriate ND range selection, are key tools to obtaining an informative weather radar display on the ND.

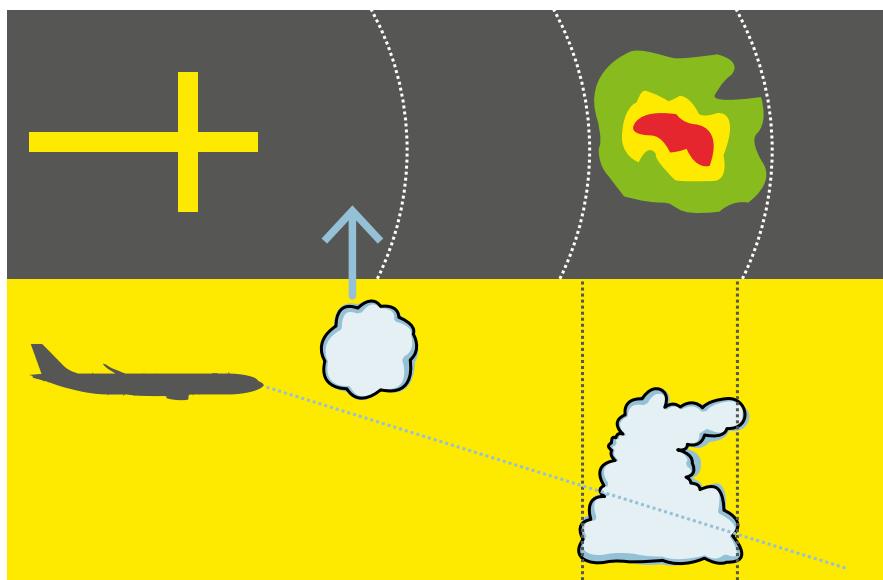
The ND might not display cells at aircraft flight level, only cells that are cut by the radar beam are shown (**fig.14**). For this reason, the antenna tilt needs to be adjusted up and down regularly to scan weather ahead, and it needs to be adjusted to the ND range selection (except with the most recent radar models where this adjustment is made automatically).

The flight crew needs to periodically scan:

- Vertically, using the antenna tilt function
- Horizontally, using the range change.

If available, the automatic mode should be used as the default mode (unless mentioned differently in the FCOM), for detection and initial evaluation of displayed weather. Then, if adverse weather is suspected (e.g. according to information gathered during the pre-flight briefing), manual control should be used regularly and actively to analyze the weather ahead.

“ The automatic mode should be used as the default mode, for detection and initial evaluation of displayed weather. Then, manual control should be used periodically to analyze the weather. **”**



(fig.14)
Display along radar beam



BEST PRACTICE

Even when the tilt is adjusted automatically, pilots are advised to reverse to the manual mode “MAN” regularly in order to scan the immediate weather ahead. This action allows the crew to assess the vertical structure and expansion of convective clouds.

Factors that can affect the relevancy of the ND display and that should trigger a tilt adjustment are:

- A heading change
- An altitude change, or even a regular flight profile change (e.g. from climb to cruise)

- The shape of thunderstorms
- A pilot report from another aircraft in the vicinity.

In the case of a change in heading or altitude, leaving the antenna tilt on auto may induce a risk of overlooking weather or underestimating the

OPERATIONS

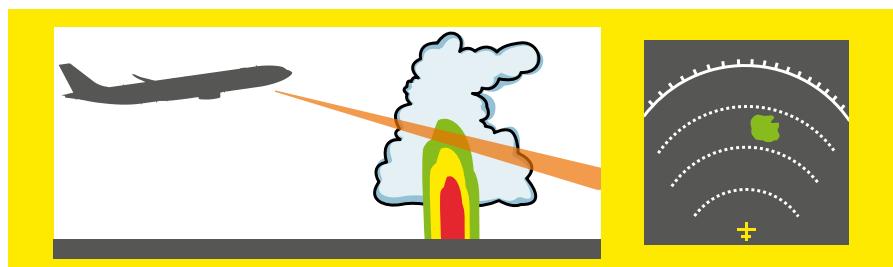
Optimum use of weather radar

(fig.15)

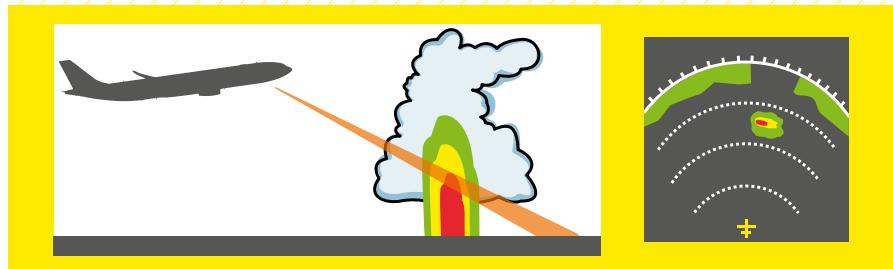
Weather radar display at different tilt settings

severity of the weather. For example, at take-off or in climb, the tilt should be set up if adverse weather is expected above the aircraft. **Figure 15** is an example of radar overshooting a

convective cell because the tilt is set incorrectly (too high in this case) while in the auto-tilt mode. When the antenna is tilted down, the ND shows a much stronger activity.



Overscanning



Correct storm display

“ Presence of yellow or green areas at high altitudes, above a red cell, may indicate a very turbulent area. ”

To analyze a convective cell, the flight crew should use the tilt knob to obtain a correct display and point the weather radar beam to the most reflective part of the cell. At high altitude, a thunderstorm may contain ice particles that have low reflectivity. If the tilt setting is not adapted, the ND may display only the upper (less reflective) part of the convective cloud (overscanning). As a result, the flight crew may underestimate or not detect a thunderstorm. In order to get accurate weather detection, the weather radar antenna should also be pointed toward lower levels (i.e. below freezing level), where water can still be found. If a red area is found at a lower level, the antenna tilt should

then be used to scan the area vertically. Presence of yellow or green areas at high altitudes, above a red cell, may indicate a very turbulent area.

In most cases in flight, the adequate antenna tilt setting shows some ground returns at the top edge of the ND, which may be difficult to differentiate from genuine weather echoes. A change in antenna tilt rapidly changes the shape and color of ground returns and eventually causes them to disappear. This is not the case for weather echoes. Some weather radars are fitted with a Ground Clutter Suppress (GCS) function. When turned ON, it suppresses the ground return from the display.

Display range management

To maintain a comprehensive situation awareness, the flight crew needs to monitor both the short-distance and long-distance weather. To this end, the crew should select different ranges on the Pilot Monitoring (PM) and Pilot Flying (PF) ND.

To avoid threatening convective weather, the flight crew should make deviation decisions while still at least 40 NM away;

therefore, the following ranges should be selected on the NDs:

- Pilot Monitoring (PM) adjusts ranges to plan the long-term weather avoidance strategy (in cruise, typically 160 NM and below).
- Pilot Flying (PF) adjusts ranges to monitor the severity of adverse weather, and decide on avoidance tactics (in cruise, typically 80 NM and below as required).

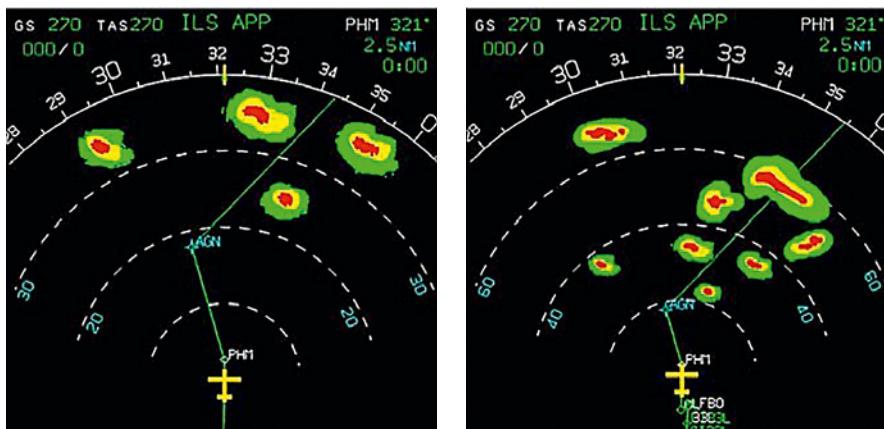


DID YOU KNOW

The FCTM provides useful guidance to correctly tune the weather radar in accordance with the flight phase.

Course changes to avoid adverse weather should be determined using both displays. This prevents the “blind alley” effect: a course change that may

seem safe when using a low range ND display may reveal a blocked passage when observed at a higher range (**fig.16**).



“ The crew should select different ranges on the Pilot Monitoring (PM) and Pilot Flying (PF) ND. ”

(fig.16)
Blind alley effect

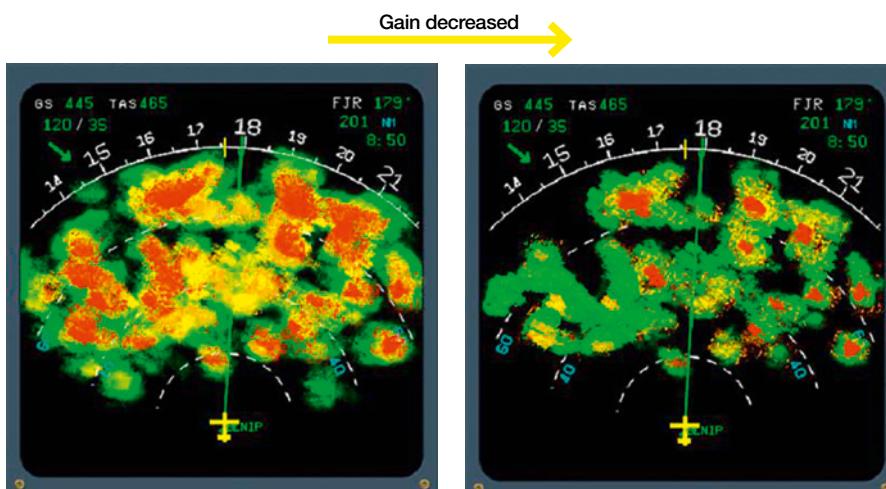
Gain adjustment

The sensitivity of the receiver may vary from one type of radar system to another. In the CAL (AUTO) position, the gain is in the optimum position to detect standard convective clouds. Manual settings are also available and can be used to analyze weather.

At low altitudes, reducing the gain might be justified for proper weather analysis. Due to increased humidity at lower levels, convective cells are usually more reflective and the weather radar display may have a tendency to show a lot of red areas. This can also be the case at higher altitude with

significant positive ISA deviations in a very humid atmosphere (typically the Indian monsoon). In these cases, slowly reducing the gain allows the detection of threatening areas: most red areas slowly turn yellow, the yellow areas turn green and the green areas slowly disappear. The remaining red areas – i.e. the red areas that are the last to turn yellow, - are the most active parts of the cell and must be avoided (**fig.17**).

At high altitudes, water particles are frozen and clouds are less reflective. In this case, gain should be increased for threat evaluation purposes.



(fig.17)
Effect of gain reduction

OPERATIONS

Optimum use of weather radar

“ The TURB function needs humidity; therefore clear air turbulence will not be displayed. **”**

Turbulence and weather threats detection

Turbulence can be difficult to predict, but signs such as frequent and strong lightning and/or the specific shape of clouds (see the next section) can alert the crew to the likely presence of severe turbulence. If necessary and when available (according to the standard of weather radar onboard), the TURB function can additionally be used to confirm the presence of wet turbulence up to 40 NM (or 60 NM depending on

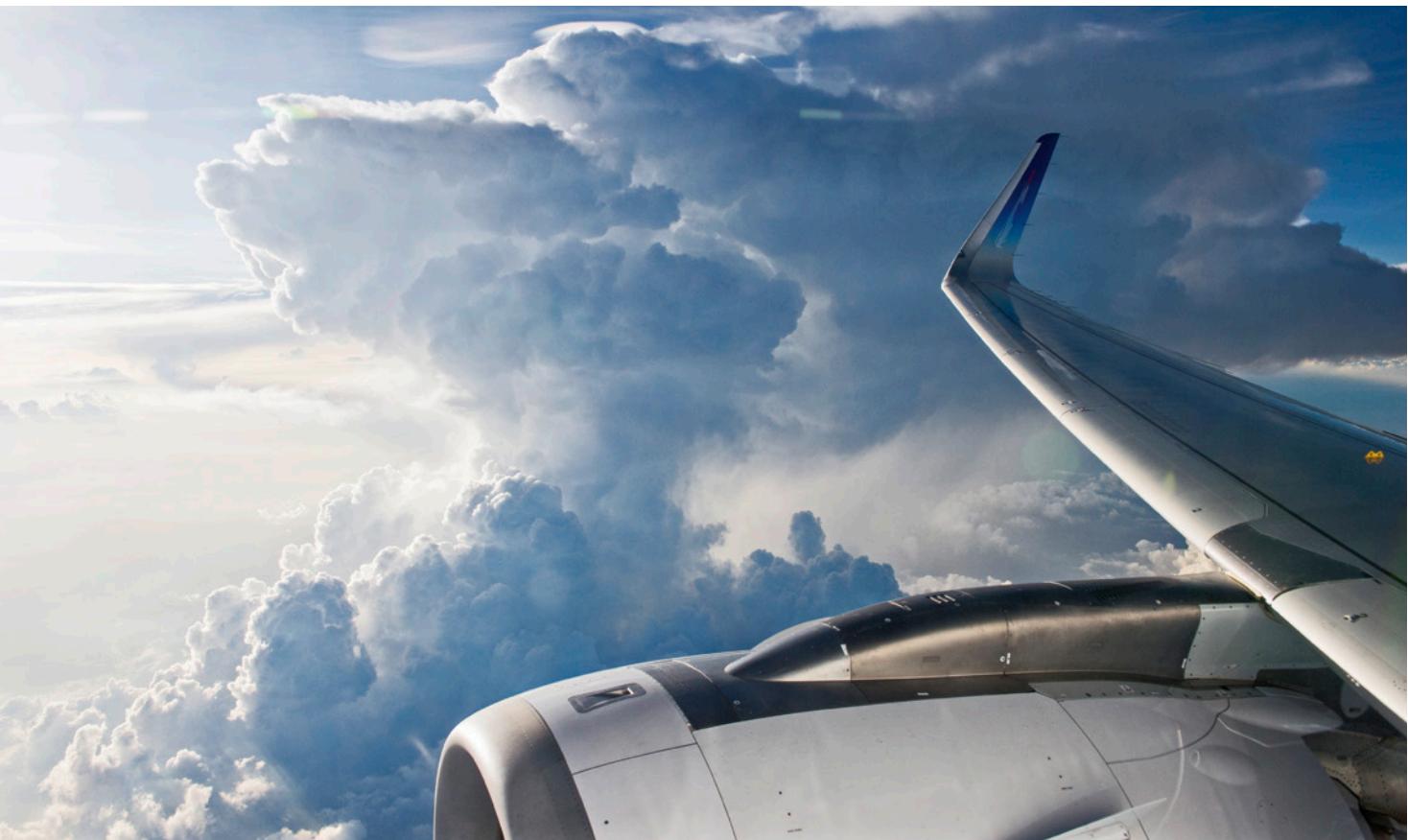
the radar standard) (fig.18). Remember that the TURB function needs humidity; therefore clear air turbulence will not be displayed.

In addition, the flight crew may be alerted by visual cues provided by the latest generations of weather radars that offer weather threat assessment functions, such as hail or lightning predictions.



(fig.18)

Turbulence detection (in magenta)



HOW TO CORRECTLY TUNE THE WEATHER RADAR AT A GLANCE



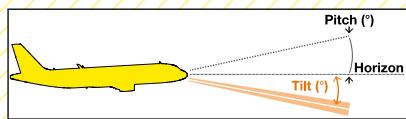
Before flight

Study the weather radar's specificities and limitations through the FCOM, FCTM and **weather radar user guide**.



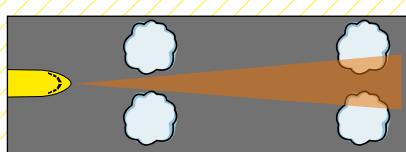
Before and during flight

Gather information about the **forecasted weather** and update regularly during flight: weather briefing, route climatology knowledge, reported turbulence...



During flight

Set the **antenna tilt** to auto as the default mode for detection and initial evaluation of weather, and periodically use the manual modes to scan and analyze the weather situation.



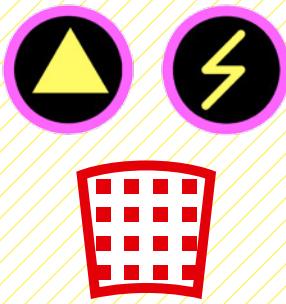
During flight

In cruise the combination of the following **ranges** provides good weather awareness and allows to avoid the "blind alley effect":
 - 160 NM on the PM ND
 - 80 NM on the PF ND.



During flight

Use **gain** in AUTO/CAL mode by default, then regularly reduce the gain for weather severity assessment.



During flight

Be attentive to the visual and oral cues provided by the **weather threat and hazard assessment functions** (as installed).

OPERATIONS

Lithium batteries: safe to fly?

Weather radar data understanding: how to decide on an effective avoidance strategy?

Before any avoidance maneuver is initiated, the analysis the flight crew makes of the weather radar display is essential. Doing so, the crew is able

to conduct an in-depth analysis of the convective weather situation on-path and off-path and eventually, initiate action if needed.

Correctly understanding the weather display is paramount

After the weather radar has been tuned correctly, the data displayed should be supplemented with the available weather charts, reports and the meteorological knowledge of the pilot. Altogether these data enable the flight crew to get a complete weather picture and establish an "area of threat". This "area of threat" corresponds to the zone where the flight crew estimates that the weather

conditions are too dangerous to fly in.

Some ND displays contain specific cues that should alert the flight crew. Cloud shapes, in addition to colors, should be observed carefully in order to detect adverse weather conditions. Closely spaced areas of different colors usually indicate highly turbulent zones (**fig.19**).

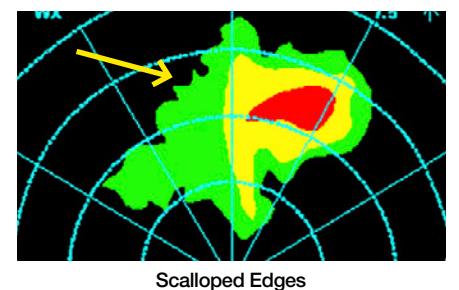
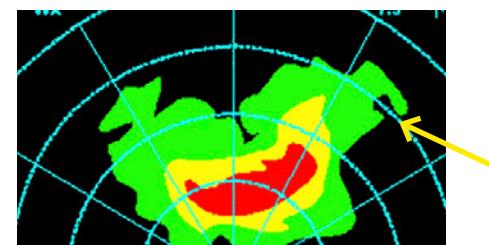
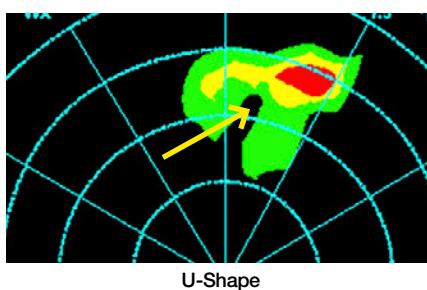
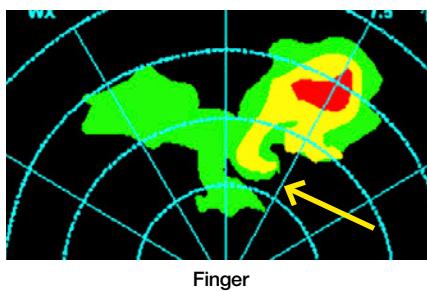


(fig.19)

Indication of a threat: closely spaced areas of different colors

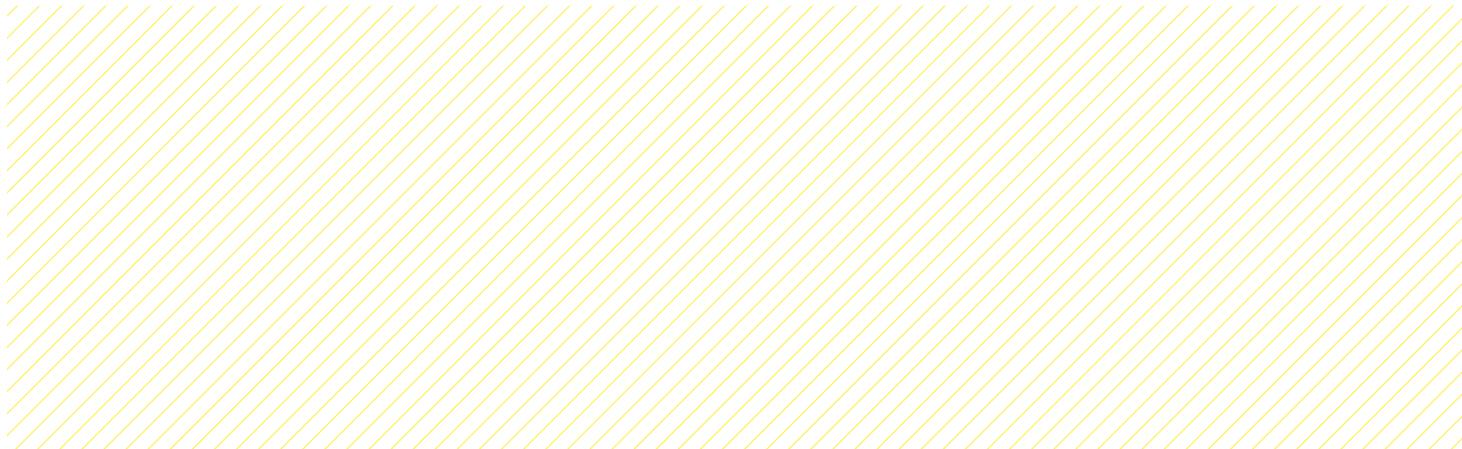
Some shapes are good indicators of severe hail that also indicate strong vertical drafts (**fig.20**). Finally, fast

changing shapes, whatever the form they take, also indicate high weather activity.



(fig.20)

Shapes indicative of adverse weather



Avoidance strategy

The flight crew needs to remain vigilant and active in using and tuning the weather radar in order to be able to initiate an avoidance maneuver as early as possible. Indeed, weather radar information becomes more intense as the aircraft gets nearer the convective weather zone, thus making avoidance decisions more difficult. For this reason, crews should consider a minimum distance of 40 NM from the convective cloud to initiate the avoidance maneuver.

Once the decision to deviate course has

been taken, flight crews need to bear in mind the following advisory precautions and limits before actually deciding the trajectory of the avoidance maneuver.

If possible, it is preferable to perform lateral avoidance instead of vertical avoidance. Indeed, vertical avoidance is not always possible (particularly at high altitude) due to the reduction of buffet and performance margins. In addition, some convective clouds may have a significant build-up speed, that extends far above the radar visible top.

“ Consider a minimum distance of 40 NM from a threatening convective cloud to initiate the avoidance maneuver. ”

» Lateral avoidance

- When possible, it is advisable to try to avoid a storm by flying on the upwind side of a cumulonimbus. Usually, there is less turbulence and hail upwind of a convective cloud.
- The “area of threat” identified by the flight crew (e.g. a cumulonimbus cloud) should be cleared by a minimum of 20 NM laterally whenever possible

(fig.21). An additional margin may be applied in case the convective clouds are very dynamic or have a significant build-up speed.

- If the aircraft trajectory goes between several convective clouds, if possible maintain a margin of at least 40 NM with the identified “area of threat”.

» Vertical avoidance

- Do not attempt to fly under a convective cloud, even when you can see through to the other side, due to possible severe turbulence, windshear, microbursts and hail. If an aircraft must fly below a convective cloud (e.g. during approach), then the flight crew should take into account

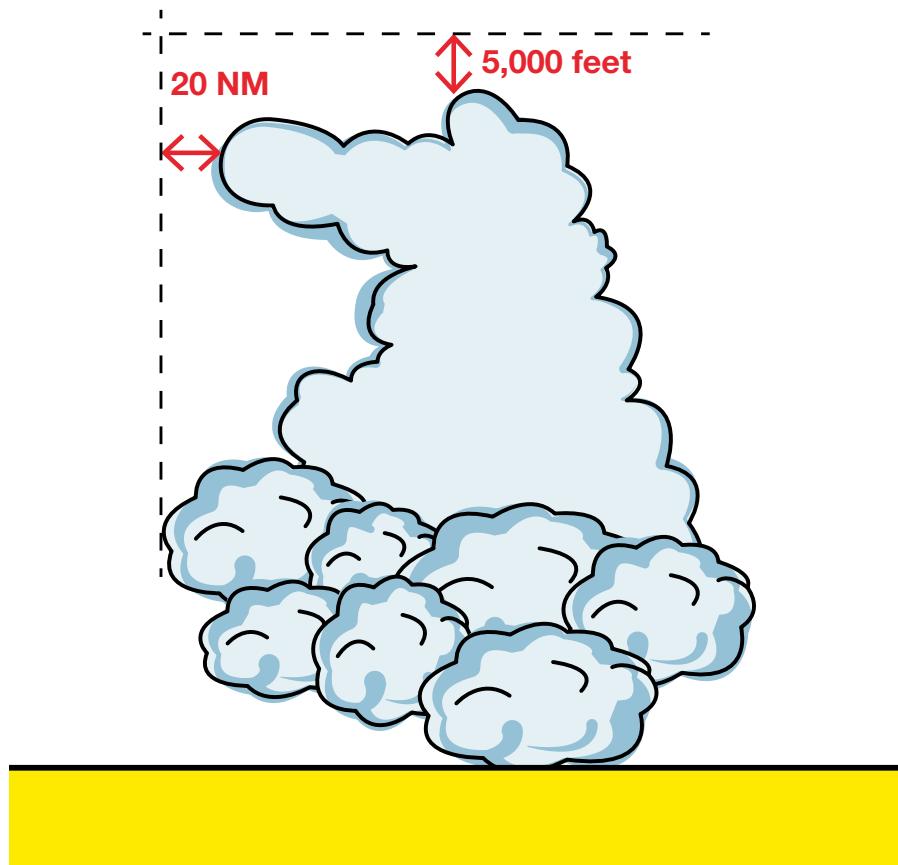
all indications (visual judgement, weather radar, weather report, pilot's report, etc) before they take the final decision.

- If overflying a convective cloud cannot be avoided, apply a vertical margin of 5 000 feet **(fig.21).**

OPERATIONS

Optimum use of weather radar

“ If possible, it is preferable to perform lateral avoidance instead of vertical avoidance. ”



(fig.21)

Lateral and vertical circumvention margins

Practical example: typical scenario of severe weather avoidance strategy

Figure 22 shows a typical weather radar display indicating multiple areas of severe weather. What route would look like the preferable option?

Route A:

this is the most direct route to destination but it navigates right through the most severe and active zone; therefore it is the path that carries the biggest risks and should not be an option.

Route B:

this route could be tempting since it requires little deviation to the mainstream route and it looks like the most active red areas are avoided. Nevertheless, this trajectory leads downwind of the convective area, thus increasing the risk of encountering severe weather. Additionally, the convective cells beneath might be developing fast and upwards, thus closing off the gap in between the red zones. Before this option is considered, the flight crew would need to tilt the radar antenna down to analyze weather and see what is below the apparent gap.

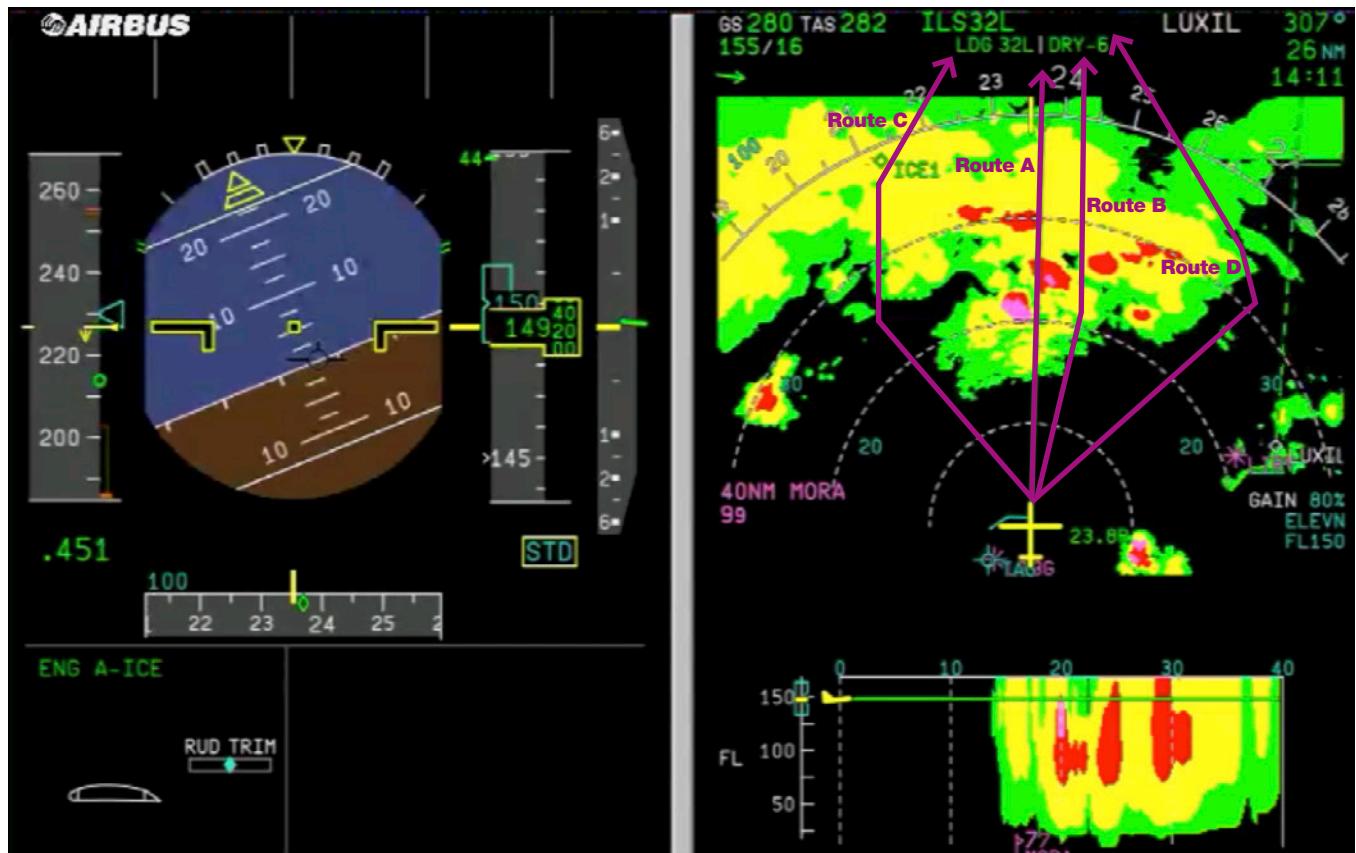
Route C:

this route looks like a possible escape route because it goes around most of the storms by a wide safety margin. However, while doing so, the flight crew would need to keep a look at the cell to the left of this route, and see whether it develops rapidly or not. In addition, this route leads away from the initial flight plan and therefore it could have operational implications such as fuel consumption or delays.

Route D:

this route would be the preferable option in terms of risks mitigation.

When faced with a situation where weather ahead reveals an extensive storm system, several options are always possible. Before the flight crew makes a decision, it is prudent to analyze weather carefully by scanning the vertical expansion of the various cells, and if possible, consider deviation to an alternate route. ■



(fig.22)

Available options to avoiding weather

Regardless of how you locate a severe weather area – visual, by radar, or from a report – a key parameter to successful route planning and avoidance strategy is time. The weather radar, and enhanced models more particularly, can help you to analyze and understand distant weather accurately and evaluate weather scenarios from a distance. This system is a key tool to planning ahead to avoid last-minute decisions, and making a decision on circumnavigating a nasty convective cell with a comfortable safety margin. In addition to technology, you need to stay active in maintaining situation awareness throughout the flight. Regularly complement the radar images displayed by a manual vertical scan of surrounding cells, as well as gain and tilt adjustments as required. Last but not least, adhere to your knowledge of meteorology basics, local climatology and weather briefing to adopt the best course of actions, and navigate safely, effectively and comfortably to destination.

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