Look out for Ice Ridges on the Lower Nose Fuselage

Ice ridges on the lower nose fuselage can cause Computed Airspeed (CAS) values delivered by the ADRs to be lower than the actual airspeed which may lead to unreliable airspeed events. This article describes the potential effect on the aircraft's systems from the takeoff phase and how to prevent such situation.

ANALYSIS OF AN EVENT

Event Description

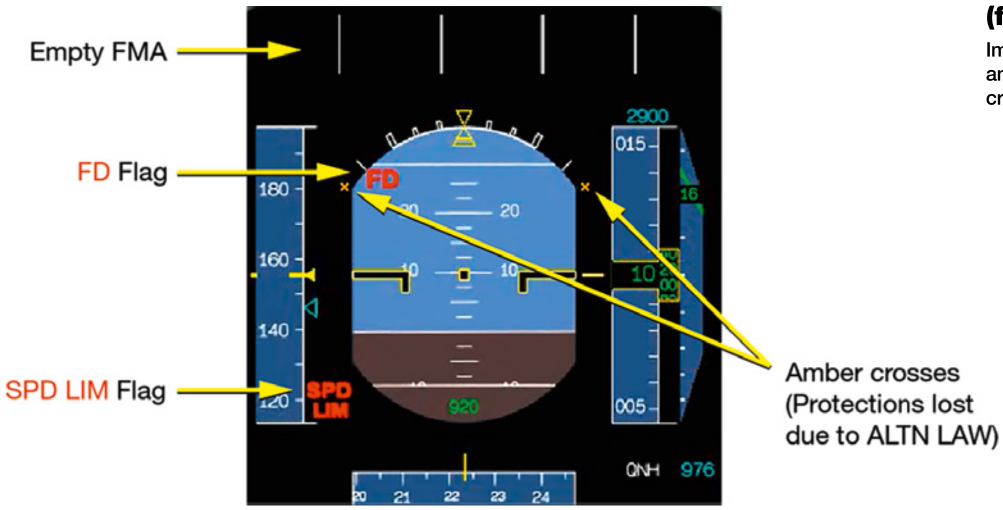
The crew of an A320 arrived at the aircraft to start a new day of flight early on a winter's morning in Northern Europe. The ground temperature was reading -5°C and their aircraft was still covered with snow and ice from the overnight layover.

A two steps de-icing/anti-icing was performed before departure. Sprayed areas were the wings, vertical fin and horizontal stabilizers. The fuselage areas were not de-iced.

With the ground servicing complete, the flight crew proceeded to takeoff. At lift-off, the flight controls law reverted to alternate law and the AUTO FLT A/THR OFF ECAM caution triggered. 12 seconds later, the Flight Directors (FD), Characteristic Speeds, TLU function and Autopilot availability were also lost. The FD and SPD LIM red flags were displayed on both PFD **(fig.1)** and at the end of the ECAM take-off inhibition phase, when the aircraft reached 1500ft, three ECAM alerts were displayed:

- NAV ADR DISAGREE
- F/CTL ALTN LAW
- AUTO FLT RUD TRV LIM SYS

The flight crew identified an airspeed discrepancy issue and then compared PFD1, PFD2 and the standby speed indications with the ground speed on the navigation display. They proceeded to switch off ADR 1+3 and performed an in-flight turn-back with the ADR2 ON.



(fig.1)
Impact on the PFD indications: SPD LIM and FD red flags, empty FMA and amber crosses of the alternate law

Flight Data Analysis and Investigation:

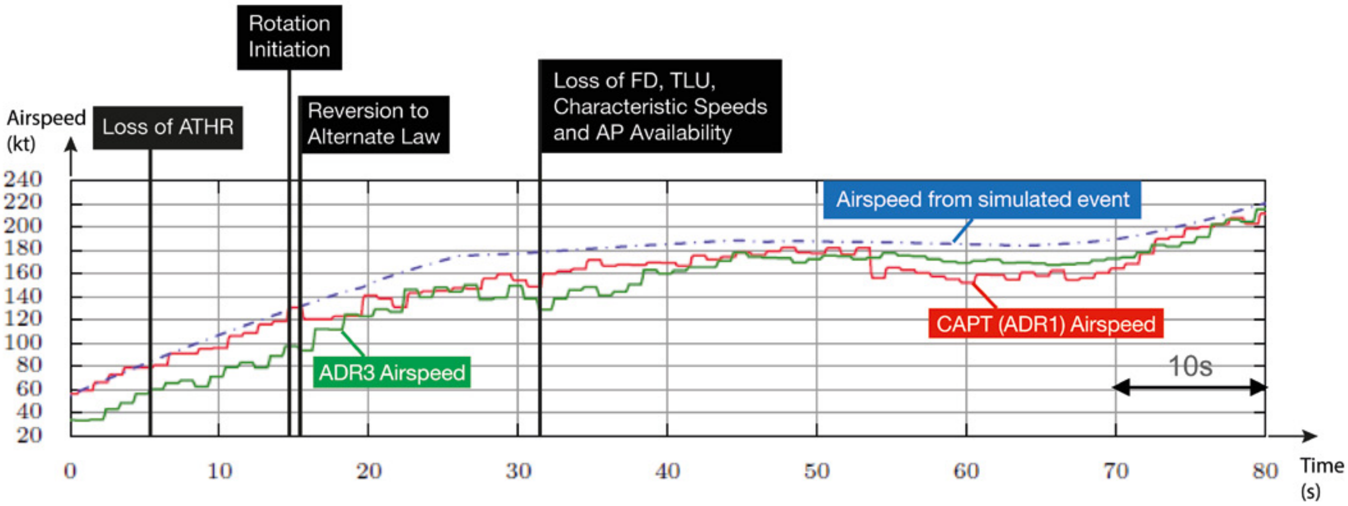
The analysis of the flight recorder's data shows successive discrepancies during the takeoff roll and takeoff phase between ADR1 and ADR 3 airspeeds. The ADR2 airspeed is not recorded in the DFDR.

For investigation purposes, the airspeed during the take-off was simulated based on an aerodynamic model of an A320 and using the recorded pitch and stick inputs from the event.

The resulting Computed Airspeed (CAS) from the simulation, representative of the actual airspeed is shown in blue on the graph **(fig.2).** This was compared to the recorded CAPT CAS (from ADR1) shown in red and ADR3 CAS, which is shown in green on the graph **(fig.2).**

From the beginning of the take-off roll, ADR3 airspeed is perpetually underestimated up to 40kts and ADR1 airspeed is underestimated from take-off roll up to 10kts and from rotation up to 35kts.

(fig.2)
Comparison between recorded ADR1 & ADR3 airspeeds and the simulated airspeed



The investigation concluded that the root cause of such speed discrepancies was the build-up of ice ridges on the lower nose fuselage in front of the Pitot probes and lower nose fuselage not de-iced before departure. This creates airflow perturbations and causes airspeed computed value to be lower than the actual airspeed.

ICE RIDGES PHENOMENON

Root Cause

The main cause of ice ridges over the lower nose fuselage of the aircraft is ice accretion during a long stay on ground in cold conditions **(fig.3).** A review of in-service events from the last 6 years shows that a large majority of ice ridges related events occurred during the first flight of the day.

Reported events also show that ice ridges may be dislodged during the flight or may remain attached to the lower nose fuselage for the entire flight **(fig.4).**

" A large majority of ice ridges related events occurred during the first flight of the day. "

(fig.3)
Example of thin ice ridges forward of the pitot probes of an A320 family aircraft

(fig.4)
Example of ice ridges that remain on the lower fuselage even after completing a flight.

A second possible cause of reported ice ridge related events is when snow falling on a heated windshield melts and the water running down from the windshield refreezes in ridges on the lower fuselage. The caution note of the FCOM PRO-SUP Adverse Weather-Cold Weather describes this phenomenon.

Effects of the Ice Ridges

The presence of ice ridges located forward of the Pitot probes on the lower nose fuselage creates airflow perturbations **(fig.5)** and may lead to airspeed data from the ADR of the impacted probe(s) to be lower than the actual airspeed.

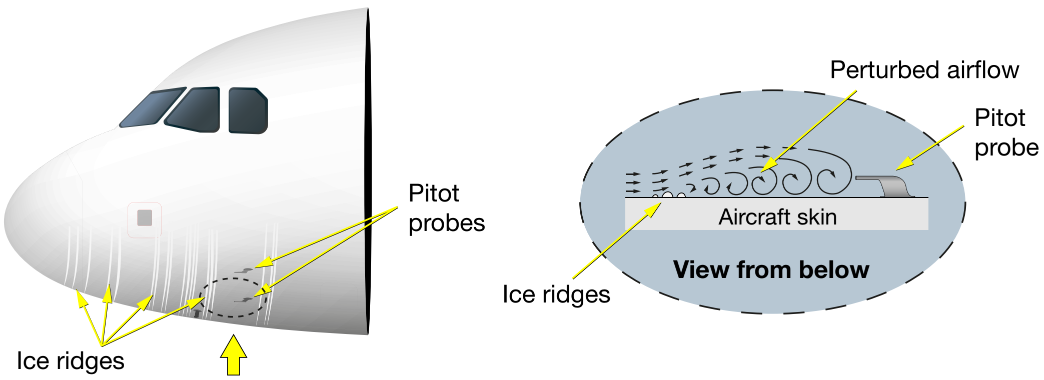
The effect of ice ridges on the measured airspeed value will depend on the location, shape and number of ice ridges present. A large ice ridge but also successive thin ice ridges can significantly impact the airspeed measurement.

Regarding the effect of airflow perturbation caused by ice ridges, theoretically they could also affect the static ports or AOA sensors, but in-service data shows no effect on static pressures and rare effect on AOA measurements.

All "ice ridge" related in-service events that were reported to Airbus occurred on A320 family aircraft with the exception of one A330 event. However, we cannot rule out potential effects of ice ridges on the Multifunction Probes (MFP) installed on the A380 and A350 families, even if they are of a different design to the probes installed on other Airbus aircraft families (A300/A310/A320/A330/A340).

> "A large ice ridge but also successive thin ice ridges can significantly impact the airspeed measurement."

(fig.5)
Effects of the ice ridges on the airflow forward of the Pitot probes



EFFECTS OF ICE RIDGES PERTURBATIONS ON THE AIRCRAFT SYSTEMS:

The perturbation of the airflow in front of the Pitot tubes/MFPs can lead to the following effects on the aircraft systems:

A300/A310 aircraft family:

On A300/A310 aircraft, in addition to the erroneous airspeed indication, if one Pitot is impacted, the affected ADC sends an incorrect speed to the associated Auto Flight System (AFS1 for ADC1 and AFS 2 for ADC2). The flight crew must select the opposite AFS that uses a correct speed. Moreover, switching manually to the non-impacted ADC displays a correct airspeed on the affected PFD.

If both ADC1 and ADC2 are impacted, the AFS must not be used by the flight crew as per FCOM procedure.

A320/A330/A340 aircraft families:

- If one probe is affected, there is no associated system loss
- If two or three Pitot probes are affected, the Auto Flight System and Electrical Flight Control System may reject the 3 ADRs. This can result in the following:
  - Loss of Autopilot
  - Loss of Flight Directors
  - Loss of Auto-thrust
  - Loss of computation of the Characteristic Speeds
  - Loss of the rudder travel limiter function
  - Reversion to manual Alternate Law

A380 aircraft family:

A380 aircraft has four airspeed probes (3 MFPs + 1 Pitot tube for ISIS) as a consequence:

- If one or two probes are affected, there is no associated system loss
- If three or four probes are affected, this results in the following:
  - Loss of Autopilot
  - Loss of Flight Directors
  - Loss of Auto-thrust
  - Loss of Characteristic speeds computation
  - Reversion to manual Direct Law

A350 aircraft family:

A350 aircraft also has four airspeed probes (3 MFPs + 1 Pitot tube for ISIS) but uses a different speed monitoring. As a consequence:

- If one or two probes are affected, there is no associated system loss
- If three sources are affected (3 MFPs or 2 MFPs + ISIS Pitot):
  - Reversion to Alternate Law
  - CAT I only
- If the four probes are affected, this results in the following:
  - Automatic display of the Backup Speed scale
  - Loss of Autopilot
  - Loss of Flight Directors
  - Loss of Auto-thrust
  - Reversion to manual Direct Law

Preventing Unreliable Airspeed Events Due to Ice Ridges

The presence of ice ridges in front of Pitot probes during flight can occur when the lower nose fuselage is not de-iced at all or not completely de-iced. This is why all personnel working to dispatch an aircraft, from maintenance staff to flight crew, should pay particular attention to the potential presence of ice ridges in cold weather conditions, especially for the first flight of the day or after an extended stay on ground. The lower nose fuselage must be clear of ice before departure to avoid unreliable airspeed situation due to ice ridges and even thin ice ridges must be removed before departure.

Maintenance & De-Icing Crew:

The maintenance crew shall follow the guidelines in the AMM/MP Procedure *12-31-12 ICE & SNOW REMOVAL - MAINTENANCE PRACTICES* to remove the snow and de-ice the aircraft.

On A320, A330 and A340 aircraft families, a dedicated AMM procedure 12-31-12-660-008-A - Forward Fuselage Ice Accretion De-Icing provides guidelines for removing ice and snow from the forward fuselage.

While performing ice removal from lower nose fuselage it is recommended that:

- The operator should spray the de-icing fluid from the rear to the front to avoid contaminating the Pitot tube
- Never spray de-icing fluid directly on static probes and AOA probes to avoid contamination

More generally, the AMM of all Airbus Aircraft types will be enhanced to highlight Ice ridges phenomenon and to provide additional guidelines for de-icing operation. It will be also highlighted that while thin hoarfrost is permitted for example on the top surface of the fuselage, it must be distinguished from thin ice ridges that must be removed from lower nose fuselage.

Flight Crew:

The FCOM and FCTM of all Airbus aircraft are being updated to take into account the lessons learnt from these events.

- **Modification of FCOM:**

  The FCOM (A320/A330/A340/A350/A380: *Supplementary Technique – Adverse Weather - Cold Weather Operations*, A300/A310: *Procedures and Techniques - Inclement Weather Operation - Aircraft Preparation for Cold Weather Operation*) is being modified to explain that, during the exterior walkaround in cold weather conditions, the flight crew must check that there are no ice ridges on the lower nose fuselage, in front of the air probes. If ice ridges are detected, the flight crew must ask the de-icing personnel to remove them.

  Lower nose fuselage check should be performed carefully because ice ridges can be difficult to see, especially on a white fuselage during night time

"The lower nose fuselage must be clear of ice before departure to avoid unreliable airspeed situation due to ice ridges and even thin ice ridges must be removed before departure."

"During the exterior walkaround in cold weather conditions, the flight crew must check that there are no ice ridges on the lower nose fuselage, in front of the air probes."

- **Modification of FCTM:**

  The FCTM (A320/A330/A340/A350/A380: *PRO – SUP - Adverse Weather - Cold Weather Operations and icing conditions section*, A300/A310: *Supplementary Information - Inclement Weather Cold Weather Operations And Icing Conditions*) is being updated to explain the effect of ice ridges in front of Pitot probes on the airspeed measurement and the potential subsequent unreliable airspeed situation.

What to do in the case of an unreliable speed event during takeoff?

The means to prevent ice ridges described in this article can reduce the likelihood of unreliable airspeed events related to this phenomenon, however in any event where an airspeed discrepancy is detected by the flight crew, the UNRELIABLE SPEED INDICATION must be applied. Refer to FCOM UNRELIABLE SPEED INDICATION procedure and associated FCTM chapter for more information on the procedure application.

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The potential consequences of ice ridges located forward of the Pitot probes (or MFPs) on the lower nose fuselage is not very well known by flight crews, maintenance and ground personnel. It is important to be aware that these ice ridges may create airflow perturbations forward of the probes. This can lead to the airspeed data coming from the ADR (or ADC) associated with the affected probe, or probes, to be at a value that is significantly lower than the actual airspeed. The outcome may be an unreliable airspeed situation from take-off, or later during the flight, with its related effects on the aircraft systems.

The FCOM and FCTM are being updated to raise awareness of this phenomenon. They highlight the need to pay particular attention to this area when performing the walk around in cold weather conditions. If the flight crew observes (even thin) ice ridges, they must ask the ground personnel to remove them before departure.

An update of the AMM will also highlight this phenomenon and provide additional guidance for de-icing the lower nose fuselage area.

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