National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 10, 1998

In reply refer to: A-98-44 through -58

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On August 7, 1997, at 1236 eastern daylight time,[1] a Douglas[2] DC-8-61, N27UA, operated by Fine Airlines Inc. (Fine Air) as flight 101, crashed after takeoff from runway 27R at Miami International Airport (MIA) in Miami, Florida. The three flightcrew members and one security guard on board were killed, and a motorist was killed on the ground. The airplane was destroyed by impact and a postcrash fire. The cargo flight, with a scheduled destination of Santo Domingo, Dominican Republic, was conducted on an instrument flight rules flight plan and operated under Title 14 Code of Federal Regulations (CFR) Part 121 as a Supplemental air carrier.

The National Transportation Safety Board determines that the probable cause of the accident, which resulted from the airplane being misloaded to produce a more aft center of gravity and a correspondingly incorrect stabilizer trim setting that precipitated an extreme pitch-up at rotation, was (1) the failure of Fine Air to exercise operational control over the cargo loading process; and (2) the failure of Aeromar to load the airplane as specified by Fine Air. Contributing to the accident was the failure of the Federal Aviation Administration (FAA) to adequately monitor Fine Air's operational control responsibilities for cargo loading and the failure of the FAA to ensure that known cargo-related deficiencies were corrected at Fine Air.[3]

Accident Scenario

The airplane departed controlled flight shortly after rotation, following an apparently normal taxi and takeoff roll. The Safety Board's correlation of data from the flight data recorder (FDR) and cockpit voice recorder (CVR) determined that the stick shaker warning activated

[1] Unless otherwise indicated, all times are eastern daylight time, based on a 24-hour clock.

[2] Boeing Commercial Airplane Group acquired the holdings of the Douglas Aircraft Company and McDonnell Douglas in 1997.

[3] National Transportation Safety Board. 1998. *Uncontrolled Impact With Terrain, Fine Airlines Flight 101, Douglas DC-8-61, N27UA, Miami, Florida, August 7, 1997.* Aircraft Accident Report NTSB/AAR-98/02. Washington, DC.

when the airplane was at an altitude of about 100 feet msl. According to the Board's performance study of the airplane's motion during the accident sequence, about 16 seconds after the start of rotation, at an altitude of about 300 feet msl, the airplane reached an extremely nose-high pitch attitude in the range of 30° and an angle-of-attack (AOA) approaching 20°, which resulted in an aerodynamic stall (an AOA of 15° was sufficient to bring the airplane into the stall region). Subsequently, the AOA decreased toward 10°, and the pitch decreased to below 20°, resulting in a brief recovery from the stall, followed by another AOA increase into the stall region 5 seconds later (the stall warning stopped at 12:36:12 and resumed at 12:36:17).

The ground scars and the airplane damage indicated that at impact, the pitch angle was about 23°, while the flight path angle was about 26° down. This resulted in an AOA of at least 49° at the time of impact, consistent with the airplane being in a deep stall. A continued stall is also consistent with the stick shaker stall warning and engine surge sounds recorded on the CVR in the final moments of the flight and the witness statements about pitch attitude during flight and at ground impact. The performance study showed that once the initial stall was reached, full recovery was unlikely because of the airplane's low altitude and the airplane's rapidly decreasing performance. Thus, based on analysis of FDR, CVR, and postaccident airplane performance data and on witness statements, the Safety Board concludes that the airplane pitched up quickly into a stall, that it recovered briefly from the stall, that it stalled again, and that recovery before ground impact was unlikely once the stall series began.

Airplane Handling Characteristics

The weight and balance form provided to the flightcrew showed a calculated center of gravity (CG) location at 30.0 percent mean aerodynamic cord (MAC). However, the Safety Board and the Douglas Products Division calculated a CG of 32.8 percent MAC based on a loading scenario developed from information provided by Aeromar loaders, Fine Air flight follower testimony, pallet weight documentation, and postaccident communication with Aeromar representatives. The Safety Board also notes that a relatively small addition to and/or redistribution of cargo could have moved the airplane's CG beyond the aft limit of 33.1 percent MAC.

The succession of errors made by Fine Air and Aeromar in loading this flight and the deficiencies in the Aeromar and Fine Air loading procedures identified during postaccident FAA inspections made it impossible to precisely determine the weight and CG from the data that were available following the accident. For example, the cargo destined for the accident airplane was listed as weighing 89,719 pounds when it arrived at Aeromar's warehouse in big pacs and boxes. After being put on pallets and secured with plastic covers and netting, the cargo was listed on the Aeromar pallet load sheet as weighing 88,923 pounds, or 796 pounds less than the cargo weighed at arrival. Pallets and netting added an additional 275 pounds per pallet (or about 4,400 pounds to the total cargo weight). Based on postaccident Aeromar statements that the entire cargo delivered to Aeromar was loaded onto pallets for shipment on the accident airplane, the actual cargo weight could have been at least 94,119 pounds. Thus, the weight of the cargo that Aeromar provided to Fine Air could have been 5,196 pounds more than listed on the pallet weight form (which resulted in the CG of 32.8 percent MAC). This additional weight could have had a

significant effect on the CG of the airplane, depending on how it was distributed through the cabin.[4]

In February 1998, the Safety Board conducted a series of tests using a DC-8 full motion flight training simulator. Multiple takeoff attempts were simulated using aircraft weight, flap settings, and thrust values equivalent to the accident conditions and a range of CG values. The simulator flight tests suggest that at 33 percent MAC, the column inputs recorded on the accident airplane's FDR might have been sufficient to prevent the pitch-up and stall. Further, at 35 percent MAC, the simulator reached the stall condition more quickly than did the accident airplane. Although adequate control power existed from the elevators and pitch trim to recover the airplane at 35 percent MAC, successful recovery required an immediate and aggressive control input response (full forward column, which could be assisted by nose-down trim). Pilots involved in the simulation reported that their immediate control inputs were successful for the conditions tested because they were anticipating the pitch-up at rotation.[5] At CG values aft of 35 percent, the airplane was increasingly subject to autorotation tendencies well before rotation speed and to tail strike on the runway, which did not occur during the accident. However, based on the loading information and the simulator tests, the Safety Board concludes that the CG of the accident airplane was near or even aft of the airplane's aft CG limit.

Statements by the flightcrew on the CVR show that the stabilizer trim was set during taxi-out at 2.4 units ANU, the value appropriate for the trim setting and CG of 30 percent MAC that the flightcrew had been given. The number of trim-in-motion tones recorded on the CVR during the recovery attempt and the full-nose-down trim setting found at impact were also consistent with the flightcrew having set 2.4 units during taxi.

The Safety Board considered the effects of different aircraft loadings on CG location and the associated pitch trim settings. The investigation found that 13 pallets had been moved farther aft than indicated on the loading sheet. At 88,923 pounds total cargo weight, moving the 13 pallets aft (and turning pallet four 90°) would have shifted the CG from 24.0 percent MAC (requiring 5.4 units airplane nose up [ANU] pitch trim) to 32.4 percent MAC (1.0 units ANU). Further, if the cargo weight were 94,119 pounds, the CG would have shifted from 24.0 percent MAC (5.4 units ANU) to 32.8 percent MAC (0.9 units ANU). Thus, pushing the 13 pallets aft shifted the CG farther aft by at least 8 percent MAC. Further, because the accident airplane's stabilizer trim setting was 2.4 units ANU, the Safety Board concludes that the CG shift resulted in the airplane's trim being mis-set by at least 1.5 units ANU (2.4 minus 0.9 units at 94,119 pounds).

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[4] Based on a payload weight of 94,119 pounds, the Safety Board calculated that the redistribution of 250 pounds from the front to the rear of the airplane could have resulted in a CG of 33.2 percent MAC. Redistribution of 1,200 pounds from the front to the rear could have resulted in a CG of 35 percent MAC.

[5] In its investigation of a 1993 accident involving a United Airlines DC-8-54F in Detroit, the Safety Board found that "recovery of the airplane at rotation was possible if immediate nose-down trim was applied along with full forward elevator input." However, the Safety Board concluded that "once the airplane left the ground and started to accelerate, recovery was improbable." (See National Transportation Safety Board. 1983. *United Airlines Flight 2885, N8053U, Douglas DC-8-54F, Detroit, Michigan, January 11, 1983.* Aircraft Accident Report NTSB/AAR-83/07. Washington, DC.)

Such a mistrim would cause a greater than expected nose-up pitching moment. This would be exacerbated by the lighter control column forces that result from an aft CG location. Consequently, the Safety Board concludes that the aft CG location and mistrimmed stabilizer presented the flightcrew with a pitch control problem; however, because the actual CG location could not be determined, the severity of the control problem could not be determined.

The simulator flight tests could not replicate the accident flight precisely because of limitations inherent in the simulator; for example, the aerodynamic data upon which the simulator's performance was based may not accurately model the actual airplane's performance in ground effect (during rotation and initial climb) or when high-pitch rates are present near stall. Further, the simulator's performance characteristics become invalid in the stall region. Timing of the control column movements in the simulated takeoff attempts was also a factor. Evaluation of the simulator data showed that small differences in the timing of inputs produced dramatically different results 5 to 10 seconds later.

Unfortunately, it was also not possible to replicate precisely the flightcrew's control inputs because, due to insufficient documentation, the control column position (CCP) positions recorded by the accident airplane's FDR could not be converted into precise position values but rather represented relative motion. The Safety Board could not determine with certainty the correlation between the CCPs recorded by the FDR and actual positions of the control column on the airplane. Thus, the simulator tests did not permit the Safety Board to determine precisely the response of the accident airplane to the flightcrew's control inputs.

Flightcrew Actions

Statements recorded on the CVR indicated that the flightcrew recognized a problem with airplane handling about the pitch axis immediately as the airplane rotated. At 12:35:51.5, 1.6 seconds after the "rotate" call out and about 1 second after the first officer began to move the control column aft, the captain began his "easy easy easy easy" remark. Based on FDR data, it appears that the captain made his statement before the airplane's pitch attitude had rotated significantly nose-up. The CCP moved aft a total of about 5°. About 2 seconds later (at 12:35:53.5), still during rotation, the FDR showed forward movement of the control column. The magnitude of the forward movement was about 4° from its most aft position; however, about 2 seconds after the start of the forward motion it was moved aft again. At 12:35:57 the control column was moved forward, and it reached its most forward position (presumed to be the full forward limit of the control column) at 12:36:01.

The first officer's continued aft column input for 2 seconds after the captain began his "easy easy easy easy" remark exacerbated the pitch-up that was developing from the mistrimmed stabilizer. However, the first officer's 2-second response time in responding to the captain was understandable in light of the physiological, neurological, and cognitive contributors to reaction time. Further, is not clear that the flightcrew would have recognized the need for abrupt, aggressive, and sustained action at the initiation of the pitch-up.

Regarding the first officer's subsequent aft control column input (at 12:35:54.5), the Safety Board notes that flightcrews are trained to avoid rapid and excessive control inputs and to gauge the results of control inputs before making additional corrections. In moving the control column forward and aft, the first officer might have been attempting to judge what nose-down control column inputs were required to correct the airplane's developing pitch-up attitude. The Safety Board also notes that the application of immediate and forceful nose-down control inputs at rotation is counter-intuitive and contrary to the training and experience of line flightcrews.

According to the CVR, the first trim-in-motion sound occurred a fraction of a second before the first aural stall warning (at 12:36:02), indicating that the trim inputs were not initiated until the accident airplane was already very close to a stall. Although aggressive nose-down trim inputs were made thereafter and until the trim reached its full nose-down position, about a 5-second delay occurred between the flightcrew's first attempt to control the pitch-up with nose-down column inputs and the first inputs of nose-down trim.

If the first officer had chosen to trim the airplane in the first, critical moments during and after rotation, he would have obtained a greater nose-down pitching moment and might have been able to correct most, or all, of the mistrim condition, preventing the airplane from stalling. The Safety Board considered the possibility that a more experienced pilot, particularly one who had previously encountered an aft-loaded, out-of-trim condition on takeoff, might have assessed the situation more rapidly and engaged the airplane's powerful pitch trim more quickly to aid in the recovery attempt. For example, if the captain had been flying the takeoff, he might have more quickly recognized the need for and applied a trim correction.

Although the Safety Board was unable to determine precisely how far aft the CG was located and thus the extent to which the airplane was mistrimmed, the Safety Board concludes that the mistrim of the airplane (based on the incorrectly loaded cargo) presented the flightcrew with a situation that, without prior training or experience, required exceptional skills and reactions that cannot be expected of a typical line pilot. Although the unanticipated nature of the rapid pitch-up was an important aspect of the situation, the Safety Board concludes that training for flightcrews in dealing with misloading, miscalculated CG, and mistrimmed stabilizers would improve the chances for recovery from such situations. However, there is no current FAA requirement for air carriers to provide flightcrews with training in identifying and responding to a rapid-pitch-up during rotation from a mistrimmed stabilizer. Therefore, the Safety Board believes that the FAA should require all 14 CFR Part 121 air carriers to provide flightcrews with instruction on mistrim cues that might be available during taxi and initial rotation, and require air carriers using full flight simulators in their training programs to provide flightcrews with Special Purpose Operational Training that includes an unanticipated pitch mistrim condition encountered on takeoff.

Cargo Document Preparation, Communications, and Ramp Delivery Procedures

In the hours before the accident flight, the exchange of airplanes required a series of significant cargo paperwork changes by Fine Air flight followers and Aeromar employees. Fine Air flight followers determined that the cargo weight would be 87,923 pounds and that the CG and trim would be 30 percent MAC and 2.4 units ANU if the airplane was loaded as directed.

Fine Air flight followers refined the weight and balance calculations for N30UA, the originally assigned airplane, to accommodate weight limitations for N27UA and then defined the pallet sequence to produce a more aft CG of 30 percent MAC (moving the pallet in position 13 to position 17 and leaving position 13 vacant). Fine Air flight followers stated that these changes were communicated to Aeromar by fax and by direct telephone conversations. However, the fax communications were the subject of conflicting statements by personnel from both companies. Further, there was no evidence that the revised paperwork was picked up by the Aeromar security guard responsible for the accident flight's cargo.

Although the Fine Air flight follower told Aeromar to reduce the weight of pallet "G" by 1,000 pounds (reducing the total cargo weight to 87,923 pounds) because of the landing weight restrictions for N27UA, that weight was not removed by Aeromar. Therefore, the final load sheet provided to the flightcrew was in error by an additional 1,000 pounds. The mistake was missed by Aeromar and Fine Air. The Fine Air flight follower also improperly recorded the pallet weight in position 17 as 5,860 pounds on the final load sheet, rather than 5,960 pounds as recorded by Aeromar on the pallet loading form.

The Safety Board's investigation also revealed errors in the printed load sheet form. The form indicated that it was for a DC-8-61 airplane, but one part of the form that affected the CG calculation (the fuel distribution scale) was based on data for DC-8-62 and -63 airplanes. The printed Fine Air load sheet form also incorrectly listed the maximum weight allowable for pallet position 18 as 6,088 pounds, instead of the correct weight of 3,780 pounds, which resulted in pallet position 18 exceeding its weight limitation by 1,247 pounds on the accident flight. Calculations based on this form resulted in a computed CG that was farther aft than the actual CG. The proper loading form would have yielded a 26.5 percent MAC CG for 87,923 pounds rather than 30 percent MAC. The built-in CG errors could have accounted for reported flightcrew requests to Fine Air flight followers to provide more rearward CGs to improve the flying characteristics of their airplanes. However, moving the CG aft would not correct the mistrim but would lighten control forces somewhat.

Weight and balance errors were a persistent problem at Fine Air previously identified by two Department of Defense (DoD) inspections (in 1994 and 1996 respectively) and two FAA inspections (a preaccident national aviation safety inspection program [NASIP] inspection and a postaccident regional aviation safety inspection program [RASIP] inspection). Shortly after the 1996 DoD inspection, Fine Air proposed redesigning its load sheet "as an interim measure until they automate weight and balance computations." However, this redesign was not accomplished before the accident and would likely not have revealed the fuel loading and pallet weight errors in the load sheet. Further, the Safety Board found during its investigation that Fine Air's load sheet, revised after the accident, also contained errors and discrepancies when compared to Douglas data, and that Fine Air's stabilizer trim setting data sheet also contained errors. The Safety Board notes with disappointment that Fine Air revised the load sheet form incorrectly after errors were found after the accident, and that FAA principal inspectors assigned to Fine Air failed to detect this mistake. Based on an examination of Fine Air and Aeromar loading documents and statements from Fine Air and Aeromar employees, the Safety Board concludes that procedures used by Fine Air and Aeromar to prepare and distribute cargo weight pallet distribution forms and final weight and balance load sheets were inadequate to ensure that these

documents correctly reflected the true loading of the accident airplane. The Safety Board is concerned that similar problems may exist at other carriers. Therefore, the Safety Board believes that the FAA should conduct an audit of all CFR Part 121 supplemental cargo operators to ensure that proper weight and balance documents are being used, that the forms are based on manufacturer's data or other approved data applicable to the airplane being operated, and that FAA principal inspectors confirm that the data are entered correctly on the forms.

There was conflicting information about whether the Aeromar and Fine Air employees involved in the loading operation were aware of the airplane change and of the changes in the loading instructions for the accident airplane. Aeromar's vice president stated that a company security guard picks up loading paperwork at Fine Air "immediately prior to the loading of a plane" or when the security guard delivers the cargo to the Fine Air ramp. The Fine Air flight follower who calculated the original load for N30UA stated that the Aeromar security guard in charge of the cargo picked up the paperwork with the cargo before 0600 on the day of the accident. However, the flight follower who went on duty after 0600 stated that the security guard did not return to pick up the revised weight distribution form. Although Fine Air flight followers stated that they faxed updated weight distribution and loading information to Aeromar before the flight, Aeromar's vice president stated that such a practice was "neither customary or usual." Based on interviews with Aeromar employees, the security guard assigned to the flight's cargo would have already been on duty at the Fine Air ramp when Fine Air flight followers said that they faxed the load changes to Aeromar. Testimony by Aeromar loaders indicated that cargo pallets were arranged on the ramp for loading according to the weight distribution form calculated for N30UA. Therefore, the Safety Board concludes that the security guard was not aware of the airplane change, and that he instructed Aeromar loaders to load the airplane in accordance with the weight distribution form he possessed for N30UA.

Airplane Loading Operations

Although there were conflicting statements about several aspects of the loading process, Aeromar cargo handlers' descriptions of the initial loading were consistent with the planned weight and balance configuration for N30UA, with pallet positions 2 and 17 initially left vacant. However, Aeromar cargo handlers stated that pallets could not be secured with locks during the initial loading. A subsequent check by the Aeromar supervisor determined that pallet locks would not latch in the rear of the airplane because pallet edges were not positioned properly, preventing locks from engaging on each edge of adjacent pallets.[6] According to the statements of the loaders and supervisor, in an attempt to correct this, all pallets from position 5 aft were pushed back one position each, which resulted in pallet position 17 being filled and position 5 being emptied. Pallet 4 was turned 90° and pushed back, which resulted in the pallet occupying all of position 5 and part of position 4.[7] According to loader statements, pallet 3 was secured by

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[6] The Aeromar loading supervisor said the locks would not latch because cargo extended over the sides of the pallets. Because of conflicting testimony, it could not be determined who first identified the problem with the loading and who issued instructions to rearrange the load.

[7] These actions were initiated by the loading crew or its supervisors and did not adhere to any planned loading configuration for the cargo on this airplane, which was calculated in Fine Air operations by the Fine Air flight follower.

locks on the front and back sides, which would have left position 2, by the cargo door, empty, with position 1 (with locks up) by the forward (cockpit) bulkhead. Thus, based on loader statements about how the airplane was first loaded and subsequent changes to the cargo's configuration, the Safety Board concludes that the accident airplane (N27UA) was initially loaded according to Fine Air's load distribution for N30UA; further, the final load configuration did not match the planned load for either airplane.

Loaders gave contradictory statements about the number of pallet engaged locks from positions 6 through 18 when the rearrangement and loading was completed. The Aeromar loading supervisor, who was responsible for ensuring that pallet locks were in place, stated that he put up several locks near position 18, and that he relied on other loaders to put locks up forward of that position. However, the Safety Board found considerable evidence indicating that few of the pallet locks were engaged. For example, 57 of the 60 locks recovered from the wreckage (from a total of 85 installed) were found in the unlocked position, and postaccident testing found no evidence of cracking, shearing, or elongation associated with impact damage and failure. Although it was the Aeromar loading supervisor's responsibility (according to his job description) to ensure that the locks were in place, he did not verify that they had been latched, relying instead on the thoroughness of loaders working in what was described as a hot, cramped, and stifling environment.[8]

Moreover, the Fine Air supervisor, who was the forklift driver (and, according to all parties involved, was not acting in a supervisory capacity) for the loading of the accident airplane, stated that when he was in charge of loading operations he always checked to make certain that the locks were up around pallet position 1. He said that he did so because these locks were readily visible to the flight engineer, who otherwise might insist on a reload if locks were down or missing. This implies that he believed it was less important to engage the locks that were not visible to the flight engineer, and suggests a casual attitude about the importance of aircraft weight and balance.

Cargo loading requires the coordination of a team under the direction of a supervisor to accomplish a multistep process, including identifying the appropriate pallet, loading the pallet onto the airplane, positioning the pallet inside the airplane, and securing the pallet in position. These basic steps were not followed during the loading of the accident flight. When it became evident to the loading crew that the cargo would not secure properly, decisions were made about pallet positioning and load security that suggested a desire to complete the job quickly. Little or no attempt was made to determine whether these changes would adversely affect the airplane in flight. Therefore, the Safety Board concludes that the Aeromar cargo loading supervisor failed to ensure that the pallets were loaded according to an approved load plan (in this case neither load plan was followed) and failed to confirm that the cargo was properly restrained.

Because there were vacant spaces in the cargo distribution and the cargo was not properly secured, the Safety Board considered whether shifting cargo at rotation could have contributed to the accident. Unsecured cargo pallets could shift during acceleration, and more significantly

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[8] For example, loaders said the temperature inside of the airplane was "just like an oven." However, it could not be determined to what extent, if any, these conditions contributed to the misloading of the airplane.

during rotation, if there were empty pallet positions between unsecured pallets. However, when Aeromar loaders pushed all of the cargo pallets from position 5 rearward one position and turned pallet 4 sideways into position 5, this created a line of contiguous pallets from position 5 to position 18, the aft-most cargo pallet position in the airplane. This suggests that the misloaded, aft-heavy condition existed at the time of rotation and was not caused by cargo shifting as the airplane's deck angle increased. However, based on loader statements that cargo extended over the sides of some pallets (which prevented the locks from being engaged), some shifting of cargo and additional compression might have occurred as the airplane's deck angle increased. The Safety Board concludes that a significant shift of cargo rearward at or before rotation did not occur and was not the cause of the initial extreme pitch-up at rotation; although, cargo compression or shifting might have exacerbated the pitch-up moment as the pitch increased.

Following the accident, the FAA's RASIP inspection team found numerous problems related to Fine Air's loading operations, including improperly secured and broken pallets, frayed and broken netting, and deficiencies in the areas of weight and balance control, cargo weighing, and security. These areas were also addressed in a consent agreement Fine Air signed with the FAA in September 1997, in which the operator agreed to revise its cargo handling system and procedures, including its "maintenance program for cargo pallets and cargo restraint devices, cargo pallet loading procedures, cargo weighing procedures...aircraft loading procedures [and] aircraft weight and balance procedures."

As part of its revised procedures, Fine Air developed a loading supervisor certification form that loading supervisors must sign to indicate that the load was placed on the airplane according to plan and restrained properly. In addition, the revised Flight Operations Manual (FOM) breaks down the loading process into specific procedures and steps to be followed by the loading supervisor when loading the airplane,[9] which helps to standardize the loading process.

However, the load certification form only contains an overall statement attesting to the fact that loading was performed in accordance with Fine Air's loading requirements. Cargo loading supervisors and cargo handlers work under difficult conditions that can include physical strain, time pressure, extreme temperatures, and nighttime hours, all of which can affect job performance. Thus, the Safety Board concludes that the difficult work environment of cargo loaders has the potential to cause loading errors if the loading process is not adequately structured to compensate for the detrimental environmental effects on human performance. However, these conditions can be mitigated by developing independent controls to ensure that critical steps in the loading process are completed properly. Therefore, the Safety Board believes that the FAA should require carriers operating under 14 CFR Part 121 to develop and use loading checklists to positively verify that all loading steps have been accomplished for each loaded position on the airplane and that the condition, weight, and sequencing of each pallet is correct.

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[9] In addition to the loading supervisor certification form, Fine Air made significant revisions to its FOM, AOM, and other documents outlining new load planning procedures, loader and supervisor responsibilities, and flightcrew responsibilities after resuming operations in October 1997 under the consent agreement. The airline stated that it now has provisions in place to ensure that pallets are built properly, that weights are verified (e.g., pallets are now weighed by Fine Air before being loaded), and that loading operations are thoroughly supervised.

Operational Control

Fine Air's wet lease agreement with Aeromar called for Aeromar to provide "fuel, loading and unloading at all stops," but stipulated that Fine Air retained operational control of all flights, and that all servicing was to be done under the supervision of Fine Air employees. Fine Air's operational control responsibilities were also defined in the company's FOM and spelled out in an addendum to Fine Air's lease agreement with Aeromar. Although 14 CFR Part 121.537 outlines supplemental air carrier operational control responsibilities, the principal operations inspector (POI) assigned to Fine Air stated that operational control for loading was not specifically addressed in the regulations. Further, the Safety Board could identify no such requirement in these regulations. However, the FAA stated in an October 1997 letter to Fine Air that under provisions of Part 121, "no aspect of operational control can be negotiated away...[including] loading of cargo as it relates to weight and balance requirements, cargo restraint requirements and hazardous materials requirements."

Although the terms of the wet lease agreement (later determined by the FAA to be a "transportation" or "charter" agreement) stated that Fine Air retained operational control, Fine Air managers stated that before the accident the company did not supervise loading operations carried out by Aeromar. In addition, Fine Air did not weigh palletized cargo delivered by Aeromar or have other procedures in place to verify cargo weights and the accuracy of the load form provided to the crew by Fine Air flight following. The Safety Board concludes that Fine Air failed to exercise adequate operational control of loading operations conducted by Aeromar on the accident flight as required by Part 121, the operational control terms of its lease agreement with Aeromar, and its own operating policy. Further, the Safety Board concludes that Fine Air's failure to exercise adequate operational control was causal to the accident by creating an operational environment in which cargo was loaded into Fine Air airplanes without verification of pallet weights and proper load distribution and by fostering a management philosophy that allowed airplanes to be dispatched without verification and control procedures in place to ensure that load-related, flight safety-critical tasks had been accomplished.

Loader Experience and Training

Four of the Aeromar cargo handlers had previous experience in air cargo operations in Miami. However, one cargo handler and the Aeromar loading supervisor had no experience in air cargo operations before employment with Aeromar. The Aeromar loading supervisor was hired about 3½ months before the accident and had been promoted to supervisor about 2 weeks before the accident on the basis of his performance. All cargo loading personnel interviewed by Safety Board investigators accurately described how to engage and disengage cargo locks and demonstrated a general knowledge of proper cargo loading procedures.

Air carriers are currently not required to provide initial classroom training or recurrent training for personnel involved in cargo handling. Training for loading personnel at Aeromar and Fine Air was described as on-the-job training. Aeromar cargo handlers stated that they did not receive any classroom training and that their supervisor had provided verbal instructions and information about the job of loading an airplane when they first were assigned to the cargo ramp. Aeromar cargo handlers who had previously worked at Fine Air indicated that while at Fine Air

they received no classroom training. The Fine Air loading supervisor also stated that he had received no classroom training for cargo loading. Although it appears that on-the-job training was an effective method of instruction for the basic technical job requirements, the misloading of the accident airplane indicates that loaders did not recognize the importance of loading an airplane consistent with the calculated weight and balance plan, or the importance of properly restraining the cargo. Therefore, the Safety Board concludes the loaders who loaded the accident airplane were not aware of the potentially catastrophic consequences of misloading the airplane and the failing to properly secure cargo, and that this contributed to the accident.

It is the Safety Board's understanding that cargo handler positions are typically entry-level positions characterized by relatively high rates of turnover. The Safety Board is concerned that because of a high turnover rate it can be difficult to control the quality of instruction delivered through on-the-job training. Because it is critical to the safety of flight to ensure that cargo has been loaded according to plan and properly restrained, all individuals associated with the loading process must be provided with consistent and comprehensive training in airplane loading.

After the accident, the FAA issued air transportation bulletin Handbook Bulletin for Airworthiness and Air Transportation (HBAT) 97-12 to FAA Order 8400.10 "Air Transportation Operations Inspector's Handbook."[10] In this bulletin the FAA states the following:

> Currently, part 121, section 121.400 prescribes the requirements applicable to each certificate holder for establishing and maintaining a training program for crewmembers, aircraft dispatchers, and other operations personnel. While the term "other operations personnel" is not currently defined in this subpart, it is evident that employees of a certificate holder who have the duty to supervise the loading of an aircraft or who qualify and authorize other persons to perform this function, must be trained on the certificate holder's procedures.

The bulletin encouraged principal inspectors to review any training program operators had for their cargo loading supervisors.

In the consent agreement issued after the accident, the FAA required Fine Air to "review and revise as necessary a training program for cargo handlers and other personnel responsible for cargo handling and aircraft loading." In response, Fine Air created a training program for cargo loader supervisors and cargo handlers[11] that included approximately 7 hours of training including curriculum areas covering the following:

- basic aerodynamics
- weight and balance for ground handlers

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[10] The bulletin was issued on September 5, 1997, as a Joint Flight Standards Handbook Bulletin; therefore, it was also added to FAA Order 8300.10, "Airworthiness Inspector's Handbook" as HBAW 97-12.

[11] Fine Air's training manual states that "This category of training is for an employee whose job description includes the identification of, positioning, direct and indirect handling of cargo to be loaded on FINE AIR aircraft to ensure the proper loading and handling of cargo aboard company aircraft." In addition to initial training there are provisions for recurrent training in this program.

- safe handling of aircraft cargo
- pallet building, loading, and unloading.

The Safety Board considers the steps taken by Fine Air to provide formal training to its cargo handling personnel to be a significant improvement in its training program because the curriculum is standardized and training modules go beyond the technical requirements of the job. However, the Safety Board recognizes that the consent agreement was directed only to Fine Air and is concerned that the training programs of other operators may suffer from similar deficiencies. Further, HBAT 97-12 only encouraged inspectors to examine operators' training for supervisory cargo loading personnel, and inspectors do not have the appropriate guidance material to evaluate training programs in cargo handling operations.[12] Thus, the Safety Board concludes that formal training is necessary to ensure that cargo handling personnel receive standardized instruction on safety-critical aspects of the loading process.[13] Therefore, the Safety Board believes that the FAA should require training for cargo handling personnel and develop advisory material for carriers operating under 14 CFR Part 121 and POIs that addresses curriculum content that includes but is not limited to, weight and balance, cargo handling, cargo restraint, and hazards of misloading and require all operators to provide initial and recurrent training for cargo handling personnel consistent with this guidance.

Flightcrew Load Verification Responsibilities

According to the Fine Air Aircraft Operation Manual (AOM) used at the time of the accident, the flight engineer was required to verify that at least three cargo pallet locks were locked at each position loaded with a pallet during his preflight check in Miami. However, Fine Air representatives told Safety Board investigators that it would have been "unlikely" for a flight engineer to make this check of the entire airplane during routine operations in Miami.[14] Other company personnel indicated that in Miami airplanes were typically loaded before flightcrews arrived and some loads did not provide sufficient clearance for the flight engineer to verify the status of the locks in positions aft of the cargo door.[15] The Safety Board recognizes that Fine Air changed the flight engineer's preflight checklist after the accident as part of a review and revision of its loading procedures and that new controls are now in place to ensure that the locks are

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[12] FAA Order 8400.10 does not provide guidance on evaluating training programs for cargo loading operations. In contrast, FAA Order 8400.10 and advisory circular (AC) 120-60 provide guidance material for FAA inspectors reviewing the initial and recurrent training programs that air carriers establish as part of their ground deicing and anti-icing programs under 14 CFR 121.629.

[13] At least one industry trade union, the International Association of Machinists and Aerospace Workers, stated that it offers training to ramp workers and other aviation personnel on the impact on flight safety of routine duties such as cargo loading, hazardous materials handling, and deicing operations.

[14] According to Fine Air's FOM, it is the joint responsibility of the first officer and the flight engineer to ensure proper airplane loading at outstations.

[15] Pallets are typically configured so that there is access to the area around the cargo door, to verify that door has been secured. Therefore, it is likely that the flight engineer was able to verify locks were up on positions 1 and 3 in the accident airplane. Loaders told Safety Board investigators that if these locks were not locked and visible to the flightcrew they risked being asked to reload. The current Flight Engineer's Preflight expanded checklist (page 6-12-19, issued 9/26/97, revision 35) only requires a check that all pallet locks installed in the airplane be operable. It no longer requires the engineer to ensure that a minimum of three pallet locks per position be used and locked.

engaged. However, at the time of the accident the flight engineer faced inconsistent guidance and expectations about this task. Thus, the Safety Board concludes that although the flight engineer was required to ensure that all cargo pallet locks were locked, company operating procedures and practices in MIA hindered him from accomplishing this task. Further, the Safety Board is concerned that such differences between flightcrew requirements for loading oversight and actual operational procedures may exist at other air carriers. Therefore, the Safety Board believes that the FAA should review the cargo loading procedures of carriers operating under 14 CFR Part 121 to ensure that flightcrew requirements for loading oversight are consistent with the loading procedures in use.

Although they possessed the airplane's load sheet (based on numbers provided by Fine Air flight followers) and the flight engineer was required to conduct a visual inspection, the accident flightcrew had no practical way to verify the airplane's weight and balance and gross weight before takeoff. However, the Safety Board notes that an electronic system has been in widespread use for years in both cargo and passenger operations that provides flightcrews with a digital readout in the cockpit of weight and balance and gross weight values. The STAN (Sum Total Aft and Nose) system uses pressure transducers to convert main gear and nose gear shock strut air pressure to an electronic signal. The cockpit readout, on the flight engineer's instrument panel, provides the flightcrew with an independent, direct measure of the airplane's gross weight and CG. Cockpit instrumentation showing these values would have added a critical last-minute safeguard for this flightcrew. Thus, the Safety Board concludes that if the flightcrew had had an independent method for verifying the accident airplane's actual weight and balance and gross weight in the cockpit, it might have alerted them to the loading anomalies, and might have prevented the accident. Therefore, the Safety Board believes that the FAA should evaluate the benefit of the STAN and similar systems and require, if warranted, the installation of a system that displays airplane weight and balance and gross weight in the cockpit of transport-category cargo airplanes.

FAA Surveillance and Oversight

The FAA's RASIP inspection of Fine Air following the accident found anomalies that the inspection team's report characterized as "an indication of a systemic problem at Fine Airlines." Echoing findings in previous preaccident FAA and DoD inspections, the RASIP report stated that inspectors had found problems in the areas of weight and balance control, cargo weighing, the accuracy of pallet weights, the condition of pallets and netting, and the condition of airplane cargo compartments and equipment. All of these findings, the report concluded, had "an impact on the safety of flight."

FAA inspectors assigned to Fine Air and Miami Flight Standards District Office (FSDO) managers stated that before the Fine Air accident, there was "no guidance," or "minimal guidance," in FAA written directives for the surveillance of cargo operations, and that there were no guidelines on how to evaluate the condition of pallets, netting, and other cargo equipment. The principal maintenance inspector (PMI) assigned to Fine Air described his attitude to cargo inspection before the accident as "to us, cargo is cargo." However, the team leader of the postaccident RASIP inspection at Fine Air, who is a PMI assigned to the United Parcel Service certificate, stated that specific guidance should not have been needed to discover the problems the RASIP inspection team found relating to the condition of pallets, nets, and cargo deck

flooring, noting that these problems were "evident." Moreover, during an en route inspection to Santo Domingo conducted a week before the accident, the Fine Air PMI was able to identify numerous loading problems, including damaged pallet netting, improper cargo loading, and a scale that was not in a location to weigh pallets. Although the PMI wrote a letter to Fine Air after the accident (on August 11, 1997) that asked Fine Air to amend its work cards for "C" checks in the areas identified as deficient during the en route inspection, no enforcement case was opened based on these findings, and the PMI did not take any other direct action to correct the immediate problem.

The manager of the FAA's Miami FSDO stated that he believed that the FAA surveillance of Fine Air's operations was "adequate" before the accident, but acknowledged that inspectors were "concentrating their emphasis on other areas," not on cargo loading. The FAA regional director, based in Atlanta, whose jurisdiction included the Miami FSDO, stated that "it's hard to define quality of surveillance," but acknowledged that the problems found in the RASIP should have been found earlier by the principal inspectors assigned to Fine Air.

Although the regional director noted that local inspectors can become bogged down in "certificate maintenance" (manual revisions, training program oversight, and other paperwork duties) at the expense of surveillance, even when they are aware of the findings of special inspections conducted by other teams, the director conceded that operations involving older airplanes, less experienced crews, and a "smaller [cost/profit] margin...are a concern." Nevertheless, cargo loading and weight and balance problems were repeatedly identified at Fine Air before and after the accident, and inspectors assigned to Fine Air had discovered and documented at least some of these problems before the accident. Therefore, the Safety Board concludes that the FAA inspectors assigned to Fine Air failed to ensure that known deficiencies in Fine Air's cargo operations were corrected. Thus, these problems went beyond a lack of broader FAA inspector guidance on inspecting cargo operations, and the FSDO manager conceded that senior FAA management had expressed "concern that we're not proactive."

Although the problems with the Miami FSDO's surveillance program at Fine Air pertained mostly to a failure to act on findings, the Safety Board is also concerned that the surveillance of cargo loading operations is not specifically required in the annual work programs established for FAA flight standards inspectors. The Safety Board concludes that the entire sequence of cargo loading operations, from preparation of the pallets/containers through the information provided to flightcrews, has a direct effect on flight safety and should not be neglected by the FAA surveillance program, particularly for the cargo air carriers operating under 14 CFR Part 121. Therefore, the Safety Board believes that the FAA should require all principal inspectors assigned to 14 CFR Part 121 cargo air carriers to observe, as part of their annual work program requirements, the complete loading operation including cargo weighing, weight and balance compliance, flight following, and dispatch of an airplane.

During its investigation of this accident, the Safety Board found numerous preaccident indicators of problems not only at Fine Air, but at other cargo Part 121 operators under the jurisdiction of the Miami FSDO. In the case of Fine Air, these included the findings of previous NASIP, RASIP, and DoD inspections at Fine Air. In another situation similar to Fine Air, Miami-based cargo operator Millon Air voluntarily ceased operations on October 24, 1996,

following an FAA inspection conducted after a Millon Air Boeing 707 freighter crashed in Manta, Ecuador, two days earlier on October 22, 1996. (In its investigation of several previous accident and incidents involving Millon Air, the Safety Board had found a series of FDR-related maintenance deficiencies). In 1995, the FAA suspended the operating certificate of another Miami-based Part 121 cargo and passenger carrier, Arrow Air, after an inspection found evidence of serious safety violations. Thus, the Safety Board concludes that the Miami FSDO lacked clear management policies to ensure that sufficient and appropriate surveillance was conducted and that surveillance results were acted upon; further, the FSDO was not aggressive in its inspection and management of the Fine Air certificate and this contributed to the accident.

Such cases were not limited to the Miami FSDO. In the case of the May 11, 1996, accident in the Florida Everglades involving a ValuJet DC-9-32, FAA postaccident inspections found numerous maintenance and operational deficiencies that resulted in the air carrier ceasing operations when it entered into a consent agreement with the FAA in June 1996. Deficiencies in ValuJet's operations had been thoroughly documented in an FAA report prepared before the accident and in RASIP and NASIP inspections conducted before the accident. The February 14, 1996, report noted "some weakness in the FAA surveillance" of the airline and inattention to "critical surveillance activities." The report, which recommended that consideration be given to the "immediate recertification" of the airline, was not provided to the Atlanta FSDO or to ValuJet until after the accident. These maintenance and operations-related problems, which were identified by FAA regional management as requiring greater scrutiny and concern, should have been sufficient to alert the FAA's senior managers to the need for more aggressive surveillance and before the Fine Air accident. Since the accident, FAA officials have acknowledged that under current oversight programs what they described as system failures like Fine Air are difficult to detect, and that the existing system of surveillance was inadequate. Moreover, a recent GAO report on the effectiveness of FAA inspector surveillance concluded that many FAA inspections "are not thorough or structured enough to detect many violations," and that inspectors often do not initiate enforcement actions because "doing so entails too much paperwork." Based on these repeated problem indicators and the FAA's acknowledgement of the shortcomings of its current oversight system, the Safety Board concludes that the deficiencies found in the Miami FSDO's oversight of Fine Air and other carriers in its jurisdiction are indicative of a broader failure of the FAA to adequately monitor air carriers, especially supplemental cargo carriers, in which operational problems had been identified.

Based on its investigation of the ValuJet Everglades and the Fine Air accidents, the Safety Board is also concerned about the effectiveness of the NASIP and RASIP inspection processes. In the case of each airline, preaccident inspections identified operational and airworthiness deficiencies. Although the findings of these inspections resulted in short-term corrective actions for the specific items that were found to be deficient, the inspections failed to identify and address systemic problems that were found in postaccident inspections of both carriers and that resulted in their temporary shutdown. The FAA has developed considerable information on cargo-related problems from the results of two special emphasis ramp checks conducted after the Fine Air accident. However, the FAA Administrator noted in a March 3, 1998, memorandum that "much work remains to correct systemic problems with FAA's aviation safety inspection program." Further, FAA representatives told Safety Board investigators that "data collection, analysis and corrective actions are not well focused." The results of this

investigation indicate that these deficiencies apply to both local FSDO surveillance and to NASIP and RASIP inspections. Thus, the Safety Board concludes that NASIP and RASIP inspections are not adequately identifying and addressing systemic safety problems that exist in air carrier operations at the time the inspections are conducted. Therefore, the Safety Board believes that the FAA should review its NASIP and RASIP inspection procedures to determine why inspections preceding these accidents failed to identify systemic safety problems at ValuJet and Fine Air and, based on the findings of this review, modify these inspection procedures to ensure that such systemic indicators are identified and corrected before they result in an accident.

The Safety Board notes current FAA initiatives to redesign and improve FAA oversight of air carriers, including the development and implementation of the Air Transportation Oversight System (ATOS) program designed to target resources and inspections to identify systemic safety problems. The Safety Board is also encouraged by the FAA's recent enforcement actions against cargo carriers based on standards developed after the Fine Air accident. Also encouraging are FAA proposals to better focus geographic inspector surveillance, planned changes in the new entrant carrier certification process and improved methods for the collection, analysis, and inspector access to FAA surveillance and safety trend data (the more effective use and dissemination of safety performance analysis system and program tracking and reporting system data). Although these and other proposed changes are in response to Safety Recommendation A-96-163, issued following the 1995 Tower Air accident, are steps forward, the Safety Board is concerned that some operators that may benefit most from additional scrutiny have not been included in the initial implementation phases of the ATOS program. The program is being launched at 10 of the nation's largest carriers, for which FAA surveillance is already considerable, and operational incidents and accidents are relatively rare.

Although it is understandable why the FAA wants to "refine the new model" before expanding to other sectors of the industry, the Safety Board is nevertheless concerned about the potential for delays inherent in the implementation of such a comprehensive redesign of the FAA surveillance system. Initial implementation at the 10 designated carriers is not scheduled until October 1998. Although the proposed changes to the FAA oversight system address the intent of Safety Recommendation A-95-163, the Safety Board will continue to monitor the FAA's progress in implementing these changes. Pending further action, the Safety Board reiterates its February 23, 1998, classification of Safety Recommendation A-95-163 as "Open—Acceptable Response."

However, the Safety Board remains concerned about the FAA's ability to successfully enhance its surveillance capability at current budget and personnel resource levels, especially at a time when the aviation industry is growing rapidly and increasing demands are being placed on the agency's certificate management system. Indeed, principal inspectors assigned to Fine Air stated that they needed assistance in accomplishing their tasks and that the number of en route inspections they conducted were reduced because of scheduling, workload, and budget constraints. Following a February 16, 1995, accident involving an Air Transport International DC-8-63, the Safety Board issued Safety Recommendation A-95-111, which asked the FAA to determine whether its budget and personnel resources were sufficient to maintain its surveillance programs adequately. Although the Safety Board in 1996 classified A-95-111 "Closed—Acceptable Action" following an FAA response stating that resources were "properly allocated to

maintain oversight at an adequate level," the Safety Board concludes that, based on its investigation of the Fine Air accident, current FAA personnel and budget resources may not be sufficient to ensure that the quality of air carrier surveillance will improve. Therefore, the Safety Board believes that the FAA should evaluate the surveillance programs to ensure that budget and personnel resources are sufficient and used effectively to maintain adequate oversight of the operation and maintenance of both passenger and cargo carriers, irrespective of size.

Loss of FDR Data

The failure of the accident airplane's FDR to record 6 of the 11 required parameters of data hampered the Safety Board's investigation into the pitch-up and stall events that resulted in the airplane's departure from controlled flight. The FDR did not record information about engine data, airspeed, pitch and roll attitudes, vertical acceleration, and microphone keying, all of which would have been immensely useful in understanding the accident scenario.

The Safety Board has long been concerned about problems related to the absence of FDR data critical to accident investigations and has made a series of recommendations beginning in the early 1970s to improve FDR accuracy, expand the number of parameters, and require verification of parameter recordings. Continued concerns about the airworthiness of FDRs resulted in the Safety Board's issuing two recommendations to the FAA in 1991 (Safety Recommendations A-91-23 and -24) aimed at developing a permanent policy for FDR maintenance and recordkeeping. Further, in 1997, following a series of accidents that involved problems with recordings on retrofitted FDRs, the Safety Board issued two additional safety recommendations (Safety Recommendations A-97-29 and -30) asking the FAA to require readouts of retrofitted 11-parameter FDRs to ensure that all required parameters were being recorded properly and to complete, by January 1998, an FAA-promised AC addressing the installation and maintenance of FDRs.

The problems with the Fine Air FDR in this accident once again underscore the need for prompt action in determining the functionality and airworthiness of retrofitted 11-parameter FDRs, the importance of FDR certification and maintenance requirements, and the importance of accurate FDR documentation. In the case of Fine Air, in addition to the six parameters that were missing, the heading data were recorded on three parameters and in reverse. The Safety Board notes with concern that these deficiencies were found less than 4 months after a maintenance examination of the FDR that required the unit to be "downloaded into a computer capable of determining that all parameters are being recorded" and 3 months after it was overhauled and bench checked.

The Safety Board also notes with disappointment that the AC promised by the FAA to be issued by January 1998 has not yet been completed, even though the Safety Board provided a draft version of the AC upon request by FAA staff. The Safety Board has stated several times that inclusion of guidance relating to FDR maintenance documentation (which was addressed in FAA Notice N8110.65) into this AC would satisfy the intent of Safety Recommendations A-91-23 and -24. An AC addressing FDR maintenance and FDR certification would also satisfy the intent of Safety Recommendation A-97-30. However, the Safety Board is concerned that the AC, already delayed more than 7 years, still may not be produced in a timely manner. This AC is also

essential to reduce retrofit problems that could occur on a much larger scale than those encountered during the less-sophisticated 11-parameter retrofit program. Accordingly, the Safety Board classifies Safety Recommendations A-91-23, A-91-24, and A-97-30 "Open—Unacceptable Response" pending the FAA's completion of the AC.

The Safety Board is also disappointed with the adequacy of the FAA's response to determine the airworthiness of retrofitted, 11-parameter FDRs, as requested in Safety Recommendation A-97-29 in May 1997. Although the FAA stated in a July 1997 response letter that it agreed with the intent of the recommendation and planned to require air carriers to perform readouts of all retrofitted 11-parameter FDRs within 180 days of the issuance of a new FDR flight standards bulletin (which became effective on December 15, 1997), the timetable intended for these readouts was not specified. For example, HBAW-97-13B, issued in response to Safety Recommendation A-97-29, made no mention of the 180-day timetable for readouts and only proposed scheduling FDR maintenance at "C" check intervals as part of the new FDR maintenance program guidelines it outlined.[16] Under the "C" check interval inspection plan described in the bulletin, Fine Air flight 101's FDR might not have been due for inspection until January 2001. This timeframe for completing a full readout of 11-parameter FDRs is not acceptable and does not address the intent of Safety Recommendation A-97-29.

Recent events suggest that the necessity for these readouts remains. Since the Fine Air accident, the Safety Board encountered yet another malfunction involving an 11-parameter retrofit, installed on an American Airlines Boeing 727 that landed short of runway 14R at O'Hare International Airport, in Chicago, Illinois, on February 9, 1998. Although the investigation is not complete, an initial readout of the accident airplane's FDR determined that data recorded on the elevator/pitch and longitudinal acceleration parameters were unuseable, resulting in the loss of information potentially critical to determining the cause of the accident. The Safety Board notes that this FDR malfunction occurred on an airplane maintained by a large international air carrier with extensive maintenance resources and substantial FAA oversight. FDR system documentation provided by the airline indicates that the elevator position sensor might have been installed incorrectly, and that this condition was not discovered during a functional test conducted at a "C" check in November 1997. Examination of the elevator parameter data suggested that the person who performed the functional test either wrote the results in the wrong place or that the elevator values were reversed, with the value for "full column forward" in the correct value range for "full column aft" and vice-versa. Although the Safety Board has not yet drawn a conclusion regarding the ground test, the Safety Board is concerned that these malfunctions might have resulted in improper parameter installation and/or maintenance.[17]

The Fine Air accident also highlights the importance of proper documentation of FDR maintenance actions and readout results. Although Fine Air's maintenance manual required that the accident airplane's FDR data be downloaded into a computer to determine that the parameters were being recorded properly, the maintenance job card that tracked the work

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[16] At Fine Air, a C check interval occurs every 3,300 hours, or 36 months.

[17] Examination of the data recorded on the longitudinal acceleration parameter indicated that the data were more representative of data for lateral acceleration, suggesting that the accelerometer might have been incorrectly installed on the airplane, resulting in lateral, rather than longitudinal, data being recorded.

performed did not require this readout data to be printed or retained. Only a mechanic's signature was required to certify that the readout had been accomplished. Consequently, there was no way for another person to verify that the readout was correct. The Safety Board concludes that permanent documentation of FDR computer readouts is needed to later verify that such readouts have been properly accomplished.

Based on the continued discovery of malfunctioning 11-parameter FDRs and because the findings of this accident investigation indicate that it is advisable to require air carriers to maintain the records of FDR readouts, the Safety Board classifies Safety Recommendation A-97-29 "Closed—Unacceptable Action/Superseded" and believes that the FAA should require an immediate readout of all 11-parameter retrofitted FDRs to ensure that all mandatory parameters are being recorded properly; that the FDR system documentation is in compliance with the range, accuracy, resolution, and recording interval specified in 14 CFR Part 121, Appendix B; and require that the readout be retained with each airplane's records.[18]

The number of recent confirmed FDR malfunctions also suggests that the problem may go well beyond the scope of 11-parameter retrofits. Indeed, the number of problems encountered with 11-parameter FDRs suggests either inadequate installations or maintenance of FDR systems. The Safety Board is concerned that the problems encountered with 11-parameter FDR retrofits will not only continue, but worsen, without further corrective action as additional mandated parameters are added according to phase-in requirements under 14 CFR Part 121.343 and Appendix B.[19] Thus, the Safety Board concludes that current and proposed inspection intervals for FDRs (at each "C" check) are not adequate because of fleet utilization variables at many carriers. Therefore, the Safety Board believes that the FAA should require maintenance checks for all FDRs of aircraft operated under 14 CFR Parts 121, 129, 125, and 135 every 12 months or after any maintenance affecting the performance of the FDR system, until the effectiveness of the proposed AC and new FAA inspector guidance on continuing FDR airworthiness (maintenance and inspections) is proven; further, these checks should require air carriers to attach to the maintenance job card records a computer printout, or equivalent document, showing recorded data, verifying that the parameters were functioning properly during the FDR maintenance check and require that this document be part of the permanent reporting and recordkeeping maintenance system.

Although an FDR's primary function is to provide detailed flight information following an accident or incident, this detailed flight information is useful even in the absence of an accident or incident. The Safety Board notes that the FDR phase-in requirement and the quick access capabilities of modern solid-state FDRs offer operators the opportunity to develop and implement a flight operations quality assurance (FOQA) program. Analysis of downloaded

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[18] Appendix B outlines FDR specifications, including parameters, range, accuracy, sampling interval, and resolution.

[19] Under Part 121.343, all airplanes manufactured on or before October 11, 1991, with 30 or more seats will be required to have FDRs equipped with 22 channels (or 18 for those units that do not have flight data acquisition unitss no later than August 18, 2001). Airplanes manufactured after October 11, 1991, up to August 18, 2000, will be required to have FDRs with 34 channels. Transport airplanes manufactured between 2000 and 2002 will be required to have 57-parameter FDRs, and airplanes manufactured after August 18, 2002, will be required to have 88-parameter FDRs.

FOQA data enables operators to enhance crew and aircraft performance, to develop tailored training and safety programs, and to increase operating efficiency. FOQA programs can also be used to refine ATC procedures and airport configurations and to improve aircraft designs. Although FOQA programs based on the minimum 18 parameters called for in the FDR phase-in requirements would have some limitations, the potential safety and operational benefits of even a limited program are significant.

Because frequent FDR data downloads and data analysis are components of a viable FOQA program, the requirement for periodic readouts to validate the quality of the mandatory FDR parameters would likely be met if the operator corrected recording problems discovered in the readout. The need to download and analyze FDR would also require operators to maintain sufficient FDR system documentation to meet the Safety Board's needs in the event of an accident or incident.

In a May 1997 letter to the FAA, the Safety Board listed a series of accidents and incidents from 1991 through 1997 that involved problems extracting data from retrofitted FDRs. Because many of the problems encountered with retrofitted FDRs have resulted from improper installation and poor system documentation, the Safety Board is concerned that deficiencies may exist in the supplemental type certificate (STC) process; and that retrofit errors and problems are not being identified and corrected by FAA inspectors.[20] An FDR's primary function is to provide detailed flight information following an accident or incident; it does not otherwise affect the airworthiness of an aircraft. As a result, air carrier maintenance technicians may not view the FDR system as critical to the operation of the airplane, and FAA avionics inspectors may have little or no exposure to the complex data collection and recording features of FDR systems. Thus, the Safety Board concludes that FAA principal avionics inspectors (PAIs) may lack the experience and training to provide adequate oversight of FDR installations and continued FDR airworthiness requirements. Therefore, the Safety Board believes that the FAA should provide FAA PAIs with training that addresses the unique and complex characteristics of FDR systems. Further, the Safety Board believes that the FAA should create a national certification team of FDR system specialists to approve all STC changes to FDR systems.

Deficiencies in Fine Air's CAS Maintenance Program

A Safety Board review of the accident airplane's maintenance logs for the 90-day period before the accident indicated a significant number of recurring problems involving the engines, belly cargo doors, and thrust reversers. Although none of these problems were factors in the accident, the Safety Board is concerned because the continuing analysis and surveillance (CAS) program was designed to alert operators to repeat deficiencies and to facilitate prompt corrective maintenance action in problem areas. Fine Air's director of quality control stated that these repetitive repairs often involved "different parts" of "an old system." However, the number and similarity of the maintenance discrepancies on the accident airplane suggests that repeated problem indicators were either missed or ignored. Thus, the Safety Board concludes that Fine Air's CAS program was not as rigorous as its program description indicated and failed to result

[20] An STC authorizes alteration of an aircraft engine or other component that is operated under an approved-type certificate.

in the correction of systemic maintenance deficiencies. Therefore, the Safety Board believes that the FAA should direct the PMI assigned to Fine Air to reexamine the airline's CAS program and take action, if necessary, to ensure that repetitive maintenance discrepancies are being identified and corrected.

The Safety Board's review of the accident airplane's maintenance logs also found that all significant maintenance discrepancies were logged by flightcrews on return trips to Miami, where Fine Air's maintenance facilities are located. No significant entries were made at any outstation location. The FAA PMI assigned to Fine Air told Safety Board investigators that he had "raised concerns" with Fine Air management about flightcrews "having all their problems on final in Miami," adding that proving when the discrepancies actually occurred was impossible unless the inspector was accompanying the flightcrew on an en route inspection. In addition, an FAA PMI based in Milwaukee, Wisconsin, stated that such log entries "are common every day practice...if you're passenger or freight, that's standard." This inspector also described the difficulty inspectors encounter when trying to enforce proper logbook entry procedures, asking "how do you do something about it [prove the entries were intentionally deferred until the return leg]." In the case of Fine Air, the Safety Board found no evidence that corrective action was taken by the airline after the PMI raised his concerns to Fine Air management and no evidence of further FAA followup on the matter.

During its investigation of an uncontained engine failure on a Delta Air Lines MD-88,[21] the Safety Board determined that flightcrew members who found drops of oil on an engine bullet nose and two missing wing rivets did not have clear guidance on what constituted "maintenance 'discrepancies' and 'irregularities' and when to contact maintenance personnel and to log anomalies." Although the captain's decision to defer maintenance in Pensacola (the departure airport) until arrival in Atlanta, a Delta hub, appeared to have been contrary to Delta's FOM, Delta management later supported the flightcrew's failure to log the discrepancies or to contact maintenance.

The Safety Board is concerned that this return leg logging practice, which may be as widespread in the industry as it is difficult to verify, has become an unspoken, and largely tolerated, way of avoiding costly outstation repairs and flight delays. Safety Recommendation A-98-21, issued to the FAA as a result of the investigation of the Delta accident, was aimed at clarifying flightcrew responsibilities and when flightcrews "can, if at all, make independent determinations to depart when maintenance irregularities are noted." The recommendation called for POIs to review and clarify these policies at their respective operators. However, these policies may differ significantly among operators. Moreover, 14 CFR Part 121.363,[22] while outlining the airworthiness responsibilities of operators, contains no specific requirement to ensure that maintenance discrepancies are logged when they are discovered. According to 14 CFR Part

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[21] National Transportation Safety Board. 1998. *Uncontained Engine Failure, Delta Air Lines Flight 1288, McDonnell Douglas MD-88, N927DA, Pensacola, Florida, July 6, 1996.* Aircraft Accident Report NTSB/AAR-98/01. Washington, DC.

[22] Part 121.363, "Responsibility for Airworthiness," states that "each certificate holder is primarily responsible for...the airworthiness of its aircraft...[and] the performance of the maintenance, preventive maintenance...in accordance with its manual and the regulations of this chapter."

121.563, the pilot in command is required to "ensure that all mechanical irregularities occurring during flight time are entered in the maintenance log of the airplane at the end of that flight time" and to "ascertain the status of each irregularity entered in the log at the end of the preceding flight." The Safety Board is concerned that the term "flight time" is not specifically defined, and could be interpreted by flight crews as meaning at the end of the last flight of a multiple-leg duty day, instead of at the end of the flight during which the irregularity was discovered. Part 121.563 also does not address irregularities and specific logging responsibilities for irregularities found during preflight inspections.

Faced with a maintenance irregularity at an outstation, flightcrews (under schedule pressures and perhaps a management preference for home-base repairs when possible) may be reluctant to risk the delay that a logbook entry could incur. Language addressing specific logging requirements in Part 121.563 (that defined specific logging requirements or stated that logging is mandatory, rather than referring only to the general airworthiness of the airplane) would reduce ambiguity. This would require flightcrews, especially at outstations, to contact maintenance for a deferral or a decision to seek contract maintenance repairs before departing. Although there may be circumstances in which independent flightcrew evaluation of maintenance discrepancies is warranted, maintenance personnel are the best qualified personnel to make such determinations. Thus, the Safety Board concludes that Fine Air's maintenance logs for the accident airplane suggest a practice of logging significant maintenance discrepancies on return flights to Miami, where repairs were completed, and that such practices may be widespread in the industry. Further, the Safety Board concludes that although the PMI noted a pattern of logging entries on return flights to Miami and expressed his concerns to Fine Air management, no further action was taken either by the PMI or Fine Air management to address this problem. Therefore, the Safety Board believes that the FAA should amend 14 CFR Part 121.563 to specifically require that all discrepancies be logged when they occur and be resolved before departure through repair or deferral in consultation with (the certificate holder's or contracted) maintenance personnel.

As a result of the investigation of this accident, the National Transportation Safety Board recommends the following to the Federal Aviation Administration:

> Require all 14 Code of Federal Regulations Part 121 air carriers to provide flightcrews with instruction on mistrim cues that might be available during taxi and initial rotation, and require air carriers using full flight simulators in their training programs to provide flightcrews with Special Purpose Operational Training that includes an unanticipated pitch mistrim condition encountered on takeoff. (A-98-44)

> Conduct an audit of all Code of Federal Regulations Part 121 supplemental cargo operators to ensure that proper weight and balance documents are being used, that the forms are based on manufacturer's data or other approved data applicable to the airplane being operated, and that FAA principal inspectors confirm that the data are entered correctly on the forms. (A-98-45)

> Require carriers operating under 14 Code of Federal Regulations Part 121 to develop and use loading checklists to positively verify that all loading steps have

been accomplished for each loaded position on the airplane and that the condition, weight, and sequencing of each pallet is correct. (A-98-46)

Require training for cargo handling personnel and develop advisory material for carriers operating under 14 Code of Federal Regulations Part 121 and principal operations inspectors that addresses curriculum content that includes but is not limited to, weight and balance, cargo handling, cargo restraint, and hazards of misloading and require all operators to provide initial and recurrent training for cargo handling personnel consistent with this guidance. (A-98-47)

Review the cargo loading procedures of carriers operating under 14 Code of Federal Regulations Part 121 to ensure that flightcrew requirements for loading oversight are consistent with the loading procedures in use. (A-98-48)

Evaluate the benefit of the STAN (Sum Total Aft and Nose) and similar systems and require, if warranted, the installation of a system that displays airplane weight and balance and gross weight in the cockpit of transport-category cargo airplanes. (A-98-49)

Require all principal inspectors assigned to 14 Code of Federal Regulations Part 121 cargo air carriers to observe, as part of their annual work program requirements, the complete loading operation including cargo weighing, weight and balance compliance, flight following, and dispatch of an airplane. (A-98-50)

Review its national aviation safety inspection program and regional aviation safety inspection program inspection procedures to determine why inspections preceding these accidents failed to identify systemic safety problems at ValuJet and Fine Air and, based on the findings of this review, modify these inspection procedures to ensure that such systemic indicators are identified and corrected before they result in an accident. (A-98-51)

Evaluate the surveillance programs to ensure that budget and personnel resources are sufficient and used effectively to maintain adequate oversight of the operation and maintenance of both passenger and cargo carriers, irrespective of size. (A-98-52)

Require an immediate readout of all 11-parameter retrofitted flight data recorders (FDRs) to ensure that all mandatory parameters are being recorded properly; that the FDR system documentation is in compliance with the range, accuracy, resolution, and recording interval specified in 14 Code of Federal Regulations Part 121, Appendix B; and require that the readout be retained with each airplane's records. (A-98-53)

Require maintenance checks for all FDRs of aircraft operated under 14 Code of Federal Regulations Parts 121, 129, 125, and 135 every 12 months or after any maintenance affecting the performance of the FDR system, until the effectiveness

of the proposed advisory circular and new FAA inspector guidance on continuing FDR airworthiness (maintenance and inspections) is proven; further, these checks should require air carriers to attach to the maintenance job card records a computer printout, or equivalent document, showing recorded data, verifying that the parameters were functioning properly during the FDR maintenance check and require that this document be part of the permanent reporting and recordkeeping maintenance system. (A-98-54)

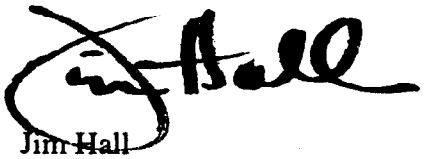
Provide FAA principal avionics inspectors with training that addresses the unique and complex characteristics of flight data recorder systems. (A-98-55)

Create a national certification team of flight data recorder (FDR) system specialists to approve all supplemental type certificate changes to FDR systems. (A-98-56)

Direct the principal maintenance inspector assigned to Fine Air to reexamine the airline's continuing analysis and surveillance program and take action, if necessary, to ensure that repetitive maintenance discrepancies are being identified and corrected. (A-98-57)

Amend 14 Code of Federal Regulations Part 121.563 to specifically require that all discrepancies be logged when they occur and be resolved before departure through repair or deferral in consultation with (the certificate holder's or contracted) maintenance personnel. (A-98-58)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.



By: Jim Hall
Chairman