Docket No. SA-522

Exhibit No. 2-V

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Airbus Industrie Submission to the
National Transportation Safety Board
Regarding American Airlines Flight 903

(11 Pages)

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DATE Blagnac, August 12th, 1998
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Mr. Jim HALL
Chairman
National Transportation Safety Board
490 L'Enfant Plaza East SW
Washington D.C. 20594-2000
U.S.A.

Dear Mr. Hall,

In May 1997, an A300-600 operated by American Airlines experienced an in-flight upset above Palm Beach. The aircraft subsequently landed safely. Only a few injuries were reported.

Airbus Industrie was given the opportunity to investigate this event with your technical experts and I take this opportunity to thank all of them for the very fruitful co-operation encountered during the work.

Please find attached the Airbus Industrie submission to support the National Transportation Safety Board in this investigation.

Obviously, I remain with all my team at your disposal should you require any further information from us.

With my best regards,

Yves BENOIST
Director Flight Safety

Airbus Industrie Submission

Related To The American Airlines Flight 903 Investigation

Airbus Industrie welcomes the opportunity to make this submission in its continuing efforts to support the National Transportation Safety Board (NTSB) in its investigation of the events that occurred on American Airlines Flight 903 on May 12, 1997.

Airbus Industrie commends the NTSB for the professional manner in which this investigation was conducted. The investigation was very thorough and all significant operational and technical factors were examined in detail. The factual reports of the various Groups show that the pertinent events were thoroughly examined and the significant factors associated with these events were fully understood, considering the limitations of the information available. To further assist the NTSB in its deliberations in the next phase of its investigation, Airbus Industrie offers the following comments for consideration.

Comments Concerning Aircraft Motion During The Event.

Airbus Industrie believes that the following portions of the conclusions in the Aircraft Performance Group Report very succinctly summarize the most significant aspects of the event. Airbus Industrie is in full agreement with these conclusions.

"The evidence presented and analyzed by this Performance Study indicates that after descending to 16,000 ft., AA903 slowly decelerated until the angle of attack exceeded the angle of attack for maximum lift and the aircraft stalled. Following the nose down pitching motion associated with the stall, the aircraft pitched nose up in response to elevator commands, increasing the angle of attack into a secondary stall. This cycle was repeated three more times for a total of five excursions above the stall angle of attack."

"During these pitch oscillations, the aircraft underwent large oscillations in the lateral and directional axes in response to full coordinated lateral/directional control inputs. The oscillations about all three aircraft axes resulted in large longitudinal, lateral, and vertical load factors at the aircraft CG. Control of the aircraft was regained when the airspeed increased to the point that the pitch excursions no longer increased the angle of attack beyond stall."

"Prior to the first stall, the aircraft was in a right turn. In spite of left roll control commands by the autopilot, the bank angle departed to the right and reached 56° before it was arrested with left rudder inputs just as the aircraft reached stall[1]. The effect of the bank angle disturbance is to increase the lift required for level flight and accelerate the rate at which the angle of attach increases, thereby shortening the time required to exceed the stall angle of attack."

"Conclusive knowledge of the reasons for the roll departure is not required to evaluate the significance of the departure in the mechanics of the overall upset, or to determine its effects on the aircraft motion if encountered at a different initial condition. On the accident flight, the roll departure resulted in a stall because the aircraft was flying at an airspeed that did not allow sufficient angle of attack margin to increase the lift as necessary to compensate for the increased bank angle. Simulator tests indicate that had the roll upset been encountered at an airspeed of 210 kts. The event could have been controlled easily by the autopilot."

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[1] In the text of the final factual report, this statement is slightly amended, to take into account the fact that the rudder inputs were not the only means for arresting the roll.

"Simulator tests also indicate that the control techniques used to recover from the stall have a strong effect on the post stall motion. Techniques that attempt to maintain a nose-high attitude while controlling bank angle with large rudder and wheel inputs result in the secondary stalls and large lateral/directional oscillations experienced by AA903. Techniques that attempt to first lower the nose and angle of attack and use small, coordinated rudder and wheel inputs result in a quicker and smoother return to controlled, level flight."

Comments Concerning Procedure Application.

The Aircraft Performance Group, Operations Group, Air Traffic Control Group, and Meteorological Group all determined that significant weather existed in the area. The American Airlines Operating Manual has very detailed guidance for crews operating in these conditions.

Airbus Industrie supports the guidance American Airlines provides to its flight crews in its Flight Manual, Part 1, Human Factors Policy. The Human Factors Policy states, in part, "maintain situation awareness by preparing for what can be reasonably expected and by setting and acting on priorities in any abnormal situation." The Turbulent Air Section of the Operating Manual provides detailed guidance on how to comply with the Human Factors Policy when operating in an area of known turbulence. Specific guidance is provided, in the Turbulent Air Section, for target airspeed, autopilot/autothrottle use, and proper aircraft attitude.

The American Airlines Windshear/Microburst Escape Procedure is also detailed in the Operating Manual. It provides specific procedures for crews to use in a windshear encounter. Additionally, it emphasizes the phases of flight in which the use of this procedure is appropriate. All of these phases involve flight in close proximity to the ground. The procedure is not associated with operations at medium to high altitude.

Unusual Attitude Recoveries are referenced in the Techniques Section of the American Airlines Operating Manual. This section specifies recovery methods for both nose-high and nose-low situations. The nose-high recovery procedure instructs pilots to unload the aircraft and roll to regain the horizon. This procedure is opposite, for valid reasons, to the Windshear/ Microburst Escape Procedure, which instructs the pilot to increase pitch to the target attitude to minimize altitude loss and thereby avoid ground contact.

Comments On The Reason For The Very Low Speed.

As noted in the Aircraft Performance Group Report, the aircraft slowly decelerated to 178 knots (32 knots below the 210-knot target speed) because the Autopilot was maintaining 16,000 feet and the engines were at idle, until just before the stall occurred.

The engagement status of the Autothrottle system was not recorded by the DFDR. This is due to the mismatch of the a/c wiring introduced when American Airline installed an improved FDAU. However, other information on the DFDR shows that the autothrottles were disconnected during the descent to 16,000 feet.

During the early stages of this descent, supporting data indicates that the autothrottles were most likely still engaged because the Throttle Lever Angle (TLA) is never lower than 5°. This is the minimum position that the autothrottles can command (when flaps are retracted) and this is the normal throttles position during a typical descent

However, supporting data shows that the autothrottles were most likely disconnected at DFDR time 19:25:46, prior to reaching 16,000 feet and about 3 minutes and 20 seconds prior to the first stall. At this time, the TLA is reduced to 0° (TRA=38°), which is below the operating range of the autothrottles. This means that the throttles were disconnected and manually moved to the flight idle position.

The supporting data also shows that the autothrottles remained functional and there were no failures. If the autothrottle system had failed prior to the stall, the Alpha Floor "thrust protection" function would not have remained armed. Since the Alpha Floor function remained armed and was activated during the event, it is very unlikely that there was a failure in the autothrottles. Furthermore, the autothrottle system is a "dual" design, which makes it very unlikely that the system experienced a latent undetected failure.

Note : The autothrottle may be a "dual dual" design should a standard option being selected (installation of a second Thrust Control Computer).

The throttles stayed in the flight idle position until just 8 seconds prior to the first stall, which caused the speed to slowly decrease to 178 knots, after the autopilot captured and maintained 16,000 feet. The deceleration from 210 knots to stall occurred over a forty-second period.

Comments On Autothrottle Disconnection and Pilot Attention Getters.

The NTSB is correct in noting that the design of the A300-600 autothrottle system is different from some of the other manufacturers. However, Airbus Industrie believes that the A300-600 system design is more robust and more tolerant to human error than the other designs.

First, as previously mentioned, the system is a "dual" system, which makes the occurrence of undetected failures very remote.

Second, when the autothrottle are disconnected, an amber "MAN THR" warning appears in the "thrust window" of the Flight Mode Annunciator (FMA) which is located across the top of the Primary Flight Display (PFD). This amber warning remains in the FMA as long as the autothrottle remains disconnected. Therefore, the "thrust window" in the FMA continuously provides both pilots with information, within their primary field of view, concerning the engagement status of the autothrottle. Since the FMA is part of a pilots normal instrument scan, information concerning the autothrottle engagement status is continuously available to both pilots.

Third, if a failure occurs in the autothrottle system, the system is automatically disconnected. An immediate aural and visual warning is generated to alert the pilots.

The only time that an aural warning is not provided is when a pilot pushes the "instinctive disconnect" button. In this case, the visual amber "MAN THR" annunciation is provided on the PFD FMA to confirm that the system has properly responded to the pilot's instruction. In the AA903 event, it is the Airbus Industrie opinion that the only possible explanation is that the autothrottle was disconnected by one of the pilots pressing the autothrottle instinctive disconnect button.

Airbus Industrie is aware that some aircraft from other manufacturers use a "two click" process for disconnection of the autothrottles. However, operational experience has shown that many pilots routinely "double click" the autothrottle instinctive disconnect button in these aircraft, thereby negating any perceived benefits from a "two click" disconnection design.

Airbus Industrie believes that continuously displaying the current autothrottle engagement status in the FMA "thrust window" is more tolerant to human error than a design that permits information concerning the engagement status to be cancelled or erased. Furthermore, Airbus Industrie believes that this design is more error tolerant than designs that rely on a "two click" disconnection process.

Nevertheless, Airbus Industrie is evaluating the NTSB recommendation to determine if further design enhancements are necessary.

Comments Concerning Unusual Attitude Recovery Techniques.

The conclusions in the Aircraft Performance Group Report concerning recovery techniques are consistent with Airbus Industrie recommended training practices, which are supported by flight test results on all Airbus Industrie aircraft. Furthermore, all major aircraft manufacturers and the FAA support the use of these techniques. Boeing (including Douglas) and Airbus Industrie have joined their efforts to produce a common document "Aerodynamic Principles of Large Airplane Upsets). A copy of this brochure is given in annex.

In Unusual Attitude Recovery training, it is important to initially stress unloading the wing through (up to) full down elevator, and down stabilizer trim as necessary. Roll inputs will only be efficient when angle of attack has been reduced. Roll should be introduced only after exhausting the use of the pitch axis controls and after considering the reduction of engine thrust (on airplanes with wing mounted engine). Accident and incident data indicate that many nose high, high angle of attack events are because of inappropriate stabilizer trim. The initial use of elevator and down stabilizer trim will normally be adequate in establishing a nose-down pitch rate. In combination with thrust reduction few failures can be conceived for which these measures would not be sufficient.

As with all proposed scenarios, the use of roll to assist pitch attitude reduction cannot be ruled out, but if the airplane is at high angles of attack, the sideslip introduced by rapid roll may result in departure from controlled flight.

Although a simple rule about rudder usage cannot be stated, an appropriate standard is to first use full aileron control. Then, if the aircraft is not responding, use rudder as necessary to obtain the desired airplane response. Momentary actuation of spoilers during roll input does not significantly increase drag.

Sideslip angle is a crucial parameter during a recovery maneuver. This is probably not well understood by many line pilots, but it has a significant impact on an airplane's stability and control. Large or abrupt rudder usage at high angles of attack can rapidly create large sideslip angles and can lead to rapid loss of controlled flight. Rudder reversals such as those that might be involved in dynamic maneuvers created by using too much rudder in a recovery attempt can lead to structural loads that exceed the design strength of the fin and other associated airframe components. The hazards of inappropriate rudder use during a windshear encounter, wake turbulence recovery, or recovery from low airspeed at high angle of attack (e.g., stick shaker) should also be included in any Unusual Attitude Recovery discussion.

Comments On The Momentary Loss Of The Primary Flight Displays.

The pilots involved in the incident noted that the Primary Flight Displays (PFDs) blanked for a few seconds during one of the post-stall recovery maneuvers. The investigation into this possibility shows that this event occurred and that it was triggered by the extreme roll rates induced by the piloting techniques used during the recovery.

During one of the recovery maneuvers, the roll rate exceeded 45 degrees per second. This extremely high roll rate caused the Symbol Generator Unit (SGU) monitoring function to blank the PFDs for about 3 seconds. The DFDR shows that the data that passes through the SGU (pitch, roll, etc.) were actually frozen for 3 seconds. This is a consequence of a reset of the SGU caused by the extreme roll rates experienced at this time.

One of the monitoring functions in the SGU is to assure that the roll attitude information displayed on the PFD is equivalent to the information sent by the Inertial Reference System (IRS). In other words, the purpose of this monitoring function is to prevent displaying false attitude information to the pilots.

With respect to roll angle, the monitoring function compares the roll angle coming from the IRS to the roll angle derived from the roll information received by the PFD. The process for computing and comparing the IRS information and the "reverse computation" (the roll angle derived from the information received by the PFD) requires a finite amount of time. Therefore, computational delays can cause the monitoring function to trigger when extreme roll rates are encountered.

The monitoring function triggering level used in the A300-600 takes into account the normal operating and upset recovery techniques recommended by all major manufacturers and all major regulatory agencies. This triggering level was also determined to be acceptable by all of the aircraft certification authorities.

The SGU monitoring function prevents the display of erroneous roll attitude information by triggering a reset of the SGU when the difference between the roll angle coming from the IRS and the one resulting from the "reverse computation" exceeds the monitoring function triggering level.

Airbus Industrie believes that the current triggering threshold for the SGU monitoring function is an appropriate selection, considering the potentially hazardous consequences of displaying erroneous roll information to pilots as well as the recovery techniques and recommended safe operating practices commonly accepted within the industry. Furthermore, pilots cannot properly decipher and use information that is changing at extreme rates.

Nevertheless, Airbus Industrie is re-examining these design choices, in light of the NTSB's recommendations, to determine if it is practical to implement other techniques to accomplish the SGU monitoring function's safety objectives.

Airbus Industrie Corrective Actions.

In March 1998, Airbus Industrie issued Temporary Revisions to the A300-600 Flight Crew Operating Manual (FCOM) and the Quick Reference Handbook (QRH) to alert flight crews to the possibility of momentary blanking of the Primary Flight Displays in situations such as the AA903 event. These changes have also been incorporated into the Airbus Industrie flight crew training programs for the A300-600. This properly responds to the NTSB's recommendation n° 2

As already mentioned above, Airbus Industrie is re-examining the design choices, in light of the two other NTSB's recommendations:
. First to determine if it is practical to implement other techniques to accomplish the SGU monitoring function's safety objectives
. and second to determine if further design enhancements to the autothrottle system are necessary.

Attachment 1

Copies of the Temporary Revisions to the FCOM and QRH.

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Attachment 2

FAST Special Dated June 1998

Aerodynamic Principles of Large-Airplane Upsets

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Dominique Buisson → Y. Benoist

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Dear Colleagues and Party Co-ordinators,

Please find attached the Airbus Industrie submission given to the National Transportation Safety Board in the frame of the AAL903 upset investigation.

I remain obviously at your disposal to answer any query you may have.

With my best regards,

Yves BENOIST
Director Flight Safety

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