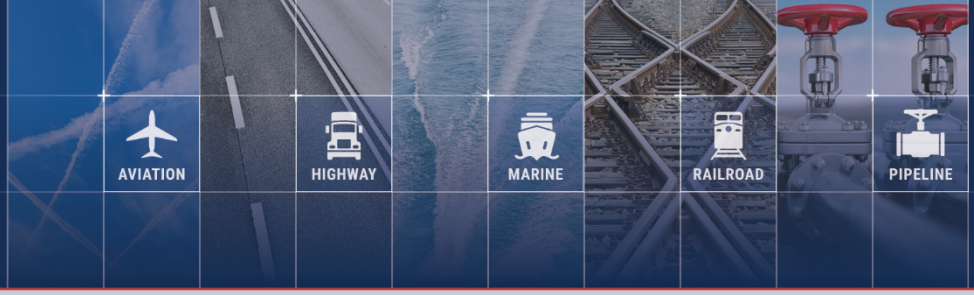

Aviation Investigation Factual Report

Location:	Kagoshima,	**Incident Number:**	DCA09IA064
Date & Time:	June 23, 2009, 03:03 UTC	**Registration:**	N805NW
Aircraft:	Airbus A330-323	**Aircraft Damage:**	None
Defining Event:	Flight instrument malf/fail	**Injuries:**	217 None
Flight Conducted Under:	Non-U.S., commercial		

Factual Information

HISTORY OF FLIGHT

On June 23, 2009, at 0301 coordinated universal time (UTC) an Airbus A330-323, US registration N805NW, manufacturer serial number 552, operated by Northwest Airlines as flight 08 between Hong Kong and Tokyo experienced airspeed and other flight deck anomalies while in cruise flight at FL390, 50 miles southwest of the Kagoshima Airport, Japan.

The flight was passing nearby an area of convective weather activity. The airplane was in level flight, on autopilot, at a speed of mach 0.81, heading approximately 065 magnetic along RNAV (area navigation) route M750. The flight crew was aware of the weather, and reported they were adjusting the airborne weather radar tilt and cycling between MANUAL and AUTO modes in an attempt to get the most complete picture to avoid penetrating the convective activity. Outside (static) air temperature was about -52ºC. They reported that the main cell appeared to be about 25 miles north of their flight path. However, just prior to the event the airplane entered an area of cirrus clouds with light turbulence and moderate rain with a brief period of intense rain, and hail aloft.

The crew received a master warning and master caution alert, and the autopilot (AP), autothrust (ATH) and flight directors disengaged. The crew reported airspeed fluctuations on the Captain's, First Officer's (FO), and the standby airspeed indicators. They reported receiving a stall warning, noted the flight law switched to Alternate Law, and saw messages indicating NAV ADR DISAGREE and NAV IAS DISCREPANCY. They reported the airspeed fluctuations and warnings lasted about one minute, and they controlled the airplane by pitch and power reference, per applicable checklist procedures until normal airspeed indications returned. They received ATC clearance to turn farther from the convective area, and after a short period the airspeed fluctuations and messages repeated for a duration of about two minutes. The airspeed indicators returned to normal and the crew re-engaged autopilot and completed the flight in alternate law.

A review of Flight Data Recorder (FDR) and Quick Access Recorder (QAR) information indicated the initial airspeed fluctuation between about 245 knots and 110 knots (Mach 0.81 to Mach 0.35) on the No.1 (Captain) Air Data Reference unit (ADR), followed within one second by the autopilot and autothrust disengagement and a brief stall warning. Note that the No.2 (First Officer) ADR airspeed was not recorded. Flight law switched to alternate law twice in the initial 35 seconds of the event. There were some minor pitch and altitude variations, less than 150 feet from assigned altitude. About 35 seconds after the initial fluctuation the flight control laws returned to normal, and the crew was able to re-engage the autopilot while turning farther from the weather area. About one minute 45 seconds after the initial event, the airspeed began to fluctuate again similarly between 245 and 110 knots on both the No.1 ADR and the

standby airspeed. The autopilot again disconnected, and the flight control laws reverted to alternate law. Pitch and altitude excursions resulted in a brief climb of about 250 feet before returning to FL390. The No.1 ADR experienced fluctuations for about 3 minutes, while the standby airspeed dropped to 110 knots for about 30 seconds during the event. After the standby airspeed returned to normal, the crew was able to reengage the autopilot, although flight law remained in alternate for the remainder of the flight. Shortly after the fluctuations on No.1 ADR ceased, the autothrust was also re-engaged and the flight continued to land at Tokyo/Narita with no injuries, damage, or further incident. Post flight maintenance checks on the airspeed system revealed no discrepancies. The investigation of this incident was delegated to the U.S. by the Japan Transport Safety Board (JTSB). Note that this type of airspeed anomaly event is not normally reportable to the NTSB under the provisions of 49 Code of Federal Regulations (CFR) 830.5.

On May 21, 2009, at 2147 eastern daylight time (EDT), an Airbus A330-233, Brazilian registration PT-MVB, manufacturer serial number 238, operated by TAM Airlines as flight 8091 from Miami International Airport, Florida, to Sao Paulo Guarulhos International Airport, Sao Paulo, Brazil, experienced a loss of primary speed and altitude information while in cruise flight at FL370 over international waters, south of Haiti. The flight crew noted an abrupt drop in outside air temperature and observed St. Elmo's Fire, followed by the loss of the Air Data Reference System, disconnections of autopilot and autothrust, and loss of primary airspeed and altitude. The flight crew continued using backup instruments, and after a short time, primary data was restored. The airplane remained in alternate flight law and displayed a rudder travel limit flag. The crew determined they could not restore normal law and continued the flight under the appropriate procedures. The flight landed at Sao Paulo with no further incident and there were no injuries or damage. The Brazilian Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA), delegated the incident investigation into this event to the NTSB.

A review of recorded flight data indicated that while level at FL370, indicating mach 0.8 (260 knots), and in moderately turbulent conditions with an outside (static) air temperature of -45º C the No.1 ADR airspeed dropped rapidly from about 260 knots to approximately 60 knots for a few seconds, then rose to 100 knots. At the same time, the recorded pressure altitude dropped by about 300 feet. About one minute later, the autothrust and autopilot disengaged, consistent with the pilot report that the co-pilot's airspeed also began to fluctuate. The Captain took over and began to fly by reference to the standby airspeed and instruments which he reported still appeared normal. Flight law reverted to alternate and the NAV ADR DISAGREE message was displayed.

About 6 seconds after the autopilot disengaged, recorded data indicated two brief re-engagements of the autopilot. Concurrent with the re-engagement, a pitch up to about 7 degrees nose up and slight climb was recorded, and the pilot reported a stall warning. Left side stick pitch inputs were recorded about one second after the autopilot disengaged from the second brief engagement, as the airplane climbed to about 38,000 feet. The autopilot remained disengaged during the remainder of the event, and the crew turned about 60 degrees

to the left to diverge from the weather area, and the altitude decreased to about 36,500 feet, before reversing and increasing again. About 3 minutes and 30 seconds after the initial airspeed drop, the No.1 ADR returned to 260 knots, and the 300 foot altitude discontinuity ceased, indicating an altitude of about 37,400 feet. Left nose down stick inputs and a decrease in pitch were concurrent with the altitude returning to 37,000 (FL370). Then autopilot and autothrust were then re-engaged and the flight continued to Sao Paulo in alternate law with no further incident, no injuries, and no damage. Post flight maintenance checks on the airspeed system revealed no discrepancies.

AIRCRAFT INFORMATION

The Northwest airplane, N805NW, operator ship number 3305, was an Airbus A330-323, widebody twin engine long range aircraft. The TAM airplane, PT-MVB, was an Airbus A330-233. Although slightly different variants, the systems relevant to these incidents are nearly identical. Both airplanes were equipped with Pratt & Whitney 4168 engines. N805NW, the -300 series variant, had a longer fuselage and greater seating capacity, while PT-MVB, the -200 series variant, had a greater fuel capacity and range. N805NW was equipped with an optional software feature that was not installed on PT-MVB. The feature detects if a difference of more than 16 knots exists with any of the air data systems and displays a caution message indicating NAV IAS DISCREPANCY, and activates a chime and master caution alert. The only other significant difference was in the variant of pitot probes installed, discussed below.

Airspeed is measured by comparing the difference between total pressure, measured by forward projecting pitot probes, and static air pressure, measured via static ports oriented flush along the airplane surface. The A330 is equipped with three pitot probes and six static pressure ports. The pitot probes are fitted with water drains and electrical anti-ice heating elements. Heating is automatically activated when in flight.

The No.1 and No.2 pitot probes (Captain and First Officer) pneumatic measurements are converted into electrical signals by air data modules which deliver the signals to the Air Data Reference (ADR) units which convert the signals into speed data for display to the pilots, among other aircraft functions. The No.3 (standby) pitot probe also feeds an air data module which delivers the electrical signal to an additional ADR, as well as sending pneumatic information directly to the Integrated Standby Instrument System (ISIS), which is a unit that combines the standby airspeed, altitude and attitude indicators into one instrument.

Air data is used by many functions of the Auto Flight System, which is comprised of two Flight Management Guidance and Envelope Computers (FMGEC), a Flight Control Unit (FCU), which allows the selection of flight parameters, and three Multipurpose Control and Display Units (MCDU), which allow the flight crew to interface with the FMGEC. Each FMGEC includes a Flight Management component, controlling navigation and performance optimization functions among others, a Flight Guidance component which controls the autopilot, flight director (FD) and autothrust (ATHR), and a Flight Envelope component which controls data computation for the flight envelope and speed functions, center of gravity information and

other information. The Electrical Flight Control System (EFCS) is comprised of five flight control computers which process pilot and autopilot inputs, according to normal, alternate or direct flight control laws. Three PRIM (Flight Control Primary Computer – FCPC) computers are used for Normal, alternate and direct control laws, speed-brake and ground spoiler control, protection speed computation and rudder travel limit. Two SEC (Flight Control Secondary Computer – FCSC) computers are used for direct control laws, including yaw damper function and rudder trim and rudder travel limit.

All the pitot probes on N805NW, and the No.1 and No.2 probes on PT-MVB were manufactured by Thales Aerospace, part number C16195AA ("AA") The No.3 probe on PT-MVB was a Thales Aerospace part number C16195BA ("BA").

During entry into service, Airbus A330s were equipped with Goodrich 0851GR pitot probes. In 1998 the Thales AA probes were added as an option. In 2001, following some inconsistent speed problems, Airbus replaced the original 0851GR probes with either Goodrich 0851HL probes or the Thales AA probes. Operators had the option to install either of those probes in any location and could have any mix of both types on the same airplane.

In 2007 and 2008, Airbus issued Service Bulletin A330-34-3206 and Operators Information TELEX 999.0006/08/BB, recommending the replacement of AA probes with the BA probes. At the time of the N805NW and PT-MVB events, there was no requirement to replace the AA probes, so an A330 could be equipped with any combination of the Goodrich 0851HL, or Thales AA or BA probes.

In February of 2009, Thales conducted comparative testing between the AA and BA probes to the maximum capability of an icing wind tunnel. The study noted that real life conditions were not possible to completely reproduce, and the testing was beyond the certification requirements. The BA probes were found to be more resistant to blockage, with only a few "perturbations" when the AA probes would become blocked.

In July 2009, Airbus recommended that the No.1 and No.3 positions be fitted with the Goodrich 0851HL probes. In August of 2009, EASA issued an airworthiness directive requiring the replacement of all AA probes, with Goodrich 0851HL probes in the No.1 and No.3 positions, and a Thales BA or Goodrich 0851HL probe in the No.2 position. The FAA concurrently issued Airworthiness Directive (AD) 2009-18-08, requiring the same. The AD noted that "This same pitot probe standard has been made available as an optional installation on Model A330 and A340 airplanes, and although this has shown to be an improvement over the previous Thales Avionics pitot probe, P/N C16195AA standard, it has not yet demonstrated the same level of robustness to withstand high-altitude ice crystals as Goodrich pitot probes having P/N 0851HL. In 2010 further directives were issued by EASA/FAA and Airbus clarifying flight crew procedures in responding to unreliable airspeed.

The Quick Reference Handbook abnormal procedure checklists for UNRELIABLE AIRSPEED INDICATION for Northwest, TAM, and the basic Airbus aircraft operating manual, all call for

autopilot and autothrottle OFF, and instruct crews to use pitch and power reference tables to control the airplane in cruise flight.

METEOROLOGICAL INFORMATION

In the vicinity of the Northwest Airlines event, satellite images and radiative cloud top analysis indicated a temperature of 208.89 Kelvin or -64.27º C which corresponded to cloud tops near 47,000 feet north of the route of flight. Satellite imagery depicted a defined area of cumulonimbus clouds. A review of the local sounding indicated a deep moist low-level environment with a conditionally unstable atmosphere with the most unstable lifted index of -0.1 with a potential maximum vertical velocity of 9 meters per second. The tropopause was at 56,000 feet with the level of maximum wind below at 36,000 feet with winds from 260 degrees at 56 knots. At FL390, winds were from 260 degrees at 52 knots, temperature of -46º C or approximately 13º C above standard.

Satellite imagery obtained for the TAM event indicated an area with cloud top temperatures of approximately 190 Kelvin or -83º C, corresponding to cloud tops of approximately 54,000 feet. The aircraft passed downwind of the convective area, through areas of radar reflective returns consistent with anvil top blow-off.

FLIGHT RECORDERS

The Digital Flight Data Recorder (DFDR) and Digital Aircraft Condition Monitoring System (DAR) aboard N805NW was downloaded by Northwest Airlines and data provided to the investigative team.

Due to the elapsed time following the event the DFDR aboard PT-MVB was not available, however, the airline provided the investigative team data downloaded from the airplane's DAR. This DAR did not record flight control law or stall warning parameters.

The Cockpit Voice Recorder aboard both aircraft was overwritten due to the length of the flights and did not capture the events.

Post-flight maintenance recorded reports from both aircraft were provided to the investigative team.

TESTS AND RESEARCH

Airbus conducted an examination of the recorded data from both flights. During review of the Northwest incident, the initial autopilot, ATH and flight directors disconnection on N805NW was determined to most likely be due to a rejection of ADR No.1 showing a discrepancy of greater than 20 knots from the other ADRs, then a discrepancy of greater than 20 knots between the remaining ADRs.

A brief transient increase of angle of attack to 4.2 degrees or more, likely due to turbulence, likely resulted in the stall warning.

The crew could re-engage the autopilot, because at least two ADR values were consistent and valid. The EFCS was able to temporarily return to Normal law because the discrepancy between the ADRs was shorter than the confirmation time to latch the Alternate law. When the airspeed discrepancies returned, including the longer duration No.3 airspeed drop, the autopilot disconnected, and Alternate law then latched for the remainder of the flight.

Similarly on PT-MVB, the initial discrepancy led to the autopilot and autothrust disconnection. During the first few seconds of the discrepancy, the autopilot was transiently engaged and disengaged twice, and elevator movement and pitch up was recorded. The autopilot was reengaged while the airspeed indication was incorrect and low, but the airspeed parameter from at least two of the ADRs agreed within the prescribed 20 knot limit. The altitude error of 300 feet was indicating at this time as well. The fluctuations again led to airspeed discrepancies and autopilot disconnection. A brief increase in pitch from the autopilot engagement, followed by pilot stick inputs led to a pitch attitude that briefly reached 7 degrees airplane nose up, and the altitude deviation. After the fluctuations ceased the autopilot was reengaged and the airplane remained in alternate law.

The Airbus examination concluded that the behavior of both airplanes were entirely consistent with the recorded flight crew inputs and the expected autoflight and EFCS responses to partially and intermittently obstructed pitot probes.

The investigation examined the event flight data, and recorded data from other likely unreliable airspeed indication events, and observed that the altitude error that occurs concurrent with the airspeed loss appears consistently on the two variants of the aircraft, A330-200 and -300 aircraft, although is much smaller on the -300 examples. According to an Airbus examination of flight data and systems evaluation, the corrections applied on static pressure measurements depend on different parameters such as, aircraft type, engine type, flight conditions (angle of attack, airspeed, altitude). For the subject events, an erroneous Mach, used to correct the static pressure, was at the origin of the altitude change. Consequently, for the subject flight conditions and different aircraft types, Airbus concluded that an error of -300 feet was consistent with the Mach drop as experienced by PT-MVB, and a discontinuity of +5 feet was consistent with the Mach drop as experienced by N805NW.

ADDITIONAL INFORMATION

On June 1, 2009, an Airbus A330-203, French registration F-GZCP, operated by Air France as flight 447, crashed into the Atlantic Ocean while enroute from Rio de Janiero, Brazil to Paris, France. Initial information indicated that automated aircraft health monitoring data was sent that was consistent with an unreliable airspeed event. The airplane was equipped with Thales pitot probes. The Bureau d'Enquêtes et d'Analyses (BEA) of France is conducting the investigation. Interim reports and further information regarding actions involving Airbus and

Thales can be found at: http://www.bea.aero/en/enquetes/flight.af.447/flight.af.447.php

On October 28, 2009, an A330-202, Australian registration VH-EBA, operated by JetStar Airlines, experienced an unreliable airspeed event while in cruise flight approximately 400 miles south of Guam. The airplane was equipped with Goodrich 0851HL probes. The Australian Transport Safety Bureau final report on this event, is found at: http://www.atsb.gov.au/publications/investigation_reports/2009/aair/ao-2009-065.aspx

Both of these resources provide information on pitot probe design and certification criteria.

NEW OR USEFUL INVESTIGATIVE TECHNIQUES

Northwest's safety programs provide continual monitoring and analysis of safety trends. This is accomplished, in part, by monitoring of flight data recorded on QARs and investigation information derived from pilot submitted reports. Prior to the subject event, the historical QAR data revealed 10 similar occurrences within the previous 2 years where unreliable airspeed indications were experienced. Although some identifying data was not included in the files examined, all of the events appeared to have occurred at cruise altitude, and in an area where convective weather would not be unusual.

A complete list of historical unreliable airspeed/pitot blockage events is contained in Appendix 7 of the second Air France 447 interim report, available at the BEA link above.

Information

Certificate:	**Age:**
Airplane Rating(s):	**Seat Occupied:**
Other Aircraft Rating(s):	**Restraint Used:**
Instrument Rating(s):	**Second Pilot Present:**
Instructor Rating(s):	**Toxicology Performed:**
Medical Certification:	**Last FAA Medical Exam:**
Occupational Pilot:	**Last Flight Review or Equivalent:**
Flight Time:	

Aircraft and Owner/Operator Information

Aircraft Make:	Airbus	**Registration:**	N805NW
Model/Series:	A330-323	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	0552
Landing Gear Type:	Retractable - Tricycle	**Seats:**	
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:		**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	PW4000 SER
Registered Owner:	NORTHWEST AIRLINES INC	**Rated Power:**	0 Lbs thrust
Operator:	NORTHWEST AIRLINES INC	**Operating Certificate(s) Held:**	Flag carrier (121)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument (IMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	Hong Kong	**Type of Flight Plan Filed:**	IFR
Destination:	Tokyo	**Type of Clearance:**	IFR
Departure Time:		**Type of Airspace:**	

Airport Information

Airport:	Kagoshima	**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	9 None	**Aircraft Damage:**	None
Passenger Injuries:	208 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	
Total Injuries:	217 None	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	English, William
Additional Participating Persons:	
Report Date:	June 27, 2011
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=74203