SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A350-1041, G-XWBC
No & Type of Engines:	2 Rolls-Royce Trent XWB-97 turbofan engines
Year of Manufacture:	2019 (Serial no: 362)
Date & Time (UTC):	2 January 2022 at 1430 hrs
Location:	London Heathrow Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 12 Passengers - 326
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to aircraft skin, toilet waste panel and tailstrike sensor
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	17,305 hours (of which 652 were on type) Last 90 days - 141 hours Last 28 days - 48 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was approaching Runway 27L at London Heathrow airport at the end of a flight from Dubai. During the flare for landing the aircraft "floated" and the crew believed it would not land within the runway Touchdown Zone (TDZ). A go-around was initiated from low height and speed; the subsequent pitch rate applied caused the aircraft to reach a nose-up attitude sufficient to cause a tailstrike. The aircraft subsequently landed safely and there were no injuries.

History of the flight

The aircraft was operating a commercial passenger flight from Dubai International Airport to London Heathrow Airport. The flight crew had completed a rest period in Dubai and both reported that they felt normally rested for the start of the duty. The crew were given wake up calls at 0330 hrs and their duty commenced at 0430 hrs. The departure preparations were entirely routine, and the only entry in the aircraft technical log related to a flight deck touch screen on the commander's side. The aircraft departed Dubai at 0620 hrs.

The flight to Heathrow was uneventful and the crew briefed an approach to Runway 27L. The forecast weather indicated the possibility of gusts up to 30 kt and the crew discussed the implications of this during their briefing approximately one hour before landing. The wind was within limits[1] for the co-pilot to act as PF for the landing and that was accepted as the plan. Due to the blustery conditions the crew calculated the landing performance for both Flap 3 and Flap Full. Both are approved landing configurations, but Flap 3 is preferable in gusty conditions. The runway surface was wet and so, in accordance with the operator's SOPs, the crew assumed medium to poor braking action and no reverse thrust for landing distance calculations. The aircraft is equipped with a Brake to Vacate (BTV) autobrake system, which allows the crew to select a desired exit from the runway and then automatically varies the braking force to achieve that exit. In this case the crew selected the N6 exit (Figure 1) from Runway 27L.

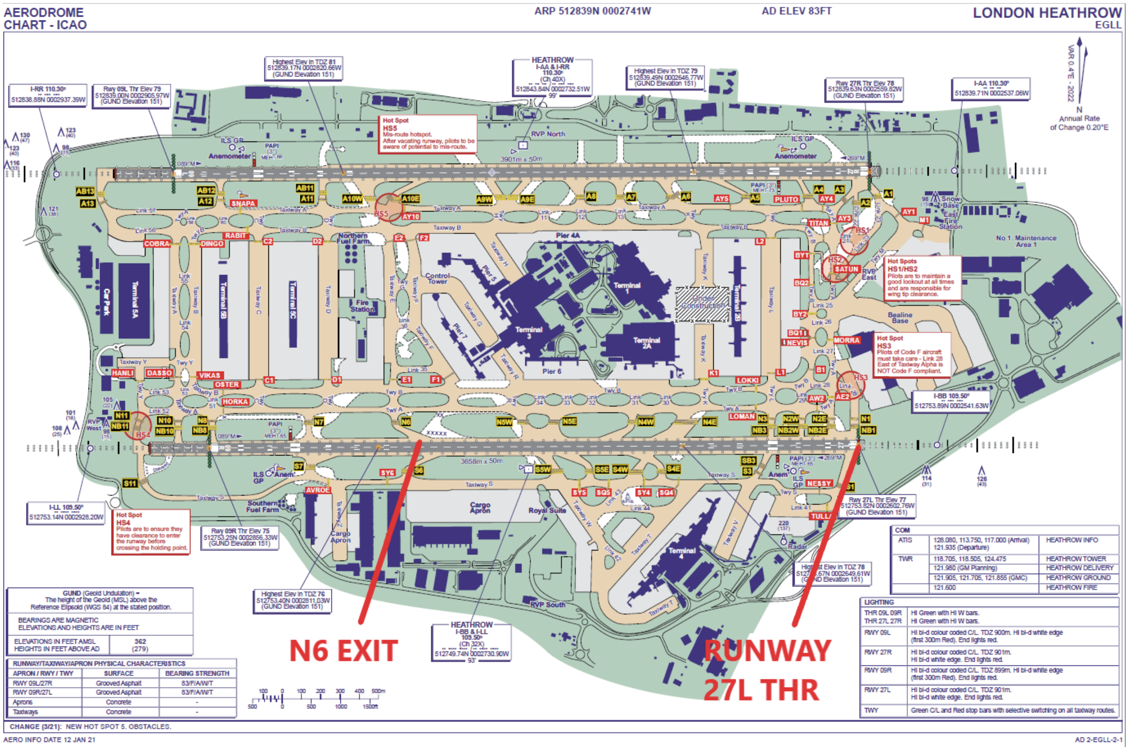

Figure 1

London Heathrow Airport Chart

The operator uses a monitored approach philosophy in which the PM for landing acts as PF for the initial stages of the approach and then hands control to the other pilot for the final approach and landing. Accordingly, the commander was PF for the initial stages of the approach.

The crew accepted a shorter arrival routing from ATC, which meant the aircraft was higher than intended with respect to the vertical path. The commander used speedbrakes to increase the descent rate, and the aircraft was in its landing configuration by 2,000 ft agl. The co-pilot took over the PF role at approximately 1,000 ft agl.

Footnote

1 The operator's crosswind limit for a landing by the co-pilot is 26 kt.

There was another aircraft landing ahead, also planning to vacate at N6, so the co-pilot elected to continue the ILS approach to Runway 27L with the autopilot engaged until that aircraft cleared the runway. The co-pilot disengaged the autopilot at approximately 400 ft agl to conduct a manual landing. The co-pilot stated that he had to make a few corrections to the flight path as a result of the wind conditions but that the approach felt normal. The ATIS reported the wind as 210 at 11 kt gusting 22 kt.

The co-pilot manually reduced thrust at approximately 50 ft agl and then flared the aircraft for touchdown. He described the flare as a "check" in pitch and then holding the attitude. The aircraft's radio altimeter audio callout sounded at 5 ft, after which the flight crew described the aircraft as "floating". The radio altimeter height increased to 9 ft and then decreased to 5 ft where there was a second 5 ft audio call. The commander considered that after the prolonged flare the aircraft would land beyond the runway TDZ. The operator has a Safe Landing Policy which directs a go-around should the crew foresee a landing outside the TDZ, and so the commander called "go-around".

The co-pilot initiated the go-around, selected Take Off Go-Around (TOGA) on the thrust levers and applied a pitch up demand on his control column, briefly reaching full aft control movement. Engine response from idle to go-around thrust takes several seconds and with the low energy state the aircraft briefly touched down. As it did so the pitch attitude was increasing in response to the co-pilot's control inputs and reached a maximum of 15° nose up. The pilots described the touchdown as firm, but not so severe that it would have constituted a heavy landing. The commander felt the initial pitch was greater than warranted but stated that by the time he could have reacted the co-pilot was already taking corrective action. With the aircraft on the ground the aural configuration warning sounded as a result of TOGA thrust being selected with a landing flap setting.

The aircraft then became airborne and climbed away in a normal go-around. The crew retracted the landing gear and reduced the flap setting to FLAP 1 to keep airspeed low and reduce the ground track for the circuit to land. As the aircraft passed 400 ft agl the Electronic Centralised Aircraft Monitor (ECAM) displayed a TAILSTRIKE warning. The warning is inhibited at lower heights. ATC informed the crew, by RTF, that they had observed a tailstrike. The crew completed the ECAM actions for a tailstrike and then the after takeoff checklist. The crew discussed the situation and decided to continue with an approach to Runway 27R, as Runway 27L was temporarily out of use for an inspection after the tailstrike. The co-pilot continued as PF while the aircraft positioned on approach and the commander took control for the landing. After landing the airport RFFS conducted an external inspection for damage and the aircraft then taxied to a parking stand and shut down.

Accident damage

An initial damage assessment found two areas of skin damage on the aircraft tail lower fuselage, one each end of the toilet waste panel aft of the tailstrike sensor. While the rearmost skin damage area was assessed as surface finish damage, the forward area appeared to have penetrated through the paint, copper mesh lightning protection layer and up to five carbon fibre reinforced plastic layers.

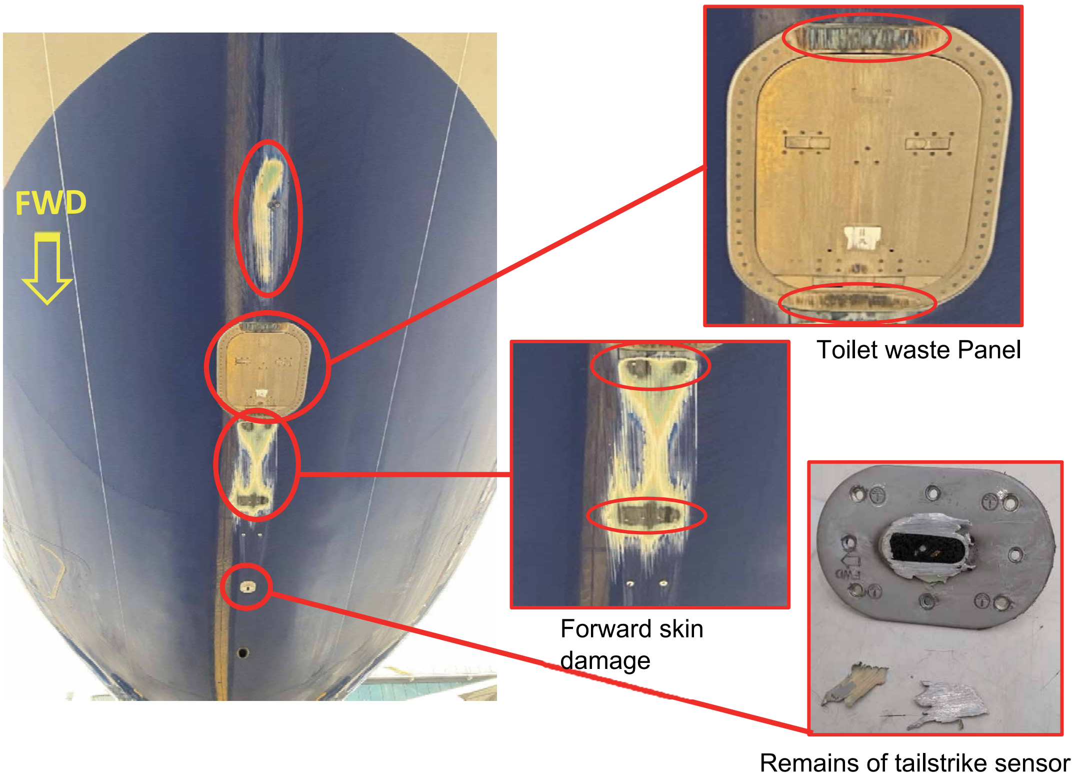

Figure 2

Rear lower fuselage damage to skin, toilet waste panel and tailstrike sensor

The leading and trailing edges and rivets on the toilet waste panel were also abraded by the runway surface, although the damage to the panel was believed to be repairable during the initial damage assessment.

As designed, the tailstrike sensor had fractured on impact (Figure 2).

Recorded information

G-XWBC was fitted with a solid-state Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR); both of which were downloaded by the AAIB and recorded the whole event.

The CVR confirmed the crew accounts of the event, and the FDR data was used to produce Figure 3, covering G-XWBC's approach from 100 ft radio altitude until initiation of the go-around during which the tailstrike occurred. The numbered points at the top of Figure 3 represent the approximate position on Runway 27L of the corresponding events shown on the graph.

Prior to point 1, as G-XWBC descended below 100 ft radio altitude, the approach was stable with a pitch attitude of between 2° and 3° nose up, a descent rate of approximately 800 ft/min and with airspeed reducing towards 150 kt. At point 1, at approximately 55 ft above the runway, the aircraft was flared for landing and shortly afterwards the thrust levers closed to idle.

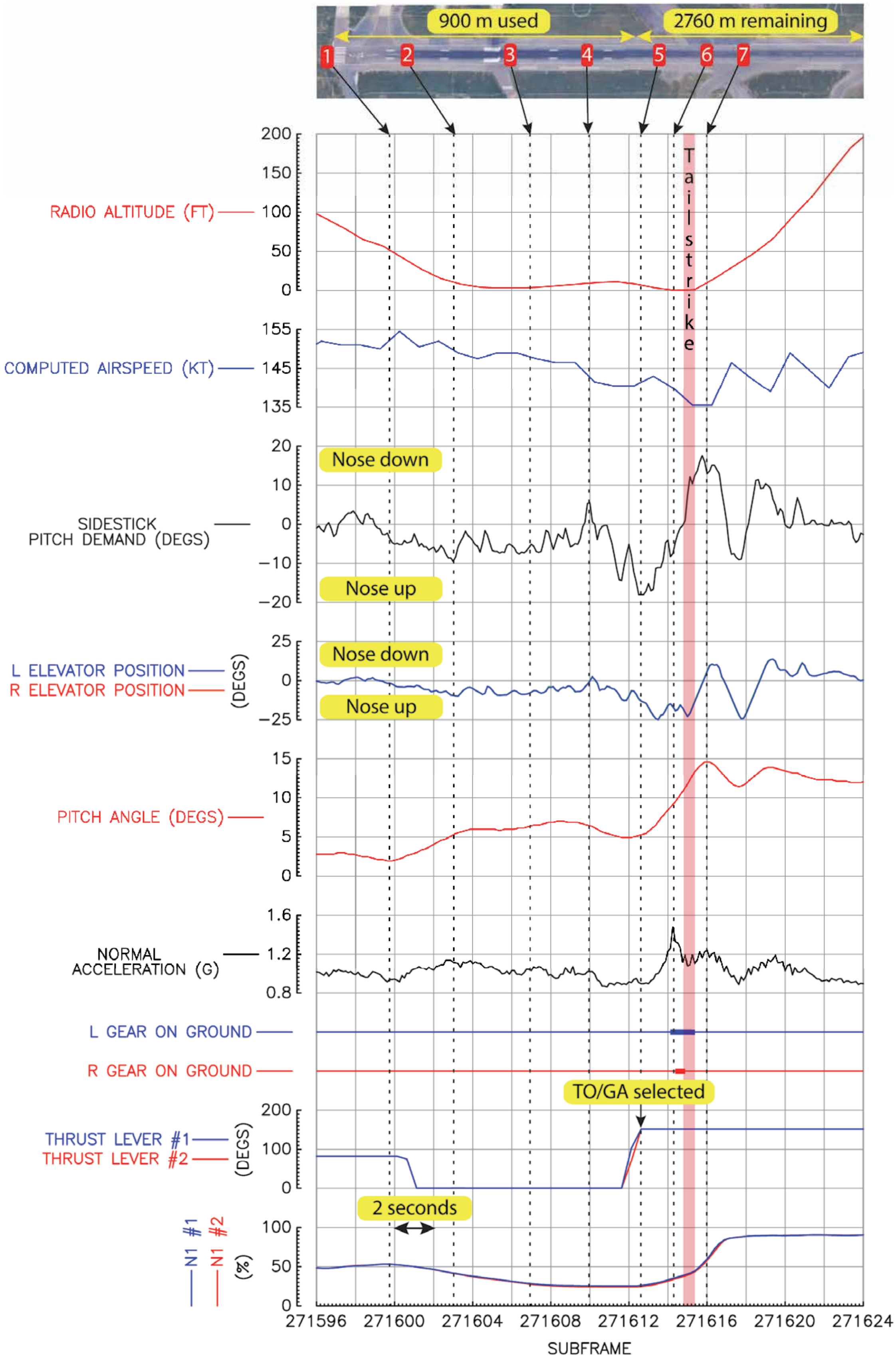

Figure 3

G-XWBC's descent from 100 ft radio altitude and the initial part of the go-around

Over the next three seconds, as G-XWBC descended through 10 ft, progressively more nose-up sidestick was applied, reaching 3/5 of maximum sidestick deflection at point 2. In response, G-XWBC's pitch attitude increased and then stabilised at around 6° nose-up, and the aircraft 'floated' 5 ft above the runway but did not touchdown.

Four seconds later, at point 3, G-XWBC began to climb and the pitch attitude increased slightly. At point 4, a sharp nose-down sidestick input (of approximately 1/3 of maximum deflection) was made. The sharpness of this input is seen in the distinct reduction of normal acceleration at point 4.

G-XWBC then descended, the pitch attitude reduced towards 5° nose up, and an increasing amount of nose-up sidestick was applied which reached full travel. In response, the elevators reached 4/5 of their full nose-up travel. At point 5, having used 900 m of runway and with the aircraft at the end of the TDZ, a go-around was initiated and the thrust levers were moved to the TOGA detent. At this point, 2,760 m of runway remained ahead of the aircraft.

The nose-up sidestick command was then reduced, although it was still maintained in the nose up sense, and the pitch attitude, which had risen rapidly because of the large elevator deflections, approached 10º nose up. At the same time, G-XWBC's airspeed had substantially decreased and, before the engines had time to significantly spool up, the aircraft briefly touched down at point 6.

Between points 6 and 7, as G-XWBC became airborne again, the airspeed reached a minimum of 135 kt and the tailstrike occurred. Although nose-down sidestick inputs were made, G-XWBC's pitch attitude continued to increase before the elevators moved to reduce the pitch attitude. A maximum pitch attitude of 16° nose-up was recorded at point 7.

After point 7, following a large nose-up sidestick demand the flight path began to stabilise.

Aircraft information

G-XWBC is an Airbus A350-1000 configured for passenger operations and is 73.79 m long. The Flight Crew Operating Manual gives the following information with regard to tail clearance warnings:

> *'"Pitch-Pitch" aural alert is triggered if the pitch attitude, monitored by the flight controls, reaches a given limit. This aural alert is only available in manual landings when the aircraft height is lower than 50 ft RA. In addition, a tailstrike pitch limit also appears on the PFD at landing below 400 ft RA.'*

The audio warning is triggered when the pitch attitude is expected to exceed 9° nose-up. The system uses a predictive phase advance term to calculate the pitch attitude one second into the future.

The tailstrike pitch limit in the Primary Flight Display (PFD) (Figure 4) is displayed at fixed pitch value, which corresponds to the pitch limit on the ground with the main landing gear compressed plus an additional margin. The illustration from the Flight Crew Training Manual

(FCTM) shows the pitch limit for an A350-900. The incident aircraft was an A350-1000, which is longer, and therefore the PFD indication would be positioned at 8.6° nose-up. The indication disappears when the groundspeed falls below 50 kt, or 4 seconds after a go-around is initiated.

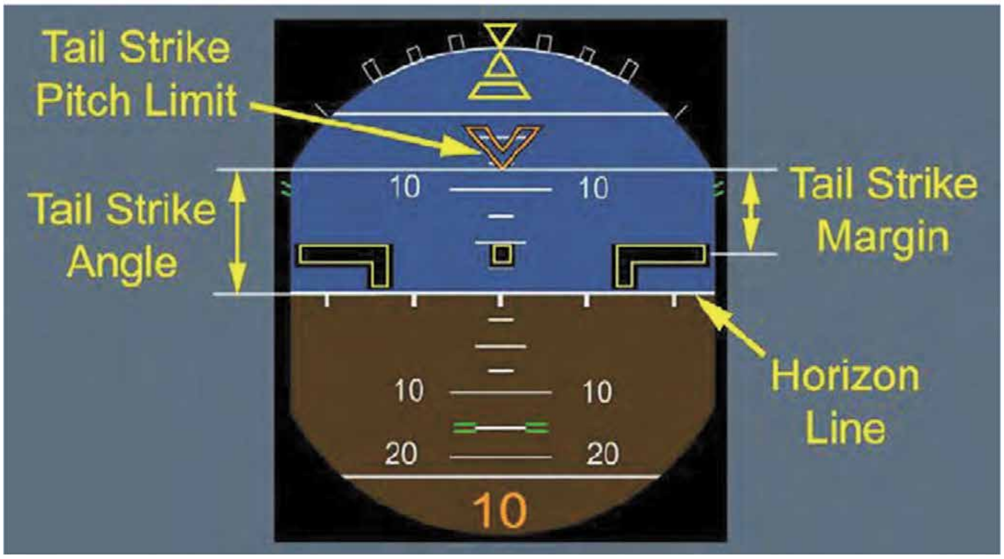

Figure 4
PFD Tailstrike Pitch Limit

The aircraft is equipped with a Runway Overrun Warning/Runway Overrun Protection (ROW/ROP) system. The ROW and ROP functions alert the flight crew if a potential runway overrun is detected at landing. The ROW function is operative until the aircraft is on the ground and the ROP function becomes active. The system uses the following definition for on ground:

'The nose landing gear is on ground, or

The ground spoilers are extended for 5 seconds.'

The ROW/ROP system monitors the computed landing distance and predicts a potential landing runway overrun in flight and during rollout. If the landing runway is too short the system will:

- *'Trigger the applicable aural and visual alerts (ROW and ROP)*
- *Automatically order maximum braking, when the autobrake system is selected to medium or if the BTV is active.'*

With regard to the limits on the tailstrike warnings and the limitations on when they are active the manufacturer gave the following information:

'The "Pitch-Pitch" alert is designed to avoid excessive pitch attitude during the landing phase. It is available during manual landing below 50ft RA.

It is triggered when the pitch is expected to become greater than 9°. The audio warning includes a phase advance term, which amounts to the pitch angle one second in the future. This phase advance is tuned to, on one hand, allow sufficient time for the pilot to correct his sidestick input, and on the other hand not to be intrusive.

This balance works well when the pitch rate is low, as is the case during landing.

During a go-around, this compromise is no longer achievable. The pitch rate is quite high, and the predicted pitch angle tends to be overestimated. This would result in spurious audio warnings that might prevent the crew from achieving the rotation rates necessary for a go-around. There is also the fact that with high pitch rates, it is impossible to give the crew sufficient time to allow them to react.

It was therefore decided to inhibit the Pitch-Pitch audio warning during a go-around.

In parallel, during landing below 400 ft, an orange chevron on the PFD indicates the maximum pitch attitude to avoid a tailstrike, at a fixed value (8,6°) corresponding to the pitch limit with the main landing gear compressed.

Upon go-around initiation, the chevron remains displayed only until the aircraft is above 10 ft RA.

It has to be noted that on A350, with the AP off, the FD pitch bar disappears below 50 ft RA.

Then, when the go-around is initiated by pushing the thrust levers in TOGA notch, the FD pitch bar is displayed again, in SRS (Speed Reference System) mode.

In the initial phase, the SRS guidance targets 12.5° as pitch target, but, as long as the tailstrike pitch limit (chevron) is displayed on PFD (i.e. as long as the aircraft is below 10ft RA), the FD pitch bar is limited by the chevron (i.e below 8.6° on the PFD pitch scale).

The FD guidance does not include any other tailstrike protection.'

Aircraft examination

After a detailed damage assessment by the operator's maintenance team, it was confirmed that the area aft of the toilet waste panel only required restoration of the surface finish. An ultrasonic Non-Destructive Test inspection of the toilet waste panel cut-out found no signs of delamination. Composite damage assessments were completed of the airframe stringers located around the areas of external damage, but no further damage was found. The abraded external fuselage skin areas were examined and again no delamination of the carbon composite layers was present.

Inspection of the external skin area forward of the toilet waste panel found the painted surface, copper mesh layer and up to three composite layers had been worn away in small patches (Figure 5). The damage was within the capability of the operator's aircraft structures maintenance team to repair. The toilet waste panel was damaged beyond repair because the abraded leading and trailing edges had thinned the material and compromised the strength of the panel. Three vent pipes positioned along the rear of the fuselage had also been bent and abraded as the aircraft tail struck the ground and had to be replaced (Figure 6).

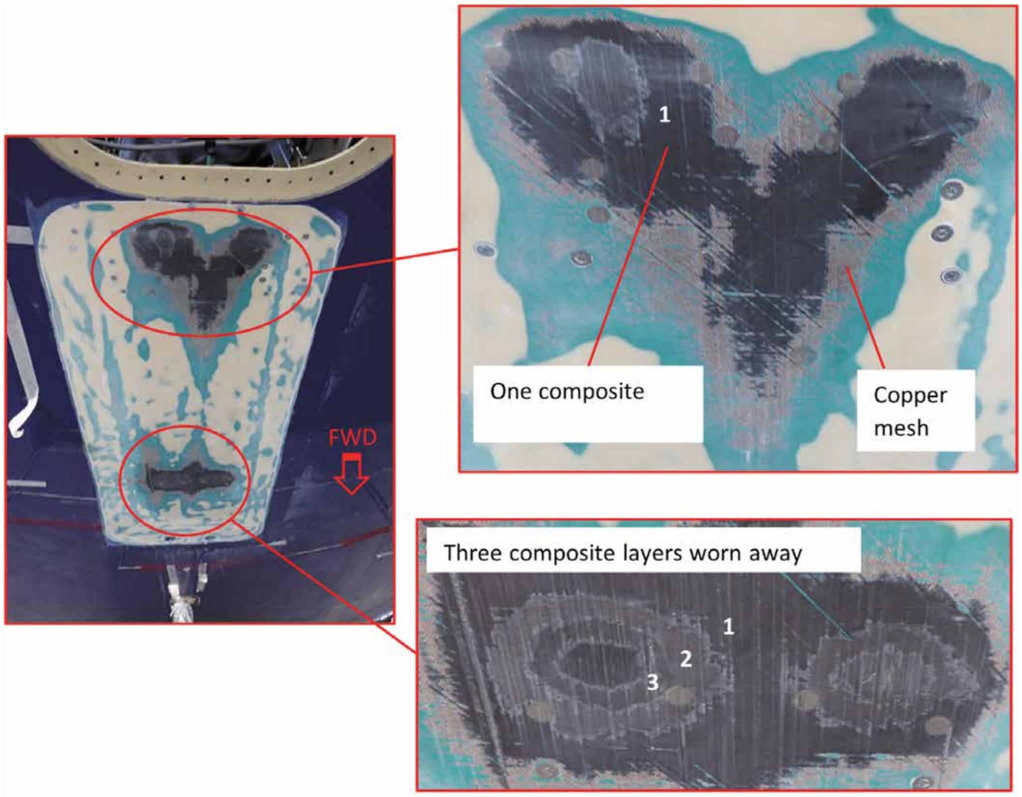

Figure 5

Damaged skin composite layers

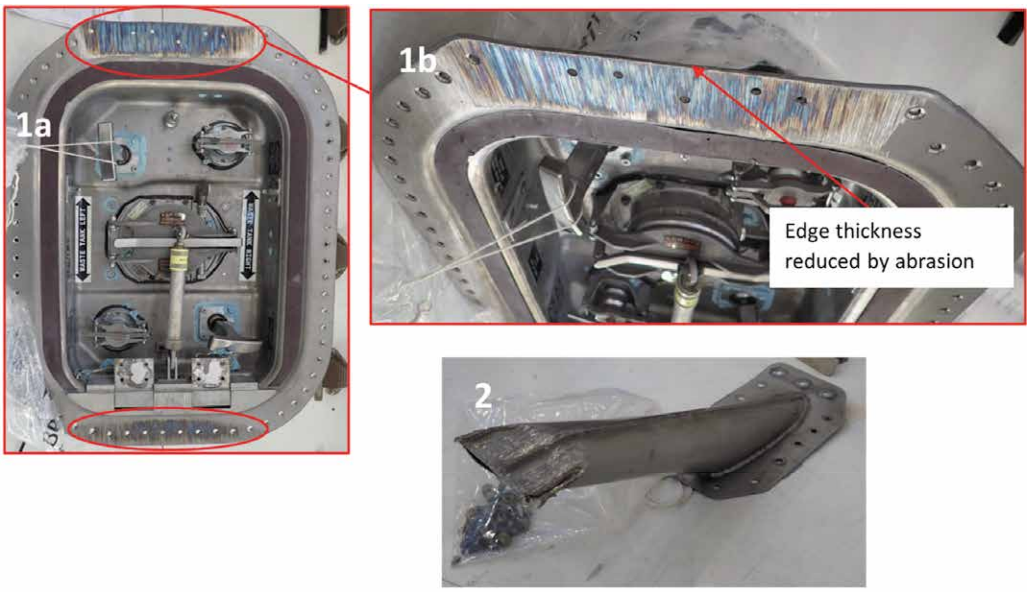

Figure 6

Toilet waste panel (1a) damaged beyond repair (1b) and damaged vent pipe (2)

Tailstrike indication system

The primary component of the tailstrike indicator system is the tailstrike sensor which is designed to fracture when the aircraft's tail hits the ground. There are two wires inside the sensor (Figure 7) to allow for a fault condition should one of the wires become open circuit. In this state no tailstrike alert is displayed and the fault is added to the post flight report by the Centralised Maintenance System and included in a maintenance check.

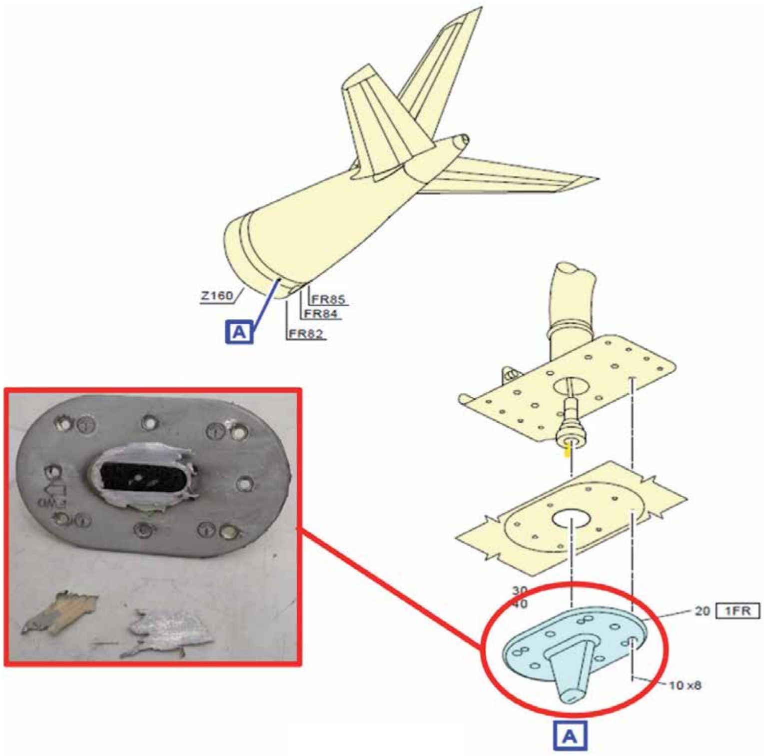

Figure 7

Tail strike sensor location

When a tailstrike does occur, the two wires in the sensor are damaged and become open circuit from their normally grounded (GND) state. The change of signal state is detected by the Common Remote Data Concentrators which change the format of the data and transmits it to the Flight Warning System (FWS) via the Avionics Full Duplex Switched Ethernet (AFDX). The FWS shows a warning on the ECAM Warning Display providing the aircraft is in the appropriate flight phase, landing or taking off. A single chime is also produced from the flight deck loudspeakers. On the cockpit glare shield and panels 411VU and 412VU, MASTER CAUT push buttons are also illuminated (Figure 8). Other than an ECAM message, the system warnings are inhibited when TOGA is selected during landing.

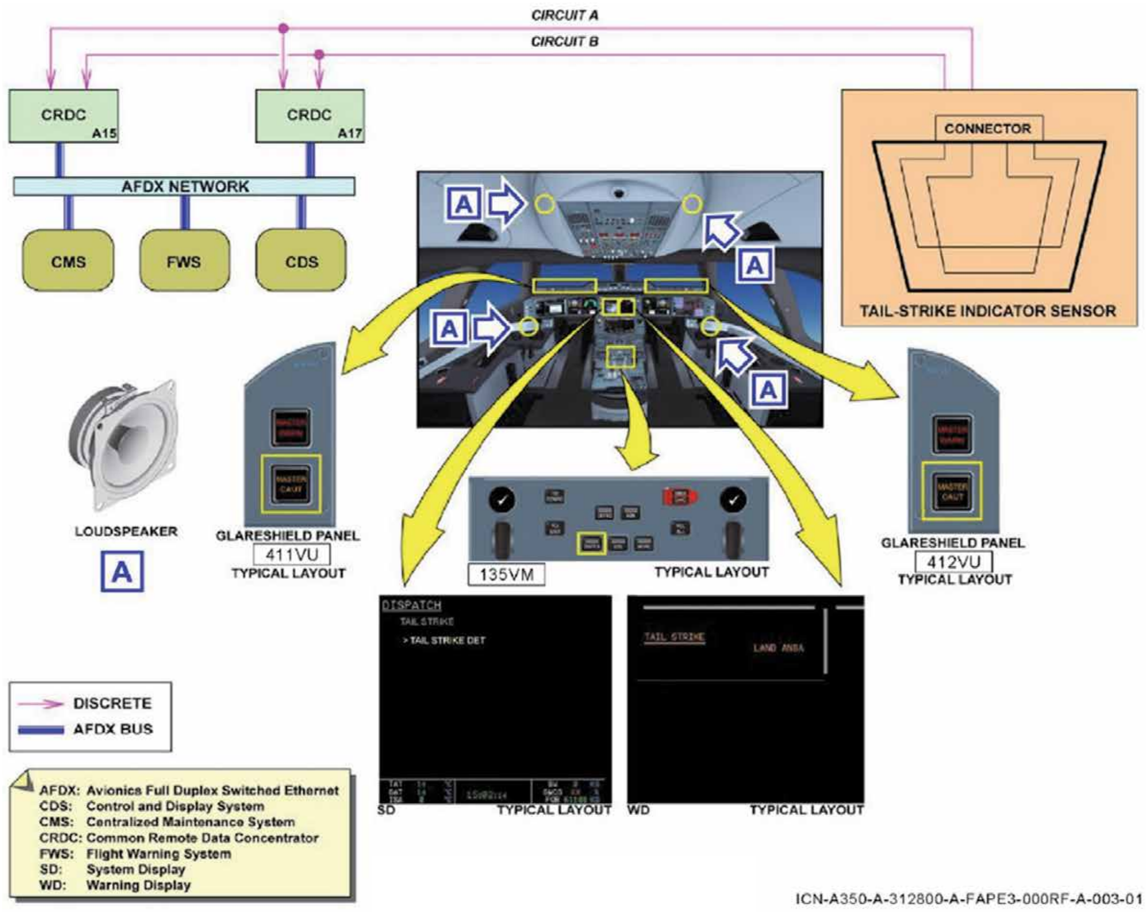

Figure 8

Tail strike system diagram

Meteorology

The weather report at 1420 hrs gave the wind as 210° at 13 kt. There was a report of cumulonimbus cloud indicating shower conditions in the vicinity of the airport and therefore an increased likelihood of gusts.

An amended weather forecast had been issued for Heathrow at 1256 hrs. That indicated a wind of 230° at 12 kt, with temporary periods of wind from 220° at 20 kt with gusts to 30 kt, associated with heavy showers of rain and cumulonimbus cloud.

Airfield information

Heathrow Airport lies approximately 14 miles to the west of central London. It has two parallel runways, and Runway 27L, where the incident occurred, has a Landing Distance Available of 3,658 m. TDZs are marked by pairs of stripes symmetrically placed on the two sides of a runway centreline. The number of pairs depends on the runway length, with one pair for runways that are shorter than 900 m and six if the length is 2,400 m or more. The aiming point marking coincides with one of these pairs and is noticeably wider (Figure 9). The TDZ on Runway 27L has six pairs of stripes and is 900 m long.

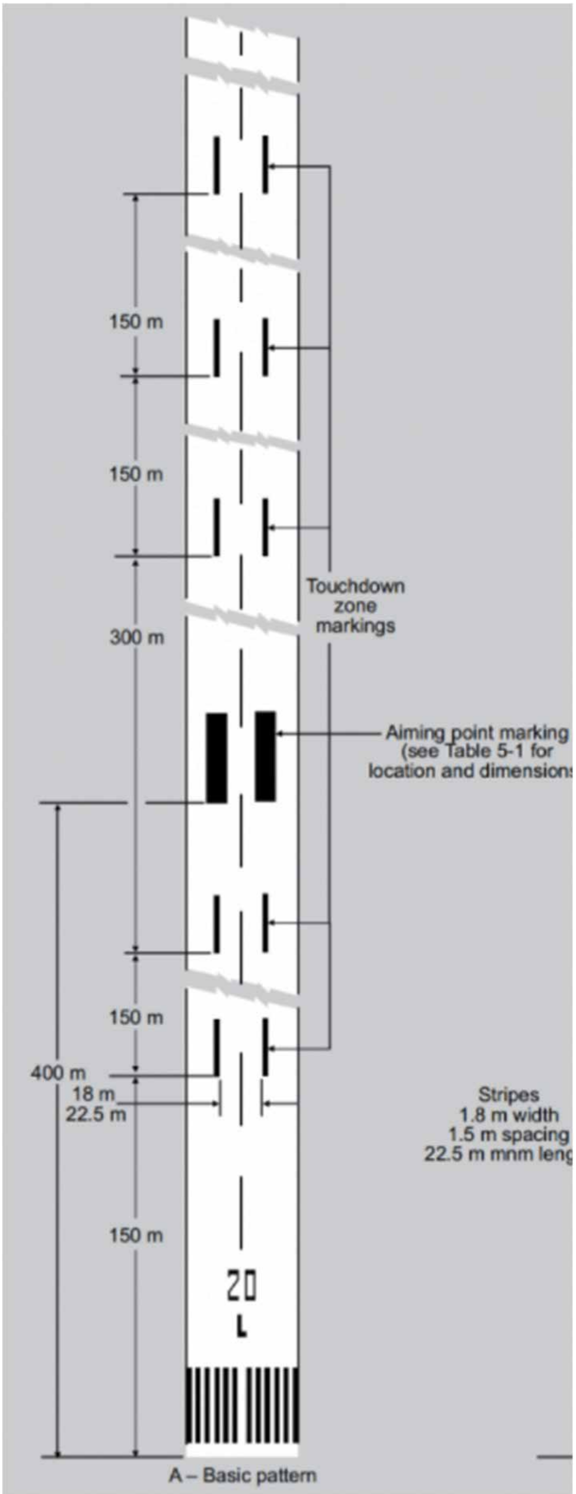

Figure 9

Example of Runway TDZ Markings

Organisational information

The FCTM contains guidance for the flare (Figure 10), and states that the flare height would normally be approximately 40 ft agl.

FLARE AND TOUCHDOWN

PITCH CONTROL

In stabilized conditions, the flare height is around 40 ft. This height varies due to the operational conditions that directly affect the rate of descent.

[...]

In order to assess the rate of descent during the flare and the aircraft position vs. the ground, look well ahead of the aircraft. Do not allow the aircraft to float or do not attempt to extend the flare by increasing pitch attitude in order to achieve a perfect smooth touchdown. A prolonged float increases both the landing distance and the risk of tail strike.

Figure 10

FCTM Flare Guidance

In order to create a robust defence against runway excursions on landing, the operator has defined *'Safe Touchdown Criteria'* in its operations Manual Part A (OMA), which include:

- *'Main Gear Touchdown within the TDZ (See Note 1, 2).*
- *Main Gear Touchdown and trajectory within runway edge is guaranteed.*
- *Normal Runway contact within the aircraft geometric landing limits.*

  Note 1: If the aircraft is still airborne at the end of the TDZ, or it is obvious that the landing will not be within the TDZ, a rejected landing shall be initiated. The crew need not wait until the aircraft physically touches down to perform the rejected landing.

  If the Safe Touchdown Criteria are not achieved, PM will use the following call:

- *"go-around".'*

If a landing is made beyond the TDZ then it would be recorded as an event by the operator's Flight Data Monitoring programme. The operator's expectation is that a crew who land beyond the TDZ would file an Air Safety Report. If such an event is recorded, the operator stated that it would be investigated with the crew to understand the event and give guidance to prevent recurrence. The operator's A350 fleet operates to runways with landing distance as short as 2,400 m.

In the case of a go-around being initiated close to the ground, the operator's FCTM contains the following advice:

'If the flight crew performs a go-around near the ground, they should take into account the following:

- *The PF should avoid excessive rotation rate, in order to prevent a tailstrike.*
- *A temporary landing gear contact with the runway is acceptable.'*

Analysis

Although the wind conditions at Heathrow were gusty, they were within limits for the approach. The approach was flown with the APs engaged until approximately 400 ft agl and then manually. The flare was initiated at 50 ft agl with the pitch attitude raised to 7° nose-up. This caused the rate of descent to reduce to 0 ft/min and so the aircraft floated along the runway. The thrust levers were retarded at 30 ft agl and the airspeed decreased with a concomitant reduction in lift. The aircraft then started to descend once more.

As the commander felt the aircraft would land beyond the TDZ, he directed a go-around in accordance with the operator's policy. TOGA was selected on the thrust levers and, simultaneously, the co-pilot briefly applied full nose-up pitch control before partially reducing the command. This caused a pitch-up rate of approximately 3°/s. The aircraft touched down, and as the pitch attitude reached 9° nose-up the tail struck the ground.

The go-around was initiated before touchdown but as the engine thrust had been reduced to idle it took some seconds to develop go-around thrust. The airspeed had reduced significantly below approach speed and so the aircraft lacked the performance to gain height immediately and the touchdown resulted. This possibility is recognised in the FCTM which gives guidance for handling the aircraft in such circumstances.

From the point at which the go-around was initiated, 2,760 m of runway remained ahead of the aircraft, which would have been sufficient distance for the aircraft to land and safely decelerate. In these circumstances, it is unlikely that the control inputs that led to the significant pitch up would have been made and the aircraft might not have been damaged. However, landing would have been against the operator's policy – common across all its fleets – to reject a landing if a touchdown beyond the defined TDZ is anticipated. The policy is applicable to a wide range of aircraft and airports, including many with restrictive runway lengths. The operator's view was that a single policy ensures simplicity, avoids ambiguity, and includes a consideration that runway excursions represent a greater hazard than go-arounds.

Conclusion

A go-around was initiated from low height and low speed. The aircraft had insufficient energy to climb immediately and so touched down during the go-around process. The pitch rate induced by the co-pilot caused the aircraft to reach a nose up attitude sufficient to cause a tailstrike as the aircraft touched down.

Published: 18 August 2022.