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Ineffective Tail-strike Repair Preceded Boeing 747 Breakup

Investigators said that published procedures were not followed when the repair was performed more than 20 years before a structural failure occurred and the aircraft broke apart during flight.

FSF Editorial Staff

About 1528 local time on May 25, 2002, a Boeing 747-200 that was being operated by China Airlines (CAL) as Flight CI611 on a scheduled flight from Taipei, Taiwan, China, to Hong Kong, broke up at 34,900 feet while being flown to Flight Level 350 (approximately 35,000 feet) and struck the Taiwan Strait approximately 23 nautical miles (43 kilometers) northeast of Makung, Penghu Islands. Of the 225 occupants, 175 occupants were killed; the other occupants were missing and were presumed to have been killed in the accident.

The final report on the accident by the Aviation Safety Council (ASC) of Taiwan, China, said that the following were findings related to probable causes:

- "The in-flight breakup of CI611, as it approached its cruising altitude, was highly likely due to the structural failure in the aft lower lobe section of the fuselage [i.e., where the belly of the aircraft begins to curve upward toward the tail];
- "[On] Feb. 7, 1980, the accident aircraft suffered a tail-strike occurrence in Hong Kong. The aircraft was ferried back to Taiwan [China] on the same day, unpressurized, and a temporary repair was conducted the day after. A permanent repair was conducted on May 23 through 26, 1980;
- "The permanent repair of the tail strike was not accomplished in accordance with the Boeing SRM [structural repair manual], in that the area of damaged skin in Section 46 was not removed (trimmed) and the repair doubler [a piece of sheet metal placed against the skin to provide stiffness and/or additional strength] did not extend sufficiently beyond the entire damaged area to restore the structural strength;
- "Evidence of fatigue damage was found … under the repair doubler near its edge and outside the outer row of securing rivets. Multiple-site [fatigue] damage (MSD) [the simultaneous presence of multiple fatigue cracks in a single structural element], including a 15.1-inch [38.4-centimeter] main fatigue crack and some small fatigue cracks, [was] confirmed. The 15.1-inch crack and most of the MSD cracks initiated from the scratching damage associated with the 1980 tail strike incident;

- "Residual strength analysis [conducted to determine the maximum damage that can exist before a structure no longer can meet maximum load requirements] indicated that the main fatigue crack in combination with the [MSD was] of sufficient magnitude and distribution to facilitate the local linking of the fatigue cracks so as to produce a continuous crack within a two-bay region (40 inches [102 centimeters]). Analysis further indicated that during the application of normal operational loads, the residual strength of the fuselage would be compromised with a continuous crack of 58 inches [147 centimeters] or longer length. Although the ASC could not determine the length of cracking prior to the accident flight, the ASC believes that the … fretting marks found on the doubler and the regularly spaced marks and deformed cladding found on the fracture surface suggest that a continuous crack of at least 71 inches [180 centimeters] in length — a crack length considered long enough to cause structural separation of the fuselage — was present before the in-flight breakup of the aircraft; [and,]

- "Maintenance inspection of B-18255 [the accident aircraft] did not detect the ineffective 1980 structural repair and the fatigue cracks that were developing under the repair doubler. However, the time that the fatigue cracks propagated through the skin thickness could not be determined."

The report said that the following were among other findings of the investigation:

- "The possibilities of midair collision, engine failure or separation, cabin overpressurization, cargo-door opening, adverse weather or natural phenomena, explosive device, fuel-tank explosion, [and] hazardous cargo or dangerous goods were ruled out as [factors in] this in-flight breakup accident; [and,]

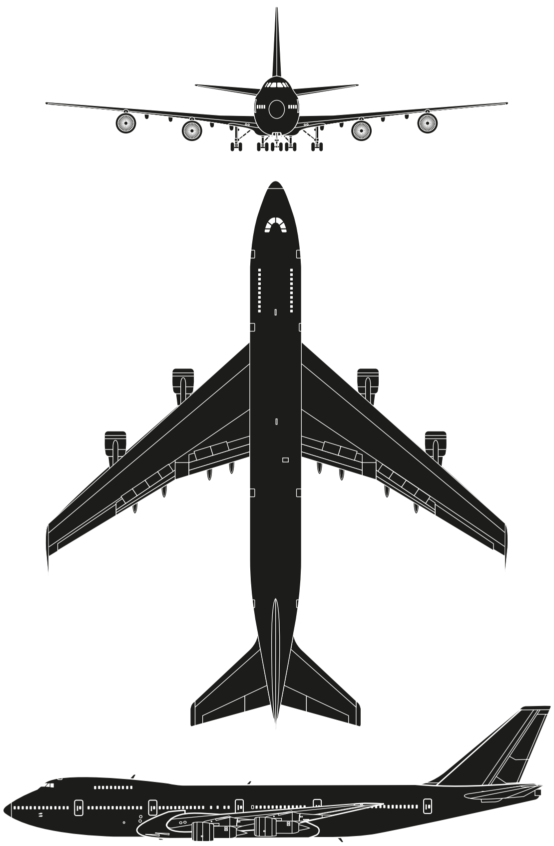
- "There was no indication of penetration of fragments, residual chemicals or burns that could be associated with a high-energy explosion or fire within the aircraft."

The accident aircraft was manufactured and was acquired by CAL in 1979. The aircraft had accumulated 64,810 flight hours and 21,398 cycles at time of the accident.

A preliminary inspection of the aircraft after the tail strike in 1980 found abrasion damage on two areas of the skin on the bottom of the aft fuselage. The aft water-drain mast was detached, and the door on the left outflow valve was cut.

The airline's records indicate that the temporary repair performed at Taipei included a "close visual inspection … for any defect inside the abraded skin," installation of two doublers in the abraded areas, installation of an aft water-drain mast and a temporary repair of the cut outflow-valve door.

The Boeing field service representative (FSR) assigned to provide technical assistance to CAL in 1980 told investigators that he consulted with the airline's chief engineer during the temporary repair but did not monitor, and was not required to monitor, the permanent repair.



Boeing 747-200

The first flight of the Boeing 747 wide-body transport was made in 1969. The first production model, the B-747-100, entered commercial service in 1970; the airplane accommodates three flight crewmembers and up to 500 passengers.

The B-747-200, which entered commercial service in 1971, has the same accommodations as the earlier model but has higher maximum takeoff weights (775,000 pounds [351,540 kilograms], basic) and greater fuel capacities (52,410 gallons [198,372 liters], basic).

Standard engines include General Electric CF6-50E2s (52,500 pounds [234 kilonewtons] thrust each), Pratt & Whitney JT9D-7R4G2s (54,750 pounds [244 kilonewtons] thrust each) and Rolls-Royce RB211-524D4s (53,110 pounds [236 kilonewtons] thrust each).

Cruise ceiling is 45,000 feet. Equipped with JT9D-7 engines, maximum cruise speed at 30,000 feet is 527 knots, and maximum range with reserves is 6,550 nautical miles (12,131 kilometers). Basic maximum landing weight is 564,000 pounds (255,830 kilograms).♦

Source: *Jane's All the World's Aircraft*

The aircraft logbook indicated that the permanent repair was performed according to the SRM. No other records were available to investigators. CAL said that the records-storage area had been moved several times since 1980 and that the records of the temporary repair and permanent repair of the tail-strike damage could not be found.

"Due to the lack of detailed maintenance records for both the temporary [repair] and permanent repair in 1980, the [ASC] was unable to determine how the repairs were actually conducted," the report said. "Therefore, the analysis of the repair planning and workmanship is based primarily on the results of the wreckage examination."

The examination showed that the permanent repair was not performed according to the SRM. The SRM specified limits on the amount of "cleanup" of fuselage skin that could be performed to remove scratches and other damage (e.g., cracks, corrosion, punctures, etc.). For example, the maximum depth of cleanup of a scratch longer than 11 inches (28 centimeters) was 15 percent of the original skin thickness. If cleanup could not be performed within the specified limits, the SRM required either replacement of the damaged skin or removal (trimming) of the damaged skin and installation of a doubler over the trimmed area. The SRM said that the doubler had to extend beyond the trimmed area by at least three rows of rivets.

"Instead of either of these acceptable options, a doubler was installed over the scratched skin," the report said. "In addition, the external doubler did not effectively cover the entire damaged area, as scratches were found at and outside the outer row of fasteners securing the doubler. When the doubler was installed with some scratches outside the rivets, there was no protection against the propagation of a concealed crack in the area between the rivets and the perimeter of the doubler."

"The external doubler did not effectively cover the entire damaged area."

The chief structural engineer employed by CAL when the tail-strike repairs were performed in 1980 told investigators that because the area of damaged skin was large, compliance with the SRM repair instructions would have been difficult. The doubler was 125 inches (318 centimeters) long and 23 inches (58 centimeters) wide.

"Because of this difficulty, they decided not to follow the SRM [requirement] to cut out the damaged skin; rather, they used the method similar to the temporary repair by applying a reinforcement doubler directly onto the damaged skin," the report said. "[The chief structural engineer] stated that he did inform the Boeing FSR of the difficulties [they] encountered and [asked] the Boeing FSR to inform Boeing of the repair method, and no response was received. Since CAL did not receive any response regarding the suggested permanent-repair process, the chief structural engineer considered that Boeing had agreed to the repair."

The FSR said that he was not told about the permanent repair.

"Due to the lack of maintenance records of the accident aircraft, the [ASC] can not make an adequate assessment of what actually happened in communication between CAL maintenance personnel/engineers and the Boeing FSR in 1980 relevant to the permanent repairs of the tail strike," the report said.

The accident aircraft was the second B-747 acquired by CAL. The report said that because the B-747 was a relatively new addition to the airline's fleet, the FSR should have been more proactive in providing technical assistance to the airline.

"If a more proactive approach had been taken, one could have expected questions to the operator about the permanent repair," the report said. "The opportunity to provide expert advice on a critical repair was lost."

The report said that several scratches on the damaged fuselage skin beneath the doubler became fatigue cracks that increased in size with each cabin-pressurization cycle. Examination by ASC investigators of fretting (wear) marks indicated that the main fatigue crack was at least 71 inches long before the breakup occurred. Examination of the wreckage by Boeing indicated that the main fatigue crack was about 93 inches (236 centimeters) long before the breakup occurred.

Investigators found corrosion on the damaged skin near several shear ties, which are located between stringers and connect the fuselage skin to fuselage frames. Some of the corrosion had perforated the skin.

The nondestructive-inspection (NDI) methods typically used by CAL were visual inspections and high-frequency eddy-current inspections [in which electrical current is induced in a metal part by the electromagnetic field of an external coil]. Because the fatigue cracks were beneath the doubler and propagated inward from the exterior surface of the fuselage skin, the cracks could not have been detectable visually until they penetrated the interior surface of the fuselage skin. Maintenance records showed that eddy-current inspections had not been performed on the tail-strike-repair area.

"Moreover, high-frequency eddy-current inspection is not able to detect cracks through a doubler," the report said. "Therefore, the crack would still not be detected if external high-frequency eddy current had been used for structure inspection."

The Civil Aviation Authority of Taiwan, China, (CAA) in 1991 issued an airworthiness directive (AD) requiring operators of Boeing aircraft to incorporate into their aircraft maintenance programs corrosion-prevention-and-control programs (CPCPs) developed by Boeing.

The B-747 CPCP required that the aft lower fuselage be inspected every four years. CAL conducted the first inspection of the aft lower fuselage of the accident aircraft in 1993; the second inspection of the aft lower fuselage, due in 1997, was conducted in December 1998. Thereafter, the airline's CPCP control program began to "deteriorate," the report said; at the time of the accident, 29 CPCP inspections, involving various part of the aircraft, were overdue.

In May 2000, the U.S. Federal Aviation Administration (FAA) adopted regulations requiring U.S.-registered aircraft operators and non-U.S. aircraft operators conducting flights in U.S. airspace to incorporate into their maintenance programs procedures for evaluating repairs previously conducted on fuselage skin, door skin and bulkhead webs in pressurized areas of specific aircraft, including the B-747.

"Repairs are a concern on older aircraft because of the possibility that they may develop, cause or obscure metal fatigue, corrosion or other damage during service," the report said. "The objective of the RAP [repair-assessment program] is to ensure the continued structural integrity of the repaired [structure] and adjacent structure."

CAL established a RAP for the five B-747s in its fleet in May 2000. In November 2001, the airline photographed all 31 doublers on the accident aircraft's fuselage skin in preparation for the first required RAP inspection in November 2002. The report said that one photograph showed traces of stains on the aft lower fuselage that were an indication of possible hidden structural damage beneath the doubler.

Debris from the ruptured fuselage struck the vertical stabilizer before the empennage separated.

Before reporting for duty on the day of the accident, the three flight crewmembers had been off duty more than 24 hours. The captain, 51, joined CAL as a first officer in March 1991 and was upgraded to captain in March 1997; he had 10,148 flight hours, including 4,732 flight hours in type. The first officer, 52, joined CAL as a first officer in February 1990; he had 10,173 flight hours, including 5,831 flight hours in type. The flight engineer, 54, joined the airline as a flight engineer in March 1977; he had 19,118 flight hours, including 15,397 flight hours in type.

The report said that the aircraft was within weight-and-balance limits when it departed at 1507 from Runway 06 at Chiang Kai Shek International Airport. At 1516, air traffic control (ATC) told the crew to climb to FL 350. The crew's acknowledgement of the instruction was the last radio transmission received from the aircraft.

As cabin pressurization increased during the climb, the fatigue cracks beneath the doubler "reached the length that reduced the residual strength to its operating limits and resulted in an unstable separation, along with a rapid loss of cabin pressure," the report said. Debris from the ruptured fuselage struck the vertical stabilizer before the empennage separated from the aircraft.

"During the breakup process, the abrupt change in aerodynamic characteristics would likely have resulted in significant inertial forces that led to the separation of the engines at altitude," the report said. "All four engines separated from the main fuselage almost simultaneously. … The remaining portion of the aircraft (the forward fuselage and attached wings) was intact and hit the water in a relatively flat attitude."

Search-and-rescue operations were begun when ATC radar contact with the aircraft was lost at 1528:03. At 1800, searchers found wreckage floating on the water.

"The first 82 bodies were found floating on the ocean surface of the Taiwan Strait and were recovered by fishing boats, coast guard [vessels] and military vessels," the report said. "Contracted recovery vessels were subsequently utilized for the recovery of the aircraft wreckage and the remaining victims' bodies. … Most of the victims had extensive injuries, and consistencies were found with head injuries, tibia and fibula fractures, significant back abrasion, pelvic injuries and other more traumatic injuries. In general, most of [the] bodies were nearly intact except for fractured bones."

The results of toxicological tests of the flight crewmembers were negative for illegal drugs and over-the-counter medications.

The report said that until the last 130 milliseconds of the cockpit voice recorder (CVR) recording, the CVR provided no significant information about the accident. Analysis of the sound signature of the last 130 milliseconds of the recording indicated that the breakup began in the pressurized area of the aircraft.

The sources of 31 sounds recorded by the CVR after takeoff were not identified; eight of the unidentified sounds were attributed to CVR tape damage. Moreover, a splice in the tape prevented recording for 0.3 seconds soon after takeoff.

The CVR and the flight data recorder (FDR) were installed at the rear of the pressurized area of the aircraft. Both recorders stopped recording at the same time, likely because their power sources were damaged when the breakup began. The report said that the aircraft continued flying momentarily after the recorders stopped recording. A ballistic analysis indicated that the aircraft might have remained flying more than four seconds after the recorders stopped recording.

"If there were a backup CVR and FDR installed near the cockpit with [independent power sources], more information could [have been] provided to the investigators," the report said.

Based on the findings of the investigation, the ASC made the following recommendations to CAL:

- "Perform structural repairs according to the SRM or other regulatory-agency-approved methods, without deviation, and perform damage assessment in accordance with the approved regulations, procedures and best practices."

  In response, CAL said: "CAL accomplished Boeing Service Bulletin (SB) 747-53A2489 [recommended procedures for inspection of repairs in the tail-strike area of B-747s] on March 6, 2003, in accordance with an advance telex from Boeing.

  "CAA concurred with the CAL publication of QP [Quality Procedure] 12ME009 dated Aug. 7, 2003, to re-examine all previous patch repairs on the aircraft pressure boundary for the whole fleet, in response to CAA AD 2003-03-020A dated April 30, 2003. [The AD required evaluation of all previous repairs to the pressurized fuselage to ensure that the repairs were accomplished in accordance with approved data.]

  "QP 12ME009 specifies EO (engineering order) documentation for pressure boundary repair. The current repair EO must include:

  – "Warning wording: 'Hidden structural damage can cause aircraft structure failure';

  – "Categorization of the repair as 'major';

  – "Complete defect type and location description;

  – "Step-by-step instructions and signature requirements;

  – "A detailed drawing showing the extent and nature of damage, its location on the aircraft, doubler dimensions, material specification (including fasteners), applicable SRM section, and any special instructions; [and,]

  – "RII (required item inspection) specified for the repair.

  "For structural repairs that are classified as RII, inspectors must follow *Duplicate Inspections on Aircraft and Aircraft Components*, QR [Quality Regulation] 8.1.5 Issue No. 6, dated Dec. 1, 2003, and QP 08MI043 Issue No. 5, dated Aug. 31, 2004; inspectors must review work sheets in advance and conduct inspection both during the repair process and after completion to ensure a damage-free condition and compliance with maintenance processes specified in the SRM procedures."

- "Review the record-keeping system to ensure that all maintenance activities have been properly recorded."

  In response, CAL said: "CAL has revised QP 12MI002 (Rev. 2, dated July 30, 2004) in accordance with AC 43-001A, issued by the CAA (dated May 19, 2004) for maintenance record keeping; notably, structural repair records are to be retained in accordance with CAA regulations, and an additional copy of the major repair record will be specifically archived to establish a historical structural record for each aircraft."

- "Assess and implement safety-related airworthiness requirements, such as the RAP, at the earliest practicable time."

  In response, CAL said: "Currently, CAL has scheduled early implementation of CPCP tasks on all affected 747-400 airplanes."

- "Review the self-audit inspection procedures to ensure that all the mandatory requirements for continuing airworthiness, such as CPCP, are completed in accordance with the approved maintenance documents."

  In response, CAL said: "CAL has changed the philosophy of control for planned maintenance tasks that do not correspond with the intervals of letter checks [e.g., an 'A' check required every 350 flight hours]. The relevant data has been reviewed and transferred to a computer system so that such tasks can be controlled by an automatic system in accordance with the aircraft maintenance program. Thus, a basic (first-level) self-audit system has been established with the aid of an automatic computer system. Implementation of this control methodology commenced before April 30, 2004.

  "CAL EMD [Engineering and Maintenance Division] established a dedicated department, Engineering Planning Department (EPD), on May 10, 2004, to integrate such functions as planning, control, issuance of work orders, monitoring, etc., to ensure the overlap integrity of various tasks.

  "In accordance with CAA requirements, a check form (QP 08MI052F1R0) … was developed on June 15, 2004, to ensure that all the mandatory requirements for continuing airworthiness are completed in accordance with the approved maintenance documents. Columns for the conformity of maintenance-task planning and execution will be signed by an authorized person following review.

  "The Quality Management Office will conduct a yearly audit of EPD to monitor its operational effectiveness."

- "Enhance maintenance crews' awareness with regard to the irregular shape of the aircraft structure, as well as any potential signs that may indicate hidden structural damage."

  In response, CAL said: "As there is no existing visual-inspection methodology that uses the liquid-trace phenomenon to detect the structural anomalies, the case study of the CI611 accident will be put into the training program by the CAL Technical Training Office to instruct maintenance crew on how to detect hidden structural damage which results in irregular shape of the aircraft surface or visible liquid traces or stains. The OJT (on-the-job training) was conducted prior to Aug. 1, 2004. It includes discussion with maintenance crews of the indication(s) of possible hidden damage as shown in the photographs of the CI116 doubler area. The formal training material was set up on July 30, 2004, by the CAL Technical Training Office.

  "The [CAL] Aircraft Inspection Section issued an 'Inspection Circular' using the CI611 accident as a case study to instruct inspectors on how to recognize early indications of hidden structural damage on July 27, 2004; advanced OJT has been, and will continue to be, conducted periodically by the Aircraft Inspection Section on a randomly scheduled, as-necessary basis, on maintenance-inspection subjects that are necessary for inspectors to know. The advanced OJT may be conducted by issuance of inspection circulars or provision of in-situ inspection guidance by the foreman or duty manager."

- "Reassess the relationship with the manufacturer's [FSRs] to actively seek assistance and consultation from manufacturers' [FSRs], especially in maintenance [operations] and repair operations."

  In response, CAL said: "CAL currently enjoys the benefit of a strong and communicative relationship with the [FSRs] from both Boeing and Airbus; both have proven cooperative and responsive to the requests for technical support by the airline."

ASC made the following recommendations to the CAC [the report did not include responses by the CAC]:

- "Ensure that all safety-related service documentation relevant to [aircraft registered in Taiwan, China] is received and assessed by the carriers for safety-of-flight implications. The regulatory-authority process should ensure that the carriers are effectively assessing the aspects of service documentation that affect the safety of flight;

- "Consider reviewing [the] inspection procedure for maintenance records. This should be done with a view to ensuring that the carriers' systems are adequate and are operating effectively to make certain that the timeliness and completeness of the continuing-airworthiness programs for their aircraft are being met;

- "Ensure that the process for determining the implementation threshold for mandatory continuing airworthiness information, such as RAP, includes safety aspects, operational factors and the uncertainty factors in workmanship and inspection. The information of the analysis used to determine the threshold should be fully documented;

- "Encourage operators to establish a mechanism to manage their maintenance-record-keeping systems, in order to provide a clear view for inspectors/auditors conducting records reviews;

- "Encourage operators to assess and implement safety-related airworthiness requirements at the earliest practicable time;

- "Consider the implementation of independent power sources for flight recorders and dual-combination recorders to improve the effectiveness of flight-occurrence investigation;

- "Consider adding cabin pressure as one of the mandatory FDR parameters; [and,]

- "Closely monitor international technology development regarding more effective [NDI] devices and procedures."

ASC made the following recommendations to Boeing Commercial Airplanes:

- "Reassess the relationship of Boeing's [FSRs] with the operators such that a more proactive and problem-solving consultation effort to the operators can be achieved, especially in the area of maintenance operations."

  In response, Boeing said: "In 1999, Boeing undertook an extensive re-evaluation of the role of our [FSRs]. This re-evaluation did not change the technical-support role of our representatives, but rather expanded the role to emphasize consultative support on larger and more forward-looking issues as listed below:

  – "A greater emphasis with airline management concerns involving complex technical and business issues;

  – "Advising customer personnel regarding cost of airplane ownership, safety issues and operational efficiency;

– "Facilitating changes to Boeing-recommended maintenance procedures, operational procedures or designs in response to technical and operational problems observed at operators; [and,]

– "Above all, strive to recognize problems and trends before they have an adverse impact on safety.

"We believe these changes, already in place, meet the intent of the ASC recommendation."

- "Develop or enhance research effort for more effective [NDI] devices and procedures."

  In response, Boeing said: "Boeing's NDI staff researches and develops for operator use new [NDI] methods and tools that incorporate technological advances and accommodate evolving inspection needs. For example, new ultrasonic methods and tools were developed to assist operators with the inspection of repairs associated with tail strikes in accordance with [SB] 747-53A2489. These Boeing NDI research and development efforts will continue."

ASC made the following recommendations to FAA [the report did not include responses by FAA]:

- "Consider the implementation of independent power sources for flight recorders and dual-combination recorders to improve the effectiveness of flight-occurrence investigation;

- "Consider adding cabin pressure as one of the mandatory FDR parameters; [and,]

- "Ensure that the process for determining the implementation threshold for mandatory continuing airworthiness information, such as RAP, includes safety aspects, operational factors and the uncertainty factors in workmanship and inspection. The information of the analysis used to determine the threshold should be fully documented."

ASC recommended that it should "coordinate with the Ministry of Defense [of Taiwan, China] to sign a memorandum of agreement for the utilization of the defense tracking radar information when necessary to improve efficiency and timeliness of safety investigations" and that it should "coordinate with the Ministry of Justice to develop autopsy guidelines and procedures in aviation accident investigation."

The report said that the U.S. National Transportation Safety Board (NTSB), which participated in the accident investigation, made the following recommendations to FAA in April 2003:

- "Establish appropriate criteria (taking into account the size of the repair and other relevant considerations) to identify those pressure-vessel repairs to transport category airplanes that could be hiding damage that, if not addressed, may lead to [MSD] and fatigue cracking and could result in structural failure of the airplane. (A-03-07)."

  In response, FAA in July 2003 said: "[FAA] agrees that appropriate criteria need to be established to identify those pressure-vessel repairs to transport category airplanes that could be hiding damage. The FAA agrees that if this issue is not addressed, it may lead to [MSD] and fatigue cracking, and could result in structural failure of the airplane. The FAA is working with airplane manufacturers to establish appropriate criteria. The effort involves independent discussions with various manufacturers to determine what criteria are appropriate for their airplanes and consolidation of the information into one general set of criteria. It is estimated that this effort could take approximately eight months to complete. [FAA] will inform [NTSB] of the FAA's course of action to address the safety recommendation upon completion of this effort." [As of May 5, 2005, FAA had made no change to this response.]

- "Issue an [AD] requiring all operators of transport category airplanes with pressure-vessel repairs identified as a result of applying the criteria discussed in Safety Recommendation A-03-07 (other than those covered by [SB] 747-53A2489) to (1) immediately remove the repair doubler to determine whether hidden damage that could lead to [MSD] or fatigue cracking is present and, if so, repair the damage in accordance with the applicable [SRM] or (2) perform repetitive visual [inspections] and [NDI] for MSD and fatigue cracking at appropriately conservative intervals until the doubler is removed and, if any cracking is detected, immediately remove the doubler and repair the damage in accordance with the applicable SRM. The results of these inspections should be provided to the FAA. The only repairs that should be eligible for exemption from these requirements are those that are supported by credible and detailed engineering documentation substantiating that the repair was performed in accordance with the applicable SRM and only after a visual inspection to confirm that the repair conforms to that documentation. (A-03-08)."

  In response, FAA in July 2003 said: "In response to Safety Recommendation A-03-07, the FAA is working with airplane manufacturers to establish appropriate criteria to identify those pressure-vessel repairs to transport category airplanes that could be hiding damage. Once the criteria are established and the FAA has identified airplane models that are determined to be at risk of failure due to hidden [MSD] as a result of improper repairs to the pressure vessel, the FAA will initiate appropriate [AD] action. [FAA] will keep

[NTSB] informed of the FAA's progress on this safety recommendation." [As of May 5, 2005, FAA had made no change to this response.]

- "Inform maintenance personnel about the circumstances of this accident and emphasize that improper repairs to the pressure vessel may be hiding damage that allows the development of [MSD] and fatigue fracturing that could lead to structural failure. (A-03-09)."

  In response, FAA in July 2003 said: "The FAA will issue a flight standards information bulletin to discuss the circumstances of this accident and to address potentially catastrophic consequences of improper pressure-vessel repairs. The bulletin will ask maintenance inspectors to emphasize to their respective air carriers during required inspections that improper repairs to the pressure vessel may be hiding damage that allows the development of [MSD] and fatigue fracturing that could lead to structural failure. The FAA plans to issue the bulletin by October 2003." [FAA in July 2003 issued Flight Standards Information Bulletin for Airworthiness 03-01, *Safety Hazards Associated With Hidden Structural Damage on Transport Category Airplanes*.]

- "Require the manufacturers of pressurized transport category airplanes to include in their [SRMs], training programs and other maintenance guidance warnings about the possibility of structural failure resulting from hidden damage. (A-03-10)."

  In response, FAA in July 2003 said: "The FAA is working with Boeing to determine what warnings might be appropriate to include in the Boeing [SRMs]. The FAA is also working with other transport airplane manufacturers to review their repair manuals to determine if additional warnings or cautions need to be included in the SRMs. In those cases where there is ambiguity in the repair instructions, the FAA will ask manufacturers to include clarifying material or warnings in the SRMs. The FAA is also evaluating the need for general guidance relating to the repair of tail-strike damage or of the damage that can result from hidden damage. [FAA] will provide [NTSB] with any guidance material issued as a result of the evaluation." [As of May 5, 2005, FAA had made no change to this response.]♦

[FSF editorial note: This article, except where specifically noted, is based on Aviation Safety Council of Taiwan (China) Aviation Occurrence Report ASC-AOR-05-02-001, *In-flight Breakup Over the Taiwan Strait Northeast of Makung, Penghu Island; China Airlines Flight CI611, Boeing 747-200, B-18255, May 25, 2002*. The 704-page report, published in two volumes, includes illustrations and appendixes.]

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