A300-600 PILOTS
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March 22, 2002

Honorable Marion C. Blakey
Chairman
National Transportation Safety Board
NTSB Headquarters
490 L'Enfant Plaza
Washington, D.C. 20594

Ms. Jane F. Garvey
Administrator
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Ms. Blakey and Ms. Garvey:

As professional line pilots who fly the A300-600 for American Airlines, we have been following the NTSB investigation into the crash of American Airlines Flight 587 with a great deal of interest and concern. Never in the history of commercial aviation has a vertical stabilizer separated from an aircraft. As such, there is a pressing need to conduct a rapid investigation with significant rigor. This is a daunting task at best. The information discovered thus far in the investigation has literally shaken the foundations upon which we define what is, or is not, safe. Certainly, determination of probable cause(s) will provide a measure of closure to those families who have suffered as a result of this tragedy, as well as insight into how to prevent a similar occurrence. However, some of the issues being analyzed suggest that there are areas of concern which transcend AA 587, and have the potential to impact the future of commercial aviation in a manner never anticipated. Flight 587 must now be considered the new paradigm for the airline industry.

This presentation will focus on all the issues raised so far in the investigation. It will demonstrate that nondestructive inspections (NDI) must be conducted immediately to establish baseline data and ensure the structural integrity of the existing fleet. It will call into question the use of composite materials in critical load-bearing structures. It will illustrate the risks associated with the A300 rudder pedal design given existing structural certification standards. It will bring to light deficiencies in pilot training in several areas critical to safe operations. Finally, it will underscore the pressing need to consider the grounding of the A300-600 fleet until such time as its airworthiness can be assured.

We do not represent, or in any way speak for, American Airlines or the Allied Pilots Association. However, our observations, questions and concerns about the airworthiness of the A300 in general, and the investigation into the crash of AA 587 in particular, are shared by many of our fellow pilots. By trade, we are not engineers, physicists, mechanics or investigators. Rather, we are professional pilots with extensive flight experience who fly the A300 day in and day out. We are educated, well-informed and also bring to the table a good measure of "seat of the pants" common sense.

The flying public must have assurances that every aircraft they board is designed and maintained to the highest standards. Conducting a thorough and impartial investigation is serious business and the findings often have far reaching impact on all parties concerned. American Airlines Chairman Don Carty has often stated that his "core value" is safety. He believes every employee should be committed to it and American Airlines expects no less *(enclosure 1)*. In keeping with this philosophy, this package is submitted to present line pilots' points of view on the critical issues brought to light in the wake of the AA 587 disaster. It is being sent to the two agencies that we feel can best recommend and implement procedures and actions to ensure the absolute safest aviation system in the world.

Yours very truly,

CA Robert Tamburini, A300/LGA

CA Glenn Schafer, A300/LGA

CA Gary Rivenson, A300/LGA

CA Pete Bruder, A300/LGA

CA Cliff Wilson, A300/LGA

CA Paul Csibrik, A300/LGA

FO Todd Wissing, A300/LGA

FO Jason Goldberg, A300/LGA

Enc.

cc: Donald J. Carty, Chairman, AMR Corp.

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INTRODUCTION

As a result of the ongoing investigation of AA 587, the NTSB has recently issued **Safety Recommendation A-02-01 and -02** *(enclosure 2)*, which discusses a shortfall in pilot training as it relates to “information about the structural certification requirements for the rudder and vertical stabilizer on transport-category aircraft.” It goes on to say that “the investigation is still examining many issues, including the adequacy of the certification standards for transport-category aircraft, the structural requirements and integrity of the vertical stabilizer and rudder, the operational status of the rudder system at the time of the accident, the adequacy of pilot training, and the role of pilot actions in the accident.”

In other words, this recommendation not only highlights an industry-wide problem, but suggests there may be others, both of a general nature and specific to the A300-600. Any further statements or recommendations made by the NTSB, and subsequent actions taken by the FAA, airlines and manufacturers on some or all of the issues raised will have a significant impact on commercial aviation as we know it today.

Every pilot, regardless of what airplane they are flying now, or will be flying in the future, needs to be aware of these issues and how they affect continued safe operations. At the end of the day, we are the ones who must ensure that we are operating in the safest environment possible and are not taking unacceptable risks.

This presentation will supply information, pose questions, render opinions and suggest possible scenarios. We realize that all of the concerns stated below are most likely already being analyzed in depth during the course of the investigation. However, that said, perhaps we will raise some points that may warrant additional consideration. At the very least, we will have made known the true concerns of pilots on a number of these issues. We believe that the information developed in this presentation will lead to the following conclusions:

(1) That visual inspection techniques presently used to verify the integrity of composite materials are inadequate. That NDI (nondestructive inspection) technology must be developed and applied to all aircraft that utilize composite parts, both diagnostically and in preventive maintenance procedures. That all A300-600 aircraft be immediately subjected to a baseline NDI in order to ensure the structural integrity of composite materials.

(2) That the structural certification requirement for the rudder and vertical stabilizer for ALL commercial aircraft should be re-evaluated, especially when considering the properties of structures made of composites versus metal.

(3) That A300 flight control systems have had a disproportionate number of serious malfunctions/failures, resulting in uncommanded rudder movements. As a result, there are serious concerns about reliability of operation and the affect on safe operations.

(4) That the inherent qualities of composite materials and our present understanding of their properties may make them unsuitable for major load-bearing structures.

(5) That the A300 design philosophy in certain areas (e.g. -- rudder limiter and vertical stabilizer attachment) may need to be reviewed for appropriateness, when juxtaposed with certification requirements of the vertical stabilizer and rudder plus the properties and characteristics of composite materials.

(6) That pilot training has been seriously deficient in regards to what constitutes safe versus unsafe application of flight controls.

(7) That the inaccurate definition of maneuvering speed should be corrected in light of the current certification standards, and that the flying community should be made aware of the dangers of rudder reversals through detailed and specific training.

(8) That when considering the cumulative deficiencies of composite technology, certification standards, rudder design and flight control malfunctions; serious consideration should be given to grounding the A300-600 fleet until such time as the safety of the flying public can be assured.

We hope that a thorough analysis of the issues raised by the tragedy of AA 587 may provide insight not only to specific causal factors, but also validate the serious safety concerns of the pilots who fly the A300.

COMPOSITES AND NONDESTRUCTIVE TECHNOLOGY

The failure of the vertical stabilizer and rudder of AA 587 has raised questions about the characteristics and integrity of composite materials. Solid laminate composites have been used more and more frequently since the mid to late eighties, and on an increasingly greater number of critical aircraft structures. Advantages are said to be reduced weight, better fatigue and corrosion resistance, greater reliability, etc. These advantages translate to lower operating costs. There remains, however, a significant amount of disagreement and incongruity on a number of aspects of composite technology. Many professional publications related to aviation have contained articles regarding the appropriateness of composite technology in the future of commercial aviation. The disagreements rest not just with the properties and design of composite materials for use in aviation, but what kind of inspections need to be performed to ensure their integrity over the long-term. Even to the uninitiated, it is obvious that although much is known regarding composites, there are still many unknowns; and these unknowns may have the potential to place the safety of the public at risk.

What is it about the theories of composite material that makes agreement so difficult? We have asked questions and spoken to a number of individuals who are experts in the field, and what we have learned is startling.

The A300-600 was certified in 1988, and was the first civil aircraft to use composites for critical load-bearing structures. It is our understanding that when Airbus introduced the use of composites for critical structural parts, no previous life expectation data was available. Graphite composites were new and had essentially been designed for Airbus. Consequently, no certification requirements were available since such material had never been used before. Therefore, the certification authorities used data which was exclusively provided by Airbus engineers. Airworthiness regulations were then written, most likely based upon those in existence for aircraft built with metal components. *If this is true, then given what we now know of the unique properties and possible limitations of composite materials, perhaps some areas of the certification process should be revisited to ensure that certification standards developed in the late eighties are still appropriate?*

Boeing, in its *Airliner* magazine dedicated to the B-777, makes some interesting comments. They state that "ongoing analysis and testing have greatly increased knowledge of the properties and behavior of composites", but that "airlines may subsequently revise the minimum requirements [re: maintenance programs] to reflect knowledge and experience gained during service." In other words, manufacturers don't know all there is to know, and the milieu in which these aircraft operate is tantamount to a laboratory of sorts. Cessna Aircraft, for one, eschews composite materials and explains why in the following excerpt from the Q&A section of its website (Cessna.com):

> ***Q.*** *Why does Cessna build aircraft with aluminum as the primary structure material instead of employing so-called modern composite materials?*

__A.__ Cessna has many years of experience manufacturing and assembling aluminum airframes. Modern construction does not necessarily mean composites. In the professional opinion of Cessna's advanced engineering group, we do not yet feel the long promised benefits of composite construction have been realized. Real concerns with composites remain in the areas of: weight, cost, field reparability, environmental susceptibility (primarily heat/sunlight), long-term structural integrity and lightning protection. Until these issues are fully resolved, Cessna feels aluminum aircraft offer the best combination of proven technology, value and reliability for our customers.

Most experts agree that composites are stiff (non-ductile) when compared to metals and have differing thermal coefficients than metals at attachment points. Also, air and water are invariably entrained during the manufacturing process. As the aircraft operates over a wide range of external temperatures and pressure altitudes, these water and air deposits expand and contract, eventually causing delamination (fatigue) within the composite. These, plus other known and unknown factors affect composite material to one extent or another, ultimately reducing its utility. According to Dr. Debra Chung, Director of the Composites Research Lab at the University of New York at Buffalo, composites thought to have a useful life of 30 years may, in fact, only last 1/3 of that original estimate because they become brittle and lose elasticity. So an aircraft which is expected to operate for 30,000 cycles, may only last 10,000. Charles F. Marschner[1], a pioneer in the use of plastics in aircraft structures, reminds us that "the laws of physics and mechanics are immutable – today's composites still have no ductility as do wrought metals."

Stephen W. Hawking, the renowned physicist, makes a telling statement about theories in his best-selling book, A Brief History of Time:

"Any physical theory is always provisional, in the sense that it is only a hypothesis: you can never prove it. No matter how many times the results of experiments agree with some theory, you can never be sure that the next time the result will not contradict the theory. On the other hand, you can disprove a theory by finding even a single observation that disagrees with the prediction of the theory."

Airbus has stated emphatically in its literature, through the media, and in every other forum possible that once the aircraft is manufactured and passes through the quality assurance process, that any existing flaw in composite materials will not propagate. Further, once in service, any delamination will be readily detectable by conducting visual inspections only. Nondestructive inspections are not required or recommended. Airbus Industrie insists that pre-certification testing has taken into consideration any and all

[1] Charles F. Marschner – BS Aeronautical Engineering (University of Michigan). Has had published numerous articles on various aircraft-related subjects, including R&D, design, testing and manufacture of composites and metals. Proposed use of glass fibers for reinforcing plastic materials (now called composites). Past employment includes Chance Vought, Martin Co., McDonnell Aircraft Corp (helped found in 1939), and Lockheed Aircraft.

operating parameters which might affect integrity of composite structures and that it can predict with assurance how composites will react in the real world. In other words, Airbus appears to be supremely confident in its theories of how composites will behave in just about any environment under every condition imaginable. In support of their statement, Airbus can simply refer to current certification standards. *Now that composites are understood somewhat better than they were in 1988, are visual inspections sufficient?*

As a result of our research, we have found that many experts disagree with the standard of "visual inspections only". In February of 2002, NBC television published an excellent report in which four reliable sources were quoted. All agreed that visual inspections alone are inadequate to guarantee the structural integrity of composite materials. Part of that report is reproduced below:

> *Michael Peat of the International Association of Machinists and Aerospace Workers has repaired airplanes for 36 years and represents more than 15,000 mechanics nationwide. Peat says the problem relates to aircraft built by Airbus and the company's insistence that to inspect their aircraft, you need only the naked eye. "There might be a flaw in there and by our normal inspection methods that we use now, we can't detect that flaw," Peat said. "For this we need either ultrasound equipment or X-ray equipment to see those flaws. There might be many aircraft running around right now, Airbus aircraft, with flaws in various composite components of that aircraft."*
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> *Airbus explained that if delamination can't be seen on the outside, there is no problem. According to a recent Airbus statement: "Because non-visible damage does not reduce strength below requirements and will not grow."*
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> *"That is basically a ludicrous statement," said Massachusetts Institute of Technology professor and pioneer in the field of non-destructive testing Dr. James Williams*[2]*. "Visual inspection is simply the lowest level at which one would want to inspect one of these structures. Invariably, one would want to do more in order to increase a sense of reliability or comfort with respect to their integrity."*
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> *Mike Gorman, a physicist who taught aircraft structures at the Navy's Post-Graduate School and whose company builds ultrasonic inspection machines for Boeing and also built the machine that NASA is now using to ultrasonically inspect the tail section of flight 587, disagrees with Airbus' policy. Using*

[2] Professor James H. Williams, Jr. (S.B., 1967 and S.M., 1968 -- Massachusetts Institute of Technology; Ph.D., 1970 -- Trinity College, Cambridge University) is the School of Engineering Professor of Teaching Excellence, Charles F. Hopewell Faculty Fellow, and Professor of Applied Mechanics in the Mechanical Engineering Department at the Massachusetts Institute of Technology).

> *ultrasound, Gorman demonstrated that the naked eye is not always enough when it comes to detecting flaws within composites.*

Aviation Today, a comprehensive Internet resource for aviation industry news, analysis and business information has been reporting extensively on the issues surrounding the crash of AA 587. In its publication, *Air Safety Week* (January 14, p. 1), composites engineer David Maass questioned the utility of visual inspections, which in turn generated a number of comments from Airbus (*ASW,* Feb. 18, p. 10). Asked to amplify on his views, Maass' responses were extensive (*see Enclosure 9*). In part, Maass states, *"Given that NDT is routinely performed, and the far greater information it provides, it surprised me and every other composites engineer I know that its use is not even suggested, let alone not mandated, under the circumstances."*

The inadequacy of visual inspections and the paradox of not requiring them are hammered home after viewing a training tape used by Boeing that shows the care with which composites are handled during the manufacturing stage. According to the tape: **"A low-energy impact, say from a bump or a tool drop, can show little, if any, external sign of damage, however, internally there may be extensive delamination spreading in a cone-shaped area from the point of impact. The key point is that just because an impact doesn't leave a mark, doesn't mean that damage hasn't occurred."** This statement is in direct conflict with a "visual only inspection policy."

A300s are in service throughout the world, logging millions of cycles under a multitude of conditions. Given the variables inherent in such deployment, one would expect there to be some "unknowns" affecting critical structural fatigue. Additionally, many experts have stated that composites are not understood on a molecular level, as are metals. As a result, what has been created is a serious credibility gap which calls into question the thought-process when the original certification standards were being developed.

Recently a number of A300 crewmembers were invited to American Airlines' maintenance headquarters in Tulsa for a briefing on the Airbus since it was known by AA that there were serious airworthiness concerns in the field. When discussing the differences between the Boeing 777 and the Airbus A300 vertical stabilizer and methods of attachment, a senior executive in AA's Maintenance and Engineering Department stated, "Boeing would have done it just like Airbus if they had the time to get it right." Since that meeting, we have come to learn that Boeing uses a traditional design structure, building spars and stringers out of monolithic composite materials. Consequently, the attachment to the fuselage is much more traditional as well (*Enclosure 12*). Airbus, on the other hand, builds their vertical stabilizers as entirely separate structures. The structure is basically hollow inside. To attach the vertical stabilizer to the fuselage, the hollow monolithic composite structure is lowered into 6 attachment brackets that can best be described as clevises. The vertical stabilizer is then secured to the brackets with a combination of bushings, sleeves and bolts that essentially act as clevis pins. The vertical stabilizer's entire load is carried by these 6 brackets that attach it to the fuselage (*Enclosure 11*).

So what is really suggested by Management's comment, "… if they had the time to get it right"? Boeing is the recognized leader in the industry with research and development capability second to none. Yet, even though the A300 had been in service for over ten years, Boeing chose a fundamentally different design for the B-777 vertical stabilizer. *Could it be that Boeing believed there was a better way to do it?*

On this point we asked some specific questions to Mr. John Sampson[3]:

Would you comment on the differences between the A300 and B777 vertical stabilizers?

"Honeycomb sandwich composite is very strong but actuators, trim and hinge-mounts should attach to substantial subframes, not just doubler-strengthened areas of composite (perhaps with minor secondary-spar support). I would guess that the 777 arrangement is along that more sensible line... whereas the A300 actuators were simply "grabbing and pushing" the rudder's composite skin."

Is Boeing's method of building the composite vertical stabilizer superior to that of Airbus?

"Probably a case of deciding to do it safer and smarter.... or at least showing less hubris and more caution."

Is Airbus' method of attaching the vertical stabilizer to the fuselage sound from an engineering standpoint?

"No, because a metal to metal mate would've circumvented the mismatched inherent characteristics of the two materials."

Charles Marschner refers to attachment issues as well when he states the following:

> *"One area of critical concern involves thermal co-efficient difference between composite and metal. As you know, this can be significant when a major composite structure is locally joined to major metal structure – as at a composite fin to a metal fuselage with lug & clevis joints. On the A300, the distance between the 2 most extreme joint locations is substantial and we have the usual wide range of operating temperatures. Once assembled, each structure can load the other as temperature changes. So both are stress cycled. With different thermal transfer rates, metals also expand more*

[3] John Sampson, originally from Australia, is a pilot with an ATPL, extensive M.E. simulator and M.E. flying instructional experience and over 14,000 hours of flying time. He is a highly decorated combat pilot and has flown with the RAAF and the RAF. Presently he works with International Aviation Safety Association researching aviation safety and accident analysis.

rapidly than composite. This tends to exacerbate the problem. The loading can be additive to the aerodynamic loads imposed."

The A300's vertical stabilizer attachment system consists of 6 brackets that the composite tail fits in between. The composite has a hole through it at each attachment point. Inside that hole is a bushing. A tapered sleeve then fits inside the bushing. A bolt then goes through the bracket and the sleeve, and is secured with a castellated nut. The hole in the bracket is only the size of the bolt. The hole in the composite is significantly larger in order for it to accommodate the bushing and sleeve. The bolts are then torqued to a specific value (perhaps known only to Airbus). When the bolts are tightened, they expand the sleeve, which then presses against the bushing.

As a result of inspections performed in response to the AA 587 accident, many of the vertical stabilizer attachment bolts on other aircraft were found to have rotated. We know this because after the bolts were torqued, they were marked with an orange witness mark. According to Airbus, the witness marks were used solely to show that the bolts had been properly tightened. Therefore, again according to Airbus, the fact that they rotated was of no consequence. Sources with whom we have spoken say that all bolts are numbered and a written log/record is kept of when the bolts were tightened and to what torque. They say the witness marks are there specifically to determine, during visual inspections, if the bolts have rotated.

Here is what John King[4] has to say about bolt rotation at the A300's vertical stabilizer attachment points:

"Standard engineering practice (plus common sense) is that you can't have any movement between materials of vastly different wear factors (composite material and steel) moving relative to each other because the softer material (composite) will erode away. Thus the composite is bushed and the bushing must not move.

The sleeve is also a typical engineering feature and construction as it migrates the loads over a far greater surface area and the ability to expand under a given torque of the bolt passing through it makes good sense. Nothing needs to rotate and any rotation invites the wear factor. Wear is not wanted here but rather only a continued (close tolerance) bond.

[4] John King received his FAA mechanic's license in 1963. He has worked in light aviation, as an engine overhaul mechanic for Northeast Airlines, as an engine inspector at General Electric, and as a mechanic for Eastern Airlines. He has also worked contract maintenance for freight industry haulers Amerijet and Kallita and as the station supervisor for Air Transport International's DC-8 freighters. Since 1996 John has worked on various safety issues. In 2000, John began work as a data specialist for the International Aviation Safety Association (IASA).

Airbus claims that the witness marks were used not to determine if the bolts rotated, but they were marked to show they had been properly tightened is balderdash.

If no mechanical provision is incorporated (i.e. metal tabs), there is no assurance that the installed torque remains. Any rotation means the torque is gone (metals do 'flow' and stretch like any other materials). Painting a mark across the bolt surface and the nut and onto the adjacent airframe is the STANDARD practice to assure NO rotation (loosening) has occurred since the last inspection.

STANDARD practice is that proper tightening <u>at the time of assembly</u> is documented in the work process control paperwork with specific words the bolt was torqued to a specific value.

Simply, tightening to a specific value a bolt at assembly is not assurance enough that this bolt remains so some five years (plus) down the road. The paint line (unbroken) and in its original alignment is the method used for many such critical connections.

Although the fastener guidelines do dictate a castellated nut where rotation can be expected (i.e. control rod ends with pivoting bushings). Elsewhere on the aircraft, and for non-rotating applications, a fiber self-locking nut is permissible. Here I believe they went with the highest guarantee of the nut not backing off . . . . the mechanical lock of a pin through a castellated nut because there could hardly be a more critical application. (The engines can come off but they don't usually bring down the aircraft).
The paint (slippage) marks is still the best assurance that the torque remains, the sleeve is still swelled against the bushing and that neither the bushing, sleeve or bolt have loosened and allowed any wear out of the composite hole.

It's very tricky stuff from an engineering point of view. You can't see this bushing-composite area and taking the stabilizer off to check the composite holes isn't viable, but yet you've got to guarantee there is no composite hole-wearout."

After viewing the photos of the vertical fin of AA 587, George Richard Sharp[5], in a letter to <u>Aviation Week & Space Technology</u> (February 18, 2002) observed the following:

[5] G. Richard Sharp-BS Industrial Engineering (New York University); MS Engineering Mechanics (Case Western Reserve University); PE Ohio. Employment: 1956-1958 Goodyear Tire and Rubber Company; 1958-1963 Goodyear Aerospace Corporation; 1963-1993 NASA (Chief Engineer of Space Experiments Division 1991-1993). Has extensive spacecraft structures design, analysis and fabrication experience including graphite and metal matrix composites. Has authored or co-authored 44 reports.

"The tear-out shear distance appears to be only about half the diameter of the pin, while good design practice would indicate it should be 1-1.5 diameters. I would think that with a material known to have brittle fracturing characteristics that the design would have been beefed up. Using attachment points violates the fundamental approach of trying to stay away from point loads. Why weren't the main spars continued down into the fuselage and anchored at its top and bottom? How does Boeing attach the fin? A good design should have permanent deformation before failure to relieve the load rather than fracturing catastrophically."

After speaking to Mr. Sharp, he further amplified on these comments. His observations are reproduced in *Enclosure 10*. Of course, it must be emphasized here that Mr. Sharp's comments are based solely on his interpretation of the photos, combined with his extensive experience in engineering and composites. However, his observations may very well raise valid concerns on issues that may have been overlooked in the design and certification process.

<u>Aviation Week & Space Technology</u> (January 21, 2002 – "Did Rudder Motions Snap Off A300 Fin) compares Boeing's and Airbus' vertical stabilizer design as it relates to FAR 25:

"Manufacturers are free to have their own requirements that exceed the FARs, and Airbus declined to comment on its techniques. Boeing says its requirements are proprietary, but one engineer familiar with the company believed the requirement was that rudder reversal in a sideslip…not exceed ultimate load."

It needs to be emphasized that the unique properties of composites are one reason why the current certification requirements for the vertical stabilizer and rudder may be deficient. In the past, with aluminum tails, there was an expectation that there would be some bending before total failure. However, due to lack of ductility, this is not the case with composites. Therefore, new certification standards are needed to compensate for the dissimilarity in how composites and metals react under high loads. **There should be no differences of opinion on this issue as this goes to the heart of safe design.**

Several composites experts raised an issue with regard to the nomex honeycomb/composite sandwich rudder. Even with the best bonding process, the bond between the honeycomb material and the sheet material is not perfect. Significant pressure changes can force air into and out of honeycomb cells that are not perfectly sealed. Because airplanes experience such large pressure altitude changes while climbing and descending they are particularly susceptible to this. Additionally, because air at altitude is so much colder than air on the surface it holds much less moisture (AA's A300 aircraft are operated principally in coastal locations). When an airplane goes from sea level to altitude (roughly half the pressure altitude), air is forced out of some cells that are not bonded perfectly. Because this air is also cooling, some of the moisture condenses out and remains in the honeycomb cell. As the airplane descends, warmer, moister air then reenters the cell and the process repeats itself. Over time this cell eventually fills with water. Each time the aircraft climbs to altitude, where it is extremely cold, the water in this cell freezes, and thus expands, further weakening the bond. In this manner, disbonding can occur in neighboring cells and the process repeats itself again and again. This disbonding cannot be detected visually.

Charles Marschner comments that "moisture and air is entrained in the synthetic matrix during manufacture. In addition, the matrix itself is normally somewhat hygroscopic. It is inevitable there will be some entrained air and moisture which will expand or freeze and shrink or melt alternately during a flight cycle. As a result, the composite will be slowly delaminated. A kind of "fatigue" for composites, if you will."

The NTSB noted that a delamination had been found on the vertical stabilizer of AA 587, although it is not yet known whether it was a result of impact forces or a previous defect. *Where exactly was this flaw? Was the flaw an indication that the vertical stabilizer had suffered fatigue? Could the flaw have been previously discovered using NDI technology? Were there any other flaws discovered by NASA after the completion of non-destructive and destructive testing?*

The NTSB recently advised American Airlines to remove and inspect the tail of aircraft #070, using nondestructive ultrasound technology. As a result of this inspection, two areas of delamination were found, each approximately 2 inches in length, in one of the aft attachment lugs. This is an aircraft which had been visually inspected no less than two times, without the discovery of these major flaws. Although Airbus said that the flaw could be repaired, American Airlines has chosen the much wiser course of having the entire vertical stabilizer of aircraft #070 replaced.

Incidentally, Airbus had previously made one major repair on a lug of another aircraft -- aircraft #053, the aircraft assigned to AA 587. *Did that coincidence have any bearing on AA's decision to replace the tail, rather than repair it? Was the repair on #053 certified properly?* Some experts have suggested that such a repair may have caused unequal loads across the vertical stabilizer, resulting in "weak points". *Is it just a coincidence that the only tail with such a repair was the one that failed?*

The reason the inspection of #070 was ordered was because this aircraft had been in an upset back in 1997, experiencing loads similar to #053. Our investigation has revealed that it has had a tail strike incident as well.

> NTSB Identification: ATL98IA024 . The docket is stored in the (offline) NTSB Imaging System.
>
> Scheduled 14 CFRPart 121 operation of Air Carrier AMERICAN AIRLINES. Incident occurred Monday, December 15, 1997 at MONTEGO BAY. Aircraft:Airbus Industrie
> A300-00, registration: **N90070**. Injuries: 246 Uninjured.

How can we be sure that the damage to #070 was caused by the loads experienced in the upset? Couldn't the damage have been a result of the tail strike? It is our understanding that over 30 tail strikes have occurred since AA started operating the A300. What this suggests is that we really don't know what may have caused the damage to #070, and at a minimum calls into question the integrity of any aircraft that has had a tail strike.

It is important to note that the NDT inspection accomplished on #070 examined only the attachment lugs, not all load bearing composite components. Our knowledge of the structural integrity of the A300 fleet is incomplete. Thirty-one aircraft have not undergone NDT inspections. Of the three aircraft inspected using NDT, only the attachment lugs have been examined, and one aircraft was found to have delamination. Since delamination was also discovered on AA587, fifty percent of the aircraft inspected using NDT have revealed flaws.

Recently, the FAA has directed that in the future, other aircraft with documented upsets of a minor or major intensity should, respectively, receive NDIs within a few days, or be grounded immediately until an inspection can be performed. Although a step in the right direction, we believe the directive should go much further. *Shouldn't it include as well aircraft that have had tail strikes?*

In response to the fact that the FAA had ordered more aircraft to be inspected, Airbus spokeswoman Mary Anne Greczyn said, "In normal operations, a visual inspection is effective in recognizing internal damage that may affect the airworthiness of the aircraft. In unusual operating conditions, a further inspection beyond visual might be called for." An inspection only after an unusual event, without prior baseline information, is of limited use in determining when and why damage occurred.

During the first week of March, Airbus officials had a series of meetings with AA, NTSB, FAA and Union personnel. At this meeting, Airbus made some admissions as it related to composite structures. For example, the first 80 rudders in the A310/A300-600R fleets were replaced due to extensive skin-core disbonding. Additionally there has been a long-term problem (since 1983) with elevator delamination due to water ingress. Apparently, this problem has been so endemic that an investigation has been launched and "new materials" are forthcoming. Airbus now states that they will replace sandwich design by monolithic construction where possible and reinforce protection to prevent water ingress in sandwich parts. They also mentioned at this meeting that the fin structure met the 1.5LL regulatory limit, but were not forthcoming as to whether the rudder did as well. To date this information has not been detailed or made public.

Composite materials are expected to be used to an increasingly greater extent in the future. Therefore, it is imperative that no erroneous assumptions be made. History has shown that manufacturers can, and do, make mistakes and doing so can lead to multiple incidents that end with tragic results. A lack of prompt action, for whatever reasons, on the part of regulatory agencies can, unfortunately, lead to further unnecessary tragedies.

For example, in the 1950s, the British Comet used the innovative design of square windows. Unfortunately, corrosion around these windows was causing explosive decompressions and it wasn't until three were lost that the fleet was grounded and eventually scrapped. In the 1960s, the Lockheed Electra had several accidents resulting from a flawed design. Two aircraft were lost before it was determined that engine vibrations, combined with flawed mountings, were at fault. (The military version had a different wing spar and thus did not experience the same malfunction.) Then, in the late 1980s and early 1990s, the Boeing 737 lost three aircraft as a result of a faulty power control unit. In 1979, American Airlines discovered a design flaw in the DC-10 engine pylon after a crash at Chicago O'Hare. The accident occurred on May 25 and, three days later, the FAA grounded the fleet until the problem was rectified. What would have happened had the FAA not grounded the fleet when it did? After a crash in the 1990s, the entire ATR fleet nationwide was prohibited from flying in icing conditions. It was unfortunate in this case that the large number of incidents the fleet had experienced in icing conditions was not correctly identified as a harbinger of what was to come.

One accident, in particular, highlights the issue of metal fatigue. On April 28, 1988, an Aloha Airlines 737 experienced structural failure, which resulted in an explosive decompression. Examination of the aircraft revealed disbonding and fatigue damage that led to the separation of a portion of the fuselage upper skin. As a result of this accident, high frequency eddy current inspections were ordered for the entire fleet. At the time of this accident, the properties of metals were thought to be well understood. In spite of that, this accident brought to light issues of metal fatigue that were not previously known. It is safe to say that we know less about composites today than we knew about metals in 1988.

Airbus has not been immune to manufacturing problems. According to Air Safety Week (January 14, 2002),

> *…there is a case of Airbus aircraft leaving the factory with flaws requiring subsequent repair. Last year Swissair took delivery of some six new A330 twinjets. SR Technics personnel using NDT found delamination of the composite material between the tailfin ribs and the outer surface, according to an internal ST Technics document. French authorities issued an AD mandating repairs, and the work was performed by Airbus under warranty. According to an Airbus official, anywhere from a few rivets to 200-300 were required on each tail.*

Enclosure (3) provides summaries of 34 Airworthiness Directives (ADs) recently issued by the FAA on various Airbus Industrie aircraft, most over the past 6 months. Twenty-four of these summaries end with the sentence -- **"This action is intended to address the identified unsafe condition."** Four of these ADs deal with issues of structural integrity, one with reduced brake performance, one with reduced controllability during approach and landing and another with complete loss of aircraft control. In a quick comparison to ADs issued to the B757/767 fleet worldwide, Airbus had approximately 50% more in the same amount of time! The significance of these ADs is twofold. One, they clearly illustrate that everything cannot be anticipated or contemplated in the engineering, development and certification process. Unforeseen issues will always arise – addressing them properly and in a timely fashion is what is important. Two, the disproportionate number of ADs may very well indicate a quality control problem with the Airbus fleet in general.

One AD of particular interest was issued on February 4, 2002 (enclosure 3, #4). This AD calls for ultrasonic inspections of A319/320/321 series aircraft to detect composite disbonding that could reduce the structural integrity of the vertical stabilizer. A logical question is: If Airbus Industrie manufactured A319, A320, and A321 aircraft have potential disbonding that requires ultrasonic inspections, why are the Airbus Industrie manufactured A300 and A310 immune from such problems? Logic would lead one to conclude that since the A319/320/321 series of aircraft is a later generation model than the A300/310 series of aircraft that the manufacturing techniques and processes would be more refined.

The crash of Flight 587 should act as the new paradigm for the way composites structures are certified and inspected. The current ongoing investigation provides the opportunity to revisit the genesis of the certification process, and make the necessary changes to correct any possible errors of omission. The theory that visual inspections are sufficient to discover all damage may have been forever discredited on November 12, 2001. In order to confirm the structural integrity of the entire A300/A310 fleet, establish baseline data, and restore the confidence of its crews, every aircraft needs to receive a one time inspection using appropriate nondestructive technology. This is something that can and should be accomplished immediately. Additionally, in order to make certain that the integrity of existing structures is maintained, <u>all</u> aircraft must be ultrasonically inspected on a <u>scheduled</u> basis.

The completed investigation of the crash of AA 587 may lead to the determination that composites are less suited for primary structures when compared to wrought metals. Periodic NDI inspections might make much of composite technology cost-prohibitive. Less drastic, but still economically unattractive conclusions might be reached as well. Regardless, in response to these possibilities, the commitment to safety must be stressed and always be the number one priority.

STRUCTURAL CERTIFICATION REQUIREMENTS

The NTSB's decision to single out "rudder reversal" is important for a number of reasons. First, it defines the phenomenon and its devastating effects, heretofore unknown to just about all commercial pilots. Second, it highlights the need to revisit the certification requirements of rudders and vertical stabilizers. (Pilots are extremely uncomfortable with the idea that within the normal flight envelope, a few swings of the rudder can cause a tail fin to separate from a perfectly good airplane.) Last, and perhaps most important, it raises the serious question as to why pilots were never made aware of this critical safety issue.

It is safe to say that pilots all over the world are shocked to learn that rudder-limiter systems, under certain conditions, do not provide adequate protection in preventing structural failure of the rudder and vertical stabilizer. To wit, structural certification requirements for all transport-category airplanes do not allow for "sequential full opposite rudder inputs" and that such a maneuver "may result in structural loads which exceed those requirements." This revelation flies in the face of the way pilots have operated aircraft since the beginning of time. Recommending that pilot training programs be redesigned to make crews aware of this fact falls short of addressing the real deficiency – the certification requirements themselves. The NTSB and the FAA must immediately correct this shortfall and resolve to strengthen tails and/or make more restrictive the requirements for rudder-limiting system. Recently it was reported that some in the FAA are concerned about the ramifications of a NTSB position backing changes to certification requirements of the rudder and vertical stabilizer. Although we appreciate the industry-wide ramifications of such a change, we are troubled by this response. Given the fact that composite material is known to be much less forgiving when overstressed, current standards may very well be inadequate and we strongly support changes that will toughen these standards.

Apparently just about every organization in the aviation industry -- manufacturers, operators, the FAA, and the NTSB -- is acutely aware of the fact that certification requirements of the rudder and vertical stabilizer do not take into account maneuvers termed "rudder reversals". According to one test pilot who has had extensive experience both in the Navy and with the FAA: "Boeing covers [this] in preflight briefings." During test flights "both sideslip and tail loads are readily displayed to test pilots during steady-heading sideslip tests for lateral-directional stability and certain other testing." It seems that the only major group which hasn't been informed is the line pilots who fly the aircraft each and every day. The fact that this information was never provided to the line pilot, arguably the one who would benefit most, is unconscionable. To make matters dangerously worse, the A300 Operating Manual includes a procedure, **L/G UNSAFE INDICATION** (*enclosure 4*) that directs the crew to "perform alternating sideslips in an attempt to lock the gear". There is no caution or warning as to the hazards of such a maneuver which, in effect, is an intentional "rudder reversal". *How was such a procedure, which authorizes control movements* ***with the potential to exceed design and certification standards*** *of the vertical stabilizer and rudder, approved?*

RUDDER LIMITER/YAW DAMPER SYSTEMS

The rudder of the A300 is essentially operated in 4 basic ways. The most common is direct pilot input to the rudder pedals. The autopilot actuator can also drive the rudder, and will transmit deflection back to the pedals; in this case, one or both autopilots must be engaged and slats extended. Yaw dampers can command rudder displacement as well, depending on requirements, but without deflection feedback to the pedals. Finally, small movements of the rudder can be accomplished through the rudder trim system. There is a fifth way however, which is unusual but can occur -- outside forces, (strong winds, for example) will attempt to move the rudder, but would normally not be strong enough to do so given the hydraulic pressure acting against it.

The A300 has had a history of flight control malfunctions *(enclosure 5)* that in many cases defy reasonable explanations. In fact, the numbers of incidents appear to be disproportionate when compared to any other fleet in service. **As recently as March 18, 2002, aircraft #061 had an incident *(enclosure 5, #21)* that is currently being "investigated".** This is the same aircraft that had three separate rudder anomalies in January 2002 (enclosure 5 -- #16, #17 & #18), which led to the aircraft being ferried to AA's maintenance facility in Tulsa. The maintenance that was performed in Tulsa to fix the problem apparently was ineffective. Yaw dampers recently removed from two other American Airlines A300 aircraft are still in France undergoing tests to determine whether they may have caused reported rudder oscillations. At this point, based upon what we know, it is unlikely that they will be found to be faulty.

In speaking with line pilots, anomalies continue to occur with enough frequency to cause ongoing concern -- further evidenced by the abnormally high numbers of ADs. Rudder pedals have been known to simply "freeze", unable to be moved by either pilot. Pilots have experienced uncommanded yaws, jolts, bumps, and unusual oscillations. So far, adjusting actuators, swapping components and other "Band-aid" approaches do not appear to be solving the ongoing uncommanded rudder inputs. Although a laborious task, requiring many man-hours and expense, it would seem that the time has come to thoroughly inspect the entire electrical flow and physical design of wire bundles and connectors to find the hidden cause of these anomalies.

Note that there was at least one case of uncommanded rudder swings (*enclosure 5, #8*) traced back to the autopilot actuator; and what is especially troublesome about this incident is that the rudder moved a full 12 degrees either side of center. A Pink Bulletin (temporary Operating Manual update - *enclosure 6*) was published as a direct result of that incident and later followed with an Operating Manual procedure entitled **Uncommanded Flight Control Inputs** *(enclosure 7).* This procedure was developed after consultation with Airbus and approved by the FAA. The point here is that uncommanded rudder malfunctions have been of such a serious nature as to generate procedural changes to our flight manuals.

Within the last few weeks, yet another Pink Bulletin (300-1-137), **Upset Recovery/Unusual Attitudes**, has been issued. This one is apparently in response to the NTSB's most recent safety recommendation. In many cases it directs the pilot to apply "only a small amount of rudder" and cautions that excessive rudder input can lead to structural failure.

These Operating Manual procedures are simply not addressing the more critical problems – uncommanded rudder inputs and certification standards for the vertical stabilizer and rudder. ***Why is it that apparently no relationship has been drawn, even after AA 587, between demonstrated flight control malfunctions, approved Operating Manual procedures and the potential for inadvertent rudder reversals? Why is the onus shifted to the pilots to respond to events without appropriate safety considerations?*** **Such a glaring omission puts our crews and passengers in harm's way and we question why such a situation has not received the immediate attention it deserves.**

NTSB Recommendation A-02-01 and -02 goes into great detail explaining the operation of the A300 rudder-limiter system and reminds us that there are "several other types of rudder limiter systems that operate differently." It also suggests that better pilot training in its operation, along with the knowledge of certification standards, will be the panacea to prevent rudder reversals. We believe that such awareness, should a pilot choose to use the rudder in conditions of extremis, will make no difference whatsoever given the design of the A300 rudder system.

Consider the fact that at 250 knots, it takes a mere 32 pounds of breakout force to move the rudder pedals 1.3 inches, which displaces the rudder +/- 9.3 degrees. Now put that aircraft in a moderate upset associated with turbulence (wake or weather related, it doesn't matter) and ask the pilot to correct heading and angle of bank changes using controlled aileron and rudder inputs. Remember, pushing the rudder pedals in either direction only 1.3 inches will achieve full rudder deflection. *Should the pilot only push half that amount, or .65 inches? Is the pilot even capable of discriminating such small distances of rudder pedal throw? Should the pilot not use the rudder pedals at all? Is there a correct answer?*

All of us have flown aircraft where the rudder pedal displacement remains the same in all flight regimes; the only difference being the actual movement of the rudder itself based upon how it is limited. This is explained in more detail on page 3 of the NTSB's report. Considering what we now know of vertical stabilizer and rudder certifications, it would seem that such a rudder pedal system should be standard as the only safe design. The A300-600's rudder pedal design, from an operator's perspective, appears to be ill conceived.

On another related point, it is our understanding that in the case of AA 587, the rudder movement events on the DFDR were rapid; it was difficult to duplicate such inputs in the simulator. Additionally, the investigation has been hampered by the "filtering" effect of the DFDR, even though the NTSB had ruled in 1997 to eliminate the practice of feeding filtered data to the DFDR. We think it extremely important that this discrepancy is clarified so that investigators are not similarly hamstrung in the future. In addition, consideration should be given to the use of force transducers on all commercial aircraft such that there is never any doubt as to exactly what control surface inputs pilots are making at any given time. Test pilots make use of force transducers routinely and it is a wonder they are not standard on today's sophisticated aircraft. The mutual goal of the NTSB and FAA should be to improve the safety of our aviation system, no matter what the cost or inconvenience.

AA 587: DISCUSSION AND OPINIONS

Within one day of the crash, the NTSB was quoted in newspapers as describing this incident as a "significant wake turbulence event", which was reinforced on television over the next few days when, with charts and graphs, it was explained how the JAL wake turbulence was such a danger. It would seem premature to have classified this accident in such a way until empirical data was available for corroboration.

It is important to note that in the history of modern commercial aviation, there have been countless wake turbulence *(enclosure 7)* and weather encounters far worse than that experienced by AA 587. Severe events have caused radical, uncontrollable banks, with large yaw and pitch changes. Given such amplitudes, one would expect that the involved crews would have needed significantly more control inputs to recover from such out-of-limit situations. Yet, never have critical structural members separated from an airplane. To be sure, in many cases a great deal of damage was done, but the crews and passengers lived to tell about it.

According to radar data, AA #587 took off approximately 105 seconds after JAL 47, yet clearances for takeoff were issued a full 140 seconds apart. There is a critical 35 seconds that was lost most likely due to the delayed initiation, or length of, JAL's takeoff roll. Although this happens often at JFK with transatlantic 747's, it raises the question as to whether the existing wake turbulence separation standards are sufficient, in that they apparently do not allow for commonplace occurrences that reduce planned/expected separation.

That being said, there are theories which postulate that significant side loads can be achieved under certain wake turbulence conditions. For example:

Martin Aubury, formerly Head of Aircraft Structures at the Australian Civil Aviation Authority, responded to us with the following comments:

> *"Irrespective of whether continuous turbulence caused the loss of FL 587; the risk is not properly addressed by FAR 25.*
>
> *In the same way that two structural modes at similar frequencies can interact to cause flutter (e.g. rudder rotation with fin bending); excessive structural loads occur if gust loads are applied repetitively at a critical structural frequency. It is analogous to pushing a swing.*
>
> *Response to continuous turbulence is handled statistically in FAR 25 Appendix G but the statistical definition of turbulence in Appendix G was formulated long before wake turbulence from wide body aircraft began. So there is a greater risk of*

encountering an overload condition than postulated by the certification standard.

Moreover composites are more susceptible than metals to repetitive loads in the range between limit and ultimate. That is because composites do not deform plastically so there is no redistribution/alleviation of loads – as alluded to elsewhere in your "Questions".

Metal structures have the advantage that the material has approximately the same strength in all directions. So small unanticipated loads in an unanticipated direction are of no consequence. Composites are different. Fibers are oriented to carry expected load and where there are no fibers there is very little strength. An unanticipated load in unanticipated direction has far more serious consequences for composite structures than for metals."

G. Richard Sharp supports Aubury when he observes that:

"If the following aircraft penetrates the disturbance above or below the disturbance centerline (the path of the preceding aircraft), it will encounter quickly reversing loads on its vertical stabilizer. The strength of these loads will be governed by how old the disturbance is and how close to the centerline of the disturbance the following aircraft flies. The velocity of the following aircraft and the angle at which it crosses the reversing disturbance will govern the excitation frequency of the reversing disturbance on the following aircraft.

If the frequency of the two closely timed disturbances coincides with the natural frequency of the cantilevered vertical stabilizer of the following aircraft, a dynamic load factor of more than two must be applied to the tailfin aerodynamic side loads. Could this have been a contributing cause of the accident?"

If the phenomenon explained above by Mr. Aubury and Mr. Sharp is true, then once again, in light of the lack of ductility of composites, the structural certification requirements for the vertical stabilizer and rudder must be re-examined. As well, perhaps both distance and time standards for wake turbulence separation need to be changed to account for this and other variables.

The separation of the composite vertical stabilizer is the first known failure of a primary structure in a transport-category aircraft. In the history of modern aviation, it seems reasonable that other aircraft have been subjected to loads at least as great as those encountered by AA 587. It also seems probable that at one time or another, pilots commanded “rudder reversals” during these upsets, as necessary, to regain control. *Why then did this particular tail separate from the fuselage?*

The composite construction of the A300 rudder is somewhat different from that of the vertical stabilizer – sandwich versus monolithic. The rudder of AA 587 split in at least three pieces and it appears that the timing of that event is critical. *What stresses were placed on the rudder to have caused it to fail in such a way?* Let’s take a look at some of the things we do know; since there are possible causal factors far more likely to exist than simply wake turbulence or pilot rudder usage:

AA 587 took off without incident. Shortly after takeoff, the aircraft twice encountered wake turbulence. During and shortly after the second encounter, the DFDR recorded large rudder swings with corresponding pedal movements. The analysis of this 7-10 second timeframe is the real focus of the NTSB investigation and the knowledge gained can provide some clues as to what happened. Unfortunately, we are not privy to the specifics, but can venture our own theories based upon what we do know.

During preflight, the #1 pitch trim and #1 yaw damper control would not engage. The computer controlling these components was reset by a mechanic, apparently correcting the engagement problem, and the aircraft was released for flight. *Was the inability to initially engage these switches an indication of a more serious problem with the yaw damper system? If a faulty yaw damper was excited/exacerbated by even a mild wake turbulence event, then abrupt, severe and uncommanded inputs to the rudder may have occurred.* (It is unfortunate that the yaw damper mechanism could not be analyzed since it was burned in the crash.) The yaw damper is a powerful tool when it provides small forces at the right moment to reduce oscillations. However, a yaw damper “gone bad” can be devastating, particularly in light of what we now know of the inadequate certification requirements of the vertical stabilizer and rudder.

Let us assume, for the purpose of this argument, that the yaw damper did malfunction. The pilots, sensing what may have been improper and/or sudden unexpected aircraft movements may have operated the rudder pedals in an effort to regain stability. Pilot input competing with that of a faulty yaw damper could have put severe stress on the rudder, possibly causing it to split into sections. Earlier it was shown that the rudder, because of its sandwich construction, is subject to water ingress related fatigue. *Had the rudder experienced disbonding? Was it fatigued to the point that it split under less than ultimate loads?*

Related to competing rudder inputs is the malfunction called “desynchronization”. Desynchronization is essentially when one or more of the three hydraulic channels (green, yellow and blue) are “out of phase” with the others, resulting in additional loads being placed on the composite structures. An Australian Airworthiness Directive (*enclosure 3, #32*), originally issued in 1997, addresses this malfunction, and required inspections to detect and prevent rudder servo-control desynchronization, which could lead to **structural fatigue and adverse aircraft handling quality.** If you refer to *enclosure 5*, entry (18), in February of this year, a Fedex A300-600 was found to have a bent rudder actuator (green system) that was traced back to a desynchronization malfunction. The mechanics reported oscillations in the rudder and a loud bang when operating the rudder pedals while troubleshooting. *Could the wake event have caused a yaw damper malfunction or did a desynchronization occur?* The pilots may have been responding to either or both malfunctions. Either scenario may have caused the necessary stress/torque to split a rudder that was structurally sound, let alone one that may have been unsound due to delamination/disbonding. Once the rudder failed, the separation of the vertical fin most likely was not far behind.

What about the vertical fin itself? Were the stress/strain properties of the vertical stabilizer altered by the factory repair? Were one or more of the attachment lugs loose? If so, how did that affect structural integrity? Did the lack of ductility of the vertical stabilizer lead to premature separation? Would a metal fin have remained on the aircraft, all things being equal? Was the flutter sound heard on the cockpit voice recorder caused by a split rudder, with one or more parts free-floating? There is an AD (*enclosure 3*, #25) which refers to "freeplay" of the elevator causing severe vibrations in the back of the airplane. *Could "freeplay" in a rudder cause similar vibrations which in turn were picked up on the voice recorder as a "flutter" sound?*

It should be noted that in attempting to make the same rudder inputs in the simulator as were recorded on the DFDR, it becomes obvious to the pilot that the airplane was not meant to be flown in such a way. It also must be recognized that commercial pilots do not routinely operate rudder pedals other than on takeoffs and landings. The tenets of basic airmanship acquired throughout a pilot's career suggest that hasty rudder pedal movements are not the norm. If yaw upsets occur, it is far more likely for a professional pilot to avoid abrupt rudder use than to continue to aggravate a situation with multiple, aggressive inputs. *Therefore, how realistic is it that such a "rudder reversal" maneuver was solely pilot induced?*

Dr. Robert O. Besco, President of Professional Performance Improvement Company and a retired American Airlines captain had this to say:

> *"Speaking as an Airline Captain with AAL for 21 years, and USAF Fighter Pilot for 13 years and a Board Certified Human Factors Aviation Psychologist for over 40 years, I have never heard of any professional aviator making the type of rudder inputs described. Particularly, if there was any type of force required to move the rudder pedals from neutral to full deflection. The break out forces as well as the forces to complete the travel would not permit the pilot to even attempt such a set of inputs."*

John Sampson states,

> *"In my opinion it would constitute unbelievably inept mishandling that is quite inappropriate to the speed regime they were in at the time. At somewhere below 1.3VS I might be able to be convinced*

about the inputs being attempted - but not the rate at which they were being made.... nor the inspiration/motivation behind them."

Regardless of why and how the vertical stabilizer separated from the aircraft, would another tail without a repair have survived the events? Similarly, would a metal tail which has the ductility to bend and not break at critical loads, have allowed this crew to safely land their aircraft and save 265 lives? The way the events played out, it is doubtful that the pilots had time to react either appropriately, or inappropriately.

RECOMMENDATIONS

We are not design engineers, experts in composites or investigators. We do not have the data or resources available which would allow us to reach definitive conclusions on certain issues. However, in spite of these limitations, we have been able to collect sufficient information and testimony to support the recommendations below:

1) Use and certification of composite materials for critical, load-bearing structures should be exhaustively reviewed, taking into account the substantial differences as compared to metal (ductility, thermal expansion coefficients, hygroscopics, attachment philosophies, etc.). This must include, as well, certification of any repairs made to structures. Does the cost/safety analysis justify such use based upon industry technical knowledge at this point in time?

2) Appropriate NDI technology must be developed for use by all certificate holders. All aircraft should immediately receive baseline inspections on any load-bearing structures made of composite materials, in particular the vertical stabilizers and rudders. Requirements should be established for ongoing, scheduled inspections to ensure structural integrity.

3) The current structural certification requirements for the vertical stabilizer and rudder on all transport-category aircraft should be reviewed and consideration given to making them more stringent. This is particularly important in light of the reduced flexibility of composite structures. In the interim, definition of maneuvering speed should be revised, as appropriate, and pilot training should include a thorough operational knowledge of the actual limitations of speed and safe flight control usage under existing certification criteria.

4) Rudder limiter systems should be redesigned and re-certified to the extent that they protect against "rudder reversals." The new design should restrict the movement of the rudder to prevent inadvertent "rudder reversal-type" maneuvering. The design should also require that full rudder pedal travel is available throughout the flight regime, and that only actual rudder movement be limited. The design should be standard across fleet-types and incorporated into FAR Part 25 certification requirements.

5) All aircraft certified to operate in the US should have, as standard equipment, DFDRs that can provide "unfiltered" data for investigative purposes. Additionally, to protect the interests of pilots worldwide and to further aid in investigations, all primary flight controls should be equipped with "force transducers".

6) The attachment method of the A300-600 vertical stabilizer should be reviewed as to whether it constitutes safe design given the characteristics of composite material.

7) There must be continued thorough analysis of electrical/mechanical inputs to the rudder/flight control system on the A300-600 to determine the cause of the uncommanded flight control inputs…the object being to prevent incidents which may lead to rudder reversal mishaps.

8) Finally, based on the concerns listed below, **serious consideration must be given to grounding the entire A300-600 fleet until its airworthiness can be assured**.

   (a) Certification requirements of the vertical stabilizer and rudder are insufficient to prevent structural separation of the tail assembly under certain “rudder reversal” conditions.

   (b) There have been documented cases of delamination in the elevators, rudders and vertical stabilizers, compromising the integrity of these structures. Nondestructive technology is not being used and baseline date has not been established to ensure the integrity of composite structures on an ongoing basis.

   (c) There have been a disproportionately high number of documented cases of uncommanded rudder inputs which have, at times, led to large rudder displacements.

   (d) The rudder limiter/pedal design is ill-conceived and its limitations may contribute to, rather than prevent, inadvertent “rudder reversals”.

   (e) The A300 vertical stabilizer design should be reevaluated as to its method of attachment to the fuselage, in light of its composite structure.

CONCLUSIONS

It is said that the economics and politics will win out over safety every time; and that changes are made only after a catastrophic event. By all accounts, the crash of AA 587 **was** that catastrophic event.

As an industry staggering from the events of September 11, airlines continue to look for cost savings in every facet of operations. Manufacturers are driven by providing technology that meets these needs. With the increased use of automation, there seems to be a design philosophy taking hold in the airline industry that has ominous long-term effects. Systems technology now drives the industry, and the pilots are less and less “in the loop”. Two crewmembers are the norm, fatigue issues remain, and security has taken on another dimension.

To take a position that any theory, technology, design, certification or product is forever without flaw is an ethos which has no place when public safety is the primary concern. In the interest of public safety and as a demonstration of corporate responsibility, every organization needs to step forward and work together to ensure that aircraft are built, maintained, and operated in the absolute safest possible manner. At times, economics and politics must be pushed aside to allow safety to occupy the position of prime importance. We believe that this is such a time; and that the NTSB and the FAA, together, are in the position to ensure that our aviation system and the aircraft that operate within it remain the safest in the world.

On behalf of our fellow pilots, thank you for your attention to this matter.

AMERICAN AIRLINES COMMITMENT TO SAFETY

For all of us at American Airlines, our first priority is the safety of our customers and co-workers. We strive to be the world leader in safety and rely on the sound judgment and experience of employees and managers alike to accomplish this goal. Safety is the first and foremost consideration in any decision and is the foundation of our success.

My further commitment to you is that safety is held as a core value to our airline and that:

- Each officer is accountable for the safety performance of his or her department
- Each department is responsible for providing policies, procedures and training to prevent accidents and injuries and ensure compliance.
- Each employee group must help identify, define and promote safe operating practices.
- Each employee is responsible for performing his or her job safely.

SAFETY MISSION STATEMENT

The conduct of the business of air transport imposes an extraordinary duty upon American Airlines and its employees to ensure that no harm come to passengers while entrusted to our care. Both our inherent moral obligation and the success of our business enterprise depend upon the provision of safe transportation. The Captains, Dispatchers and other flight crewmembers have a particular responsibility, vested by Federal Air Regulations and American Airlines policy, for operational control and decision-making associated with a specific flight. Every American Airlines flight will be operated in compliance with regulations, procedures, policies and prudent judgment so as to provide the highest degree of safety for our customers.

Enclosure 1 (Don Carty's Statement)

NTSB SAFETY RECOMMENDATION A-02-01 AND -02

National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

7439
Date: February 8, 2002
In reply refer to: A-02-01 and -02
Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

This safety recommendation letter addresses an industry-wide safety issue involving omissions in pilot training on transport-category airplanes. Specifically, the National Transportation Safety Board has learned that many pilot training programs do not include information about the structural certification requirements for the rudder and vertical stabilizer on transport-category airplanes. Further, the Safety Board has learned that sequential full opposite rudder inputs (sometimes colloquially referred to as "rudder reversals")—even at speeds below the design maneuvering speed[1]—may result in structural loads that exceed those addressed by the requirements. In fact, pilots may have the impression that the rudder limiter systems installed on most transport-category airplanes, which limit rudder travel as airspeed increases to prevent a single full rudder input from overloading the structure, also prevent sequential full opposite rudder deflections from damaging the structure. However, the structural certification requirements for transport-category airplanes do not take such maneuvers into account; therefore, such sequential opposite rudder inputs, even when a rudder limiter is in effect, can produce loads higher than those required for certification and that may exceed the structural capabilities of the aircraft.

This safety issue was identified in connection with the Safety Board's ongoing investigation of the November 12, 2001, accident involving American Airlines flight 587, an Airbus Industrie A300-600.[2] Flight 587 was destroyed when it crashed into a residential area of Belle Harbor, New York, shortly after takeoff from John F. Kennedy International Airport (JFK), Jamaica, New York. Before impact, the vertical stabilizer and rudder separated from the fuselage.[3] The 2 pilots, 7 flight attendants, 251 passengers, and 5 persons on the ground were

[1] The design maneuvering airspeed is the maximum speed at which the structural design's limit load can be imposed (either by gusts or full deflection of the control surfaces) without causing structural damage.

[2] Under the provisions of Annex 13 to the Convention on International Civil Aviation, the Bureau Enquêtes-Accidents and Airbus Industrie are participating in the Safety Board's investigation of this accident as the Accredited Representative and technical Advisor, respectively, of the State of Design and Manufacture.

[3] The vertical stabilizer and rudder assemblies were found floating in the water about 0.7 mile from the main impact crater. The vertical stabilizer was largely intact with no significant damage, although some localized areas of

killed. Visual meteorological conditions prevailed and an instrument flight rules flight plan had been filed for the flight destined for Santo Domingo, Dominican Republic. The scheduled passenger flight was conducted under 14 *Code of Federal Regulations* (CFR) Part 121.

The investigation is still examining many issues, including the adequacy of the certification standards for transport-category airplanes, the structural requirements and integrity of the vertical stabilizer and rudder, the operational status of the rudder system at the time of the accident, the adequacy of pilot training, and the role of pilot actions in the accident. It must be emphasized that, at this time, the Board has not yet determined the probable cause of the accident. Further, the Board is not aware of any prior events in which rudder movements have resulted in separation of a vertical stabilizer or rudder. Nonetheless, the investigation has revealed this safety issue, which should be immediately addressed.

Before the separation of the vertical stabilizer and rudder, flight 587 twice experienced turbulence consistent with encountering wake vortices from a Boeing 747 that departed JFK ahead of the accident aircraft. The two airplanes were separated by about 5 (statute) miles and 90 seconds at the time of the vortex encounters. During and shortly after the second encounter, the flight data recorder (FDR) on the accident aircraft recorded several large rudder movements (and corresponding pedal movements) to full or nearly full available rudder deflection in one direction followed by full or nearly full available rudder deflection in the opposite direction.[4] The subsequent loss of reliable rudder position data is consistent with the vertical stabilizer separating from the airplane. The cause of the rudder movements is still under investigation. Among the potential causes being examined are rudder system malfunction, as well as flight crew action.

Preliminary calculations by Safety Board and Airbus engineers show that large sideloads were likely present on the vertical stabilizer and rudder at the time they separated from the airplane. Calculations and simulations show that, at the time of the separation, the airplane was in an 8° to 10° airplane nose-left sideslip while the rudder was deflected 9.5° to the right. Airbus engineers have determined that this combination of local nose-left sideslip on the vertical stabilizer and right rudder deflection produced air loads on the vertical stabilizer that could exceed the airplane's design loads. The Board notes that, at the time the vertical stabilizer and rudder separated from the airplane, the airplane was flying at 255 knots indicated airspeed (KIAS), which is significantly below the airplane's design maneuvering speed of 273 KIAS.

Transport-category airplanes certified by the Federal Aviation Administration (FAA) must meet the airworthiness standards in 14 CFR Part 25. Subpart C, pertaining to the airplane structure, includes Section 25.351, titled "Yaw maneuver conditions," which requires that the

damage were evident around the stabilizer-to-fuselage interface. At the lower end of the stabilizer, all of the attachment fittings were either fractured through the attachment hole or the stabilizer structure was fractured around the fittings. Portions of the closure rib and skin attach angle and front spar were also fractured from the stabilizer. Most of the rudder was separated from the vertical stabilizer except for portions of the rudder spar, which remained attached to the actuators and the upper hinge (no. 5 and 7).

[4] Preliminary information based on FDR data and an analysis of the manner in which rudder position data is filtered by the airplane's systems indicates that within about 7 seconds, the rudder traveled 11° right for 0.5 second, 10.5° left for 0.3 second, between 11° and 10.5° right for about 2 seconds, 10° left for about 1 second, and, finally, 9.5° right before the data became unreliable.

airplane be designed for loads resulting from the following series of maneuvers in unaccelerated flight, beginning at zero yaw: (1) full rudder input resulting in full rudder deflection (or as limited by the rudder limiter system); (2) holding this full deflection input throughout the resulting over-swing[5] and steady-state sideslip angles; and (3) while the airplane is at the steady-state sideslip angle, a release of this rudder input and the return of the rudder to neutral. The A300 was certified as having met this regulatory standard. In other words, the airplane must be designed to withstand the results of a full rudder input in one direction followed by (after the airplane reaches equilibrium) a release of that rudder input.

It is noteworthy that these certification requirements do not consider a return of the rudder to neutral from the over-swing sideslip angle, nor do they consider a full rudder movement in one direction followed by a movement in the opposite direction. Although, as previously mentioned, most transport-category airplanes are equipped with rudder limiter systems that limit rudder deflection at higher airspeeds, which prevents single rudder inputs from causing structural overload, the Safety Board is concerned that pilots have not been made aware that, a full or nearly full rudder deflection in one direction followed by a full or nearly full rudder deflection in the other direction, even at speeds below the design maneuvering speed, can dramatically increase the risk of structural failure of the vertical stabilizer or the rudder.

The Safety Board is also concerned that pilots may not be aware that, on some airplane types, full available rudder deflections can be achieved with small pedal movements and comparatively light pedal forces. In these airplanes, at low speeds (for example, on the runway during the early takeoff run or during flight control checks on the ground or simulator training) the rudder pedal forces required to obtain full available rudder may be two times greater and the rudder pedal movements required may be three times greater than those required to obtain full available rudder at higher airspeeds.

On the A300-600, for example, at airspeeds lower than 165 knots (when rudder travel is unrestricted by the airplane's rudder limiter system) the rudder can travel +/-30°, requiring a pilot force of about 65 pounds to move the rudder pedals about 4.0 inches. However, at 250 knots, when the limiter restricts rudder travel to about +/-9.3°, a pilot force of about 32 pounds is required to move the rudder pedals about 1.3 inches. The rudder system on the A300-600 uses a breakout force[6] of about 22 pounds. Thus, at 250 knots, the rudder can reach full available travel (9.3°) with a pedal force of only 10 pounds over the breakout force. There are several other types of rudder limiter systems that operate differently. For example, on some airplanes, full pedal travel (and corresponding pedal force) is required to obtain full available rudder, regardless of airspeed, even though the maximum available rudder deflection is reduced with airspeed by mechanical means. Lacking an awareness of these differences in necessary pedal force and movement, some pilots, when sensing the need for a rudder input at high speeds, may use rudder pedal movements and pressures similar to those used during operations at lower airspeeds, potentially resulting in full available rudder deflection.

[5] Over-swing refers to the maximum sideslip angle resulting from the airplane's momentum as it yaws in response to the rudder's movement; the over-swing sideslip angle will always be greater than the subsequent steady-state sideslip angle.

[6] Breakout force is the force required to start moving a flight control such as the rudder pedal or control column.

The Safety Board notes that there is a potential for pilots to make large and/or sequential rudder inputs in response to unusual or emergency situations, such as an unusual attitude or upset, turbulence, or a hijacking or terrorist situation. In fact, unusual attitude training already exists[7] that encourages pilots to use full flight control authority (including rudder), if necessary, in response to an airplane upset. Further, the Board is aware that, since the terrorist attacks of September 11, 2001, operators and pilots have been discussing ways to disable or incapacitate would-be hijackers in cockpits or in cabins during flight. Although the Board understands the need to formulate effective maneuvers for addressing such unusual or emergency situations, the Board is also concerned that, without specific and appropriate training in such maneuvers, pilots could inadvertently create an even more dangerous situation if those maneuvers result in loads that approach or exceed the structural limits of the airplane.

Finally, notwithstanding the concerns noted above about the potential danger of large and/or sequential rudder inputs in flight, it should be emphasized that pilots should not become reluctant to command full rudder when required and when appropriate, such as during an engine failure shortly after takeoff or during strong or gusty crosswind takeoffs or landings. The instruction of proper rudder use in such conditions should remain intact but should also emphasize the differences between aircraft motion resulting from a single, large rudder input and that resulting from a series of full or nearly full opposite rudder inputs.

As previously noted, the Safety Board's examination of the adequacy of the certification standards is ongoing and no conclusions have yet been reached in that regard. However, on the basis of the investigative findings to date, the Board believes that the FAA should require the manufacturers and operators of transport-category airplanes to establish and implement pilot training programs that: (1) explain the structural certification requirements for the rudder and vertical stabilizer on transport-category airplanes; (2) explain that a full or nearly full rudder deflection in one direction followed by a full or nearly full rudder deflection in the opposite direction, or certain combinations of sideslip angle and opposite rudder deflection can result in potentially dangerous loads on the vertical stabilizer, even at speeds below the design maneuvering speed; and (3) explain that, on some aircraft, as speed increases, the maximum available rudder deflection can be obtained with comparatively light pedal forces and small pedal deflections. The FAA should also require revisions to airplane and pilot operating manuals that reflect and reinforce this information. In addition, the FAA should ensure that this training does not compromise the substance or effectiveness of existing training regarding proper rudder use, such as during engine failure shortly after takeoff or during strong or gusty crosswind takeoffs or landings. The Safety Board also believes that the FAA should carefully review all existing and proposed guidance and training provided to pilots of transport-category airplanes concerning special maneuvers intended to address unusual or emergency situations and, if necessary, require modifications to ensure that flight crews are not trained to use the rudder in a way that could result in dangerous combinations of sideslip angle and rudder position or other flight parameters.

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[7] The widely used *Airplane Upset Recovery Training Aid*, which was created by Airbus Industrie, the Boeing Company, many major domestic and international airlines, and major pilot organizations, states that, "pilots must be prepared to use full control authority, when necessary. The tendency is for pilots not to use full control authority because they rarely are required to do this. This habit must be overcome when recovering from severe upsets."

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require the manufacturers and operators of transport-category airplanes to establish and implement pilot training programs that: (1) explain the structural certification requirements for the rudder and vertical stabilizer on transport-category airplanes; (2) explain that a full or nearly full rudder deflection in one direction followed by a full or nearly full rudder deflection in the opposite direction, or certain combinations of sideslip angle and opposite rudder deflection can result in potentially dangerous loads on the vertical stabilizer, even at speeds below the design maneuvering speed; and (3) explain that, on some aircraft, as speed increases, the maximum available rudder deflection can be obtained with comparatively light pedal forces and small pedal deflections. The FAA should also require revisions to airplane and pilot operating manuals that reflect and reinforce this information. In addition, the FAA should ensure that this training does not compromise the substance or effectiveness of existing training regarding proper rudder use, such as during engine failure shortly after takeoff or during strong or gusty crosswind takeoffs or landings. (A-02-01)

Carefully review all existing and proposed guidance and training provided to pilots of transport-category airplanes concerning special maneuvers intended to address unusual or emergency situations and, if necessary, require modifications to ensure that flight crews are not trained to use the rudder in a way that could result in dangerous combinations of sideslip angle and rudder position or other flight parameters. (A-02-02)

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these safety recommendations.
By: Marion C. Blakey
Chairman
Original Signed

Enclosure 2e

AIRBUS AIRWORTHINESS DIRECTIVES

(1) [Docket No. 2001-NM-252-AD; Amendment 39-12667; AD 2002-04-10]

Airworthiness Directives; Airbus Model A319 Series Airplanes and A320-200 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A319 series airplanes and A320-200 series airplanes that require repetitive inspections to detect loose or missing rivets in specified areas of the door frames of the overwing emergency exits and corrective action, if necessary. This AD also requires measurement of the grip length of all rivets in the specified areas and corrective action, if necessary, which terminates the repetitive inspections. This amendment is prompted by mandatory continuing **airworthiness** information from a foreign **airworthiness** authority. The actions specified by this AD are intended to detect and correct loose or missing rivets or discrepant rivets, which could lead to reduced structural integrity of the overwing emergency exit door frames. This action is intended to address the identified unsafe condition.

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(2) [Docket No. 2001-NM-205-AD; Amendment 39-12662; AD 2002-04-05]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 and A300 B4 Series Airplanes; Model A300 F4-605R Airplanes; Model A300 B4-600 and A300 B4-600R Series Airplanes; and Model A310 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A300 B2 and A300 B4 series airplanes; certain Model A300 F4-

605R airplanes and Model A300 B4-600 and A300 B4-600R series airplanes; and certain Model A310 series airplanes, that requires repetitive inspections to detect damage of the fillet seals and feeder cables, and of the wiring looms in the wing/pylon interface area; and corrective action, if necessary. This amendment also provides for optional terminating action for the repetitive inspections. The actions specified by this AD are intended to prevent wire chafing and short circuits in the wing leading edge/pylon interface area, which could result in loss of the power supply generator and/or system functions. This action is intended to address the identified unsafe condition.

DATES: Effective April 2, 2002.

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(3) [Docket No. 2000-NM-390-AD; Amendment 39-12659; AD 2002-04-02]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 F4-605R Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A300 F4-605R airplanes, that requires installation of external doublers at frames 29 and 33. The actions specified by this AD are intended to prevent fatigue cracking of certain circumferential joints, which could result in reduced structural integrity of the fuselage in the vicinity of the upper deck cargo door.

DATES: Effective March 28, 2002.

(4) [Docket No. 2000-NM-413-AD; Amendment 39-12652; AD 2002-03-11]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment supersedes an existing **airworthiness** directive (AD), applicable to certain Airbus Model A319, A320, and A321 series airplanes, that currently requires a one-time ultrasonic inspection to detect disbonding of the skin attachments at the stringers and spars of the vertical stabilizer, repair, if necessary, and, for certain airplanes, prior or concurrent modification of the vertical stabilizer to ensure proper reinforcement of its attachment to the skin. This amendment adds repetitive ultrasonic inspections of the subject area, and repair, if necessary. It also adds installation of fasteners to reinforce the bonds to the skin, which terminates the repetitive inspections. This amendment is prompted by issuance of mandatory continuing **airworthiness** information by a foreign civil **airworthiness** authority. The actions specified by this AD are intended to prevent failure of the bonds of the vertical stabilizer spar boxes to the skin, which could lead to reduced structural integrity of the spar boxes.

DATES: Effective March 19, 2002.

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(5) [Docket No. 2001-NM-153-AD; Amendment 39-12635; AD 2002-02-07]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330 and A340 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to all Airbus Model A330 and A340 series airplanes, that requires repetitive inspections and operational checks of the spring function of the emergency exit door slider mechanism, and corrective action if necessary. This action is necessary to prevent failure of the spring locking function of the slider mechanism due to corrosion, which could result in the escape slide detaching from the airplane in an emergency evacuation. This action is intended to address the identified unsafe condition.

DATES: Effective March 19, 2002.

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(6) [Docket No. 2001-NM-392-AD; Amendment 39-12634; AD 2002-02-06]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330-243, -341, -342, and -343 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD) that is applicable to certain Airbus Model A330-243, -341, -342, and -343 series airplanes. This action requires modifying the rear engine mount by replacing the existing fail-safe link with a new, improved fail-safe link. This action is necessary to prevent failure of the fail-safe link of the rear engine mount, which, in combination with failure of the primary load path for the engine, could result in separation of the engine from the airplane. This action is intended to address the identified unsafe condition.

DATES: Effective February 27, 2002.

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(7) [Docket No. 2001-NM-253-AD; Amendment 39-12633; AD 2002-02-05]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 and A300 B4; A300 B4-600, B4-600R, and F4-600R (Collectively Called A300-600); and Model A310 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A300 B2 and A300 B4; A300 B4-600, B4-600R, and F4-600R (collectively called A300-600); and A310 series airplanes. This AD requires repetitive overhaul, including associated modifications, of the ram air turbine (RAT). This action is necessary to prevent failure of the RAT to deploy or operate properly in the event of an emergency, which could result in reduced hydraulic pressure or electrical power on the airplane. This action is intended to address the identified unsafe condition.

DATES: Effective March 19, 2002.

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(8) [Docket No. 2001-NM-71-AD; Amendment 39-12612; AD 2002-01-18]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A319, A320, and A321 series airplanes, that requires replacement of the trigger spring of the slide bar on each of the passenger doors with a new, stronger trigger spring. This action is necessary to prevent corrosion of the trigger spring on the slide bar of the passenger doors, which could result in incorrect locking of the slide bar and, during deployment of the escape slide, lead to a delay in evacuating passengers in an emergency. This action is intended to address the identified unsafe condition.

DATES: Effective March 6, 2002.

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(9) [Docket No. 2002-NM-01-AD; Amendment 39-12608; AD 2002-01-14]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment supersedes an existing **airworthiness** directive (AD), applicable to certain Airbus Model A319, A320, and A321 series airplanes, that currently requires an in-situ one-time detailed visual inspection of Draeger Type I oxygen containers, located in the passenger service units, and Draeger Type II oxygen containers, located in the utility areas, for the presence of foam pads. That action also currently requires the installation of a new foam pad, if necessary; and other actions to ensure proper operation of the masks. This amendment retains those requirements and expands the applicability of the existing AD to include additional airplanes that were inadvertently excluded from that AD. The actions specified in this AD are intended to prevent failure of the oxygen containers to deliver oxygen to the passengers in the event of a rapid decompression or cabin depressurization. This action is intended to address the identified unsafe condition.

DATES: Effective January 22, 2002.

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(10) [Docket No. 2001-NM-255-AD; Amendment 39-12587; AD 2001-26-21]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A319, A320, and A321 series airplanes, that requires replacement of the low-pressure solenoid valve for the crew oxygen supply with a modified valve. This action is necessary to prevent faulty operation of the low-pressure solenoid valve for the crew oxygen supply, which could prevent oxygen from being supplied to the airplane crew when needed, such as in the event of smoke in the cabin or rapid depressurization of the airplane. This action is intended to address the identified unsafe condition.

DATES: Effective February 8, 2002.

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(11) [Docket No. 2001-NM-132-AD; Amendment 39-12586; AD 2001-26-20]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

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SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A319, A320, and A321 series airplanes, that requires a one-time inspection of the forward and aft lower bogies of the left- and right-hand sliding windows of the flightcrew compartment for the presence of a lock pin. If the lock pin is missing, this amendment requires corrective action. This action is necessary to prevent the inability of the flightcrew to open the left- or right-hand sliding window for evacuation in an emergency, due to a window jamming in the closed position. This action is intended to address the identified unsafe condition.

DATES: Effective February 8, 2002.

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(12) [Docket No. 2001-NM-28-AD; Amendment 39-12583; AD 2001-26-17]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A330 series airplanes, that requires removal of the shear pins that keep the rear fixed panels on the center landing gear closed and installation of new solid shear pins. This amendment is prompted by issuance of mandatory continuing **airworthiness** information from a foreign **airworthiness** authority. This action is intended to prevent the shear pins on the rear fixed panels of the center landing gear from failing, which could result in loss of the panels during flight with consequent injury to people on the ground. This action is intended to address the identified unsafe condition.

DATES: Effective February 8, 2002.

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(13) [Docket No. 2001-NM-354-AD; Amendment 39-12574; AD 2001-26-10]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD) that is applicable to certain Airbus Model A319, A320, and A321 series airplanes. This action requires an in-situ one-time detailed visual inspection of Draeger Type I oxygen containers, located in the passenger service units, and Draeger Type II oxygen containers, located in the utility areas, for the presence of foam pads. This action also requires the installation of a new foam pad, if necessary; and other actions to ensure proper operations of the masks. This action is necessary to prevent failure of the oxygen containers to deliver oxygen to the passengers in the event of a rapid decompression or cabin depressurization. This action is intended to address the identified unsafe condition.

DATES: Effective January 11, 2002.

(14) [Docket No. 2000-NM-247-AD; Amendment 39-12572; AD 2001-26-08]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 Series Airplanes and Model A300 B4-2C, B4-103, and B4-203 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to all Airbus Model A300 B2 series airplanes and Model A300 B4-2C, B4-103, and B4-203 series airplanes that require identifying the types and areas of repairs on the airplane between frame 10 and frame 80, and performing follow-on actions for certain repairs. These actions are necessary to detect and correct fatigue cracking of certain repairs of the fuselage between frame 10 and frame 80, which could result in reduced structural integrity of the airplane. These actions are intended to address the identified unsafe condition.

DATES: Effective January 31, 2002.

(15) [Docket No. 2001-NM-204-AD; Amendment 39-12543; AD 2001-24-26]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 and B4, A300 B4-600 and B4-600R, and A310 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A300 B2 and B4, A300 B4-600 and B4-600R, and A310 series airplanes, that requires modification of the terminal blocks of the starter feeder line of the auxiliary power unit (APU). This action is necessary to prevent slackness and subsequent overheat and arcing of certain wiring connections. This action is intended to address the identified unsafe condition.

DATES: Effective January 16, 2002.

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(16) [Docket No. 2001-NM-349-AD; Amendment 39-12526; AD 2001-23-51]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B4-600, B4-600R, and F4-600R (Collectively Called A300-600) Series Airplanes; and Model A310 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This document publishes in the Federal Register an amendment adopting **airworthiness** directive (AD) 2001-23-51 that was sent previously to all known U.S. owners and operators of certain Airbus Model A300 B4-600, B4-600R, and F4-600R (collectively called A300-600) series airplanes; and Model A310 series airplanes by individual notices. This AD requires a one-time detailed visual inspection to detect repairs and alterations to, and damage of the vertical stabilizer attachment fittings, including the main attachment lugs and the transverse (side) load fittings; and the rudder hinge fittings, hinge arms, and support fittings for all rudder hinges, and rudder actuator support fittings; and repair, if necessary. This AD also requires that operators report results of inspection findings to the FAA. This action is prompted by an airplane accident shortly after takeoff from John F. Kennedy International Airport, Jamaica, New York. The actions specified by this AD are intended to prevent failure of the vertical stabilizer-to-fuselage attachment fittings or transverse (side) load fittings, or rudder-to-vertical stabilizer attachment fittings, which could result in loss of the vertical stabilizer and/or rudder and consequent loss of control of the airplane.

DATES: Effective December 10, 2001, to all persons except those persons to whom it was made immediately effective by emergency AD 2001-23-51, issued on November 16, 2001, which contained the requirements of this amendment.

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(17) [Docket No. 2000-NM-358-AD; Amendment 39-12521; AD 2001-24-05]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment supersedes an existing **airworthiness** directive (AD), applicable to certain Airbus Model A320 series airplanes, that currently requires modification of the autopilot mode engagement/disengagement lever of the rudder artificial feel unit. This amendment requires a different modification of the lever. This amendment also revises the applicability to include Airbus Model A319 and A321 series airplanes, as well as all Model A320 series airplanes. This amendment is prompted by issuance of mandatory continuing **airworthiness** information by a foreign civil **airworthiness** authority. The actions specified by this AD are intended to prevent reduced controllability of the airplane due to the failure of the rudder artificial feel unit to disengage properly from autopilot mode during approach and landing.

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(18) [Docket No. 2001-NM-300-AD; Amendment 39-12481; AD 2001-22-02]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 and B4 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD) that is applicable to certain Airbus Model A300 B2 and B4 series airplanes. This action requires determining the part and amendment numbers of the variable lever arm (VLA) of the rudder control system to verify the parts were installed using the correct standard and corrective actions, if necessary. This action is necessary to prevent failure of both spring boxes of the VLA due to corrosion damage, which could result in loss of rudder control and consequent reduced controllability of the airplane. This action is intended to address the identified unsafe condition.

DATES: Effective November 13, 2001.

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(19) [Docket No. 2001-NM-287-AD; Amendment 39-12464; AD 2001-20-16]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319 and A320 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD) that is applicable to certain Airbus Model A319 and A320 series airplanes. This action requires revising the Airplane Flight Manual to advise the flight crew of performance corrections necessary to ensure adequate runway lengths for certain takeoff and landing conditions. This action is necessary to prevent the airplane from departing the end of the runway during a landing or a rejected takeoff due to reduced braking performance.

DATES: Effective October 26, 2001.

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(20) [Docket No. 2001-NM-282-AD; Amendment 39-12454; AD 2001-20-06]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 and B4 Series Airplane, and Model A300 B4-600, B4-600R, and F4-600R (Collectively Called A300-600) Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment supersedes an existing **airworthiness** directive (AD), applicable to certain Airbus Model A300 B2 and B4 series airplanes, and certain Model A300 B4-600, B4-60-R, and F4-600R (collectively called A300-600) series airplanes, that currently requires a one-time inspection to detect cracks in gear rib 5 (let and right) of the main landing gear (MLG) attachment fittings at the lower flange and vertical web, and repair if necessary. This amendment revises the applicability by including additional airplanes. The actions specified in this AD are intended to detect and correct fatigue cracking of the MLG attachment fittings, which could result in reduced structural integrity of the airplane.

DATES: October 19, 2001.

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(21) [Docket No. 2000-NM-246-AD; Amendment 39-12427; AD 2001-18-01]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A340-211 Series Airplanes Modified by Supplemental Type Certificate ST09092AC-D

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to all Airbus Model A340-211 series airplanes modified by supplemental type certificate ST09092AC-D that requires modifying the passenger entertainment system (PES) and revising the Flight Crew Operating Manual. This action is necessary to ensure that the flight crew is able to remove electrical power from the entire PES when necessary and is advised of appropriate procedures for such action. Inability to remove power from the PES during a non-normal or emergency situation could result in inability to control smoke or fumes in the airplane flight deck or cabin. This action is intended to address the identified unsafe condition.

DATES: Effective October 15, 2001.

(22) [Docket No. 2001-NM-263-AD; Amendment 39-12420; AD 2001-17-29]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 and B4 Series Airplanes, and Model A300 B4-600, B4-600R, and F4-600R (Collectively Called A300-600) Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD) that is applicable to certain Airbus Model A300 B2 and B4 series airplanes, and certain Model A300 B4-600, B4-600R, and F4-600R (collectively called A300-600) series airplanes. This action requires a one-time inspection to detect cracks in gear rib 5 (left and right) of the main landing gear (MLG) attachment fittings at the lower flange and vertical web, and repair if necessary. This action is necessary to detect and correct fatigue cracking of the MLG attachment fittings, which could result in reduced structural integrity of the airplane. This action is intended to address the identified unsafe condition.

DATES: Effective September 13, 2001.

(23) [Docket No. 2001-NM-70-AD; Amendment 39-12382; AD 2001-16-13]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Model A330 series airplanes. This action requires a one-time roto-test inspection of fastener holes of certain fuselage joints for cracks and reinforcement of the fuselage between frames 31 and 37.1. If cracks are detected, this action requires a follow-up high frequency eddy current (HFEC) inspection and repair. This action is necessary to prevent fatigue cracking of the fuselage longitudinal buttstrap, which could result in reduced structural integrity of the fuselage. This action is intended to address the identified unsafe condition.

DATES: Effective September 7, 2001.

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(24) [Docket No. 2001-NM-257-AD; Amendment 39-12385; AD 2001-16-16]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330 and A340 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

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SUMMARY: This amendment adopts a new **airworthiness** directive (AD) that is applicable to all Airbus Model A330 and A340 series airplanes. This action requires a one-time inspection to detect cracking of the bogie beams of the main landing gear (MLG), and follow-on actions, if necessary. This action is necessary to detect and correct cracking of the MLG bogie beams, which could result in failure of the beams and consequent loss of the landing gear wheels and brakes, and structural damage to the MLG strut and airframe. This action is intended to address the identified unsafe condition.

DATES: Effective September 7, 2001.

(25) [Docket No. 2000-NM-342-AD; Amendment 39-12377; AD 2001-16-09]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment supersedes an existing **airworthiness** directive (AD), which is applicable to all Model A320 series airplanes, that currently requires repetitive measurements of the deflection of the elevator trailing edge; inspections of the elevator servo controls and their attachments; and replacement of worn or damaged parts, if necessary. This amendment requires periodic inspection of the elevators for excessive freeplay, repair of worn parts if excessive freeplay is detected, and modification of the elevator neutral setting. It also revises the applicability to include additional airplane models. This amendment is prompted by additional reports of severe vibration in the aft cabin of Model A320 series airplanes and studies that indicate that the primary cause is excessive freeplay in the elevator attachments. The actions specified by this AD are intended to prevent excessive vibration of the elevators, which could result in reduced structural integrity and reduced controllability of the airplane.

DATES: Effective September 24, 2001.

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(26) [Docket No. 2001-NM-138-AD; Amendment 39-12383; AD 2001-16-14]
RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new airworthiness directive (AD) that is applicable to certain Airbus Model A319, A320, and A321 series airplanes. This action requires modification of the telescopic girt bar of the escape slide/raft assembly, and follow-on actions. This action is necessary to prevent failure of the escape slide/raft to deploy correctly, which could result in the slide being unusable during an emergency evacuation and consequent injury to passengers or airplane crewmembers. This action is intended to address the identified unsafe condition.

DATES: Effective August 31, 2001.

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(27) [Docket No. 2001-NM-136-AD; Amendment 39-12369; AD 2001-16-01]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330-301, -321, -322, -341, and -342 Series Airplanes, and Model A340 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD) that is applicable to certain Airbus Model A330-301, -321, -322, -341, and -342 series airplanes, and certain Model A340 series airplanes. This action requires repetitive inspections to detect cracking of the aft cargo compartment door, and corrective action if necessary. This action also provides for optional terminating action for the repetitive inspections. This action is necessary to detect and correct cracking of the aft cargo compartment door, which could result in reduced structural integrity of the airplane. This action is intended to address the identified unsafe condition.

DATES: Effective August 21, 2001.

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(28) [Docket No. 2000-NM-383-AD; Amendment 39-12357; AD 2001-15-22]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A319, A320, and A321 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A319, A320, and A321 series airplanes, that requires modifications of route segregation between the low voltage wire bundles of the fuel quantity indicating system and the high voltage wire bundles of the ground power control unit. This amendment is prompted by mandatory continuing **airworthiness** information from a civil **airworthiness** authority. The actions specified by this AD are intended to prevent injection of 115 volt alternating current (VAC) into 28 volt direct current (VDC) wire bundles, which could result in high voltage conditions within the fuel tank and the potential for damage to equipment, electrical arcing, and fuel vapor ignition on the ground. This action is intended to address the identified unsafe condition.

DATES: Effective September 10, 2001.

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(29) [Docket No. 2000-NM-412-AD; Amendment 39-12356; AD 2001-15-21]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A300 B2 and B4; A310; and A300 B4-600, B4-600R, and F4-600R (Collectively Called A300-600) Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A300 B2 and B4; A310; and A300 B4-600, B4-600R, and F4-600R (collectively called A300-600) series airplanes; that require modification of certain components related to the fuel level sensors. This action is necessary to prevent the possibility of overheating of the fuel level sensors, which could lead to the risk of explosion in the fuel tank. This action is intended to address the identified unsafe condition.

DATES: Effective September 10, 2001.

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(30) [Docket No. 2001-NM-195-AD; Amendment 39-12364; AD 2001-15-29]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330-301, -321, -322, -341, and -342 Series Airplanes and Airbus Model A340 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment supersedes an existing **airworthiness** directive (AD), applicable to certain Airbus Model A330-301, -321, -322, and -342 series airplanes and certain Airbus Model A340 series airplanes, that currently requires reinforcement of the wing structure at the inboard pylon rear pickup area. This amendment revises the applicability to include additional airplanes. The actions specified by this AD are intended to prevent fatigue cracking of the bottom skin and reinforcing plate of the wing due to bending, which could lead to reduced structural integrity of the airplane wing. This action is intended to address the identified unsafe condition.

DATES: Effective August 20, 2001.

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(31) [Docket No. 2000-NM-230-AD; Amendment 39-12348; AD 2001-15-14]

RIN 2120-AA64

Airworthiness Directives; Airbus Model A330 and A340 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule.

SUMMARY: This amendment adopts a new **airworthiness** directive (AD), applicable to certain Airbus Model A330 and A340 series airplanes, that requires installation of a retainer device on the attachment pin of the brake torque rod of the main landing gear (MLG). The actions specified by this AD are intended to prevent the attachment pin from fully migrating from the brake torque rod and to prevent the collar from detaching from the MLG; these conditions could result in loss of braking on two wheels and the inability to extend the MLG. This action is intended to address the identified unsafe condition.

DATES: Effective September 5, 2001.

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(32) COMMONWEALTH OF AUSTRALIA *(Civil Aviation Regulations 1998)*, PART 39 - 105
CIVIL AVIATION SAFETY AUTHORITY
SCHEDULE OF AIRWORTHINESS DIRECTIVES
Airbus Industrie A300 and A310 Series Aeroplanes
AD/AB3/88
Amdt 1
Rudder Servo Control Desynchronisation 5/98
Applicability: All Airbus Industrie model A300, A310 and A300-600 aircraft.
Requirement: Check the synchronization of the rudder servo controls in accordance with the instructions of Airbus Industrie Service Bulletins A300-27-188 Rev 2, A310-27-2082 Rev 2 and A300-27-6036 Rev 2 (as applicable). Subject to the results of the desynchronisation check, perform a structural inspection in accordance with the instructions of Airbus Industrie Service Bulletins A300-55-0044, A310-55-2026 and A300-55-6023.
Note: DGAC AD 96-242-208B R2 dated 19 November 1997 refers.

Compliance: Unless previously accomplished, this check must be performed within 500 flight hours, or accumulation of 1300 flight hours from new, whichever is the later, following the effective date of this Airworthiness Directive. The desynchronisation check is to be repeated every 1300 flight hours. Structural checks are to be repeated at the intervals specified in the Airbus Industrie Service Bulletins A300-55-044, A310-55-2026 and A300-55-6023.

This amendment becomes effective on 23 April 1998.

Background: This AD is raised to detect and prevent rudder servo-control desynchronisation which could lead to structural fatigue and adverse aircraft handling quality. The AD also mandates structural inspections to detect the onset of fatigue damage resulting from servo control de-synchronisation. This amendment recognises changes to Service Bulletin revision status and incorporates a new compliance clause. The original issue of this airworthiness directive became effective on 2 January 1997.

(33) Airbus Industrie A300 & A310 Series Aeroplanes

AD/AB3/107 Rudder Trim Control Switch 9/97

Applicability: All models A300-600.

Requirement: Replace control switches P/N 097-023-00 with new switches P/N 097-023-01 in accordance with Airbus Industrie Service Bulletin A300-27-6037. Note 1. AD/AB3/90 is cancelled. Note 2. DGAC AD 97-111-219(B) refers.

Compliance: Unless previously accomplished prior to 14 January 1998. This airworthiness directive becomes effective on 14 August 1997.

Background: The actions required by this AD are to prevent any interference between the 408VU panel and the rudder trim control knob, which could prevent the self recentering of the switch to the neutral position when released, **thus causing a rudder movement up to the maximum deflection, and which could lead to critical flight situations**. AD/AB3/90 required an ongoing compliance whenever the switch was replaced. This AD supersedes AD/AB3/90 and constitutes terminating action for that AD.

(34) DEPARTMENT OF TRANSPORTATION Federal Aviation Administration 14 CFR Part 39 [64 FR 43061 No. 152 08/09/99][Docket No. 99-NM-189-AD, Amendment 39-11249, AD 99-16-14]RIN 2120-AA64Airworthiness Directives; Airbus Model A300, A310, and A300-600 Series AirplanesAGENCY: Federal Aviation Administration, DOT. ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new airworthiness directive (AD) that is applicable to all Airbus Model A300, A310, and A300-600 series airplanes. This action requires a one-time inspection of the autopilot systems for proper engagement to determine if the main electro valve electrical connectors of the yaw, roll, and pitch autopilot actuators are correctly installed; and corrective actions, if necessary. This amendment is prompted by issuance of mandatory continuing airworthiness information by a foreign civil airworthiness authority. The actions specified in this AD are intended to prevent erratic movements of the ailerons, elevator, and/or rudder that are commanded by discrepant autopilot actuators, which could result in reduced controllability of the airplane. DATES: Effective August 24, 1999. SUPPLEMENTARY: **This condition, if not corrected, could result in uncommanded deflections of the ailerons, elevator, and/or rudder, which could result in reduced controllability of the airplane.**

OPERATING MANUAL: L/G UNSAFE INDICATION

L/G UNSAFE INDICATION

If Landing Gear Handle is Selected DOWN

If the gear is extended at speeds near V_{LO}, deceleration may be required obtain a satisfactory gear door uplock.

■ **If green light(s) extinguished on both panels:**

L/G NOT DOWN LOCKED

L/G GRAVITY EXT [LAND 4] .... PERFORM

▪ **If unsuccessful:**

LDG WITH ABNORM L/G PROC [LAND 1].................... APPLY

■ **If green light extinguished on one panel:**

L/G POS DET SYS 1 (2) FAULT

[The unsafe indication on the other panel is spurious.]

L/G POS DET SYS.. SYS 2 (1)

[Select other detection system.]

NOTE

If one gear remains unlocked, perform turns to increase load factor and perform alternating side slips in an attempt to lock the gear. Prior to performing any side slip maneuver, ensure all Flight Attendants and passengers are seated.

■ **If nose gear indication unsafe on overhead panel only;**

GPWS "TOO LOW GEAR" WARNING................................. DISREGAR

If Landing Gear Handle is Selected UP

■ **If red light(s) illuminated on both panels:**

L/G NOT UP LOCKED

MAX SPD 270

L/G...DOWN

FUEL CONSUMPTION INCREASED

[Flight with extended gear has a significant effect on fuel consumption and climb gradient.]

■ **If red light(s) illuminated on one panel:**

[If light(s) are illuminated on one panel, but indications are normal on the other panel, the unsafe indication is spurious.]

L/G POS DET SYS 1 (2) FAULT

L/G POS DET SYS.. SYS 2 (1)

[Select other detection system.]

Enclosure 4

UNCOMMANDED RUDDER/YAW DAMPER INCIDENTS

(1) Jan/1990: A/C #68 (JFK—STT) Multiple system failures including continuous stick shaker, loss of flight instruments, no landing gear or flap indications, and **continuous uncontrollable rudder deflections**. Crew deviated to Bermuda using raw data and stand-by instruments. On landing, A/C experienced significant yawing moment that caused it to depart or almost depart the runway.

(2) Mid-late 1990: On takeoff from AUA, A/C experienced **significant yawing** to left. Takeoff aborted and A/C departed or almost departed the runway. First Officer on this flight, who related this incident, is currently LGA-based 777 Captain.

(3) May 1995: Airbus has advised the NTSB that a FedEx Airbus experienced large rudder deflections, but not rudder reversals. The deflections were the result of a rudder trim/autopilot interaction.

(4) Aug/1996: Airbus experienced a variety of problems with control. Event included a stuck throttle at climb power and was accompanied by an apparently unrelated **pitot-static problem** that caused multiple instrument system failures. *Worthy of note: computers that may cause uncommanded control inputs receive their airspeed and altitude information through the pitot-static system. (A small static port pressure discrepancy can have a large effect on ADC-sensed airspeed. Those sensed airspeeds control yaw-damper action and rudder ratio limiting - at any one point in time.)* (ASRS #345226)

(5) Aug/1996: Service Difficulty Report was filed (#199610100087. A300B4622R.) A/C serial number 743. N88881. Flight C1-618. **Rudder Travel Systems 1 and 2 fault**. Rudder travel actuator changed. ARTF Feel Limiting Computer changed. 309CY1 and 309CY2 Relay changed. Functional test OK per A300-600R AMM 27-23-00. Ref. page 51, FAA/King A300 SDR Datarun 12/18/01.

(6) Sep/1996: A/C started to **shake and yaw with rudder pedal movement** shortly after leveling at FL 310. A/C slowed down and flight characteristics returned to normal. Emergency declared and overweight landing made at SJU. ASRS 347914 (page 10)

(7) Oct/1999: SDQ-JFK. A/C experienced **uncommanded "rudder jolt"** (NTSB #DCA99SA090)

Enclosure 5a

(8) May /1999: A/C #82 (BOG – MIA) A/C experienced significant **uncommanded rudder inputs** on final. (NTSB # DCA99IA058) *FAA issued AD to perform wiring inspections.*

(9) Dec/2000: A300F4605R. Federal Express, N674FE. At FL 310, A/C began to experience **flutter type vibration** as cruise power was set. Auto pilot was engaged/disengaged and vibration continued. Turned one yaw damper off at time, vibration continued. When both yaw dampers turned off, vibration stopped. Ref. page 182, FAA/King A300 SDR Datarun 12/18/01. No FAA OR NTSB Accident/Incident Reports found. Service Difficulty Report: #200101120692

(10) Unk/2000: Departing LHR experienced what the crew described as **"excessive yawing incident"** that resulted in the aircraft returning to LHR. (AAIB reference #EW/C2000/6/10 - Category: 1.1) *Investigators still insist that crew encountered only wake turbulence!*

(11) Nov/2001: A/C #051 (JFK—SDQ). AA587 Results well-documented, investigation ongoing. Heading changed radically in an extremely rapid fashion in the lateral axis just before the crash. (NTSB #DCA02MA001)

(12) Nov/2001: A/C #055 (Departing Lima) Crew experienced **uncommanded rudder inputs**. Returned to Lima and A/C remained there for approximately 1 week. (NTSB# DCA02WA011)

(13) Dec/2001: A/C #054 (approach to MCO) A/C experienced **"rudder pulsing"**.

(14) Jan/2002: A/C #051 (MIA – CCS) Crew experienced significant **uncommanded rudder inputs** on departure climbing through 10,000. While accelerating through 290 knots the pilots experienced **"smooth, uncommanded yawing"** that caused 2L/2R doors to **"buckle and pop".** After slowing to L/D Max, aircraft returned to MIA and made an uneventful landing.

(15) Jan/2002: A/C #051 (MIA – CCS) Same aircraft, different crew experienced **uncommanded rudder inputs** after having both FAC and a yaw damper servo actuator replaced the previous night in MIA. The aircraft continued to CCS. It was ferried to back to MIA and then on to TUL.

(16) Jan/2002: A/C #061 (departing SJU). Crew experienced **uncommanded "rudder jolt".**

(17) Jan/2002: A/C #061 (EWR – JFK). Crew experienced an **uncommanded "rudder thump or kick"** at 50 feet that **"moved the whole aircraft 5 or 10 feet from side to side".**

Enclosure 5b

(18) Jan/2002: A/C #061 (JFK – TUL). During the test flight the **#1 yaw damper would not reset** after tripping.

(19) Feb/2002: FedEx A300-600 was inspected at a Memphis, Tennessee hangar and was found to have a **bent rudder control rod and delamination in the tail**. The hydraulic system was pressurized and the rudder was depressed. Mechanics observed **oscillation in the rudder** and heard a loud "bang" that was described as **"a sound like a shotgun"**. **Rudder oscillations** occurred in flight subsequent to a control rod change and maintenance signoff.

After the resolutions of the last three events, AA has taken a new tack: remove parts of the yaw and rudder system, replace them--along with an engine--and then tell the press that it was "just" an engine problem.

(20) Feb/2002: A/C #080 (SJU – JFK). On climbout, pilots reported a **large, uncommanded yawing motion** upon #2 autopilot engagement.

(21) Mar/2002: <u>This malfunction occurred on March 18, 2002</u>

AC 061 AA PIR.46 SYS 2250
ARM CODE: 22210399 MSG NBR: 02200566
MDIS.18MAR/MIA T-0934 EMPL 052119

Aircraft fishtails during all phases of flight, especially noticeable during entire climb to cruise altitude. No feel in pedals but can occasionally see rudder movement on ECAM. This was observed in smooth air. Also during approach more than one large abrupt uncommanded rudder input.

These are the only incidents we were able to find given limited time and resources. It is reasonable to assume that there were many others not found or reported.

EXTRACT FROM PINK BULLETEN 300-1-90

'Land as Soon as Practical'

AA Issued June 3, 1999, to all American Airlines A300 captains and first officers (extracts)

Subject: Uncommanded Flight Control Inputs

Background: In a recent incident an A300 experienced uncommanded rudder inputs which included rudder deflections up to 12 degrees. Post-incident investigation determined the rudder inputs were caused by a failure of the autopilot yaw actuator to disengage when the autopilot was disconnected … These actuators are only powered by the Green and Yellow hydraulic systems; the Green system is associated with Autopilot 1 and the Yellow system is associated with Autopilot 2. Indications of this type of failure are random flight control surface deflections accompanied by higher than normal control forces.

In the case of uncommanded flight control inputs with the autopilot selected off, accomplish the following:

CAUTION

The rudder is not controlled by the autopilot with the slats retracted. If abnormal rudder control ceases upon slat retraction without deselection of either the Green or Yellow SERVO CTL, be alert for possible uncommanded rudder inputs upon subsequent slat extension.

GREEN SERVO CONTROL SWITCH……………..…..…OFF

- If normal flight behavior returns:
  Leave Green Servo Control Switch OFF for remainder of flight.
  LAND AS SOON AS PRACTICAL [Emphasis in original]
- If abnormal flight control behavior continues:
  GREEN SERVO CONTROL SWITCH………....ON
  YELLOW SERVO CONTROL SWITCH……….OFF
- If normal flight control behavior returns:
  Leave Yellow Servo Control Switch OFF for remainder of flight.
  LAND AS SOON AS PRACTICAL
- If abnormal flight control behavior continues:
  YELLOW SERVO CONTROL SWITCH………..ON
  LAND AS SOON AS PRACTICAL

Source: AA A300 bulletin No. 300-1-90 ■

Enclosure 6

OPERATING MANUAL:
UNCOMMANDED FLIGHT CONTROL INPUTS

Uncommanded Flight Control Inputs

CAUTION

The rudder is not controlled by the autopilot with the slats retracted. If abnormal rudder control ceases upon slat retraction without deselection of either the Green or Yellow SERVO CTL, be alert for possible uncommanded rudder inputs upon subsequent slat extension.

GREEN SERVO CONTROL SWITCH..OFF

■ **If normal flight control behavior returns:**

Leave Green Servo Control Switch OFF for remainder of flight.

LAND AS SOON AS PRACTICAL.

NOTES

- AP 2 is available as required, however, turn AP 2 OFF and conduct controllability check prior to commencing approach.
- The following equipment is lost with the Green Servo Control Switch OFF:
  - AP1
  - PITCH FEEL 1
  - SPLR 6

■ **If abnormal flight control behavior continues:**

GREEN SERVO CONTROL SWITCH..ON

YELLOW SERVO CONTROL SWITCH...OFF

■ **If normal flight control behavior returns:**

Leave Yellow Servo Control Switch OFF for remainder of flight.

LAND AS SOON AS PRACTICAL.

NOTES

- AP 1 is available as required, however, turn AP 1 OFF and conduct controllability check prior to commencing approach.
- The following equipment is lost with the Yellow Servo Control Switch OFF:
  - AP2
  - PITCH FEEL 2
  - YAW DAMPER 2
  - SPLR 2,3,5

LDG DIST (MISC 25)...MULTIPLY BY 1.3

■ **If abnormal flight control behavior continues:**

YELLOW SERVO CONTROL SWITCH..ON

LAND AS SOON AS POSSIBLE.

(END)

Enclosure 7

WAKE TURBULENCE INCIDENTS

9-2-99: *NTSB Identification:* **LAX99LA291** .
The docket is stored in the (offline) NTSB Imaging System.
Scheduled 14, CFR Part 121 operation of Air Carrier
UNITED AIRLINES, Inc.
Accident occurred Thursday, September 02, 1999 at
SANTA BARBARA, CA
Aircraft: Boeing 737-322, registration: N371UA
Injuries: 1 Serious, 14 Minor, 98 Uninjured.

-- 737 encountered left roll with corresponding changes in pitch.

8-7-98: *NTSB Identification:* **NYC98IA165**
Scheduled 14, CFR Part 121 operation of Air Carrier USAIRWAYS, INC.
Incident occurred Friday, August 07, 1998 at MCCONNELLSBURG, PA
Aircraft: Boeing 737-300, registration: N515AU
Injuries: 10 Minor, 122 Uninjured.

737 encountered wake for 2-3 seconds. Roll rate to the right was slow at first, like the autopilot was fighting it (the autopilot was on), to 15 to 20 degrees then it quickened. The FDR showed right wing down to 37 degrees within 2 seconds and reached a maximum left roll angle of -27 degrees. Total 14 seconds left wing down, then right wing down between 4 and 6 degrees.

4-18-98: *NTSB Identification*: **NYC98FA094**
The docket is stored in the (offline) NTSB Imaging System.
Scheduled 14, CFR Part 121 operation of Air Carrier TOWER AIR INC.
Accident occurred Saturday, April 18, 1998 at ATLANTIC OCEAN, AO
Aircraft: Boeing 747-200, registration: N623FF
Injuries: 2 Serious, 18 Minor, 399 Uninjured.

The data during the 3 seconds prior to the incident show the vertical acceleration and pitch decreasing as altitude and airspeed are increasing. Within a 2 second period the vertical acceleration fluctuated suddenly from .72 g's to -.45 g's to 1.39 g's. During this time, the autopilot command B disengaged and the autopilot manual B engaged. The cockpit shows the least amount of disturbance bottoming at 0g's. The vertical acceleration at the CG registers -.45g's, row 50 shows -.68g's, row 55 shows -.77g's and the aft end zone E registered -1.0g's.

Enclosure 8a

5-16-96: *NTSB Identification*: **ANC96FA072**
The docket is stored in the (offline) NTSB Imaging System.
Nonscheduled 14, CFR Part 121 operation of Air Carrier
FEDERAL EXPRESS
Accident occurred Thursday, May 16, 1996 at ANCHORAGE, AK
Aircraft: McDonnell Douglas MD-11-F, registration: N614FE
Injuries: 1 Minor, 1 Uninjured.

At subframe 2975, the airplane began a slight roll to the left reaching 3.52 degrees. The roll rate decreased and the airplane then began a roll toward the right.

At subframe 2976, the vertical acceleration decreased to 0.84 g's and returned to 1.11 g's in subframe 2977. It then began decreasing once again. The airspeed began increasing from 151 knots.

At subframe 2978, the thrust resolver angles began decreasing in response to the autothrottle commands. The lower rudder began moving toward 7.47 degrees trailing edge left and then began moving toward the right. The airplane experienced a lateral acceleration to the left of 0.09 g's. The airspeed reached 158.5 knots and then began decreasing. In subframe 2978 and 2979, the number 1 and number 2 angle of attack indicators displayed about a 3 degree difference in their respective values.

At subframe 2979, the right roll reached 8.09 degrees right wing down. The vertical acceleration moved upward from a low of 0.65 g's. The thrust resolver angle for engine number 2 and 3 increased in subframe 2980 to 85.80 degrees. The elevators began to deflect toward 22.85 degrees trailing edge up.

At subframe 2981, the pitch angle of the airplane reached 11.6 degrees nose up. A vertical acceleration spike of 2.6 g's occurred. The thrust resolver angle decreased to previous settings. The lower rudder reached 23.38 degrees trailing edge to the right. The airplane was near wings level and on a 249.7 degree heading.

From subframe 2982 to 2984, the elevators were deflected to 15.47 degrees trailing edge down and then toward 22.59 degrees trailing edge up. The pitch angle of the airplane decreased to 2.11. From subframe 2282 to 2985, the left wing spoilers reached 34.13 degrees. The right wing spoilers reached 28.41 degrees. Both wing spoilers then began to retract.

At subframe 2984, a second vertical acceleration spike of 3.03 g's occurred

From subframe 2985 through 2988, the elevators were deflected in a similar manner as subframe 2982 through 2984 but to a lesser degree.

At subframe 2987, a third vertical acceleration spike of 1.77 g's occurred.

At subframe 2990, the nose gear compressed.

Examination of flight data revealed an average descent rate of approximately 1,380 feet per minute during the last 20 seconds of the landing approach. The average airspeed was 152 knots. Calculation of the descent angle of the airplane, based on the above averages, indicated a flight path angle of 5.12 degrees.

1-1-95: *NTSB Identification*: **FTW95IA083**
The docket is stored in the (offline) NTSB Imaging System.
Scheduled 14, CFR Part 121 operation of Air Carrier
SOUTHWEST AIRLINES CO.
Incident occurred Sunday, January 01, 1995 at HOUSTON, TX
Aircraft: BOEING 737-3A4, registration: N326SW
Injuries: 66 Uninjured.

Airplane then rolled into a 30 degree left bank and the copilot applied full right aileron, but the roll continued to the left. The captain took control of the airplane and applied right rudder as he maintained the aileron input. Control was regained and the remainder of the flight was normal.

COMMENTS OF DAVID MAASS

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‣ **Airbus position on flaw growth:** "The certification test program, followed by in-service experience, has DEMONSTRATED that 'allowable' flaws DO NOT grow in fatigue. Flaws beyond 'allowable' MAY grow, MAY adversely affect residual strength, which is why they MUST be repaired before being placed in service."

Maass: "The damage tolerance testing that Airbus performed is exactly the kind of information necessary to determine whether or not composite flaws have been at the root of this [Flight 587] accident. The certification tests that were conducted on the A300 tail verify that *in the specific case* [emphasis on original] of flaws simulated, they believe they have demonstrated that certain size flaws – and associated flaw types and locations – do not propagate. However, it is not generally true that *any* concealed damage will not grow.

"The Airbus position seems to be that their data tells them, 'If you can't see 'em, don't worry about 'em.' The Airbus qualification data may support that [contention] and, in fact, when the A300 was originally qualified, the DGAC [**Direction Générale de l'Aviation Civile**] and FAA [**Federal Aviation Administration**] apparently agreed. This would not be the first time, however, that closer re-examination of original certification data (in light of an unexplained accident or after close to 20 years of additional industry experience with composites) *may* shed new light on the data."

‣ **Airbus position on ultrasonic testing:** "Our point regarding the difficulty of doing ultrasonic inspections in a field environment referred specifically to the [tail] fin and attach[ment] structures … the geometry of these fittings is complex, to the point where there is very little area of constant thickness …"

Maass: "Geometry and thickness effects are important considerations to get a meaningful test result. Without known the details of the structure, it is difficult to judge the complexity of the inspection. That said, it is worth noting that many, if not most, composite or metal aircraft parts are not constant thickness. Thickness is tailored to the local strength and stiffness requirements in any weight-sensitive structure. Composites by their nature are produced by ply (or layer) by ply, where more plies (thickness) are used in more highly loaded regions (like the attachment lugs on the A300 tailfin). The ability to tailor thickness to local loads is one way that composites provide significant weight savings in aerospace structures.

"If varying thickness were to preclude (or drastically limit) the use of ultrasonic inspection, then it would have a very limited application in critical aircraft structure, metal or composite. That is not the case, however. Typically, calibration standards are prepared with simulated flaws and varying thickness to verify the setup and confirm that machine settings and operator technique are proper for the thickness and flaw size variations of interest.

Enclosure 9a

"In regions of widely varying thickness, it is not unusual to use different setups for different zones under inspection to account for thickness variations. In other words, different gain, gate, and threshold settings would be used n the lug section of the skin (which is about an inch thick) compared with the outboard tip (which might be on the order of 0.10 or 0.20 inches thick). Yes, that does make the inspection more complicated, lengthy and costly, but it's a question of the cost/benefit vis-à-vis the quality of the flaw information obtained (versus a visual Go – No go).

"In the case of the fin, my understanding based on photos and what has been reported is that the lug area that failed is integral with the skin. In this case, the region of interest is directly accessible from the exterior surface. The Airbus point that it is difficult to inspect underling *mating parts* in a complex assembly (because of the acoustic impedance mismatch and loss of ultrasonic energy at the boundary) is well taken, but it does not appear to be relevant with respect to ultrasonic field inspection of the *exterior* skin. Structure beneath the skin would be difficult to inspect from the exterior without disassembly, but the skin (including the built-up lug) would not be difficult to access or to "see" ultrasonically. Perhaps my understanding of the structure in this region is incorrect. If so, I look forward to being corrected.

‣ **Airbus on the United Airlines [UAL] ultrasonic test result:** "The United 'finding' … was 'noteworthy' only because it was found. It was, in effect, a false positive…"
Maass: "In the United case, what we have is simply a field inspection that detected a flaw, which was brought to Airbus' attention to seek disposition instructions. That is not a 'false positive.' That is a flaw discovered by NDT (non-destructive testing) that Airbus deemed acceptable based on their engineering data. In other words, Airbus deemed it a subcritical flaw (below critical size) that they do not expect to grow.

"This is more than a semantic argument. A false positive in a [cockpit] warning system can be dangerous because it can condition people to ignore or discount the warning system.

"*Field inspection of the fleet is completely different*, especially when an accident has just occurred where an unprecedented structural failure has occurred. In such a case, operators want to detect *any* sign of possible damage and incipient failure. It's a *one-time event*, not something that would be expected to frequently ground good airplanes (as false positives on warning systems are wont to do). I understand Airbus' stated rationale for relying upon visual-only inspections, and I suppose it was on this basis that the FAA ordered visual and 'coin-tap' inspections. Given that NDT is routinely performed, and the far greater information it provides, it surprised me and *every other composites engineer I know* that its use is not even suggested, let alone not mandated, under the circumstances.

"If the one and only field NDT of an A300 tail immediately located flaws, acceptable or not, does it not stand to reason that the likelihood of detecting other flaws in the fleet is high? These flaws may be acceptable, maybe not. But the statistical value of knowing what flaws exist, where they exist, and whether or not they've grown could be of immense value. Remember that – to the best of my knowledge – the qualification tests with simulated flaws were run on only one unit. Who is to say what subtle changes in these flaws and locations may or may not be significant?"

Enclosure 9b

‣ **Airbus on NDT as a supplement:** "We do recommend ultrasonic inspection as a supplement to visual inspection, so we know that with proper training and equipment one can get reliable, consistent results."
Maass: "I'm glad to hear it."

‣ **Airbus on United's finding:** "The damage found on the UAL airplane was the same recorded at the factory …"
Maass: "In this instance, Airbus expresses no concern about NDT consistency, i.e., between their factory NDT results and the United field NDT results performed eight years later with different operators and different equipment. Airbus treats NDT consistency two different ways, depending upon the point they wish to make:

- Field NDT is too inconsistent, so it is not recommended to inspect the composite tail.
- The close agreement between Airbus and United field NDT results verifies Airbus' contention that small flaws show zero growth rate over a long service period.

There may be a perfectly good rationale, but I find it odd to advocate both positions simultaneously."

‣ **Airbus on confidence in composites:** "We, indeed the entire industry, cannot afford to have a cloud left hanging over composite structures."
Maass: "I strongly agree and support Airbus' desire to get to the bottom of this. As a 'composites guy,' it does me and my industry no good to have lingering doubts about the adequacy of the materials, manufacturing processes, inspection methods, engineering practices or certification standards.

"I am by no means trying to raise unrealistic concerns or unlikely scenarios. Rather, many of us in the composites community seek to understand exactly what happened. In the best case for composites (which remains to be seen), these facts will *confirm* that composites can definitively be *ruled out*." ✈

COMMENTS FROM G. RICHARD SHARP (Reprinted with permission)

Note: These comments apply specifically to the attachment of the vertical stabilizer to the airframe structure.

Certification method:

Was the attachment of the tailfin to the structure certified by test or analysis? What was the certification loads criteria and how were they determined? Did the loads take into consideration a dynamic loading criteria as described above or did only the engine out control criteria determine them?

If the vertical stabilizer attachment was certified by analysis using a finite element analysis computer program as I think it may have been, then what did the finite element analysis model of the attachment fitting take into consideration?

From the photographs that appeared in Aviation Week, it appears that the composite at the attachment points consisted of plies of unidirectional Graphite Fiber Reinforced Plastic (GFRP) that were positioned at very acute angles to each other so as to maximize the tensile strength along the length of the spar.

However, at the base of the attachment fitting where the pin passes through, the tension stress component circumferential to the pin is pulling the GFRP plies apart where they have the least amount of tensile strength because the fibers are positioned at very oblique angles to each other in the adjacent plies. On top of this, the tensile stress due to the pre-loading of the joint by the tapered sleeve must be added to the applied load tensile stress. Was this changing of the tensile strength property of the composite as a function of the position around the pin taken into consideration in the finite element analysis model of the pinned joint?

In the somewhat distant past, aircraft were designed using parameters developed empirically from test structures by the NACA. Bruhn, in "Analysis and Design of Flight Vehicle Structures, January, 1965" shows a graph on page C13.12, Fig. C13.20 that graphs the stress concentration factor as a function of edge distance from the pin centerline to the bottom side of the fitting. The graph shows that for an H/D ratio of 0.5 and a d/D ratio of approximately 0.35 the stress concentration factor should be 3.5! What stress concentration factor was applied in checks of the original vertical stabilizer finite element computer analysis? Here, H is the pin centerline to part edge distance, d is the pin diameter and D is the distance across the fitting at the pin. d, D and H were measured approximations from photographs in the November 19, 2001 issue of Aviation Week.

Enclosure 10a

Comparison of the A300-600 vertical stabilizer attachment to that of the Boeing 777:

Airbus uses six attachment pins to attach the GFRP vertical stabilizer directly to the fuselage structure. These pins run directly through the composite material. While this may be ideal from a maintenance point of view, it is not from a structural redundancy point of view.

The Boeing attachment by contrast uses very many fasteners in shear to attach the vertical stabilizer spars to very elaborate (strong) metal fittings that are attached directly to main fuselage bulkheads. This is the same design that has been used in the past to attach metal vertical stabilizers to Boeing aircraft. The conservatism in this design was probably developed as a result of a partial vertical stabilizer loss to a B52 when crossing a mountain range. Here, enough of the tail fin was left that the pilots were able to make a safe landing. When dynamic loads are encountered, structural redundancy can be of paramount importance.

Conclusions and Recommendations:

1. In the best of all worlds, I believe the vertical stabilizer and its attachment to the fuselage should be redesigned and all suspect vertical stabilizers replaced.
2. At the very least, a new loads analysis using dynamic gust loads as well as the original criteria should be performed.
3. The existing pin joints and their surrounding structures should be reanalyzed using these new dynamic gust side loads. Special attention should be paid to the forward attach fittings.
4. Personally, I do not believe it will be possible to “beef up” this design to an acceptable safety level without creating other problems. Metal doubler plates might have thermal miss-match or galvanic corrosion problems. Application of new composite material to the existing tail fins would need to be done at high temperature in an autoclave to get reliable adhesion. I just don’t know what I could recommend to salvage this design.