FLIGHT SAFETY FOUNDATION

Accident Prevention

Vol. 52 No. 3 *For Everyone Concerned with the Safety of Flight* March 1995

Fractured Fuse Pin in Engine Pylon Results in Dragged Engine During B-747's Landing Roll-out

Maintenance and inspection personnel who worked on the accident airplane were not adequately trained and qualified to perform the required maintenance and inspection functions, according to a special report by U.S. NTSB.

Editorial Staff Report

During landing roll-out at New Tokyo International Airport at Narita, Japan, the No. 1 engine of a Northwestern Airlines Boeing 747-251B detached from its wing mounts and struck the runway. The accident resulted in recommendations by the U.S. National Transportation Safety Board (NTSB) to the U.S. Federal Aviation Administration (FAA) and Northwest Airlines regarding human engineering principles in maintenance operations, and the critical assessment of maintenance work environments. There were no injuries in the March 1, 1994, accident.

Northwest Airlines (NWA) Flight 18 was a scheduled passenger flight from Hong Kong to New York, U.S., with an intermediate stop at Narita. The report said that during the landing at Narita, "engine thrust reversing was normal on all four engines until the flight crew moved the engine power levers out of reverse thrust at about 90 knots. During the roll-out, the No. 1 engine and pylon rotated downward about the mid-spar pylon-to-wing fittings into a position in which the lower forward part of the engine nose cowl contacted the runway. … The primary forward part of the engine nose cowl contacted the runway. The airplane was subsequently stopped on a taxiway, with the front of the No. 1 engine still contacting the ground. The lower forward engine nose cowl had been ground away as it slid along the runway. A fire near the No. 1 engine was rapidly extinguished by local fire fighters, and all passengers remained aboard. They were subsequently deplaned via portable boarding stairs about 30 minutes after the airplane was brought to a stop."

The primary forward upper-link fuse pin in the No. 1 engine pylon was found to be fractured. In addition, the aft fuse pin on the pylon diagonal brace was found to be loose in the pylon structure. The report said,"The aft diagonal-brace fuse pin is normally retained by both a primary retainer (two washer-like retainer caps and a through bolt) and a secondary retention clip (a bolt-on C-shaped bracket). … The day after the accident … a set of diagonal brace fuse-pin primary and secondary retainers had been found in the NWA maintenance facility in an unmarked white cloth bag."

The bag containing the retainers was found adjacent to a work area where regular maintenance and inspection had been performed on the No. 1 engine of the accident airplane, 15 days before the accident flight. The accident airplane had accumulated 14 flight cycles (takeoffs and subsequent landings) since the inspection.

As a result of a special investigation, the NTSB concluded that "maintenance and inspection personnel who worked on

Northwest Airlines Boeing 747's No. 1 engine and pylon rotated downward during the landing roll-out. The lower forward part of the engine cowling was ground away by dragging on the runway.
Source: U.S. National Transportation Safety Board

the airplane were not adequately trained and qualified to perform the required maintenance and inspection functions." In addition, "the work environment for the heavy maintenance of the airplane was inadequate and contributed to an error-producing situation for the workers," the report said.

The accident was investigated by the NTSB and the Japanese Aircraft Accident Investigation Commission (JAAIC). Although the full report of the investigation will be issued by the JAAIC, the NTSB decided to conduct a special investigation of the events at the NWA maintenance facility that led up to the accident "because of the ramifications to the U.S. aviation industry of the maintenance anomaly that precipitated the accident," the report said.

As part of its investigation, the NTSB interviewed 18 NWA maintenance employees (mechanics, inspectors and management personnel), and two FAA maintenance inspectors assigned to oversee NWA maintenance operations. "The [NTSB] also gathered information related to similar maintenance anomalies at airlines other than NWA," the report said.

The NTSB reviewed NWA's FAA-approved maintenance procedures that were related to the accident. The report said that these procedures included:

- "Establishment of a General Engineering and Maintenance Manual (GEMM);
- "The production of work planning instructions through a computerized system known as CITEXT [Centralized Interactive Text System];
- "Monitoring the completion of maintenance actions prescribed by CITEXT;
- "Prominent display of red tags when vital components were disassembled or disconnected; [and,]
- "The requirement for a final inspection of maintenance actions taken, by individuals not involved in performing those maintenance actions, before approval can be given to close a work area."

Investigators closely examined the CITEXT computer-generated maintenance instruction system. In describing the system, the report said that "the CITEXT-generated work cards followed the general instructions contained in the aircraft maintenance manuals. CITEXT policies and procedures are contained in the GEMM. CITEXT cards contain step-by-step instructions for the maintenance activity. NWA personnel estimated that about 95 percent of the routine maintenance procedures performed were generated by CITEXT, with the remainder coming from maintenance manuals or other instructions.

"CITEXT work instructions were written as blocks of tasks. For example, a task might describe opening an access panel, performing a maintenance or inspection activity, and closing the panel. … The tasks were then printed as a sequence of work cards, each of which contained the step-by-step instructions for a maintenance or inspection activity, sign-off areas for maintenance and inspection personnel and locations of reference information in the GEMM, maintenance manuals or other sources."

During its investigation, the NTSB said that it "identified numerous problems with the CITEXT system. For example, certain tasks were duplicative, and two cards could call for opening a common access panel. When interviewed, mechanics said that they would write 'N/A' (for Not Applicable) when work had already been performed. The director of DC-10/B-747 maintenance stated that he was aware that many people had a negative opinion of the CITEXT system and cited other problem areas. The most common CITEXT problems mentioned were conflicts with the airplane maintenance manual, and the lack of graphics and charts. Although the CITEXT system was said to have been developed to provide a single set of work instructions, the system required extensive coordination with the airplane maintenance manual.

"According to NWA officials, at the time of the accident, the CITEXT system was undergoing modifications and improvements, and the improvements were reviewed by groups of users. Still, more than half of the workers interviewed for this investigation were critical of the CITEXT instructions. Many added that the current system was an improvement over the previous system."

Investigators reviewed NWA's maintenance personnel training program. "NWA maintenance officials stated that regular formal classroom training in NWA general maintenance procedures did not exist," said the report. "General training was normally informal on-the-job training (OJT), although some employees reported having attended classroom sessions. Lead mechanics were responsible for the instruction of new employees assigned to them. OJT also had been used to teach mechanics and inspectors the subject materials contained in the GEMM for which each individual was responsible."

In 1992, NWA had implemented a one-day familiarization training program for newly hired mechanics that included company and maintenance organizations, company rules and procedures, airplane documents, the computerized maintenance tracking system, hazardous materials and airframe/powerplant familiarization, the report said.

The investigation reviewed the NWA maintenance system for handling of nonroutine conditions or work tasks. The report said: "A numbered, red 'Unit Inoperative or Removed' (NWA form OM 249) tag could be attached to the airplane in the vicinity of the system affected. The nonroutine card associated with this red tag contains a description of the condition identified, the location on the airplane and space to record maintenance actions taken to correct the discrepancy."

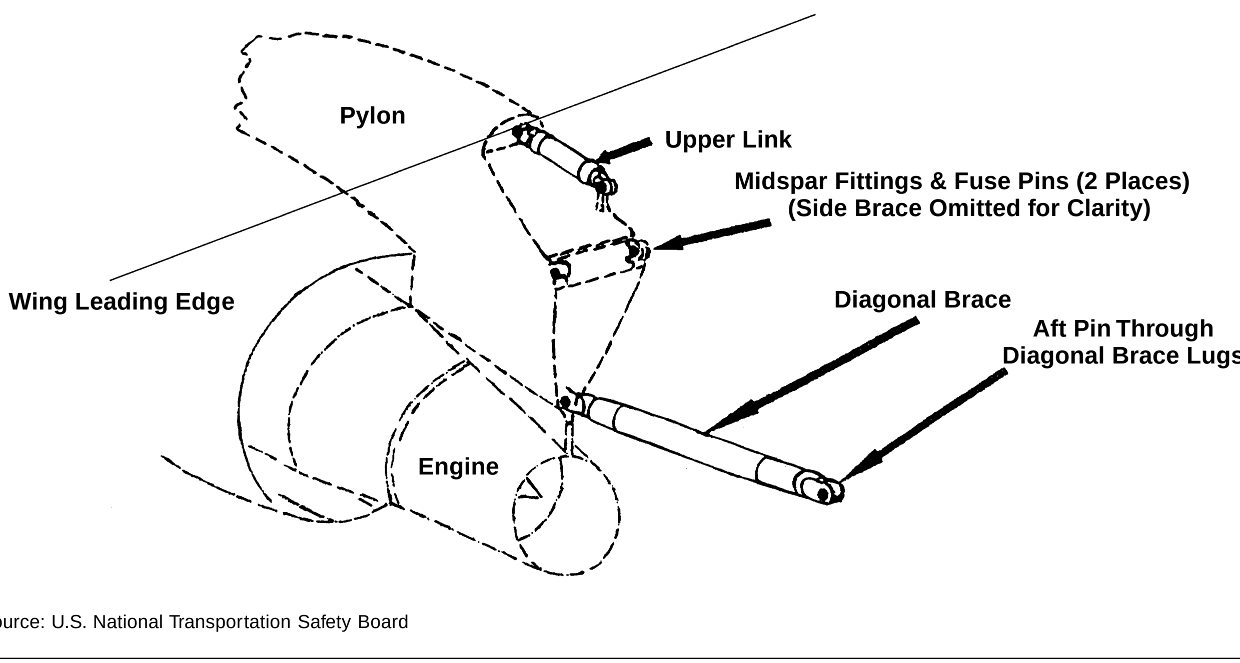
The report continued: "The nonroutine card [comprises] three copies; two copies would be placed on the airplane's 'work control board,' and one copy would go into a separate security file. … Closure of shop paperwork, prior to return of the airplane to service, required accounting for each nonroutine card. One person noted that the multiple copies prevented missing closure of necessary work items, even though red tags were occasionally lost from the airplane during subsequent maintenance activities, such as airplane washing."

Investigators interviewed maintenance personnel regarding the use of the red OM 249 tags. "All of the maintenance and inspection personnel interviewed were asked to describe the red OM 249 tags and how to use the forms," the report said. "The answers were not consistent with respect to how to use the forms, or when to complete them."

The accident airplane was placed in the NWA maintenance facility to undergo a scheduled nondestructive testing (NDT) inspection of the diagonal brace lugs (Figure 1) and other work in the No. 1 and No. 4 engine pylons, as part of what was known as a "C" check. Mechanics were assigned to open the strut aft fairing doors and prepare the diagonal brace and other components for inspection.

An NWA inspector trained in NDT then performed an ultrasonic inspection of the diagonal-brace attach-point fittings. The report said,"This NDT inspector stated that when he performed his inspection on the airplane's pylon fittings, the primary retainers were installed; however, the secondary retainers had been removed per the CITEXT cards. He did not

Typical Boeing 747 Pylon Brace Assembly



Source: U.S. National Transportation Safety Board

Figure 1

see a white cloth bag with retainer parts inside, such as the one found later. … The NDT inspector stated that he had not recognized that the secondary retainers were required on this airplane. He marked 'N/A' in step 10 of the CITEXT instructions that stated, 'Reinstall fuse-pin secondary retainers at forward and aft lug locations if removed per step 4 above.'"

When the NDT inspection of the No. 1 and No. 4 engine pylons had been completed, two mechanics (who were not experienced with engine and pylon work) were brought in to close the No. 4 engine pylon. The report said that "both of these mechanics were certificated airframe and powerplant (A & P) mechanics; however, they were normally assigned to work on the interiors of the airplanes. During the final close-up operation on the airplane, one of these mechanics found a white cloth bag containing the primary and secondary retainers for the No. 4 pylon (as opposed to the No. 1 pylon) attached to the side of the 'bat-wing' door. Neither the mechanics nor their supervisors had considered looking inside the No. 1 pylon, they said."

The report also said: "An examination of the No. 4 engine pylon area by mechanics revealed that the required fuse-pin retainers had not been installed on the No. 4 pylon diagonal brace. The retainers found in the cloth bag were then installed, and the airplane was subsequently rolled out for the operational check. The No. 1 engine and pylon had already been inspected and closed before the discovery of the uninstalled retainers on the No. 4 engine pylon. There was no attempt to reinspect the No. 1 pylon diagonal brace or to take long-term corrective actions at that time."

The inspection on the accident airplane had been completed four days earlier than anticipated. "The airplane was rolled out for an operational check in the early morning hours on Sunday, Feb. 20, 1994, and was released for revenue service on Monday, Feb. 21, 1994," the report said.

Investigators examined another airplane that was undergoing pylon maintenance. "Red OM 249 tags were seen in the area of the diagonal-brace fuse pins. … Most of the maintenance and inspection personnel reported that they did not remember seeing any red tags attached to the No. 1 pylon area on the accident airplane," the report said.

The NTSB reviewed NWA's maintenance practices to determine why the accident airplane was returned to service without the primary and secondary aft diagonal-brace fuse-pin retainers installed on the No. 1 engine pylon.

The report said: "The [NTSB] determined that the secondary retainer for the aft fuse pin on the No. 1 and No. 4 engine pylon diagonal brace had been removed, as required and directed by the CITEXT system, to permit NDT of the diagonal-brace end fittings. The inspector who performed the NDT stated that he signed the paperwork, indicating that he performed the required tests, then further stated that he also signed N/A (not applicable) in the blocks that direct the reinstallation of the secondary retainers. The person(s) who removed the primary retainers, and the reasons for their removal, were not identified."

The report continued: "The [NTSB] could not determine why there were no nonroutine work cards generated or red OM 249 tags applied to the aircraft structure in the vicinity of the primary retainer, after its removal, as required by the GEMM. Although a red OM 249 tag could have been accidentally lost by washing the airplane or other maintenance, a mechanic performing nonroutine parts removal should have generated the nonroutine card paperwork to ensure that the removed parts (in this case the primary and secondary retainer set) were reinstalled and that the area was inspected."

The NTSB concluded that 'the evidence indicates that several important maintenance procedures were either not followed or were followed incorrectly during the maintenance and inspection of the airplane.'

The NTSB concluded that "the evidence indicates that several important maintenance procedures were either not followed or were followed incorrectly during the maintenance and inspection of the airplane. On Feb. 20, 1994, after all 'C' check maintenance actions were considered to have been completed, the airplane was dispatched for revenue flights. After the airplane was returned to service, it completed 14 cycles without incident, prior to the accident flight. The diagonal-brace aft fuse-pin migrated out of the fitting at some point during the 14 flights, and the upper-link fuse pin failed in overload during roll-out at Narita."

When reviewing the CITEXT (computerized) system of generating maintenance instructions, the report revealed that "although the relevant card in this accident was created for the maintenance to be performed on the airplane, as well as the particular day in which the maintenance actions were to be carried out, it did not specify the type of fuse pin present on the particular pylon or whether secondary fuse-pin retainers were required to be present."

The report also said that "a given B-747-200 airplane could have two different types of pylon-retention fuse pins installed on the four engine pylons. The mechanic performing maintenance on the pylons would be unable to determine the particular pin installed by looking at the CITEXT card. Only by close inspection of the pin could he or she determine the particular generation of pin installed."

Investigators found that NWA mechanics needed to refer to both the CITEXT cards and the maintenance manual. "The potential for confusion was high among mechanics who were attempting to adhere to the GEMM, coordinate with the maintenance manual and follow the CITEXT directions," the report said.

Investigators examined the NWA maintenance organization and structure for the manner in which work was assigned and performed. The report said: "The [NTSB] noted the apparent compartmentalization of maintenance tasking in a large maintenance organization such as that of NWA. The mechanic, who removed the No. 1 pylon aft diagonal-brace fuse pin for several minutes to facilitate reinstallation of the No. 1 pylon upper link, was not concerned that the pin was not retained in its fitting in any manner. He believed that the retaining device or devices had conveniently been removed for some valid reason by other mechanics already, that the brace/fitting/pin system was only compromised for a few minutes and that he would return the system to its exact previous state."

The report added: "Therefore, in his mind, no nonroutine card needed to be generated, and no red OM 249 card needed to be attached to the diagonal-brace area. Had he, or any one of his various supervisors, been more aware of the overall maintenance plan for the No. 1 pylon area, the existence of a retainerless fuse pin so late in the 'C' check process might have been recognized as an anomaly, and this accident might not have occurred."

The NTSB reviewed and commented on NWA's "red tag" procedures, which the NTSB believed should have prevented the errors that led to the accident. The report said: "The investigation revealed several flaws in the application of the airline's red OM 249 tag procedures. Personnel had differing interpretations of the airline's red tag policy. Most of them appeared to understand that a red tag was to be displayed when a major or vital component or system had been compromised. However, the mechanic tasked with removing the secondary fuse-pin retainer believed that the red tag was to be posted when specified on the CITEXT. Since the CITEXT card for this action did not call for posting a red tag, he did not post one. Further, it was unclear whether different mechanics would have considered the fuse-pin retainers sufficiently critical to warrant the red tags."

The NTSB concluded that "the evidence suggests that if a red OM 249 tag had been posted following the removal of the fuse-pin retainers, someone would have noticed that the maintenance action had not been completed (at least the absence of the primary pin retainer would have been noted) and the accident could have been avoided. Therefore, the [NTSB] believes that the failure of the mechanics to use red OM 249 tags following the removal of the fuse-pin primary and secondary retainers, as well as the inadequacy of red tag training, was another in a series of errors."

The NTSB found five instances where migrations of the upper-link fuse pins or diagonal-brace fuse pins on the B-747 were reported by other airlines before the NWA Narita accident, one of which resulted in an accident similar to the one at Narita. "The other four were discovered during routine maintenance," the report said. "One other instance of pylon fuse-pin migration has occurred since the Narita accident. All of these incidents were attributed to the improper assembly of the components during maintenance."

The previous accident involved an Air India B-747 in 1990. Following the Air India accident, Boeing issued a service letter, "suggesting [that] operators ensure that fuse pins are correctly assembled and [recommending] incorporation of the secondary retention devices at the earliest maintenance opportunity," the report said.

Boeing issued a revision to the service letter following the Narita accident. The report said, "The service letter included advice to customers that all fuse-pin installations must be correctly assembled and that established maintenance procedures should be adequate to account for all removals and reinstallations of the pins and retention hardware. It also recommended that operators incorporate the secondary retention devices at the earliest maintenance opportunity. No other corrective actions were initiated by Boeing or the FAA at that time."

In August 1994 (following the Narita accident), yet another migrated fuse pin was found on a B-747. The report said that Boeing then issued another service letter that "reiterated the information contained in the earlier service bulletins on this issue. It also stated that the service bulletin requiring the inspection and replacement of diagonal-brace fuse pins … will be revised by the first quarter of 1995 to include the part number call-out in the removal and installation steps. This, Boeing states, will ensure parts accountability during installation."

Investigators interviewed the FAA principal maintenance inspector (PMI) whose sole responsibility was the oversight of maintenance operations at NWA. "The PMI stated that he believed NWA was a 'compliance-oriented' airline and that company management was professional and cooperative," the report said. "He was of the opinion that the CITEXT system has improved overall maintenance at NWA, and that it also made it easier for the FAA to monitor NWA maintenance activity."

A partial program manager (PPM) assisted the PMI in monitoring NWA's B-747 maintenance. The report said that part of the PPM's surveillance procedure "was to compare the contents of the CITEXT-generated work cards with GEMM and maintenance manual requirements. There was, however, no formal program (outside of his real-time shop observations and comparisons) to compare a general, random sampling of CITEXT-generated work cards with GEMM and maintenance manual procedures. He also stated that most of his inspections took place after a particular maintenance operation had been completed."

The report said, "According to FAA personnel, routine surveillance, unless it was required for compliance with airworthiness directives or other specific tasks, did not include monitoring the preparation of work instructions, storage and the documentation of parts removed from airplanes (housekeeping) or audits of completed work."

The NTSB also examined the physical work environment of the two NWA hangars used for B-747 maintenance. The report said: "Both hangars have work stands (known as wing docks) located under the wings of B-747s, under tail surfaces and at other locations around the airplane. The wing docks in Hangar 6 were constructed of scaffolding with plywood decking that provided openings for wing jacks and other maintenance equipment. Loose wooden planks were on the wing docks, some of which were laid across open areas to connect the wing dock to the engine stands, more than eight feet above the concrete floor. At least one inspector expressed personal safety concerns when he had to rely on the wood planks between the docks to perform his inspections. He said that after becoming tired of climbing down from the wing dock and back up the engine stand, he reluctantly used the temporary wood bridges between the docks."

When examining the work area lighting in the hangar, the report said that investigators found that "there were fixed lights on the wing docks to illuminate the underside of the wings and the airplane; however, many of the light fixtures were either covered with paint overspray and provided poor illumination, or were not in use. Mechanics were observed using portable work lights or flashlights when they were working on the undersides of the airplanes. One employee stated that Hangar 6 had previously been used for painting airplanes, and that it resulted in paint overspray on the light covers. In contrast, the wing docks in Hangar 5 were permanent fixtures that permitted the use of space below the stands."

The NTSB found that the inspector who was responsible for approving the closure of the engine pylon was hindered by the environment of the pylon area.

The NTSB found that the inspector who was responsible for approving the closure of the engine pylon was hindered by the environment of the pylon area. The poor lighting and scaffolding "combined to cause the inspector to view the fuse-pin retainers by holding onto the airplane structure with one hand, leaning under the bat-wing doors at an angle of at least 30 degrees, holding a flashlight with the other hand pointing to the area and moving his head awkwardly to face up into the pylon area," the report said.

The NTSB report cited an FAA report of a study that evaluated human factors issues in aviation maintenance, such as lighting in maintenance work areas and the scheduling of rest time for mechanics. The NTSB said that this FAA report, along with other FAA effort, "served to increase the understanding of contemporary human factors issues that affect the quality of aircraft maintenance."

The NTSB report said: "The circumstances of this accident suggest that the FAA has adequately studied many of the critical human factors issues in aviation maintenance, but that the implementation of many of the positive findings from these studies have not yet been accomplished. … Therefore, the [NTSB] believes that the FAA should issue a directive to [Federal Aviation Regulations (FARs)] Part 121 and Part 135 air carrier PMIs instructing them to have their assigned carrier(s) conduct inspections to identify human factors–related impediments to the effective performance of maintenance and inspections, such as inadequate lighting and potentially hazardous scaffolding, and require the carriers to correct those deficiencies."

Investigators examined the parts storage areas in both hangars, and found inconsistencies in how parts were organized. "Some areas were neat, with parts clearly placed in an orderly fashion on the racks," the report said. "However, as with the wooden box containing fuse pins from the subsequent airplane, storage of vital components was not the same in all areas."

The report concluded that "the lack of an organized method of storing parts removed from airplanes prevented the physical presence of the pins from alerting personnel to an error. The storage of parts was largely left to the lead mechanics, some of whom were more fastidious than others. If a location had been provided and habitually used for the No. 1 pylon retainers, they would have been visible after closure of the pylon. Instead, the parts were found behind a board on the wing dock."

The NTSB also commented on NWA's maintenance training. The report said: "The evidence indicates that NWA's method of training in the GEMM, CITEXT and application of the red OM 249 tag procedures was less than systematic. The mechanics who worked on the airplane learned the method informally, through OJT from more experienced maintenance personnel. As a result, the level of understanding of the red tag procedure was largely influenced by the quality of training a mechanic had received from his or her OJT instructor. Consequently, multiple interpretations of the system, including some that were not in accordance with the GEMM, prevailed."

NWA discussed red tag procedures with new-hire mechanics in its one-day training session, which NWA instituted in 1992. The report said that investigators found that "with one exception, the mechanics who were interviewed had been hired before this training was initiated. Therefore, nearly all of them had been taught about red OM 249 tags through OJT."

The report concluded that "this procedure, irrespective of its perceived informality, was an important part of the process of ensuring that critical maintenance procedures were performed and completed without error. Because of its importance, the [NTSB] believes that NWA should have formalized the red OM 249 tag procedure and ensured that all mechanics understood it and implemented it properly and consistently."

In a previous accident investigation, the NTSB recommended that the FAA revise the training curricula at aviation maintenance technician schools certificated under FARs Part 147 to include modern aviation industry technology. In response to that recommendation, the FAA substantially revised and modernized in 1992 the curricula at schools certificated under Part 147.

The report said, "During its investigation of this accident, the [NTSB] has learned that the FAA also intends to modify the requirements for the certification of airframe and powerplant (A & P) mechanics to create a separate category of A & P certificate to be required of mechanics who perform maintenance on aircraft certificated under [FARs] Part 25. A Notice of Proposed Rulemaking (NPRM) was promulgated to that effect, and comments were due [in October 1994.]"

The NTSB developed 12 findings as a result of its investigation.

- "Maintenance and inspection personnel who worked on the airplane were properly certificated to perform the required maintenance and inspections;
- "Maintenance and inspection personnel who worked on the airplane were not adequately trained and qualified to perform the required maintenance and inspection functions. Critical functions had been taught by on-the-job training and were not standardized or formalized in an initial or recurrent training program;
- "The mechanic who removed and failed to reinstall the No. 1 pylon aft diagonal-brace primary retainer could not be identified;
- "The inspector who performed the nondestructive testing inspection of the No. 1 pylon diagonal-brace fitting properly completed the inspection, but he improperly signed off on several subsequent steps of the centralized interactive text system (CITEXT) instruction card. This could have led other maintenance and inspection personnel to interpret that the maintenance actions on the fuse-pin retainers on engine No. 1 had been completed when they had not;
- "The 'OK to Close' inspection of the pylon area was hampered by inadequate lighting and perceived dangers of the scaffolding;
- "The CITEXT used by Northwest Airlines was inadequate because it lacked the pertinent information contained in the FAA-approved maintenance manual, it did not follow Northwest Airlines' GEMM policy and it did not contain specific instructions for actions, components or systems that were specific to the B-747 No. 1 engine pylon;
- "Mechanics and inspectors of Northwest Airlines did not adequately understand the application of the CITEXT and red OM 249 tag systems for critical maintenance items;
- "Maintenance supervisors and managers of Northwest Airlines failed to ensure that the work practices of the mechanics and inspectors were conducted in accordance with the approved maintenance manual;
- "The work environment for the heavy maintenance of the airplane was inadequate and contributed to an error-producing situation for the workers;
- "The lack of adequate and organized storage of removed parts contributed to the failure to reinstall the fuse-pin retainers;
- "FAA oversight of the maintenance facility at Northwest Airlines failed to detect deviations in red OM 249 tag procedures; [and,]
- "FAA inspectors failed to apply FAA-developed human factors elements and allowed an inadequate work environment in the hangar to exist."

Based on its findings, the NTSB made five recommendations to the FAA:

- "Review the Northwest Airlines CITEXT system, and, where practical, require modification of those sections that refer to actions, components or systems that are specific to particular airplanes to ensure that the maintenance action requested conforms to the maintenance action required for the specific airplane;
- "Apply human engineering principles to the evaluation of computer-generated work card systems to ensure that they include all of the critical information contained in, and are consistent with, the FAA-approved maintenance manuals;
- "Inform other airlines operating in the [United States], and foreign airworthiness authorities, of the circumstances of this accident and require them to implement corrective actions, where necessary, to prevent the maintenance program deficiencies noted in this accident;
- "Assess the work environments in which carriers operating under [FARs] Part 121 perform their maintenance to identify human factors–related impediments to the effective performance of maintenance and inspections, such as inadequate lighting, potentially hazardous scaffolding, and inadequate and unorganized parts storage during maintenance activity, and require those carriers to correct the deficiencies; [and,]
- "Direct operators of Boeing 747 airplanes to paint the inside surfaces of the engine pylon fuse pins a conspicuous color such as red."

The NTSB also made four recommendations to Northwest Airlines:

- "Review the CITEXT system, and, where necessary, require the modification of sections that refer to actions, components or systems that are specific to particular airplanes to ensure that the maintenance action requested conforms to the maintenance action required for the specific airplane;

- "Apply human factors engineering principles to the evaluation of the CITEXT system and implement revisions, as necessary, to ensure that the computer-generated work cards are consistent with the material contained in the FAA-approved maintenance manuals and the specified work or inspection requirements are clearly stated;

- "Review the maintenance training curricula for mechanics and inspectors to ensure that all critical airline maintenance policies and procedures are addressed during initial and recurrent training, and, in cases in which they are found deficient, incorporate such maintenance policies and procedures in the curricula; [and,]

- "Review the training records of personnel engaged in the maintenance and inspection of air carrier aircraft to ensure that such personnel have received the formal training required under [FARs Part] 121.375."

The report said that since the accident at Narita, NWA has taken the following actions to prevent a recurrence:

- "The NWA Central Engineering Division has revised all engineering orders that require the removal of engine strut fuse-pin components. These engineering orders now contain a step that requires inspection sign-off and that specifically [addresses] reinstallation of all fuse-pin retention hardware;

- "The NWA Production Planning Division has accelerated accomplishment of the Boeing service bulletin concerning engine strut third-generation fuse-pin installation. All B-747 airplanes will have third-generation pins installed by April 1, 1995;

- "The NWA Systems and Automation Division is in the process of replacing the CITEXT system with the AMI-Task system job instruction cards that include graphics. AMI-Task will be ready for B-747 periodic maintenance checks by September 1995;

- "The NWA Technical Publications Division has revised OM 249 red tag procedures via a revision to the CITEXT cards concerning pylon strut removal, installation, and opening and closing of the pylon to [ensure] mid-spar fuse-pin retainer installation; [and,]

- "The NWA Technical Operations Training Division has intensified technical training of mechanics throughout the NWA maintenance system. Also, in conjunction with the FAA, Boeing and the IAM [International Association of Machinists], NWA is implementing a Maintenance Error Decision Aid concept that addresses human factors principles in hangar work procedures."♦

Editorial note: This article was adapted from *Special Investigation Report: Maintenance Anomaly Resulting in Dragged Engine During Landing Roll-out, Northwest Airlines Flight 18, Boeing 747-251B, N637US, New Tokyo International Airport, Narita, Japan, March 1, 1994, Report No. NTSB/SIR-94/02*, prepared by the U.S. National Transportation Safety Board. The 61-page report includes figures and appendices.

ACCIDENT PREVENTION
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