AIR LINE PILOTS ASSOCIATION, INTERNATIONAL

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August 18, 2003

Ms Lorenda Ward
Investigator-in-Charge
Major Investigations Division
National Transportation Safety Board
AS-10, Room 5424
490 L'Enfant Plaza East, SW
Washington, DC 20594-0003

Reference: Air Midwest Flight 5481, DCA03MA022

Dear Ms Ward:

In accordance with the Board's rules, the Air Line Pilots Association, International (ALPA) submits the following comments regarding the aircraft accident involving Air Midwest Flight 5481, which occurred on January 8, 2003 in Charlotte, North Carolina.

The aircraft, a Raytheon Beechcraft 1900D (B-1900D), crashed on takeoff from Charlotte-Douglas International Airport (CLT), Charlotte, North Carolina. All occupants were fatally injured and the aircraft was destroyed by the impact and post-crash fire. The aircraft loading, preflight, engine start, taxi, and the takeoff roll all were uneventful. Shortly after liftoff, the aircraft began a pitch up that was not controllable by the flight crew. The aircraft reached a nose up attitude of over 50°, rolled and descended, and crashed approximately 1½ miles from the start of the takeoff roll.

Recovered aircraft wreckage, Digital Flight Data Recorder information, and NTSB post-accident interviews and testing all indicate that the aircraft elevator was improperly rigged during maintenance. The misrigged elevator limited available elevator authority to about ½ of the normally available Airplane Nose Down (AND) elevator travel.

During the investigation of this accident, ALPA identified numerous safety issues, some of which directly contributed to the chain of events leading to the accident, and others that, although they did not play a contributory role in the accident, came to light during the investigation, and must be addressed by the industry in order to improve safety. Such issues include the following:

- Inadequate Federal Aviation Administration (FAA) oversight of the Air Midwest Huntington, WV maintenance facility (HTS)

- Improper and ineffective Air Midwest oversight and training of maintenance personnel at HTS
- Inadequate separation of maintenance activities from inspection activities at HTS
- Inaccurate manufacturer's maintenance manuals
- The failure of maintenance and inspection personnel to detect the improperly rigged elevator
- The lack of cockpit indication to denote full elevator range of motion
- The lack of industry requirement for Aircraft Upset Recovery Training
- The lack of realistic passenger and baggage weights for weight and balance determination

For convenience, ALPA's findings and safety recommendations are attachments to this letter.

ALPA appreciates the opportunity to have participated as a party to the investigation and hopes that the attached analysis, conclusions and safety recommendations will be of assistance as the NTSB concludes its investigation.

Sincerely,

Captain Dan Sicchio
ALPA Coordinator

Enclosures: ALPA's Findings
ALPA's Safety Recommendations
ALPA's Submission to the NTSB

cc: Jay Hiles, IAM
Robert Ramey, Raytheon Aircraft
Steven Ring, NATCA
Jim Aiken, Air Midwest
Robert Drake, FAA
Gary Sneary, Vertex Aerospace

FINDINGS

1) Air Midwest's FAA-approved maintenance program included contracting Raytheon Aircraft, LLC (RALLC) to perform maintenance on AMW aircraft.

2) RALLC contracted Structural Modifications And Repair Technicians, Inc. (SMART) at its Huntington, WV facility to perform maintenance on AMW aircraft.

3) SMART was responsible for hiring most of the mechanics at HTS.

4) The SMART system to ensure applicants for mechanic positions were appropriately screened, and their credentials verified, was ineffective.

5) The RALLC system to identify and task foremen and inspectors did not effectively maintain the separation between maintenance and the inspection of that maintenance.

6) Common practice at HTS allowed the same individual to be alternately tasked as mechanic, inspector, or foreman.

7) Neither Air Midwest, RALLC, nor SMART had developed formal training programs or used a definitive syllabus in training mechanics, foremen, or inspectors.

8) The RALLC HTS maintenance manager worked during the day, although most maintenance at the facility was performed at night.

9) Only one Air Midwest representative was assigned to the HTS facility. That individual worked during the day, although most maintenance at the facility was performed at night.

10) The FAA Principle Maintenance Inspector (PMI) was not co-located with any Air Midwest facility. The PMI's office is in Wichita, KS, proximate to Air Midwest corporate headquarters, but far from AMW maintenance facilities.

11) An Air Midwest audit of the HTS facility identified staffing deficiencies, including the need for additional foremen and inspectors.

12) RALLC did not adequately address HTS staffing deficiencies identified by the Air Midwest audit.

13) The FAA PMI was unaware of staffing, training, and personnel turnover problems at HTS.

14) Air Midwest aircraft N233YV was at the Huntington facility for scheduled maintenance consisting of the "Detail 6" check (D-6). The D-6 check is focused generally on the tail of the aircraft, including the elevator system.

15) The mechanic who conducted the maintenance on the elevator system had no prior experience on the B-1900D elevator system, and Air Midwest procedures therefore required him to be supervised while conducting the work.

16) The individual tasked to provide OJT to the mechanic doing the D-6 elevator inspection was responsible for the work. In violation of FAR 121.371(c), he was also tasked to inspect the work.

17) The D-6 check calls for checking elevator cable tension, but the B-1900D maintenance manual contains no stand-alone procedure for adjusting elevator cable tension. The manual describes re-tensioning only in the context of adjusting the entire elevator rigging.

18) The FAA does not currently approve manufacturer's maintenance manuals.

19) The B-1900D maintenance manual does not provide any guidance on how to determine the temperature to be used to calculate proper elevator cable tension.

20) The method that the mechanic used to determine the temperature for the elevator cable tensioning may have been inappropriate.

21) The mechanic determined that the elevator cable tension was out of tolerance.

22) The B-1900D maintenance manual contains information that is not pertinent to the B-1900D aircraft, creating the impression that the manual cannot always be strictly followed.

23) The mechanic attempted to adjust the elevator cable tension and deliberately omitted steps in the maintenance manual.

24) The mechanic improperly adjusted the elevator rigging and changed the positional relationship between the elevator and the control column, restricting the travel of the elevator.

25) The B-1900D elevator rigging procedure does not include a final verification of the proper relationship between control column and elevator positions.

26) The OJT instructor/inspector failed to detect the improper elevator cable rigging and signed off the inspection.

27) The misrigged elevator was capable of only approximately half the normal nose down travel when the aircraft left the HTS maintenance facility.

28) The aircraft left the HTS maintenance facility in an unairworthy condition.

29) Subsequent to the subject maintenance, the aircraft flew nine flights without incident. Each of these nine flights was loaded such that the aircraft center of gravity was between the forward limit and the midpoint of the allowable range.

30) On the accident flight, the aircraft was loaded in accordance with FAA-approved Air Midwest procedures.

31) The crew performed the normal preflight CG calculation which, based on procedures in use at the time, correctly computed a CG near the aft limit of the allowable CG range.

32) On takeoff, the pilot made a normal rotation.

33) Aircraft pitch continued to increase after rotation, beyond the normal target value.

34) With the improperly rigged elevator, there was insufficient elevator authority to control aircraft pitch, control was lost, and the aircraft crashed.

SAFETY RECOMMENDATIONS

As a result of this investigation, the Air Line Pilots Association, International offers the following safety recommendations.

To the Federal Aviation Administration:

1) Require that air carriers and/or repair stations develop a detailed syllabus for provision of On the Job Training (OJT) for personnel performing maintenance on aircraft in commercial air carrier service.

2) Require that all flight control rigging procedures for aircraft models used in commercial air carrier service include an inspection item which verifies full and proper flight control surface response to inputs from the cockpit controls.

3) Develop and implement a system for ensuring accuracy of, and timely detection and correction of errors in the "Flight Controls" (ATA code 27) sections of all manufacturer's maintenance manuals for aircraft models used in commercial air carrier service, and which also ensures timely FAA approval and distribution of this information to affected organizations. This would include, as a minimum:

    a) Conduct a one-time accuracy review of the "Flight Controls" (ATA code 27) sections of all manufacturers' maintenance manuals for aircraft models used in commercial air carrier service.

    b) Require that the "Flight Controls" (ATA code 27) sections of all manufacturers' maintenance manuals for existing and future aircraft models used in commercial air carrier service be changed to "FAA Approved" category.

4) Require that Principal Maintenance Inspectors' (PMI) oversight of airline maintenance operations include familiarity with the actual work being performed as well as the program and documentation. This familiarity would necessarily involve regular visits to all facilities in the PMI's jurisdiction.

5) Require that oversight (by FAA or airline personnel) of every major maintenance facility of each commercial air carrier include site visits during the normal peak working hours of the facility.

6) Require that all commercial air carriers notify their respective Principal Maintenance Inspector (PMI) when certain changes to the maintenance organizations or facilities occur or are to be made. These would include changes to management structure or personnel, adding or eliminating maintenance facilities, adding or eliminating maintenance contract organizations, or other changes that would affect the PMI's ability to conduct effective oversight.

7) Continue existing activity in the Aviation Rulemaking Committee (ARC) addressing aircraft weight and balance issues. This activity should include development of a standard method to be used to create realistic estimates of passenger weight and baggage that include factors such as age, gender, destination, season, and any other factors identified as having a significant impact on passenger and bag weights.

8) Require that all commercial air carriers obtain and utilize maintenance work cards which comply with the manufacturers guidance and which contain:
   - Tasks broken down into manageable increments
   - Procedures and provisions for shift or personnel changes
   - All necessary references or information
   - Line-by-line inspection signoff provisions

9) Require that all maintenance providers (e.g., certified repair stations, contract personnel, etc.) for commercial air carriers utilize the operators' applicable maintenance work cards which comply with the manufacturers guidance and which contain:
   - Tasks broken down into manageable increments
   - Procedures and provisions for shift or personnel changes
   - All necessary references or information
   - Line-by-line inspection signoff provisions

10) Develop and implement a system (similar to Transport Canada's Safety Management System), which would require every Commercial air carrier to integrate safety risk management, including responsibilities and accountabilities, into corporate planning and performance at all levels of the corporation.

11) Develop and implement a system (similar to Transport Canada's Safety Management System) which would require airline maintenance organizations, manufacturing organizations, airports, and air traffic service organizations to integrate safety risk management, including responsibilities and accountabilities, into corporate planning and performance at all levels of the organization.

12) Require that all commercial air carriers provide flight crewmembers with Aircraft Upset Recovery training.

SUBMISSION OF THE

AIR LINE PILOTS ASSOCIATION

TO THE

NATIONAL TRANSPORTATION SAFETY BOARD

REGARDING THE ACCIDENT INVOLVING

AIR MIDWEST FLIGHT 5481

IN CHARLOTTE, NORTH CAROLINA

ON JANUARY 8, 2003

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SUMMARY

On January 8, 2003, at 0848 Eastern Standard Time (EST), a Raytheon Beechcraft 1900D (B-1900D), N233YV, operated by Air Midwest Airlines (AMW) as flight 5481 and doing business as USAirways Express, crashed on its initial climbout from Charlotte-Douglas International Airport (CLT), Charlotte, North Carolina. The flight was destined for Greenville-Spartanburg (GSP), South Carolina. There were 2 crewmembers and 19 passengers on board. All occupants were fatally injured and the aircraft was destroyed by the impact and post-crash fire.

The aircraft loading had been calculated in accordance with Air Midwest procedures, and the aircraft weight and balance were computed to be within limits. Preflight, engine start, taxi, and the takeoff roll all were uneventful. Shortly after rotation, the aircraft began a pitch up that was not controllable by the flight crew. The aircraft reached a nose up attitude of over 50° and the airspeed decayed. The aircraft rolled and descended, reaching a maximum bank angle of over 130°, and a maximum nose down attitude of approximately 40°. The flight crew was unable to regain control, and the aircraft crashed adjacent to a USAirways hangar east of the runway, approximately 1½ miles from the start of the takeoff roll.

Recovered aircraft wreckage, Digital Flight Data Recorder (DFDR) information, post-accident interviews and testing all indicate that the aircraft elevator was improperly rigged during maintenance. After this maintenance, the aircraft had flown nine uneventful flights prior to the accident flight, but none of those flights was made with the aircraft Center of Gravity (CG) as far aft as on the accident flight. The misrigged elevator limited available elevator authority to about ½ of the normally available Airplane Nose Down (AND) elevator travel. This limited authority was sufficient to control the aircraft on the flights between the maintenance and the accident, but was insufficient to control the aircraft on the accident flight.

During the investigation of this accident, the Air Line Pilots Association, International (ALPA) identified numerous safety issues, some of which directly contributed to the chain of events leading to the accident, and others that, although they did not play a contributory role in the accident, came to light during the investigation and must be addressed by the industry in order to improve safety. Such issues include the following:

- Inadequate Federal Aviation Administration (FAA) oversight of the Air Midwest Huntington, WV maintenance facility (HTS)
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B-1900D ELEVATOR

Elevator System

The elevator of the accident aircraft was misrigged during maintenance at the Air Midwest maintenance facility in Huntington, West Virginia two days prior to the accident. The misrigging occurred due to a series of deficiencies and failures within the Air Midwest maintenance organization, including the mechanic's unfamiliarity with that task, and the inspector's failure to adequately verify that the work was accomplished correctly.

The accident aircraft (N233YV) underwent a "Detail-6" (D-6) check at the Air Midwest Huntington, West Virginia maintenance facility (HTS) beginning the night of January 6, 2003. Part of this D-6 procedure requires a check of the elevator cable tension. Air Midwest utilizes the aircraft manufacturer's (Raytheon Beechcraft) maintenance manual. This maintenance manual contains a procedure to rig the elevator. However, the manual does not contain a separate, stand-alone procedure for adjusting the elevator control cable tension. Cable tensioning is an integral part of the elevator rigging procedure. If the elevator cable tension requires adjustment, the only applicable procedure in the manual is the complete elevator rigging procedure.

The B-1900 elevator control system is a closed-loop, cable operated system. The "loop" refers to a continuous mechanical path from the control column to the elevator and back to the control column, primarily via the control cables. Thus, motion of any component (column, cable, elevator) necessarily results in motion of all other components in the system. Similarly, changes in elevator cable lengths or tensions can result in subtle but significant changes in the positional relationship between the elevator and control column.

The aircraft is equipped with mechanical stops that limit the travel of the elevator and the control column separately. In order to ensure full elevator travel, normal system rigging requires that the elevator reach its stops before the control column reaches its stops. Changes in the positional relationship between the elevator and control column can result in limited elevator travel by causing the control column stops to be reached before the elevator stops are reached. Any such limitations to elevator travel will directly affect the controllability and airworthiness of the aircraft.

A flight crewmember cannot determine whether column travel is limited by the elevator stop or the column stop. Furthermore, since the B-1900D lacks an elevator position indicator in the cockpit, the flight crew cannot reliably or accurately determine whether the full range of elevator travel is available.

The normal range of elevator travel is 20° Trailing Edge Up (TEU) to 14° Trailing Edge Down (TED). The flight data recovered after the accident indicates that when the aircraft left the hangar after the maintenance, the available range of elevator travel was approximately 20° TEU to 7° TED. During post-accident testing in Wichita, Kansas, the National Transportation Safety Board (NTSB) Systems Group verified that adjustment of the elevator cable turnbuckles (without properly securing other pitch control system components) changes the positional relationship of the elevator and control column. Furthermore, the NTSB testing identified several scenarios that would result in the elevator turnbuckle lengths corresponding to those found in the wreckage.

Elevator Maintenance Activities

The elevator section of the D-6 procedure on the accident aircraft was assigned to a mechanic who had been hired eight weeks earlier by Structural Modifications And Repair Technicians, Inc. (SMART), a maintenance subcontractor. Air Midwest policy requires that mechanics have specific system training signoffs before being allowed to work unsupervised on a particular system. Contrary to this policy, the mechanic worked essentially unsupervised on the elevator although he had not been signed off to do so. The individual assigned to provide training to this mechanic was also the same individual who would later conduct the inspection of this work, contrary to Federal Aviation Regulation (FAR) 121.371(c). This trainer/inspector briefly discussed the task and provided guidance on how the specific task was to be accomplished, and then left the mechanic trainee to work unsupervised while the trainer/inspector worked on other assignments.

The mechanic trainee referred to the proper section of the Beech 1900D maintenance manual. However, this maintenance manual section contains some significant, readily detectable discrepancies between the manual and the actual aircraft, but offers the user no way to reconcile those discrepancies. This topic is discussed in detail later in this report, but those discrepancies would clearly cause a user to question the need for (or even the possibility of) strict adherence to the manual.

Although the B-1900D maintenance manual requires that ambient temperature be taken into account during cable tension measurements, it does not specify where or how this temperature is to be determined. As part of his D-6 activity, the mechanic trainee measured the temperature using an aircraft temperature probe lying on a tool cart located near the front of the aircraft and the maintenance hangar door. As detailed in the addendum of the Systems Group factual report, the location of the probe used by the mechanic may have given the mechanic erroneous temperature data. Based on this data, the mechanic trainee determined that the elevator cable tension was out of tolerance. If the maintenance manual had been more clear about temperature measurement, the elevator cable tension might have been found to be within tolerance. Therefore, it is possible that the elevator cable tensions did not actually require any adjustment, and that the subsequent re-tensioning, performed incorrectly, need not have occurred.

In his NTSB interview, the mechanic trainee acknowledged that he skipped several steps in the maintenance manual elevator rigging procedure, since he considered himself to be adjusting cable tension, and not conducting an elevator rigging. This decision was prompted in part by his discussions with his trainer for this task, who also agreed that certain steps could be omitted from the maintenance manual rigging procedure. Also, although the trainer was responsible for the proper conduct of the elevator tensioning, the trainer did not supervise the trainee on a continuous basis. The combination of this mechanic trainee skipping maintenance manual steps and working with intermittent supervision, led to the improper elevator rigging.

In two separate interviews with the NTSB, the mechanic trainee provided conflicting testimony regarding the exact procedures that he used to adjust the elevator cable tension. In testimony immediately following the accident, he stated that he pinned the controls on the Captain's (left) side. The correct procedure is to remove the floorboards and pin the controls at the forward bellcrank under the First Officer's (right) side. In subsequent testimony, the mechanic stated that he did pin the forward bellcrank on the First Officer's side. Since the control column gust lock pin installs on the Captain's side, it is possible that the mechanic mistakenly pinned the gust lock instead of the bellcrank, and then conducted his elevator cable tension adjustment. Subsequent NTSB testing in Wichita also revealed that the bellcrank on the First Officer's side could be mis-pinned if the mechanic did not remove certain access panels (e.g., in an attempt to expedite the work). However, with the access panels still in place, the mechanic could only pin the bellcrank by feel, without adequate visual reference. With the control column mis-pinned (either by erroneously pinning the gust lock or due to lack of adequate visual reference) and the elevator unrestrained, the mechanic trainee adjusted the two elevator cable turnbuckles to fair the elevator with the stabilizer per the maintenance manual procedure. Pinning the control column incorrectly and then adjusting the turnbuckle lengths to fair the elevator is an improper maintenance procedure. This improper maintenance procedure resulted in a significant alteration of the elevator rigging. NTSB testing in Wichita showed that using the improper techniques described above yielded turnbuckle lengths which closely matched the lengths of the corresponding turnbuckles found in the wreckage.

Work vs. Inspection

Federal Aviation Regulation 121.371c and Air Midwest policy require separation between maintenance and inspection activities. Inspectors cannot "sign off" or verify their own work. Contrary to these standards, the On-the-Job-Training (OJT) instructor was also tasked with inspector duties. The trainer/inspector was responsible for training the mechanic, which made him responsible for the proper conduct of the work. However, the work arrangement also made him responsible for inspecting the work. This effectively eliminated the required separation between conducting the work and inspecting the work. This led to two problems. First, since his workload precluded this trainer/inspector from closely supervising and training the mechanic conducting the D-6 elevator check, the mechanic trainee improperly rigged the elevator. Second, since the trainer/inspector was responsible for both accomplishing and inspecting the work, the natural tendency would be for him to assume the work was done correctly, and therefore be less diligent during his inspection than if he had not been involved in the work at all. The evidence indicates that the inspector signed off the mechanic trainee's work after conducting an abbreviated inspection by verifying that the turnbuckles were properly secured, and that the elevator control range appeared correct when viewed from the ground. However, the inspector did not confirm that the elevator-control column relationship was correct. The opportunity to detect the improper maintenance, which is the primary function of inspection, was missed.

Air Midwest maintenance and inspection procedures do not require verification of the elevator range of motion after completing all of the steps. Such procedures would have detected the improper rigging.

AIRCRAFT OPERATIONS

The accident occurred on the tenth flight after the aircraft left the Huntington maintenance hangar with the restricted elevator travel. The nine flights prior to the accident were conducted without any controllability issues, and none of these previous flight crews perceived any elevator irregularities or problems. This raises several questions, including how the aircraft was able to fly these nine previous flights, why the aircraft crashed on the tenth flight, and why previous flight crews did not detect any irregularities with the aircraft.

Effect of CG on Elevator Travel Required

The flight crew correctly utilized the Air Midwest loading procedures to compute the accident aircraft weight and balance. Those calculations showed takeoff gross weight and aircraft CG to be within limits. Post-accident analyses suggest that the Air Midwest procedures may not accurately reflect actual passenger and bag weight allowances. Since the aircraft payload was destroyed by the accident, the actual weight of passengers and bags can only be estimated. Post-accident analyses suggest that, although the crew's computations were accurate and correct for the information they were using, the actual loading placed the CG near or slightly beyond the aft limit. However, post accident analyses revealed instances of other B-1900 aircraft loaded to CG values beyond aft limits, and these data clearly show that a properly rigged B-1900 is fully controllable during takeoff, climb, and cruise.

CG position is a key factor in determining how much elevator travel will be required for a given flight condition. A CG toward the forward limit requires much less elevator in the AND direction, and an increasingly aft CG requires increasingly more AND elevator. The previous nine flights had CGs located much farther forward than the CG on the accident flight, and therefore did not require significant AND elevator. As a result, they were not adversely affected by the limited AND elevator travel available. However, on the accident flight with the CG near the aft limit, the elevator required was beyond the restricted range, but within the normally available range. The restricted elevator travel rendered the accident aircraft uncontrollable.

Post Maintenance Elevator Offset

The elevator cable re-tensioning changed the positional relationship between the elevator and control column. This is evident in a comparison of pre- and post-maintenance elevator position data recorded by the DFDR, which shows a noticeable offset between data recorded before and after the maintenance. The sensor that supplies the DFDR parameter labeled 'elevator position' does not directly measure the elevator position, but instead senses the position of the control column linkage. This value is then mathematically converted to elevator position; this conversion is predicated on a correct elevator-control column positional relationship. Changes to this relationship, such as those made on the accident aircraft during the subject maintenance, therefore result in erroneous elevator position data. The mechanic trainee who accomplished the maintenance on the elevator stated that he did not recalibrate the DFDR elevator sensor after re-tensioning the elevator control cables[1]. Therefore the elevator position information from the ten post maintenance flights reflects a changed position of the column.

[1] Pg. 35, Exhibit 11-J.

Based on the facts known about the maintenance activities, and the basic aerodynamic principle that there is a defined range of elevator positions for an aircraft to rotate on takeoff or to fly trimmed for cruise flight, the offset observed on the DFDR data can only be explained by the misrigging scenario.

Figure 1 shows elevator inputs for takeoff rotation for 20 flights. The upper lines represent the maximum TEU elevator during the takeoff rotation, and the lower lines represent the maximum TED elevator to arrest the rotation. The values of the maximum TEU and TED are relatively constant for the flights before the maintenance, relatively constant for the flights after maintenance, but differ significantly between the pre- and post-maintenance flights. Throughout all the flights, however, the *differences* between these TEU and TED maximums are approximately the same. None of the crews on any of the flights reported flight control anomalies, so it is reasonable to conclude that all the takeoff maneuvers were normal, and thus nearly identical. Figure 2 presents the cruise phase elevator and elevator trim values for the same 20 flights. The relatively constant trim values indicate that the actual elevator position was also relatively constant. However, the recorded elevator position exhibits the same large discontinuity (offset) between pre- and post-maintenance flights. The offsets between the pre- and post-maintenance flight data in both these figures can only be explained by the misrigging scenario.

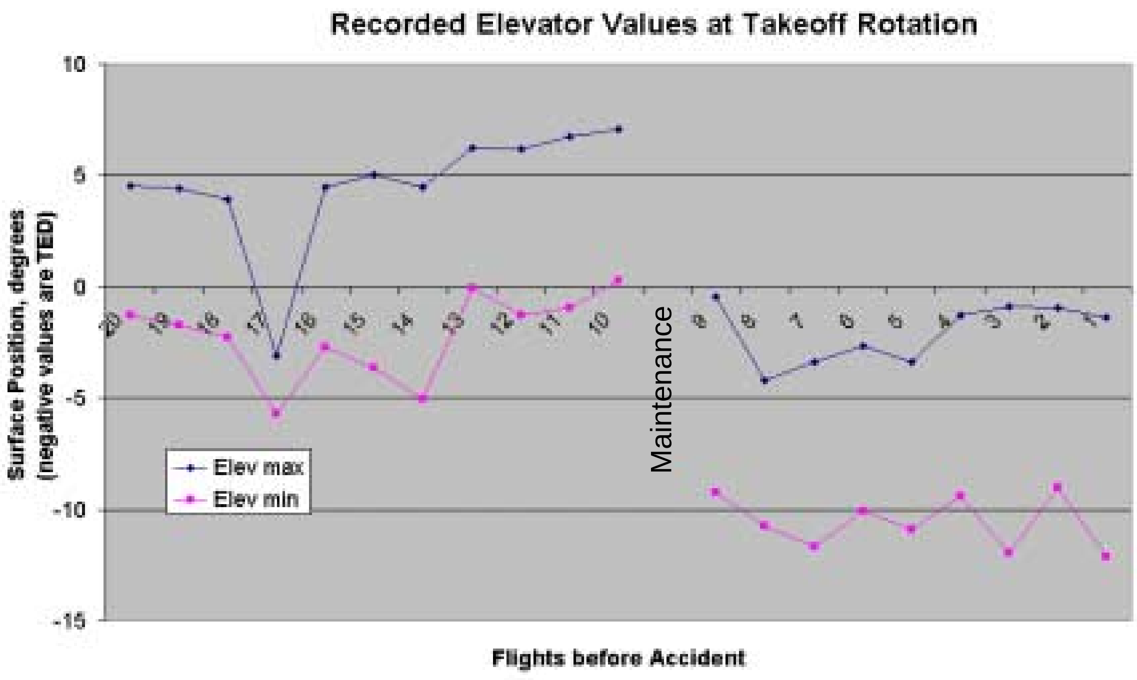

Figure 1

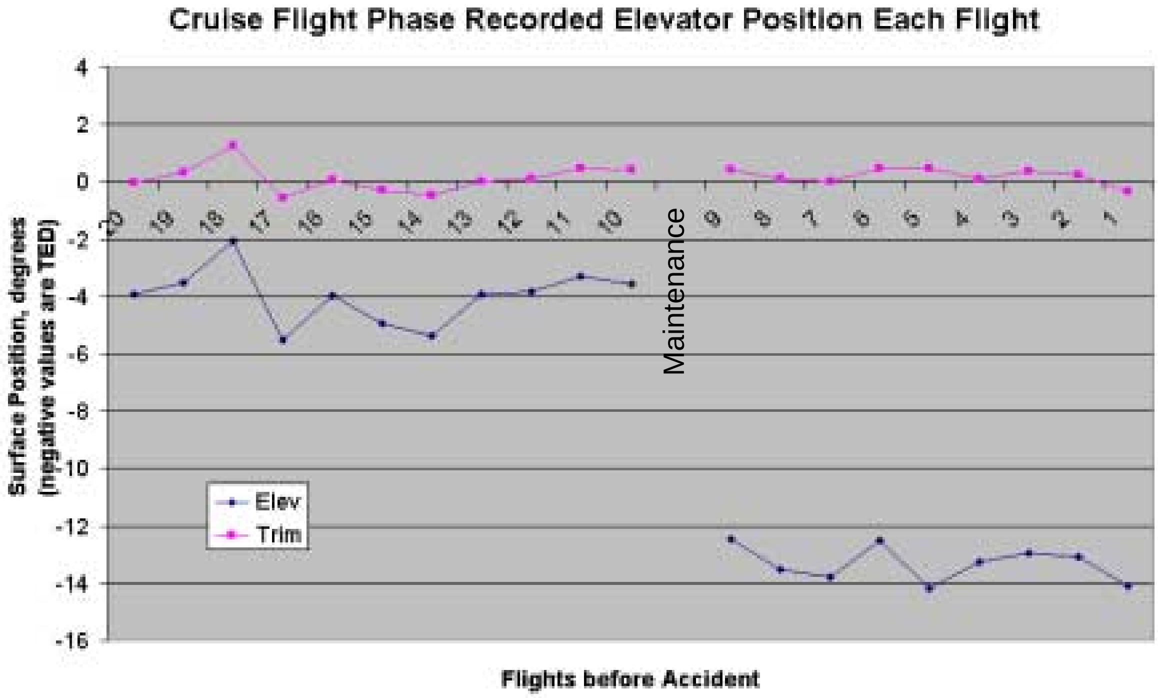

Figure 2

The B-1900D does not have any elevator position indication in the cockpit, and the elevator cannot be observed from the cockpit. Therefore, the only means that a flight crew has to determine elevator position from the cockpit is by the position of the control column. However, on the accident aircraft the maintenance induced changes to the column position were small enough to be imperceptible to the flight crews. The NTSB testing in Wichita showed that the accident aircraft's modified elevator-control column relationship would have reduced the total column travel during control sweeps by approximately 1.5 inches, and changed the cruise flight column position by approximately one inch from a properly rigged aircraft. This is within the normal range of column position changes that would be experienced due to normal shifts in aircraft CG from flight to flight, and thus would have been indiscernible to the crews.

Human Performance - Crew Handling and Upset Recovery Training

The improperly rigged elevator resulted in insufficient flight control authority to counter the aircraft's increasing pitch attitude. The flight recorder data shows that the crew immediately attempted to counter the problem using the flight controls. There is CVR evidence of significant physical exertion by the crew on the controls, and there is no evidence to indicate anything other than that both pilots understood and agreed on what the correct control inputs should be. The evidence indicates that the crew never stopped flying the aircraft, and that they continued attempting to find effective corrective action until the crash.

As part of our analysis of the facts of the accident, ALPA attempted to evaluate whether any training has been developed that addresses the scenario faced by the crew, and if so, whether the crew had received such training. Training in dealing with extreme conditions such as the one in this accident has been known by any of a number of terms, such as “unusual attitude,” “selected event,” “advanced maneuver,” and “airplane upset.” The terms are effectively interchangeable, but “airplane upset” has come to be the accepted one. In a joint effort between the FAA and industry that began in 1995, a task group was formed to analyze upset scenarios, in order to develop recovery training aids for widespread use. ALPA participated in the development of this Upset Recovery Training Program, which in turn led to the development of the Upset Training Aid, accepted by both government and industry as a definitive text on the subject. The Aid defines an airplane upset as “an airplane in flight unintentionally exceeding the parameters normally experienced in line operations or training.” It also identifies many of the potential causes of such an upset. Nearly all such causes involve either external factors (e.g., weather) or situations where control of a normally functioning airplane is lost (e.g., aerodynamic stall). These conditions, as well as the case of an actual systems malfunction (e.g., asymmetric flap), all presume that either the aircraft remains fully operational throughout, or that a system failure occurs for which there is corrective action specified by the manufacturer.

One of the scenarios in the Upset Training Aid is a pitch up exceeding 25º. The recommended recovery technique developed for this scenario involves rolling the aircraft into a steep bank to decrease the pitch attitude. Bank angles of up to sixty degrees are generally necessary to make a marked decrease in the pitch attitude. The recovery technique is practiced at altitudes as low as 1000 feet above the ground. However, the technique makes no attempt to avoid descending below that altitude in the course of the recovery.

In a recent accident involving an extreme nose-high attitude on takeoff, that crew attempted to control the pitch up with bank. The airplane remained airborne for several minutes as the crew attempted to regain control, but experienced altitude variations of approximately 400 feet, and ultimately crashed.

The flight crew of Air Midwest 5481 had not received Upset Recovery Training. The problem became apparent immediately after rotation, the attitude became extreme at approximately 75 feet above the ground, and the aircraft flight control system had been severely compromised, leaving only half the normally available authority. Even if an initial reaction could have kept the airplane airborne, the crew had no way to identify and correct the fundamental problem of the misrigged elevator.

Although, in ALPA’s view, it is unlikely that upset recovery training would have been effective in this particular case, the accident underscores the fact that even with all the safeguards that exist in the design and operation of transport airplanes, upsets still occur. ALPA strongly recommends that all flight crewmembers be exposed to this training. ALPA continues active partnership with industry and government to refine this training aid. However, to date, industry acceptance and implementation of the training aid has not reached our desired level.

AMW MAINTENANCE

FAA Oversight

In several recent accident investigations (e.g., Alaska 261, Valujet 592) the NTSB has noted deficiencies in FAA oversight. Frequently these oversight deficiencies have been cited as contributing causes of the accidents. As also noted in NTSB investigations, FAA Certificate Management Office (CMO) staffing levels sometimes negatively affected the FAA's ability to provide adequate and effective oversight. FAA oversight did not detect significant deficiencies in the Air Midwest maintenance program.

The Air Midwest maintenance deficiencies that were identified during this investigation should all have been readily detected by FAA oversight, but they were not. Aside from the geographic diversity factors discussed below, another likely contributor to this oversight failure was a shortage of FAA staffing. Although the Principal Maintenance Inspector (PMI) testified at the Public Hearing that he felt his staffing was sufficient, ALPA suggests that additional staffing at the CMO level, additional staffing at the level above the AMW CMO, additional staffing to conduct Regional Aviation Safety Inspection Programs (RASIPs), or some combination of all three, would have allowed more frequent visits to facilities, afforded more time for FAA review of AMW/Raytheon Aerospace LLC (RALLC)/SMART programs and practices, and generally increased the effectiveness of the oversight. More effective oversight would likely have identified the AMW maintenance program deficiencies. In at least two instances, the PMI's oversight was inconsistent with FAA standards or guidance, such as the following:

- FAA Order 8300.10 (Airworthiness Inspector's Handbook) contains the procedures for the PMI to evaluate an operator for regulatory compliance. This order states, "Continuous airworthiness maintenance programs are approved according to the operations specifications. These operations specifications describe the scope of the program and reference manuals." In his testimony at the Public Hearing, the PMI acknowledged that it was part of his responsibility to oversee the Air Midwest continuous airworthiness maintenance program.

- Advisory Circular (AC) 120-16C on Continuous Airworthiness Maintenance Programs (CAMP) says the program should address the maintenance and inspection organization, and the performance and approval of maintenance. This AC further states that the CAMP should, as part of the required Continuing Analysis and Surveillance System (CASS), ensure that the maintenance is performed "in accordance with the methods, standards and techniques specified in the operator's manuals" and that it should "identify indications of inadequate training." It is the PMI's responsibility to ensure that the operator's CASS is functional and effective, and it is up to the PMI to advise the operator if the CASS is not accomplishing this.

According to the NTSB's interview summary of the PMI, the PMI was unaware of the practices occurring at the HTS facility, where a subcontracted (SMART) mechanic was acting as shop foreman, and an inspector was also tasked to provide OJT. He also stated that he had been unaware of the SMART contract. ALPA can only conclude that this demonstrates that the PMI was providing inadequate oversight of the operator.

In the Public Hearing testimony of the PMI, the PMI stated that if he had known certain details of the subcontracting arrangements, and been more aware of the relatively high mechanics' turnover rate and consequent mechanics' training issues, he would have stepped up his surveillance of the HTS facility. The PMI's comment strongly suggests that he took a passive approach, assuming that all was acceptable at the HTS facility until told otherwise. ALPA feels that it is the responsibility of any PMI to actively ensure that an operator is conducting a safe and effective maintenance operation, and it is incumbent upon the PMI to actively solicit or obtain the information necessary to make that determination. ALPA also believes that the operator should be required to notify the FAA of significant changes to its program (e.g., management structure or personnel, adding or eliminating maintenance facilities, adding or eliminating maintenance contract organizations) such that proper surveillance can be maintained. The PMI should have been aware of the HTS facility's staffing, supervision, inspection, and training policies and procedures. FAA Order 8300.10 explicitly specifies that the PMI must consider the number of personnel and their experience, as well as the aircraft involved, in determining the adequacy of the operator's maintenance organization. The PMI had a fundamental responsibility to be aware of significant changes at the facility, particularly those requiring heightened surveillance.

FAR 121.367(b) states: "Each certificate holder shall have an inspection program and a program covering other maintenance, preventive maintenance, and alterations that ensures that . . . competent personnel and adequate facilities and equipment are provided for the proper performance of maintenance, preventive maintenance, and alterations." It is a fundamental responsibility of a regulator to enforce the regulations. However, the PMI testified at the Public Hearing that he was unaware of the subcontracting of mechanics to SMART; thus, there appears to have been no way for the PMI to have determined whether the mechanics were competent. The maintenance conducted by the Huntington facility clearly was not proper, indicating that the mechanics were not competent. Thus the PMI cannot have been effectively performing oversight of the operator.

In the NTSB interview of the Air Midwest PMI, the PMI stated that he was made aware of certain maintenance manual deficiencies by Air Midwest, and told Air Midwest to work directly with the manufacturer[2] to correct these deficiencies. The PMI further stated that he did not follow up on this issue with Air Midwest, and that he was not aware of any applicable Air Midwest or manufacturer actions or results of those actions. This indicates that the PMI felt that correction of maintenance manual deficiencies were not in his purview. Also, since Air Midwest is not the only operator of the B-1900D, any maintenance manual deficiencies could have negatively affected the airworthiness of aircraft at other operators. Thus, the PMI, as the on-site representative of the FAA, had a responsibility to identify problems, ensure corrective action was initiated, and evaluate the potential airworthiness impact on the B-1900D fleet. None of this was done.

The recent DOT Office of the Inspector General (DOTIG) report[3] noted that there continue to be problems with maintenance functions, and that they should receive the same level of FAA

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[2] Pg. 3, Exhibit 11-I
[3] "Review of Air Carriers' Use of Aircraft Repair Stations", Report No. AV-2003-047, issued July 8, 2003

surveillance, regardless of whether those functions are performed in-house or by a contract maintenance facility. This is not a new issue. In 1996, the FAA issued a Flight Standards Handbook Bulletin for Airworthiness 96-05C, entitled “Air Carrier Operations Specifications Authorization to Make Arrangements With Other Organizations to Perform Substantial Maintenance.” This document provided guidance that was intended help FAA personnel to detect, reduce and prevent contract maintenance-induced safety and airworthiness problems. However, the DOTIG report concluded that the same weaknesses in repair station oversight still exist. This conclusion is applicable to AMW’s HTS facility.

The Air Midwest PMI office is located in Wichita, Kansas, the corporate headquarters of Air Midwest, while the Air Midwest maintenance facilities are located in Huntington, WV; Dubois, PA; Farmington, NM; Little Rock, AR; and Panama City, FL. Air Midwest makes extensive use of contractors to operate its maintenance facilities, and these contractors subcontract for mechanics. In accordance with FAR 121.363 and as noted by the PMI in his testimony, regardless of who performs the maintenance, Air Midwest, as the operator, is ultimately responsible for the proper conduct of maintenance and the airworthiness of its aircraft. The FAA oversight was focused on Air Midwest, and did not examine either RALLC or SMART. These geographic and organizational factors complicate the oversight function, and therefore demand greater effort and attention on the part of the FAA in order to ensure safe and effective maintenance operations.

AMW Organizational Structure

Air Midwest maintenance management, in delegating maintenance and supervision to the contractor, compromised its ability to provide safe and adequate oversight of the maintenance facility. This compromise of management control was apparent in the way the HTS facility was supervised, which in turn affected the facility training and personnel management. The HTS facility was inadequately staffed, and most of the HTS mechanics were inexperienced and poorly trained. The poor supervision of HTS ultimately resulted in the inappropriate assignment of an inspector to simultaneously supervise a new mechanic needing On-The-Job-Training (OJT) for the elevator control system, and inspect the work, violating company policy and FAR 121.371(c).

In July 2002, AMW contracted with Raytheon Aerospace LLC (RALLC, now Vertex Aerospace) to run the HTS facility. As noted above, RALLC provides similar services at the AMW facilities in four geographically distant locations. RALLC had some mechanics directly in its employ, but primarily utilized contract mechanics provided by Structural Modification And Repair Technicians, Inc. (SMART) to work on the aircraft. Such a multi-layered arrangement complicates coordination, communication and control functions, and therefore demands greater attention to these aspects in order to ensure safe and effective AMW control of maintenance operations.

As previously noted, FAR 121.363 stipulates that the airline is ultimately responsible for the proper conduct of maintenance and the airworthiness of its aircraft, regardless of who performs the maintenance. NTSB interview and Public Hearing testimony indicates that AMW was detached from management of the HTS maintenance facility to the point that it resulted in AMW being essentially unaware of the day-to-day maintenance activities at that facility. AMW had only one representative at the HTS facility, the on-site manager. This person worked the day shift, but the maintenance work was typically performed at night. RALLC had a maintenance manager (MXMGR) on site who was responsible to ensure that maintenance was performed in accordance with Air Midwest policy and procedure manuals. The MXMGR was tasked, along with the foreman, with managing the work assignments and assuring that the work was properly accomplished. Like the AMW on-site manager, this MXMGR also worked the day shift, instead of at night when most of the maintenance was being accomplished. Thus, neither the AMW representative nor the MXMGR could directly observe the actual maintenance operations for which they were responsible. In particular, this arrangement prevented these individuals from observing either training or inspection on any regular basis.

HTS Staffing Levels

An AMW audit in November 2002 identified that AMW was not satisfied with the staffing levels at HTS. This primarily manifested itself as a lack of dedicated foremen, inspectors, and mechanics' OJT instructors , and appropriate training for all these positions. A November 5, 2002 letter[4] from AMW to the MXMGR indicated that the facility was identified as having insufficient staffing on each shift. The audit specifically stated that there was only one foreman and one inspector on each shift, and that there needed to be two of each. The auditor gave 30 days for the site manager to respond in writing to the findings. After approximately 60 days, the MXMGR responded to the audit letter. Rather than addressing the identified need to double the number of foremen and inspectors, the response stated only that, "We have increased our maintenance staff 20% in the last month." In addition, the cited 20% increase in staff did not include any mechanics with inspector or foreman skills. When asked to explain how his action was responsive to the audit complaint, the MXMGR stated in his Public Hearing testimony that one mechanic had been promoted to be an inspector. However, this still would not have satisfied the complaint cited in the audit.

HTS Supervision

At HTS, the responsibility of supervising work activities and directing OJT was assigned to foremen. Because the HTS facility operated seven days a week, that responsibility was rotated between several individuals. On the night of the subject maintenance error, the acting foreman assigned the acting inspector to provide OJT to two inexperienced mechanics. SMART was only to provide RALLC with mechanics; the foremen and quality inspectors were to be provided by RALLC.[5] The inspector was an employee of RALLC, but the foreman was an employee of SMART. During the NTSB Public Hearing, the Director of Recruiting for SMART stated that he was unaware that his employee was acting as foreman.

The training assignment noted above was in addition to the inspector's normal inspection responsibilities. Tasking of the inspector to give OJT was inappropriate and in conflict with the company policy and regulations. This dual tasking caused the inspector to be in the position of having to inspect his own work, since when giving training; it is the trainer who must take responsibility for the work being performed. FAR 121.371(c) states: "No person may perform a required inspection if he performed the item of work required to be inspected." The AMW

[4] Exhibit 11-K
[5] Pg. 10, Exhibit 11-A

company maintenance procedures manual presents the same regulation in full.[6] Thus, the maintenance activity at HTS was not in accordance with the FARs or AMW Company policy.

HTS Mechanics – Hiring

The investigation revealed that screening and testing of applicants for mechanic positions was seriously deficient. These deficiencies allowed AMW maintenance to be performed by persons of unknown background and skill levels, with inadequate training and supervision.

Mechanics in the Huntington, West Virginia facility are hired and employed by SMART, on behalf of RALLC, on behalf of Air Midwest. The SMART hiring process had several deficiencies, as noted in the Public Hearing. The most significant of these was that the applicant screening process was not thorough. The applicants submitted their résumés by mail or via the Internet and were selected on the basis of this information. Background checks were perfunctory, and never ensured that the person applying was actually the person documented in the records. According to the SMART Director of Recruiting, SMART performed phone interviews if their client companies requested it, but it was not a required part of their hiring. There was no face-to-face interview of the applicants. There was no skill test required to prove the applicants had the expertise claimed on their application. Further, mechanics were allowed to begin working in the facility without having ever been tested by AMW for their practical knowledge. This could clearly result in applicants making misleading statements or falsifying employment records. ALPA believes that there is a need to ensure that applicants have the expertise that they claim to have. The AMW/RALLC/SMART arrangement did not satisfy that need.

Mechanics hired by SMART were directed to report to the HTS facility, where they were given a four-hour indoctrination, followed by a fifty-question open book exam. Applicants were required to correctly respond to only 35 (70%) of the questions on this open-book exam for a passing grade.

The hiring practices of SMART do not catalog specific experience or training of individual mechanics. A mechanic's expertise in a given area is not documented, and is therefore relayed by word of mouth. For the mechanic trainee who performed the rigging on the accident aircraft, there is no evidence of any specialized training or experience in B-1900D flight control rigging.

HTS Training

In most cases the SMART mechanics at HTS have had no prior experience with the B-1900D aircraft. These mechanics worked on Air Midwest aircraft under the OJT program without receiving any prior familiarization training on that model aircraft. The PMI indicated in his Public Hearing testimony that since the accident, he had reviewed what he called an "OJT syllabus" with the operator, but that the syllabus remained basically the same as it was before the accident. An effective OJT program must include certain requirements to ensure that the training is properly structured. Such a syllabus must ensure that trainees receive sufficient theoretical and practical information in a logical sequence, and that OJT activity is built upon a sound practical base. Most importantly, the OJT syllabus must also ensure that the maintenance performed under this program is completed properly. Mechanics may need to be trained using OJT, but that training can never be allowed to compromise the safe completion of the maintenance tasks.

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[6] AMW maintenance procedures manual 210, rev. T-19, dated 8/23/01, pg. 7.3

Evidence developed during the investigation indicates that mechanics being given OJT (and therefore by definition, not qualified to perform the task) were working unsupervised while performing maintenance on critical flight control systems. During his interview with the Maintenance Records Group, the trainer/inspector stated that the mechanic working on the elevator control cable tension had convinced him that he had "good experience" with rigging. Based on this, the trainer/inspector allowed the mechanic to work unsupervised to a large degree, even though he had been employed for only eight weeks, and had never accomplished rigging on a B-1900D.

The AMW OJT program was not a thorough means of training new mechanics. The program allowed the trainees to be qualified to work on any flight control system after having been given OJT on just one of those systems. For example, the mechanic could work on the elevator system after only receiving training on the rudder. OJT should be defined for each airplane, and documented for its method for each activity in a syllabus, reviewed and approved by the FAA PMI.

Testimony at the Public Hearing indicated that training for foremen and inspectors was limited or non-existent.[7] One instance of inspector training was described as consisting only of reviewing the training record, reviewing the AMW maintenance policy manuals and being "shadowed" by another inspector mechanic for about 3 weeks. [8] The foremen's duties were identified in the maintenance policy manual but there was no formal training provided. Foremen were expected to learn the job with OJT as well. No syllabus was available to ensure that items a prospective inspector or foreman needed to know were in fact covered by any trainer or OJT program.

Although record keeping of employee training is listed as a duty of the foreman and the AMW maintenance manager, the record keeping for the OJT of some mechanics was inadequate. Testimony from the Public Hearing confirmed that many records were questionable, and possibly erroneous. During the Public Hearing, there were cases cited where OJT signoffs occurred that could not be substantiated. An example of this is apparent in the testimony of the shop foreman, where he states that four D-6 inspections were signed off in OJT records as being accomplished on one night, while only three aircraft were in that station at the time.[9]

<u>Maintenance Manuals and Work Cards</u>

Aircraft mechanics rely upon appropriate and accurate references to accomplish their work safely and correctly, and the FARs require the mechanics to utilize these references. FAR 65.81(b) states that: "A certificated mechanic may not exercise the privileges of his certificate and rating unless he understands the current instructions of the manufacturer, and the maintenance manuals, for the specific operation concerned."[10] The regulation is written to ensure that the mechanic works responsibly, and it shows the necessity for clearly written reference material. Such reference material can be maintenance manuals or job cards.

[7] Pg. 179, Public Hearing Testimony of George States
[8] Pg. 35, Exhibit 11-G
[9] Pgs. 280-281, Public Hearing Testimony
[10] Pg. 2, Exhibit 11-KK

FAR 25.1529, Instructions for Continued Airworthiness, states "The applicant must prepare Instructions for Continued Airworthiness in accordance with Appendix H to this part that are acceptable to the Administrator." Appendix H of Part 25 outlines the sections required in the maintenance manual, but nowhere in Part 25 is there a requirement that the manual be approved. In fact, there is no FAR that requires maintenance manuals to be certified as "FAA approved." The difference between a manual that is "FAA approved" (such as the Airplane Flight Manual) and one that is "accepted" by the FAA is subtle but critical. In "FAA approved" manuals, the accuracy of the contents is verified by the FAA. Manuals "accepted" by the FAA comply with the content requirements of the FARs, but the accuracy of the specific information contained in them is not necessarily verified by the FAA. Thus, "accepted" manuals are not subject to the same scrutiny, and are more easily amended than "approved" manuals. According to an FAA legal interpretation, "In various parts of the FAR are stated requirements for the contents of the maintenance manual. At the time of the initial air carrier certification, the maintenance manual is reviewed in sufficient detail to assure that the requirements of the FAR are fully met regarding manual content. The inspector does not formally approve this material. Instead he advises the air carrier of any portion that is found unacceptable."[11] Therefore it is the responsibility of the PMI to review the maintenance manuals, and advise the operator of any items needing correction.

Recognizing that it may not be feasible to require FAA involvement in the development or update of every maintenance procedure, ALPA nevertheless feels that such FAA involvement is warranted for flight critical systems. Therefore, ALPA recommends that the FAA should:

- Conduct a one-time accuracy review of the "Flight Controls" (ATA code 27) sections of all manufacturers' maintenance manuals for aircraft models used in commercial air carrier service.
- Require that the "Flight Controls" (ATA code 27) sections of all manufacturers' maintenance manuals for existing and subsequent aircraft models used in commercial air carrier service be changed to "FAA Approved" category.

The investigation revealed that the manufacturer's B-1900D maintenance manual used by Air Midwest and other B-1900D operators contained some significant errors. All these errors appeared to be procedures carried over from the B-1900C, and which did not apply to the B-1900D. The fact that the B-1900D has been in service since approximately 1991, and these errors still exist in the manuals, demonstrates one weakness of the existing "acceptance" process in comparison to the more rigorous "approval" process.

FAA Order 8300.10, Volume 2, Chapter 64 specifies that the CAMP must "fulfill an operator's/applicant's *total* [emphasis added] maintenance needs." With regard to maintenance manuals, this indicates that errors, once detected, should be rectified. In turn, this suggests that a mechanism for such error correction should be in place. While it is unknown whether any formal or informal mechanism for correcting maintenance manuals was in place at AMW, it is clear that at least some required corrections of maintenance manual errors did not occur. In ALPA's view, this is ultimately a failure of the FAA oversight program, and appropriate changes should be made. Therefore, ALPA recommends that the FAA should:

[11] July 5, 1991, from Donald P. Byrne to Mr. Gerald L. Naekel, President, Aviation Records, Inc.

- Develop and implement a system for ensuring timely detection and correction of errors in the “Flight Controls” (ATA code 27) sections of all manufacturer’s maintenance manuals for aircraft models used in commercial air carrier service, and which also ensures timely FAA approval and distribution of this information to affected organizations.

Maintenance manuals are often large and bulky, and their size can lead to mechanics’ having difficulty in using them in the course of their work. An effective means of providing the required reference information to the mechanics in usable format is with work cards (job cards). Work cards are the primary documents used at many air carriers’ maintenance facilities to delineate the specific tasks and task sequences necessary to ensure the complete and accurate accomplishment of their assignment. In concept, work cards are similar to flight crew checklists. Some work cards are fully self-contained, while others reference additional documentation such as maintenance manuals. Well-designed work cards clearly enumerate the specific steps, hardware, methods and precautions necessary to complete a given task.

The more detailed and clear the maintenance manual or work card, the more likely that the mechanics and inspectors will properly conduct their respective activities. Conversely, vague, generic or erroneous maintenance manuals or work cards will lead to errors and oversights in the maintenance and inspection processes. An example was the AMW D-6 check. The work card(s) for the D-6 elevator cable tension check referred the mechanic to a section in the maintenance manual, but this section does not contain a corresponding explicit set of steps to adjust elevator cable tension. Instead, cable tension adjustment procedures were embedded in the section on elevator rigging.

This lack of direct correspondence between the D-6 tasks and the maintenance manual procedures caused the mechanic to improvise his approach to adjusting the cable tensions. In the mechanic’s NTSB interview (Exhibit 11-J), he noted that after discussing the issue with the trainer/inspector, he determined that there were steps in this procedure that did not have to be accomplished. The mechanic justified skipping some steps in the maintenance manual on the basis that, in his experience, the adjusting of the cable tensions would not affect the elevator rigging. Improvising the procedure and skipping steps in the maintenance manual directly contributed to the mechanic’s improper rigging of the elevator.

One error in the B-1900D maintenance manual elevator rigging procedure is that the manual specifies the removal of several passenger seats to access the elevator cable turnbuckles. In the B-1900D, the turnbuckles are accessed via an external panel on the aft part of the fuselage, and no seat removal is required. Such a significant discrepancy between the manual and the actual aircraft could cause a user to doubt the overall accuracy of the information in the manual, and tend to reduce the user’s reliance on or adherence to that document.

In addition to such glaring errors, the B-1900D maintenance manual also contained vague instructions, or omitted them altogether. Again with respect to the elevator cable tensioning, although the procedure required a temperature correction for cable tension, it did not contain any guidance on how to prepare the aircraft, or how and where to obtain the temperature reading. Given that the correct tension settings varied significantly with small temperature changes, and the critical nature of the elevator system, such an omission in the maintenance manual seems inexcusable.

The aircraft manufacturer and Air Midwest (and likely other B-1900D operators as well) permitted errors to remain in the B-1900D maintenance manuals. Although the root cause for this is unknown, there are only a few possibilities: Either the error was never detected (which is highly unlikely), the operator(s) didn't advise the manufacturer (or the FAA) of, or request that they correct the error, the manufacturer didn't correct the error, or Air Midwest never received the correction. Whatever formal or informal process that existed at Air Midwest for ensuring the accuracy of the B-1900D maintenance manual failed. In the end, the result is the same; maintenance manual errors are safety of flight issues, and they must be corrected in a timely and thorough manner.

As noted previously, the operator (in this case, Air Midwest) is ultimately responsible for the airworthiness of its aircraft. Inaccurate maintenance manuals directly affect the ability of the operator to ensure the airworthiness of its aircraft, and it is therefore incumbent upon the operator to ensure the accuracy of its maintenance manuals, with assistance from the manufacturer and the FAA. It is clear that a more regimented means of detecting and correcting maintenance manual errors, and distributing this information to the end-users, is required.

SAFETY MANAGEMENT SYSTEM (SMS)

As noted above, both Air Midwest and FAA oversight of the HTS facility failed to identify and/or correct several maintenance and mechanic training deficiencies which indirectly led to this accident. Implementation of a regimented, safety-oriented system such as that currently being implemented in Canada would have helped Air Midwest and the FAA detect and potentially resolve these deficiencies.

Employment of a Safety Management System (SMS) has been demonstrated to be effective and is gaining acceptance among aviation authorities. The International Civil Aviation Organization (ICAO) is in the process of amending its Standards and Recommended Practices (SARPs) to reference the need for implementing safety management systems in each organization involved within international commercial aviation. The Canadian government recognizes the importance of a methodical, safety-oriented corporate culture in aviation, and is in the process of formalizing and requiring this approach. Transport Canada (TC), the Canadian regulatory authority, will require every Canadian Aviation Regulation (CAR) 705 (analogous to FAR Parts 121) operator to have a Safety Management System by March 2004. SMS will also subsequently be introduced into maintenance organizations, manufacturing organizations and airports in Canada. NAV CANADA, the air traffic service provider, has had an effective SMS program for a number of years.

SMS requires the integration of safety risk management with corporate planning and performance at all levels of the corporation. It includes the basic principle of the "accountable executive," as well as the need for risk management responsibilities and accountabilities, again at all levels within the corporation. SMS is characterized by the identification and analysis of hazards which could lead to unacceptable loss, and the establishment and measurement of safety goals to reduce operational risk. The "accountable executive" (the holder of the Air Operating Certificate, typically the CEO) is responsible for the establishment of SMS, and for providing the resources and training to ensure that regulatory requirements and corporate safety goals are achieved.

Essential elements of SMS include non-punitive reporting systems which improve the effectiveness of safety reporting and their subsequent investigations; clear responsibilities and accountabilities within the management structure for meeting safety goals; and widespread feedback on corporate safety priorities and decision making. The object of SMS is the establishment of a safety culture wherein safety goals and values are accepted and shared by management, and where suggestions for positive, safety-oriented change are encouraged. SMS reduces the need for regulatory oversight while improving the corporation's ability to effect internal improvements. In most cases, the introduction of SMS has resulted in improved financial performance as well.

The National Aeronautics and Space Administration (NASA) and many air carriers advocate the use of non-punitive reporting programs. A non-punitive reporting program is an effective mechanism to identify weaknesses and potential hazards in the organization structure, which in turn will enable corrective actions to be developed and implemented. The key element to these programs is the cooperation between the corporation, the regulator and the employee groups, and these programs are proving to be highly successful in identifying safety issues in every department of air carriers.

When considered in combination with the FAA’s limited ability to provide adequate and effective oversight, and the acknowledged benefits of a strong safety culture and non-punitive reporting programs, it becomes clear that the implementation of a U.S. system similar to the Canadian SMS is warranted.

COLLATERAL ISSUES

In nearly all aircraft accident investigations, facts come to light that reveal deficiencies in systems, procedures and performance that, if corrected, are expected to prevent recurrence of similar events. Other facts are revealed by the investigation that, while they may have played no direct role in the accident being investigated, can be identified as needing correction with the hope of preventing any hazard from occurring at all. ALPA notes two such items that have resulted from the investigation into the crash of AMW 5481: the method of computing aircraft weight and balance data, and the reliability of the crew's seatbelts.

Weight and Balance

The flight crew completed the weight and balance using the FAA-approved company guidance, and correctly computed a gross takeoff weight and CG that were within the operating envelope for the aircraft. Although this crew correctly followed the AMW procedures, variations of which were in use throughout the industry, the investigation prompted scrutiny of the aircraft weight and balance data that revealed potential flaws in the system used by AMW and other airlines.

Typically, aircraft weights, and resultant CG data, are determined using a combination of known and estimated values. The weight of the airframe, fuel and cargo are known. However, it is not practical to weigh each passenger and his or her baggage. Airlines rely on average passenger and baggage weights. FAA Advisory Circular (AC) 120-27C, Aircraft Weight and Balance Control, provides explicit values and an alternative of a calculation method for an operator to establish standard weights. The operator may use either approach; most use the explicit values.

Subsequent to the accident, several studies have called the use of average passenger weights for airline service into question. Debate over this practice continues, but surveys and studies conducted since the accident clearly suggest that the average passenger weights in use at the time of the accident were likely low. While it is now impossible to determine the actual passenger weight of the accident flight, estimates based on recovered remains and personal effects, and interviews with family members have been made. The NTSB Aircraft Performance Group also developed an estimate by analyzing the aircraft's performance on takeoff. These estimates provide a more realistic assessment of the actual accident aircraft's weight and balance. The order issued by the FAA following the accident showed that compared to the values in AC 120-27C, averages for passenger weights had increased by 20.63 lbs, for carry-on bags by 5.72 lbs, and for checked domestic bags by 3.81 lbs.[12] The crew computed values for weight and CG that were near, but within, limits. The actual numbers, while they cannot be known with absolute certainty, appear to have been similar to those crew-computed values. The actual values may have been beyond the limits by a small margin, but the crew could not have been aware of that.

The evidence clearly suggests that the accident aircraft weight and CG were close to allowable limits. While, as noted earlier, this accident was directly attributable to the inadequacy of elevator control due to misrigging, it is not possible to determine if the aircraft was being operated in or out of the manufacturer-defined flight envelope. As illustrated above, weight and CG information is computed in part based on estimates. The variability of these estimates has

[12] AC 120-27C stated that average passenger weight was 160/165 lbs, carry-on bags weighed 20 lbs, and domestic checked bags weighed 25 lbs.

been demonstrated in studies done as a function of this accident investigation. Since published procedures are based on the assumption that the aircraft will be operated within the prescribed flight envelope, estimates that can be used to place the aircraft in or out of that envelope must be valid, and operators must have confidence in that validity. With weight or CG at the worst-case estimates developed for this accident, and therefore slightly beyond the limits, if the elevator had been properly rigged, the airplane would have flown successfully. However, the safety margins inherent in transport airplane design would have been eroded, and that fact would have remained hidden from the crew. Aircraft maneuverability, load-bearing capacity, and performance would have been substandard with no deficiency readily identifiable to the crew.

Advisory Circular 120-27C provides a rigorous method for an operator to determine appropriate standard passenger and bag weights. The calculation method is based on sampling a significant population of passengers, and considers conditions such as season, route and type of operation. In 2003, the FAA will convene an Aviation Rulemaking Committee to revise this AC to more accurately reflect actual passenger and bag weights. ALPA fully supports this effort and will be an active participant in this process. ALPA believes that a single set of "standard" weights for passengers and bags, even if biased for passenger age and gender, is inadequate. What is needed is a requirement for operators to periodically use the established procedures of AC 120-27C for developing valid estimates of weight and CG that account for identifiable differences in flight operations such as destination, season, or other factors that affect the average passenger and bag weights.

<u>Inadvertent Seatbelt Release</u>

According to the factual report of the Survival Factors Group, the Captain's seatbelt buckle was found in the cockpit wreckage. The buckle had only the fixed lap belt component attached. The shoulder and right lap fittings were not attached to the buckle. The physical evidence indicates that the Captain's seatbelt came unbuckled. The First Officer's seatbelt remained buckled.

The evidence suggests that the Captain's seatbelt released either during the impact sequence or during the efforts to fly the airplane while in the upset. If the seatbelt latch released prematurely while the Captain was attempting to gain control of the airplane, it would have exacerbated an already serious situation. The design of the buckle includes a rotary release mechanism with tabs intended to afford the wearer a good grip to manually rotate the buckle. There is anecdotal evidence of numerous instances of the control yoke making contact with these tabs, leading to interference with the yoke, inadvertent buckle release, or both. During the investigation, the Survival Factors Group demonstrated that there was interference between the control yoke and the seatbelt release that could cause the seatbelt to be inadvertently released.

The problem of the control yoke interfering with the same or similar seatbelt buckles has been raised before. The Boeing Aircraft Company issued a July 23, 1992 Service Letter (737-SL-25-54, 757-SL-25-40) that an improved rotary buckle is available for installation on existing seats. It noted that during a test flight, a 737-400 was performing a maneuver with the control column fully aft when the clipboard on the control wheel inadvertently contacted the pilot's seatbelt buckle and caused the buckle to unlatch the seatbelt and shoulder harness.

The FAA should evaluate seatbelt design and configuration as installed in aircraft as part of a type certificate approval to ensure that the control yoke movement or other reasonably-expected crew activity cannot inadvertently cause the seatbelt to release or interfere with critical functions.

FINDINGS

1) Air Midwest's FAA-approved maintenance program included contracting Raytheon Aircraft, LLC (RALLC) to perform maintenance on AMW aircraft.

2) RALLC contracted Structural Modifications And Repair Technicians, Inc. (SMART) at its Huntington, WV facility to perform maintenance on AMW aircraft.

3) SMART was responsible for hiring most of the mechanics at HTS.

4) The SMART system to ensure applicants for mechanic positions were appropriately screened, and their credentials verified, was ineffective.

5) The RALLC system to identify and task foremen and inspectors did not effectively maintain the separation between maintenance and the inspection of that maintenance.

6) Common practice at HTS allowed the same individual to be alternately tasked as mechanic, inspector, or foreman.

7) Neither Air Midwest, RALLC, nor SMART had developed formal training programs or used a definitive syllabus in training mechanics, foremen, or inspectors.

8) The RALLC HTS maintenance manager worked during the day, although most maintenance at the facility was performed at night.

9) Only one Air Midwest representative was assigned to the HTS facility. That individual worked during the day, although most maintenance at the facility was performed at night.

10) The FAA Principle Maintenance Inspector (PMI) was not co-located with any Air Midwest facility. The PMI's office is in Wichita, KS, proximate to Air Midwest corporate headquarters, but far from AMW maintenance facilities.

11) An Air Midwest audit of the HTS facility identified staffing deficiencies, including the need for additional foremen and inspectors.

12) RALLC did not adequately address HTS staffing deficiencies identified by the Air Midwest audit.

13) The FAA PMI was unaware of staffing, training, and personnel turnover problems at HTS.

14) Air Midwest aircraft N233YV was at the Huntington facility for scheduled maintenance consisting of the "Detail 6" check (D-6). The D-6 check is focused generally on the tail of the aircraft, including the elevator system.

15) The mechanic who conducted the maintenance on the elevator system had no prior experience on the B-1900D elevator system, and Air Midwest procedures therefore required him to be supervised while conducting the work.

16) The individual tasked to provide OJT to the mechanic doing the D-6 elevator inspection was responsible for the work. In violation of FAR 121.371(c), he was also tasked to inspect the work.

17) The D-6 check calls for checking elevator cable tension, but the B-1900D maintenance manual contains no stand-alone procedure for adjusting elevator cable tension. The manual describes re-tensioning only in the context of adjusting the entire elevator rigging.

18) The FAA does not currently approve manufacturer's maintenance manuals.

19) The B-1900D maintenance manual does not provide any guidance on how to determine the temperature to be used to calculate proper elevator cable tension.

20) The method that the mechanic used to determine the temperature for the elevator cable tensioning may have been inappropriate.

21) The mechanic determined that the elevator cable tension was out of tolerance.

22) The B-1900D maintenance manual contains information that is not pertinent to the B-1900D aircraft, creating the impression that the manual cannot always be strictly followed.

23) The mechanic attempted to adjust the elevator cable tension and deliberately omitted steps in the maintenance manual.

24) The mechanic improperly adjusted the elevator rigging and changed the positional relationship between the elevator and the control column, restricting the travel of the elevator.

25) The B-1900D elevator rigging procedure does not include a final verification of the proper relationship between control column and elevator positions.

26) The OJT instructor/inspector failed to detect the improper elevator cable rigging and signed off the inspection.

27) The misrigged elevator was capable of only approximately half the normal nose down travel when the aircraft left the HTS maintenance facility.

28) The aircraft left the HTS maintenance facility in an unairworthy condition.

29) Subsequent to the subject maintenance, the aircraft flew nine flights without incident. Each of these nine flights was loaded such that the aircraft center of gravity was between the forward limit and the midpoint of the allowable range.

30) On the accident flight, the aircraft was loaded in accordance with FAA-approved Air Midwest procedures.

31) The crew performed the normal preflight CG calculation which, based on procedures in use at the time, correctly computed a CG near the aft limit of the allowable CG range.

32) On takeoff, the pilot made a normal rotation.

33) Aircraft pitch continued to increase after rotation, beyond the normal target value.

34) With the improperly rigged elevator, there was insufficient elevator authority to control aircraft pitch, control was lost, and the aircraft crashed.

SAFETY RECOMMENDATIONS

As a result of this investigation, the Air Line Pilots Association offers the following safety recommendations.

<u>To the Federal Aviation Administration:</u>

1) Require that air carriers and/or repair stations develop a detailed syllabus for provision of On the Job Training (OJT) for personnel performing maintenance on aircraft in commercial air carrier service.

2) Require that all flight control rigging procedures for aircraft models used in commercial air carrier service include an inspection item which verifies full and proper flight control surface response to inputs from the cockpit controls.

3) Develop and implement a system for ensuring accuracy of, and timely detection and correction of errors in the "Flight Controls" (ATA code 27) sections of all manufacturer's maintenance manuals for aircraft models used in commercial air carrier service, and which also ensures timely FAA approval and distribution of this information to affected organizations. This would include, as a minimum:

    a) Conduct a one-time accuracy review of the "Flight Controls" (ATA code 27) sections of all manufacturers' maintenance manuals for aircraft models used in commercial air carrier service.

    b) Require that the "Flight Controls" (ATA code 27) sections of all manufacturers' maintenance manuals for existing and future aircraft models used in commercial air carrier service be changed to "FAA Approved" category.

4) Require that Principal Maintenance Inspectors' (PMI) oversight of airline maintenance operations include familiarity with the actual work being performed as well as the program and documentation. This familiarity would necessarily involve regular visits to all facilities in the PMI's jurisdiction.

5) Require that oversight (by FAA or airline personnel) of every major maintenance facility of each commercial air carrier include site visits during the normal peak working hours of the facility.

6) Require that all commercial air carriers notify their respective Principal Maintenance Inspector (PMI) when certain changes to the maintenance organizations or facilities occur or are to be made. These would include changes to management structure or personnel, adding or eliminating maintenance facilities, adding or eliminating maintenance contract organizations, or other changes that would affect the PMI's ability to conduct effective oversight.

7) Continue existing activity in the Aviation Rulemaking Committee (ARC) addressing aircraft weight and balance issues. This activity should include development of a standard method to be used to create realistic estimates of passenger weight and baggage that include factors such as age, gender, destination, season, and any other factors identified as having a significant impact on passenger and bag weights.

8) Require that all commercial air carriers obtain and utilize maintenance work cards which comply with the manufacturers guidance and which contain:
   - Tasks broken down into manageable increments
   - Procedures and provisions for shift or personnel changes
   - All necessary references or information
   - Line-by-line inspection signoff provisions

9) Require that all maintenance providers (e.g., certified repair stations, contract personnel, etc.) for commercial air carriers utilize the operators' applicable maintenance work cards which comply with the manufacturers guidance and which contain:
   - Tasks broken down into manageable increments
   - Procedures and provisions for shift or personnel changes
   - All necessary references or information
   - Line-by-line inspection signoff provisions

10) Develop and implement a system (similar to Transport Canada's Safety Management System), which would require every commercial air carrier to integrate safety risk management, including responsibilities and accountabilities, into corporate planning and performance at all levels of the corporation.

11) Develop and implement a system (similar to Transport Canada's Safety Management System) which would require airline maintenance organizations, manufacturing organizations, airports, and air traffic service organizations to integrate safety risk management, including responsibilities and accountabilities, into corporate planning and performance at all levels of the organization.

12) Require that all commercial air carriers provide flight crewmembers with Aircraft Upset Recovery training.