National Transportation Safety Board

Investigation of

Emery Worldwide Airlines Flight 017 Accident

February 16, 2000, Sacramento, California

NTSB Identification: DCA00MA026

Emery Worldwide Airlines Proposed Findings To Be Drawn From the Evidence Produced During the Course of the Investigation, and Proposed Probable Cause

Submitted December 27, 2002

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ATTACHMENTS

EXECUTIVE SUMMARY

On February 16, 2000, at approximately 19:51 Pacific Standard Time, an Emery Worldwide Airlines Douglas DC-8-71F, Registration N8079U, operating under 14 C.F.R. Part 121 of the Federal Aviation Regulations as Flight 017, crashed near Sacramento Mather airport in Rancho Cordova, California. The flight was operating on an instrument flight plan at night under visual meteorological conditions. The captain, first officer, and second officer were fatally injured.

Despite a statement made by the cockpit crew to air traffic controllers indicating the flightcrew's suspicion that improperly loaded or shifting cargo could be a factor in the accident, neither improper cargo loading nor cargo shifting could have caused or contributed to the accident.

The results of a detailed wreckage inspection and the DFDR analysis indicate that the bolt connecting the aft end of the right-hand elevator pushrod to the elevator control tab crank fitting was missing at the time of impact. This missing bolt allowed the pushrod to become jammed in such a manner as to force the right-hand control tab to its full trailing edge down position. This jamming most likely occurred during the control rollout check preceding the accident flight. The aerodynamics of this full down control tab drove the elevator into a full trailing edge up position, forcing the nose of the aircraft up. The restricted elevator movement resulted in a loss of effective response to input from the control column and an inability to control the nose up tendency of the aircraft.

The bolt became loose because it was not restrained by a nut, which was either not installed, or not secured by a cotter pin at the time the aircraft was overhauled three months earlier. The repair station that performed the overhaul failed to install the cotter pin, or nut and cotter pin, and failed to detect the omission during the inspection, or at any time prior to releasing the aircraft as airworthy.

Subsequent to the overhaul, EWA performed no maintenance that would have required or enabled any EWA mechanic to detect the missing cotter pin, nut, or bolt.

1. FACTUAL INFORMATION

1.1 History of the Flight

On February 16, 2000, at approximately 19:51 Pacific Standard Time (PST), an Emery Worldwide Airlines (EWA) Douglas DC-8-71F, Registration N8079U, operating under 14 C.F.R. Part 121 of the Federal Aviation Regulations (FAR) as Flight 017, crashed near Sacramento Mather airport (MHR) in Rancho Cordova, California. The flight was operating on an instrument flight plan at night under visual meteorological conditions. The flightcrew, which consisted of the captain, first officer, and second officer, were the only occupants. All were fatally injured. The impact and post accident fire destroyed the aircraft.

EWA Flight 017 was a regularly scheduled cargo flight that operated from Reno, Nevada (RNO) to Dayton, Ohio (DAY) with an intermediate stop in MHR.

Earlier on February 16, 2000, the accident airplane was scheduled to operate as EWA Flight 018 from DAY to RNO with an intermediate stop in MHR. However, due to a maintenance problem with a cockpit window, the flight was delayed in DAY and re-routed to operate directly to RNO without the intermediate MHR stop. Upon arrival in RNO, there was a partial crew change with the accident captain and second officer now operating EWA Flight 017 from RNO to MHR. The accident captain had deadheaded on EWA Flight 018 from DAY to RNO and the accident second officer was awaiting the flight in RNO. EWA Flight 017 arrived at MHR at approximately 18:25 PST where the accident first officer joined the crew.

The first officer that operated from RNO to MHR was interviewed by the National Transportation Safety Board (NTSB) and indicated there were no operational problems encountered on the flight. An interview of a mechanic stationed at MHR and a review of the maintenance log sheets by the NTSB also showed no operational problems were encountered on the flight.

1.1.1 Weight and Balance Computation

According to the Load Planning Sheet (LPS) for the accident flight, the accident aircraft had a Zero Fuel Weight (ZFW) CG of 27.1%.[1] (Ex. 2G). Under the conditions on the accident flight, the aircraft's aft ZFW CG limit was 33.6%. The weights and other information for the aircraft at takeoff were as follows (Exs. 2A and 2G):

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[1] Where this paper refers to a specific aircraft CG limit or aircraft CG as loaded or assumed to be loaded, it is referring to the ZFW CG, upon which the aircraft CG limits are based.

Takeoff Weights	
	Weight (pounds)
Basic operating weight	148,767
Upper cargo load	59,290
Lower cargo load	2,690
Spare parts kit (SPK)	1,784
Total cargo	63,764
Zero fuel weight (ZFW)	212,531
Maximum ZFW	245,000
Takeoff fuel	66,700
Gross takeoff weight (TOGW)	279,231
Maximum TOGW	328,000

Takeoff Stabilizer Trim Setting, CG, Flaps, and Speeds	
Center of Gravity (CG), ZFW	27.1% Mean Aerodynamic Cord (MAC)
CG, TOGW	28.9% MAC
Aft CG limit [2]	33.6% MAC
Takeoff stabilizer trim setting	1.6 units
Takeoff flap setting	15 degrees
Takeoff speeds	V_1 = 126 knots V_R = 146 knots V_2 = 158 knots

1.1.2 Aircraft Loading

Cargo aboard a DC-8, such as the accident aircraft, can be loaded either topside, in one of eighteen locations, or in the belly, in one of four compartments (also called "pits"). Before being transported to the aircraft, topside cargo is initially loaded either on a pallet or in a ULD. [3] The pallets and ULDs are then loaded into one of the eighteen topside positions and held in place by "bear claws," which are floor-mounted clamps that are locked around the base of the pallet/ULD to prevent their unintended movement. The cargo is locked into position when the locks are "up."

EWA's freight loading procedures begin with the delivery of freight to the Emery Worldwide (EWW) [4] service center at MHR. All of the freight that is to

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[2] The aft CG limit for the DC-8 is based on the ZFW CG.

[3] By EWA procedure, positions 1, 2, and 18 must be loaded with pallets rather than ULDs. Position 18 is the only position that will not physically accept ULDs.

[4] "Emery Worldwide" was the dba for Emery Airfreight Corporation at the time of the accident. EWW was the ground-based, freight-handling affiliate of EWA. In early 2002, the dba for Emery Airfreight Corporation was changed to "Emery Forwarding".

be loaded on the main deck cargo compartment of the airplane is loaded aboard Unit Load Devices (ULDs or containers) or pallets. The ULDs and pallets are weighed and tagged by EWW personnel. The Miami Aircraft Support (MAS) load planner also notes the weight of the ULDs and pallets at the same time. EWW personnel move the ULDs and pallets to the "transfer rack." MAS personnel pick up the transfer racks and ULDs/pallets and move them to the aircraft in preparation for loading.

The MAS load planner prepares the LPS, (Ex. 2F), which shows the weight of the freight and where the freight is to be placed on the airplane. The MAS loading supervisor receives the load planning information and directs the loading of the aircraft. The MAS loading supervisor gives the final LPS to the EWA flightcrew.

Cargo aboard the accident flight consisted of EWW freight and U.S. Mail. The MAS Ramp Supervisor stated that the load for the accident flight was a normal load and that the loading process went smoothly. (Ex. 2B at 2). She testified in detail about her process to ensure that the pallets (also called PN's or pans) and ULDs (also called containers, cans, or huts) are loaded in the proper order in accordance with the load planner's intention. (Ex. 2B at 2). She also testified that she follows the same procedure every night. (Ex. 2B at 2). The MAS Load Planner also testified that the load was normal. He also stated that the center of gravity (CG) for Flight 17 was within limits.

Personnel loading the airplane and moving the pallets and containers into position reported that it was a routine operation. Pallets were loaded into positions 1, 2, and 18 on the aircraft and ULDs were loaded into all of the remaining positions.[5] (Ex. 2B at 2).

Loaders who loaded the lower cargo compartments stated that it included long freight that was difficult to load because of its length.

The loader who removed the tail stand[6] said that the tail stand was not close to touching the ground and that he would have noticed if it had been close to touching the ground. Loaders who watched the airplane taxi stated that it appeared normal.

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[5] Note that pallet identification begins with "PAG", while ULD identification begins with "AAA". Several MAS Cargo Techs recalled that positions 1, 2, and 18 were pallets.

[6] The tail stand is used to prevent the aircraft fuselage from contacting the ground if the aircraft tail moves downward excessively while on the ground.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabin Crew	Passengers	Other	Total
Fatal	3	0	0	0	3
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	3	0	0	0	3

1.3 Damage to Airplane

Impact forces and a post-accident fire destroyed the airplane.

1.4 Other Damage

The airplane cut a swath through an auto salvage yard that was approximately 600 yards long by 200 yards wide. Approximately one hundred automobiles were consumed by fire fed by the fuel from the DC-8.

1.5 Personnel Information

All three of the occupants of the aircraft were male flightcrew members.

1.5.1 The Captain

The captain, age 43, was hired by EWA on October 19, 1994. The captain held an airline transport pilot (ATP) certificate with airplane multiengine land ratings and was type-rated in the DC-8, ATR-42, ATR-72, B-727, and ND-262. In addition to his ATP, the captain held commercial privileges in airplane single engine land aircraft and a flight instructor certificate with airplane single and multiengine and instrument airplane ratings and a ground instructor certificate with advanced ground and instrument ground instructor ratings.

His most recent FAA first-class medical certificate was issued on February 15, 2000, with limitations requiring him to "wear corrective lenses for near and distant vision." The captain's most recent DC-8 proficiency check was on June 30, 1999, and his most recent recurrent training was on July 1, 1999 in airplane-specific and general subjects and on February 11, 2000 in the simulator. According to company records, the captain had logged a total of 13,329 hours, 2,128 hours of which were as a DC-8 captain with EWA. He had flown 119.1 hours, 46.1 hours, 1.2, hours, and 1.2 hours in the last 90 days, 30 days, 7 days, and 24 hours, respectively. A review of training indicated that the captain had received no failures or retests for any FAA pilot certificates or ratings.

The captain lived in Berlin, NY, and was based at RNO. He had deadheaded on the delayed flight from DAY to RNO on EWA Flight 18 before beginning duty as the captain of EWA Flight 17 at RNO.

According to witnesses, the captain was in good health and the events in the days preceding the accident had been routine.

1.5.2 The First Officer

The first officer, age 35, was hired by EWA on September 15, 1996. The first officer held an ATP certificate, with an airplane multiengine land rating, with no type rating. In addition to his ATP, the first officer held commercial privileges in airplane single engine land aircraft.

His most recent FAA first-class medical certificate was issued on June 24, 1999, with no limitations. The first officer's most recent DC-8 proficiency check was on October 29, 1999, and his most recent recurrent training was on October 27, 1999 in airplane-specific and general subjects. According to company records, the first officer had logged a total of 4,511 hours, 2,080 hours of which were with EWA in the DC-8. He had flown 142.8 hours, 47.2 hours, 0.0 hours, and 0.0 hours in the last 90 days, 30 days, 7 days, and 24 hours, respectively. A review of training indicated that the first officer had received no failures or re-tests for any FAA pilot certificates or ratings.

The first officer was based at RNO. He joined the flight at MHR.

1.5.3 The Second Officer

The second officer, age 38, was hired by EWA on September 15, 1998. The second officer held a flight engineer certificate, issued on April 12, 1999, with a turbojet powered rating. He also held an ATP certificate, issued July 19, 1998, with an airplane multiengine land rating and type ratings in the BA-3100, EMB-120, and B-737 aircraft and commercial privileges in airplane single engine land aircraft, a flight instructor certificate with airplane single and multiengine and instrument airplane ratings, and a ground instructor certificate with advanced ground and instrument ground ratings.

His most recent FAA first-class medical certificate was issued on April 22, 1999, with no limitations. The second officer's most recent DC-8 proficiency check was September 2, 1999, his most recent DC-8 line check was December 8, 1998, and his most recent recurrent training was on September 2, 1999, in airplane-specific and general subjects. According to company records, the second officer had logged a total of 9,775 hours, 675 hours of which were as a DC-8 second officer with EWA. He had flown 148.7 hours, 54.8 hours, 1.2 hours, and 1.2 hours in the last 90 days, 30 days, 7 days, and 24 hours, respectively. A review of training indicated that the second officer had no history of failures or retests for FAA flight engineer certificates or ratings

The second officer was based at RNO. He joined the flight at RNO and operated from RNO to MHR on the flight preceding the accident flight.

1.5.4 The Cargo Loading Personnel

Several employees of MAS, the contract ground handler at MHR, were involved in the actual loading of the aircraft.

The MAS ramp supervisor had been with MAS for about five years before the accident. She received training in hazardous materials, cargo loading, and safety. The MAS load planner had been employed by MAS for approximately four and a half years. He received two weeks of on the job training and worked under supervision before performing the tasks himself. MAS employed numerous cargo technicians at MHR who, at the time of the accident, had been with MAS for between nine days and three years.

1.5.5 The Maintenance Personnel

The NTSB reviewed the personnel and training records of numerous EWA mechanics. Included among these were the records of certain EWA mechanics that performed maintenance on the empennage of the accident aircraft between the completion of the D Check and the accident. The NTSB reviewed the records of the maintenance personnel who signed-off on the B-1 and B-3 work cards involving work in the elevator area of the accident aircraft. (Ex. 11A at 5). The mechanics that signed off the work card accomplishment for the elevator lubrication for the B-1 and B-3 Checks both attended the EWA Basic Indoctrination course. The B-3 Check mechanic also had on-the-job training for inspections, flight controls, and rudder control assembly. Each mechanic was a full-time employee of EWA. No discrepancies were noted in their records.

1.6 Aircraft Information

1.6.1 The aircraft

The aircraft was a Douglas DC-8-71F model aircraft, registration number N8079U. The aircraft was fuselage number 341, serial number 45947, and effectivity number UA079, and was originally delivered to United Airlines on March 20, 1968. The aircraft originally was equipped with four JT3D engines, but was re-engined in 1983 to CFM56 engines. The aircraft was converted to a freighter in 1993. EWA leased the aircraft from Aero USA. EWA performed a conformity inspection on March 27, 1994. The aircraft was placed on the EWA certificate on March 31, 1994. (Ex. 7K).

1.6.2 Maintenance history

Prior to placing the aircraft on EWA's operations specifications, EWA accomplished appropriate maintenance, which included a C-1 Check on N8079U in March 1994. (Ex. 11A at 14). This check included the complete initial inspections in compliance with EWA's Corrosion Prevention and Control Program (CPCP).

Following N8079U's initial C-1 Check, EWA performed the following C Checks and repetitive CPCP inspections at subsequent C Checks: C-2 Check in January 1996, and C-3 Check in September 1997.

As noted below, the aircraft underwent a D Check between August and November 1999. The aircraft logbook entries from the completion of the D Check on Nov. 17, 1999 through the date of the accident indicated no significant engine write-ups and no work in the area of the elevators, other than as described below.

1.6.2.1 D Check

On August 28, 1999, aircraft N8079U entered Tennessee Technical Services (TTS), Smyrna, Tennessee, for scheduled heavy maintenance to be performed during a D Check. TTS was an FAA-approved Part 145 repair facility, specifically certified by the FAA to perform D Checks on DC-8 aircraft. Before N8079U entered the D Check, EWA established the work scope for TTS's work. (Ex. 17FF at 25). The D Check included a complete inspection of all CPCP items. EWA's C-4 Check had been incorporated into the D Check. At the time N8079U entered the D Check, the aircraft had 84,050 hours.

As part of this D check, the right-hand and left-hand elevator assemblies, including their control tabs, were removed by TTS and replaced with overhauled assemblies. Work Card No. 3502D, entitled "Install Right Elevator Tabs," provided instructions to install an overhauled control tab on the elevator. (Ex. 7K at step 3). The work card also included instructions for an inspector to verify the control tab installation and security. (Ex. 7K at step 5). A general note at the top of the work card provided instructions to use the applicable DC-8 Maintenance Manual (MM), Chapter 27 when performing this work. (Ex. 7L).

Work Card No. 3504D, entitled "Install Right Elevator Assembly," provided instructions to install the elevator assembly. (Ex. 7K). It included instructions to connect and safety the control tab pushrod to the drive crank (Ex. 7K, at step 7). The work card also included instructions for an inspector to check the elevator assembly for proper installation. (Ex. 7K at steps 11-12). A general note at the top of the work card provided instructions to use the applicable DC-8 MM, Chapter 27 when performing this work. (Ex. 7L).

The completed work card indicated that the installation of the control tab was signed off by a mechanic and TTS Inspector No. 20. The work card also indicated that the final step, "Inspector verify control and geared tab installation and security," was signed off by TTS Inspector No. 2.[7]

There was a requirement to document any work stoppage, and the date was required to be included in this documentation. (EWA Maintenance Policy and Procedures Manual (MPPM), chpt. 3, p. 66, sec. X.B.3.a. [8]; TTS Repair Station Inspection Procedures Manual (IPM), secs. V, p. 2, and VI, p. 28 [9]). Database time cards taken from work card 3504D indicate that between September 9, 1999 and November 2, 1999, a period of 37 days, 19 TTS mechanics performed work tasks on those particular cards. (Ex. 17C). The actual work accomplished by any of the 19 individual TTS mechanics is unknown and undocumented because they were not interviewed. The 19 TTS mechanics that worked on work card 3504D include both FAA-certified and non-FAA-certified individuals. (Ex. 17X at 24). Only one reference to the status and/or condition of the elevators for N8079U was made in the TTS Quality Control (QC) turnover log,[10] and that was an unsigned TTS Daily Status Report, Form 62. The first mechanic began work on September 27, 1999, and the last mechanic finished on November 2, 1999.

In connection with the work performed on the elevator on N8079U, TTS received the following parts on September 9, 1999, from Willis Aeronautical Services, Tempe, Arizona, (Ex. 7S):

- RH elevator.
- RH elevator geared tab.
- RH elevator control tab. (Ex. 17A at 5).

TTS received and inspected the overhauled elevator control tab on September 9, 1999. (Ex. 17A at 12).

Among the manuals EWA provided to TTS was the United Airlines DC-8 Maintenance Manual. With respect to the installation of the elevator system during the D Check, the United Airlines DC-8 Maintenance Manual procedure states, in part:

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7 The Airworthiness Group Chairman's Factual Report, (Ex. 7A) states: "DC-8 Master Illustrated Parts Catalog, Chapter 27-30-1, Figure 20, identified the bolt, washer, and nut for this installation, the cotter pin was not identified." However, the cotter pin required at this location is identified in the DC-8 Overhaul Manual, Chapter 27-16-1. Additionally, as noted in the discussion in section 2.3.4.1, FAA-certificated airframe and powerplant mechanics are formally trained that any castellated nut or bolt with a drilled hole in it should be secured with a cotter pin.

8 Excerpts from the EWA MPPM are attached as Attachment "A".

9 Excerpts from the TTS IPM are attached as Attachment "B".

10 A turnover log is used to document tasks that span multiple work shifts.

B. Installation:

(1) Check control tab operating rods for correct installation per Figure 202.

* * * *

(7) Connect the control tab drive rod to the drive crank on the elevator control tab torque tube. (Ref. Figure 202). <u>Safety nut with cotter pin.</u>

* * * *

(9) Connect the link on the inboard elevator damper to the fittings installed in the trailing edge of the horizontal stabilizer. Safety nuts with cotter pins. Make sure that the damper allows full travel of the elevator. (United Airlines DC-8 Maintenance Manual, 27-31-01 at 202-204 (emphasis added)).[11]

A TTS Inspector described how and in what sequence the elevator dampers and control tab rod are typically installed and inspected:

> [S]tarting outboard going inboard, and look at the damper arms, the hook-ups, the safeties on those, continuing further inboard, at the tab, the tab hook-up, the installation, its safety. Look at the torque, too, and the drive rod. …[T]here is a specific adjustment on the control tab control rod that you verify and put the rod in and you safety it. (Ex. 17W at 10).

The D Check was completed on November 17, 1999, after eighty-two days of maintenance service, when TTS signed the airworthiness release for the aircraft and returned the aircraft to service. As discussed below, it was subsequently learned (i) on November 25, 1999 that TTS had installed the elevator dampers in the reversed position, and (ii) after the accident that TTS had failed to install a cotter pin, or a nut and cotter pin, correctly during the installation of the right-hand elevator during the D Check .

1.6.2.2 Aircraft manufacturer's position regarding removal of Control Tab Fairing during B Checks

The only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab

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[11] Excerpts from the United Airlines DC-8 Maintenance Manual are attached as Attachment "C".

Fairing. There is no other panel or fairing that, when removed, would provide access or visibility to this bolt.

Following statements by TTS witnesses at the public hearing that a visual inspection of the elevator control tab for "security of attachment" required that the Control Tab Fairing be removed,[12] (Doc. No. 136 at 244, line 11), the NTSB asked the Boeing Company (Boeing) to confirm EWA's position that "*all* hinges of the elevator control tab are visually inspected for 'security of attachment', including the inboard-most one that is covered by a fairing" without removing the fairing. (Doc. No. 195 at Enclosure page 1). Boeing replied that:

> The Manufacturer's Recommended Program (MRP) work cards published by the Douglas Aircraft Company and as specified by the On Aircraft Maintenance Planning (OAMP) document do not call for removal of the inboard control tab fairing during the B check. The inboard control tab fairing is not removed until the D and E checks. …" (Doc. No. 195 at Enclosure page 1 (emphasis added)).[13]

Boeing's response confirmed the testimony by EWA officials and mechanics that the Control Tab Fairing is not removed during any of the segmented B Checks.

1.6.2.3 Elevator damper swap

On November 25, 1999, approximately eight days after TTS completed the D check, aircraft N8079U flew from Fort Lauderdale, Florida to DAY. Upon arrival at DAY, the operating flightcrew entered into the Aircraft Maintenance Log four separate discrepancies. (Ex. 7O). Among these was a discrepancy regarding the elevator: "'Elevator requires more back pressure than normal to flare the aircraft. Also during elevator check. C.G. TO 25.4% ZF 23.3%." (Ex. 7O).

The Dayton line maintenance Lead Mechanic notified the supervisor on duty of the discrepancy. The supervisor assisted the Lead Mechanic in troubleshooting the discrepancy. During a visual inspection from the ground, the supervisor discovered that the elevator dampers were installed incorrectly, with the right-hand damper being installed in the left-hand position and the left-hand damper being installed in the right-hand position.

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[12] As proven by the response by Boeing, the statements by TTS witnesses were simply incorrect.

[13] The D and E Checks referred to in the Boeing letter refer to the manufacturer's nomenclature for the C and D Checks conducted by EWA and all other DC-8 operators.

EWA Maintenance personnel used the part numbers from the Illustrated Parts Catalogue (IPC) to verify that the dampers were installed in the incorrect position. [14] The dampers were swapped to place them in the correct position, and an operational check was performed by manual actuation of the control column with no defects noted. No further problems were noted, and the aircraft was placed back into service.

The corrective action entered for this discrepancy by EWA mechanics was: "Found LH & RH elevator dampners [sic] reversed, moved LT to RT side, RT to LT side, Ops ck'd good, no defects noted." (Ex. 7O). A qualified inspector inspected this corrective action. After the elevator damper swap was completed, there were no further discrepancies noted by the flightcrew or any other person.

As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing. Interviews with several EWA mechanics who worked on the elevator damper swap, including the EWA Supervisor, two Lead Mechanics, and the mechanic who performed most of the tasks associated with the work, indicate that no EWA mechanic removed the Control Tab Fairing or any other fairing or panel on the elevator during the maintenance, and that no maintenance took place in the vicinity of the Control Tab Fairing. (Doc. Nos. 198, 199, and NTSB Interview of D. Andrews, Nov. 27, 2002).

During the maintenance process, a panel directly under the damper was removed to facilitate access to the elevator dampers. (Doc. Nos. 198 and 199). However, the removal of this panel would not have provided a mechanic the ability to either access or see the elevator control tab areas at issue. There is no evidence that the Control Tab Fairing was removed during the performance of any maintenance in the elevator area during the elevator damper swap on N8079U.

A TTS inspector testified that the elevator dampers had been installed improperly before the elevator assemblies were provided to TTS. (Ex. 17W at 44). Even so, TTS did not detect this condition during the receiving inspection, and installed the incorrectly assembled components directly into N8079U.

1.6.2.4 B-1 Check

On December 17, 1999, aircraft N8079U completed a scheduled B-1 Check in Dayton, Ohio performed by EWA personnel. (Ex. 11H). The B-1 Check was accomplished at 84,179 hours. At the time the B-1 Check was performed, the Dayton Class I station had a total of twenty-five maintenance personnel to perform the B-1 Check. The personnel consisted of one manager, two supervisors, two lead mechanics, and twenty full-time mechanics. As part of the B-1 Check, EWA

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[14] The left-hand damper had s/n 1B-1 and a p/n of 5652380-505. The right-hand damper had s/n: 9812654NRC, p/n: 5652380). (Ex. 7O).

mechanics were to complete steps in the B007 inspection work card and the B013 lubrication work card.

As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing. Both Boeing and EWA confirm that neither the B-1 Check B007 inspection work card nor the B013 lubrication work card, nor any other B-1 Check work card, requires the removal of any panel or fairing in order to perform the inspections or lubrication of the elevator. (Doc. Nos. 136 at 307, line 14, 308, line 11, 537, lines 9-11; and Doc. No. 195 at Enclosure page 1).

EWA witnesses and mechanics uniformly testified that no EWA mechanic would remove the Control Tab Fairing or any other fairing or panel during any B Check inspection unless the work card specifically called for its removal. None of the work cards call for the removal of the Control Tab Fairing.

Further, there is no evidence that any EWA employee removed any such fairing or panel during the performance of any maintenance in the elevator area during the B-1 Check performed on N8079U. In addition, there were no non-routine maintenance items identified during the performance of the B-1 elevator lubrication tasks. (See Ex. 11H, at 4).

1.6.2.5 B-2 Check

On January 22, 2000, aircraft N8079U completed a scheduled B-2 Check in Dayton OH performed by EWA personnel. (Ex. 7A). The B-2 Check was accomplished at 84,312 hours. As part of the B-2 Check, EWA mechanics were to complete the steps in the B008 and B009 work cards. (Ex. 17U).

As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing. Both Boeing and EWA confirm that neither the B-2 Check B008 or B009 work card, nor any other B-2 Check work card, requires the removal of any panel or fairing in order to perform the inspections of the elevator. (Doc. Nos. 136 at 307, line 14, 308, line 11, 537, lines 9-11; and Doc. No. 195 at Enclosure page 1).

The Board interviewed mechanics that were involved in the B-2 Check, and in particular, involved in the tasks associated with work card B009. (Doc. Nos. 197 and 199). These EWA mechanics and other EWA witnesses uniformly testified that no EWA mechanic would remove the Control Tab Fairing or any other fairing or panel during any B Check inspection unless the work card specifically called for its removal. None of the work cards call for the removal of the Control Tab Fairing. Further, the EWA mechanics and other witnesses uniformly testified that no mechanic or other EWA employee removed any panel or fairing on the elevator during the performance of the B-2 Check and that no EWA mechanic performed any maintenance in the elevator area apart from the work required by the work cards.

(Doc. Nos. 197 and 199). Further, both Boeing and EWA confirm that no B Check work card requires the removal of any panel or fairing in order to perform the inspections called for by that card. (Doc. Nos. 136 at 307, line 14, 308, line 11, 537, lines 9-11; and Doc. No. 195 at Enclosure page 1).

During the B-2 Check, there were no non-routine maintenance items identified for the work accomplished in connection with work card B009 or with any other maintenance performed in the elevator area that would involve the removal of any panels or fairings.

1.6.2.6 B-3 Check

On February 12, 2000, aircraft N8079U completed a scheduled B-3 Check in Austin, TX performed by EWA personnel. (Ex. 11H). The B-3 Check was accomplished at 84,428 hours. The Austin Class I station had a total of twenty-seven maintenance personnel to perform the B-3 Check. The personnel consisted of one Manager, two Supervisors, fifteen full-time mechanics, and nine casual mechanics. A casual mechanic is any EWA mechanic who fills hourly positions, or regular hourly positions temporarily. As part of the B-1 Check, EWA mechanics were to complete steps in the B011 inspection work card and the B018 lubrication work card.

As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing. Both Boeing and EWA confirm that neither the B-3 Check B011 inspection work card nor the B018 lubrication work card, nor any other B-3 Check work card, requires the removal of any panel or fairing in order to perform the inspections or lubrications of the elevator. (Doc. Nos. 136 at 307, line 14, 308, line 11, 537, lines 9-11; and Doc. No. 195 at Enclosure page 1).

EWA witnesses and mechanics uniformly testified that no EWA mechanic would remove the Control Tab Fairing or any other fairing or panel during any B Check inspection unless the work card specifically called for its removal. None of the work cards call for the removal of the Control Tab Fairing.

Further, there is no evidence that any EWA employee removed any such fairing or panel during the performance of any maintenance in the elevator area during the B-3 Check performed on N8079U. In addition, there were no non-routine maintenance items identified during the performance of the B-3 elevator lubrication tasks. (See Ex. 11H, at 4).

1.6.3 DC-8 elevator control system

The basic flight control system for the DC-8 consists of the following primary components (Ex. 17HH):

- Control column,

- Cable runs,
- Horizontal stabilizer,
- Elevator,
- Control tabs, and
- Geared tabs.

The DC-8 uses a tab-driven elevator control system that relies on an aerodynamic boost system rather than hydraulic assistance. The system is designed to use the air stream deflected across the surface of each control tab, which is actuated by the pilot, to force the elevator up or down. This movement of the elevator is further assisted by the geared tabs, which are fixed to the elevator in such a manner as to deflect in the same direction as the control tabs.

Cables and linkages link the control column to the elevator control tabs. Actuation of the control column moves the cable attached to the base of the column. These cables are attached to a "yoke" type mechanism. Attached to this "yoke" is the pushrod for the control tab. Movement of the control tab pushrod actuates the control tab to deflect either up or down. Deflection of the control tabs causes deflection of the elevators and subsequently changes in the airplane's pitch attitude.

Two control columns are located in the cockpit and are interconnected by a torque tube beneath the cockpit floor, so that they operate in unison. The control columns travel approximately 23.75° forward and 6.5° aft of a vertical reference line (i.e., perpendicular to the inboard seat track at the First Officer's station). The elevator flight control cables are connected to the base of each control column.

The DC-8 control tabs are hinged to the trailing edge of each elevator, on the inboard aft portion of the elevators. The forward part of the elevator control tab pushrod attaches to an elevator crank fitting. The aft portion of the pushrod attaches to the control tab crank fitting.

The geared tab is hinged to the trailing edge of each elevator, immediately outboard of the control tab. Gear tabs deflect opposite the direction of the elevator deflection to assist in moving the elevator.

When either control column is moved forward or aft, the control column torque tube moves the other column in the same direction, causing the cable systems and associated mechanical linkages to drive the control tabs up or down. During flight, aerodynamic forces exerted on the deflected control tabs drive the elevators in the opposite direction, causing the aircraft pitch to move in response to the elevator movement—when the pilot pulls the control column back, the elevator control tabs move down, the elevator responds by moving trailing edge up, and the aircraft responds by pitching nose up. The geared tab drive linkages move the geared tabs in the same direction as the control tabs to assist in moving the elevators.

1.6.4 Aircraft performance

Testing was also performed regarding the aircraft performance at differing CG locations. This is addressed below, in section 1.16.1.

Review of the Digital Flight Data Recorder (DFDR) evidence identified a control anomaly beginning about 8 1/3 minutes before the aircraft's landing at MHR. The implications of this anomaly on aircraft performance are addressed below in section 1.16.3.

1.7 Meteorological Information

Visual meteorological conditions prevailed at the time of the accident.

1.8 Aids to Navigation and Air Traffic Control

Not applicable.

1.9 Communications

No external communications difficulties were reported.

1.10 Airport Information

MHR is operated by the County of Sacramento, and is located about 12 miles east of downtown Sacramento, California. The airport formerly served as an Air Force Base. The airport is served by one set of parallel runways, runways 4L-22R and 4R-22L. The airport elevation is 96 feet Mean Sea Level (MSL).

The active runway for EWA Flight 017 on the day of the accident was runway 22L, the longest runway at MHR (11,301 feet). Runway 22L is served by an instrument landing system (ILS) which is approved for Category I approaches.

1.11 Flight Recorders

Soon after the flight recorders were given to the NTSB's laboratory in Washington, D.C., investigative groups were formed to analyze the flight data recorder data and to produce a transcript of the CVR recording. A CVR sound spectrum study was also initiated to examine a sound just before rotation that had been identified by the CVR Group as a "ratcheting noise ending with a clunk." The sound spectrum study is addressed in section 1.16.2.

1.11.1 Digital Flight Data Recorder (DFDR)

A Loral Fairchild model F800 Digital Flight Recorder (DFDR) (s/n 04018, p/n 17M303-282), was installed on N8079U in conjunction with the D Check accomplished in November 1999. EWA contracted L2 Consulting Services to accomplish the engineering and installation of the DFDR.

The F800 DFDR is capable of recording 25 hours of data on a ¼ inch magnetic tape. Although the DFDR's recording capacity is 25 hours, erroneous track switching caused only the last 8 hours and 11 minutes of recording to be available to investigators. However, this was adequate to record the flight preceding the accident flight (RNO to MHR) and the accident flight.[15] No losses of sync were found in the accident data.

The DFDR recorded the following parameters:

- Aileron Position – Left.
- Altitude – Course & Fine.
- Autopilot Engage.
- Control Column Position.
- Control Wheel Position.
- Elevator Position.
- Engine #1 N1.
- Engine #2 N1.
- Engine #3 N1.
- Engine #4 N1.
- Heading.
- Indicated Airspeed.
- Longitudinal Acceleration.
- Pitch Attitude.
- Roll Attitude.
- Rudder Pedal Position.
- Rudder Position.
- Time (counter).
- Vertical Acceleration.
- VHF 1 Keying.
- VHF 2 Keying.

The DFDR was recovered from the wreckage and sent to the NTSB's Flight Recorder Laboratory in Washington, D.C. for readout and evaluation. The readout was accomplished using the laboratory's playback hardware. The results of the readout are included in NTSB Exs. 10A, 10B, 10C, 10D, 10E, 10F, 10G, 10H, 10I and 10J.

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[15] The F800 has a history of track switching problems. To date, the manufacturer has issued three Field Service Bulletins to address these problems. The part number and serial number DFDR on N8079U was not subject to these Field Service Bulletins. The exact nature of the track-switching problem with the DFDR on N8079U could not be determined due to the condition of the recorder and its components.

Two parameters, the Control Column Position (CCP) and the Elevator Position (Elev. Posn), are critical to this investigation. The Parameter Sign Conventions for these two parameters are:

Control Column Position:[16]

- >-15 = Aft
- <-15 = Forward

Elevator position:

- + = Trailing Edge Up
- - = Trailing Edge Down

DFDR data for three recorded takeoffs was evaluated, including the accident takeoff and the two previous takeoffs, including the takeoff from RNO on the flight immediately preceding the accident flight.

During taxi out on the accident flight, the crew performed a flight control rollout check. This is indicated in the data (Ex. 10F, page I-1 to I-2) by the control wheel position moving from –85.2 degrees at time 19:41:44 to 69.5 degrees at 19:41:47, the rudder pedal position moving from –21.7 inches at 19:42:24 to 21.9 inches at 19:42:26 and by the control column position moving from –17.3 degrees at 19:42:28 to –3.9 degrees at 19:42:30. During the forward (nose down) elevator portion of the check, the data shows the elevator position moving to 2.8 and 3.8 degrees trailing edge up.

During the accident takeoff, the crew performed an "80 knot" check. At 19:48:49, the relevant data from the DFDR for the accident flight shows an Indicated Airspeed (IAS) of 82.5 knots, a Pitch Attitude (Pitch Att.) of + 0.2 degrees, a Control Column Position (CCP) of -15.1 degrees, and an Elevator Position (Elev. Posn) of 5.3 degrees Trailing Edge Up (TEU). During the next two seconds, the Pitch Att. moves to -0. 6 degrees, the CCP moves to –19.0 degrees and the Elev. Posn moves to 2.2 degrees TEU. (Ex. 10A at II – 9).

During the "80 knot" check made on the previous takeoff from RNO, the data shows a CCP of –17.2 degrees that results in an Elev. Posn of 7.8 degrees Trailing Edge Down (TED) (Ex. 10A at II – 32 at DFDR subframe 27269). Comparing the data from the accident takeoff to the previous takeoff shows that

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[16] Note that the control column position is –15 degrees with the gust lock on. A control column position of 0 degrees indicates the control column is perpendicular to the floor. Forward and aft control column movement is referenced to the –15 degrees position. When using the calibration data for the elevator conversion, elevator position is –11 degrees when faired. For ease of reference, an 11 degree offset was applied to the elevator conversion. This offset is reflected in the plots.

with the CCP 1.2 degrees farther forward than on the previous takeoff (-19.0 vs. –17.2) the Elev. Posn was 10.0 degrees more TEU (2.2 degrees TEU vs. 7.8 degrees TED).

At no time during the accident flight, including during the 80-knot elevator checks, did the elevators travel below neutral.

Information from the flight immediately preceding the accident flight was examined to determine if similar circumstances existed. The review identified a control anomaly at a point 8 1/3 minutes prior to landing at MHR. The control extraction from the FDR showed that the stabilizer moved trailing edge up (airplane nose up) when the pilot pushed the airplane over to resume the descent after a brief pause. This is opposite to the airplane nose down trim one would expect at this point. A kinematic extraction shows that a control tab split began at the time of the anomaly. This tab split was easily controllable with the stabilizer trim motion returning the aircraft to trim and the elevator remaining responsive to pilot input. (Ex. 13A, at 25).

As a result of these findings, investigators from the Airworthiness Group reconvened in Sacramento to perform a detailed examination of Flight 17's wreckage to look for components of the elevator flight control systems. This examination is addressed in section 1.12.3.

1.11.2 Cockpit Voice Recorder (CVR)

A Sundstrand AV557, Serial No. 7286, CVR was installed on N8079U. The CVR was recovered from the wreckage and sent to the NTSB audio laboratory. The CVR had been exposed to intense fire and heat. The exterior of the CVR showed severe heat damage. Although the tape assembly unit did not appear to have severe heat damage, the CVR magnetic tape that was outside of the spool showed signs of shrinkage, which can be the result of CVR tape exposure to heat. The sections of the tape that had shrunk around the rollers sustained permanent damage, which resulted in several small areas of unusable audio at the beginning and end of the recording. There were two momentary interruptions in the recording as a result of the AV557 CVR tape drive reversing direction. (Ex. 12A). The overall recording, however, was in playable condition and successfully downloaded.

The recording consisted of four channels of good quality audio information. The rating of good quality indicates that the majority of the crew conversations were intelligible. The transcript indicates passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information. The first channel contained the First Officer's audio panel information. The second channel contained the audio information from the cockpit area microphone (CAM). The third channel contained the Captain's audio panel information. The fourth channel contained the Second Officer's audio panel information.

The CVR tape produced 33 minutes and 24 seconds of audio recording beginning at 19:17:45 and ending at 19:51:09. The CVR Group convened and prepared a transcript of the audio tape. This transcript is contained in Ex. 12A.

As shown in this transcript, the CVR group members could not clarify or identify a ratcheting noise that was recorded on the CAM channel immediately prior to rotation. A sound spectrum group was formed to further investigate the origin of the noise. The results of the sound spectrum study are contained in Ex. 12B. Although the sound spectrum study could not conclusively identify the source of the ratcheting noise, it did reveal, "that the source of the ratchet noise is not likely to be a cargo load rolling on the rollers within the cargo area of the aircraft." (Ex. 12B at 8).

1.12 Wreckage and Impact Information

The Airworthiness Group conducted both an initial on-site phase inspection of the wreckage and, following a review of DFDR data indicating certain anomalies as described in section 2.2, a detailed off-site wreckage inspection.

1.12.1 Location of debris

The accident occurred approximately two miles due east of the approach to runway 22L at MHR, northwest of the intersection of Sunrise Boulevard and Douglas Road, at the Insurance Auto Auction salvage yard and the Allstate Claims Service Center.

A debris field of aircraft parts extended towards the southeast, and consisted of engines, engine components, nacelles, pylons, landing gear assemblies, flight control surfaces, sections of each wing, the stabilizers, the fuselage tail cone, and numerous systems components. This debris field spanned an area approximately 500 yards long by 150 yards wide.

1.12.2 Aircraft structures

The airframe had broken up into several sections. The cockpit was found to the south of the main wreckage, the fuselage section forward of the wings to the west, a section of the right-hand wing to the north, and the rear fuselage and empennage to the southeast. (Ex. 7A).

The right-hand horizontal stabilizer was recovered from the debris field and was found essentially intact. The elevator was fractured into several sections; however, the majority of the outboard sections were consumed by post-crash fire. The right-hand control tab and the inboard end of the geared tab remained attached to the inboard section of the elevator, but had suffered severe heat and fire damage. All surfaces were sooted and heavily damaged due to impact.

The horizontal stabilizer jackscrews and associated mechanisms were heavily damaged. Both jackscrews were found extended approximately twenty-eight inches. Boeing has confirmed that this position of the jackscrews corresponds to the full nose down trim position of the horizontal stabilizer.

1.12.3 Detailed wreckage inspection of elevator components

Following discovery of an anomaly in the DFDR relating to the restricted elevator travel, the Airworthiness Group conducted, on February 7-8, 2001, a detailed wreckage examination that focused on components of the elevator control system. (Ex. 7A). During this examination, additional components of the elevator control system were identified. The group soon focused on differences in the damage to the left-hand and right-hand elevator control tab pushrods and associated attachments.

The pushrod for the left-hand elevator control tab had been heavily damaged by impact forces. Both forward and aft rod ends were fractured, and the pushrod was bent in the middle. The aft crank fitting where the pushrod attaches to the control tab had been consumed by fire.

In contrast, the pushrod for the right-hand elevator control tab, including both ends, was found intact and relatively undamaged. In addition, the aft crank fitting remained intact and attached to the control tab inboard hinge fitting. The bushings in the clevis lugs were also present with no visible signs of internal damage or deformation. The detailed wreckage examination revealed that neither the bolt that attaches the pushrod to this fitting nor the associated nut and cotter pin were found.

The missing bolt location was at the right-hand elevator control tab crank fitting, in the area where the control tab is normally attached. Although the pushrod was recovered separately, the pushrod and fitting remained structurally intact at the missing bolt location of each respective assembly. In addition, numerous indications of contact damage were noted on the forward edges of the crank fitting.

The missing bolt is made of high strength steel. It is supposed to come in contact with the flanged bushing, which is also made of hardened steel. The bolt also passes through a rod end bearing. Any deformation or smear marks are usually detectable.

Examination of the aluminum parts, including the head of the clevis, revealed no evidence that the bolt head or washer was up against the outer surface of the clevis. If the bolt and washer had been present at the time of the accident, markings should have been detectable. Rather, the outer surface of the clevis appeared to have been through a fire without protection.

Examination of the forward end of the right-hand pushrod, where the bolt had been removed after the accident, focusing on the surface of the rod, revealed evidence of a circular pattern.

Examination of the left-hand elevator control rod showed that the housing for the rod end bearing was broken. The aluminum housing for the right-hand control rod was intact.

In addition, many nicks and scrapes appear on the forward edge of the clevis and on the end of the right-hand control rod.

1.13 Medical and Pathological Information

Toxicological testing was performed on urine specimens obtained from the captain, first officer, and the second officer. The specimens tested negative for alcohol and other drugs of abuse. (Ex. 2A at 12).

1.14 Fire

A fuel-fed fire erupted upon impact.

1.15 Survival Aspects

All three flightcrew members were in the cockpit at the time of the accident. Because of impact forces, the accident was not survivable.

1.16 Tests and Research

The NTSB conducted testing into a number of areas relevant to the investigation of this accident.

1.16.1 Simulator testing related to center of gravity

In response to a Boeing request, a test of aft CG recovery procedures was conducted in the DC-8-71 flight simulator located in Dayton, Ohio on May 13, 2001. Captain Nick Gentile, from Boeing, participated along with a number of EWA DC-8 check airmen.

The DC-8 flight simulator software was reprogrammed by employees of Aeroservice, the simulator operator, to allow an instantaneous CG shift beyond the certified limit to 40% of the Mean Aerodynamic Chord (MAC).[17] The purpose of this program was to evaluate an escape maneuver from an uncommanded pitch up that might be associated with cargo shift or other (flight control) problems.

For all of the simulator tests, Los Angeles International Airport was used because it has an elevation comparable to MHR's. A number of takeoffs were accomplished with the CG being moved incrementally aft to the 40% MAC location as the aircraft was rotated through eight degrees of pitch on takeoff. Variables such as power setting, flap settings, fuel dump, landing gear positions and bank angle were explored.

During the testing, control was not lost until the CG was above 38%– well aft of the technical aft CG limit of the aircraft, which is 33.6%. Above 38%, the aircraft would "auto-rotate" as soon as power was applied, raising the nose wheel off the runway, making the simulator uncontrollable.

With the information gained from the simulator tests regarding the limits of the controllability of a DC-8-71F in relation to its CG, further testing sought to determine the specific circumstances involving an improperly loaded aircraft that could create a CG that approached or exceeded this controllability limit. The aircraft CG for six different loading conditions was calculated.[18] For

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17 Through the help of Aeroservice, the CG limits imposed by the simulator software were re-written to allow the simulator operator to move the CG aft to simulate various hypothetical cargo loads and locations.

18 The six loading conditions were:

Condition 1. *LPS loading* – The CG was determined based on the cargo being loaded in accordance with the LPS from the accident flight. The resulting CG was 27.1%.

Condition 2. *Significant improper cargo loading scenario* – The CG was determined assuming that all pallets were loaded in the proper position, but the heaviest ULD's were loaded in the furthest aft position. While it would be theoretically possible to have misloaded the aircraft in this condition, the condition would be quite unrealistic, since it would require the misloading of virtually every ULD. Nevertheless, a hypothetical load in this condition would result in a CG of 32.9%.

Condition 3. *Worst-case improper cargo loading scenario* – The CG was determined based on the heaviest ULD's and pallets being loaded in the farthest aft position. This condition would simulate an improperly loaded aircraft, but would not involve the failure of any cargo restraining devices. It would be impossible actually to have loaded the aircraft in this each of the conditions, the actual pallet and ULD weights noted on the LPS were used, since the pallets and ULDs are weighed before being sent to the aircraft. It should also be noted that the scales at both RNO and MHR had been calibrated within the two months preceding the accident. Further, the accuracy of the scales at MHR, where the vast majority of the cargo aboard the accident aircraft was weighed, was verified after the accident.[19]

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configuration, since it would require loading ULD's in positions that only physically accept pallets. Nevertheless, a hypothetical load in this condition would result in a CG of 35.4%.

Condition 4. *Single load shift scenario* – The CG was determined based on the pallet in position 18 (the heaviest pallet) being shifted aft one position. This would simulate the failure of the cargo restraining devices for position 18. It would be virtually impossible for this load shift to occur because of the physical limits imposed by the narrowing fuselage of the aircraft. A full shift of the cargo from position 18 to position 19 would cause significant damage to the interior of the aircraft. Nevertheless, this condition would result in a CG of 27.8%.

Condition 5. *Significant cargo shift scenario* – The CG was determined based on the pallets and ULD's in positions 6 through 18 each being shifted aft one position. This would simulate a failure of a significant number of cargo restraining devices. This condition is very improbable since it would require multiple failures. In addition, as noted above, it would be virtually impossible for the pallet in position 18 to shift aft because of the physical limits imposed by the narrowing of the fuselage of the aircraft. Nevertheless, a hypothetical load in this condition would result in a CG of 33.9%.

Condition 6. *Entire load shift scenario* – The CG was determined based on the entire load being shifted aft one position. It would be impossible for this load shift to occur, since it would require the failure of numerous locking devices and would ignore physical obstructions to the movement of cargo aft. Nevertheless, a hypothetical load in this condition would result in a CG of 36.2%.

[19] According to the EWW City Service Coordinator, it is standard Emery policy to calibrate the scales every six months. (Ex. 2B at 29). The scales at both RNO and MHR were calibrated before and immediately after the accident. See Daily Service Reports for MHR (showing scale calibration before the accident on February 4, 2000 and successful test after the accident on February 17, 2000) and Inspection/Calibration Certificate for RNO (showing accuracy of the RNO scales on

Condition 1 assumes a normal loading in accordance with the LPS. Conditions 2 and 3 assume improper cargo loading scenarios, with Condition 2 assuming a misloading of the ULDs, but not the pallets aboard the accident aircraft, and Condition 3 assuming a "worst case" improper loading scenario in which all topside cargo is loaded in a sequence that would load the heaviest cargo the farthest aft, and the lightest the farthest forward. It should be noted that Condition 3 would require that a ULD be located in position 18. As noted earlier, it would be physically impossible to load a ULD in position 18 given the dimensions of the ULD and the narrowing of the fuselage at position 18. Thus, Condition 3 represents a "worst case" loading that would be impossible to achieve. Conditions 4, 5, and 6 assume shifting cargo, and will be addressed below, in the discussion of the shifting cargo issue.

The cargo, when loaded in accordance with the LPS (Condition 1), resulted in a CG of 27.1%, well within the aft CG limit of 33.6%. Condition 2 resulted in a CG of 32.9%, also within the aft CG limit of 33.6%. The worst-case improper cargo-loading scenario (Condition 3) resulted in a CG of 35.9%, which would be far enough aft to exceed the technical aft CG limits of the aircraft, but would not approach the 38% controllability limits of the aircraft.

The simulator was also used to explore escape maneuvers from the unusual circumstances. The combination of variables that resulted in the best escape from this uncommanded pitch up was full nose down elevator, full nose down stabilizer trim, and the initiation of a roll to bring the nose down. The appropriate bank angle is established when the speed stabilizes and the aircraft continues in a climbing turn. This may require bank angles in excess of 60 degrees. Once the aircraft is at a safe altitude, airspeed can be increased by increasing the bank angle, until the rate of climb is zero, and the airplane can then be reconfigured to attain the best flight quality.

It was found to be critical to roll the aircraft into a bank before the airspeed decays below V_2 + 10 knots. Once the speed decays to V_2, acceleration is difficult without reducing altitude.

1.16.2 Sound spectrum study on DC-8 aircraft

As shown in the CVR transcript, (Ex. 12A), the CVR Group members could not clarify or identify the ratcheting noise that was recorded on the CAM channel immediately prior to rotation. A sound spectrum group was formed to further investigate the origin of the noise.

After the crew called "80 knots" and "elevator check" at 19:48:50, an unidentified ratchet noise was recorded on the CAM channel at 19:48:55. At

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January 21, 2000). The error was, at most, 0.33%, or 10 pounds for every 3,000 pound increment. This amount of error is inconsequential.

19:49:02 the Captain called “V one” and then “rotate”. The ratcheting noise recorded on the CAM channel is distinctive, with particular characteristics. The noise appears cyclic with a frequency of 18.8 Hz. Each ratchet is an impulse with a sharp rise in amplitude – almost 400% higher than the background noise level at the peaks.

To document the on board systems of the DC-8, two audio static ground tests were arranged on different days aboard two DC-8-71F aircraft similar to N8079U. (Ex. 12B). A variety of audio was captured during these sound spectrum analyses. Upon reviewing the audio data, the following sources had characteristics similar to the unidentified ratchet:

1. ULD/Pan movement in cargo area.
2. Crew seat motion in seat track.
3. Rudder pedal adjustment.
4. Stall Warning – stick shaker.

The results from the audio tests revealed that the noise of the movement of the ULD and pan in the cargo positions closest to the front of the aircraft – regardless of whether the cockpit door was open or closed – was not significantly pronounced to be distinguishable from the background noise. That is, on the CAM channel CVR recordings, the amplitude of the noise of the cargo load rolling over the rollers and slamming into the position locks was imbedded within the amplitude of the background noise.

During the audio tests it was evident that the seat moving in the seat track could produce a ratchet-type noise. The two separate audio tests yielded inconclusive results. Although impulse-type noises could be recreated, the seats in the test aircraft could not be moved at a constant rate to yield a cyclic noise like the noise in the accident recording.

It is possible to produce a ratcheting noise when adjusting the rudder pedal setting. During the tests, a ratchet noise was created once, but could not be created again. In subsequent trials it was possible to produce an impulse noise, but not in a series resembling the cyclic nature of the unidentified noise in the accident recording. The single occurrence of the ratchet-type noise from the audio test was not truly cyclic, in that the period of the impulses varied.

The CVR group was able to identify the stick shaker within the accident recording. The stick shaker noise is impulsive with a relatively sharp rise in amplitude that has peaks close to 250% of the level of the background noise – slightly lower than the peaks shown in the waveform of the ratcheting noise.

Although the audio tests concentrated on noise sources within the aircraft, an exterior source was considered. Specifically, in order to produce a cyclic noise recorded via the CAM, the nose gear of an aircraft would generally have to run over a series of seams or objects spaced together within a short distance from each other across the runway. An inspection of runway 22L at MHR did not reveal any seams or objects along the pavement that N8079u's nose gear could have rolled over to produce the ratcheting noise.

The unidentified ratcheting noise, which lasts less than 0.3 seconds, is impulsive and does not have a single frequency source. As a result, the sound spectrum group was unable to determine its source definitively. There are several parameters inherent to crew seat motion, rudder adjustments and the stick shaker operation that decrease the chances of repeatability during an audio test. Nevertheless, the acoustic evidence from the two audio tests reveals that the source of the ratchet noise is not likely to be a cargo load rolling in the rollers within the cargo area of the aircraft.

1.16.3 Testing related to split tab condition

Based on the information about the flight control anomaly detected in the DFDR and information obtained during the subsequent detailed wreckage examination, testing was performed on the elevator flight controls of a sample DC-8 aircraft, to identify the effects of a free pushrod when disconnected from the control tab crank fitting. The testing revealed that the disconnected control tab would result in a mismatch between the left-hand and right-hand control tabs of approximately 25°, throughout the available range of control column travel. The testing further revealed that the disconnected control tab would be deflected approximately twice as far, and in an opposite direction to, the functional control tab, even with the control columns commanded full forward.

1.17 Organizational and Management Information

1.17.1 Emery Worldwide Airlines (EWA)

EWA's original air carrier operating certificate was issued in May 1987, under the name Air Train, Inc. On January 3, 1990, the name on the certificate was changed to Emery Worldwide Airlines. At approximately the same time that the certificate name was changed, the airline management offices were moved from California to Vandalia, Ohio. At the time of the accident, EWA held FAA Air Carrier Certificate Number RRXA558B, and was authorized to operate DC-8 and DC-10 aircraft to conduct air carrier operations pursuant to Title 14 C.F.R. Part 121 under regulations applicable to supplemental operations.

1.17.1.1 EWA Maintenance Program

Each of EWA's aircraft and their component parts, accessories, and appliances were maintained in accordance with specified time limits and cycles for the accomplishment of overhauls, replacements, periodic inspections, and routine checks. EWA had established and maintained a system of continuing analysis and surveillance to continuously monitor the operational performance of aircraft airframes, power plants, systems and components through the administration of a maintenance reliability program. At the time of the accident, EWA operated 43 DC-8 aircraft, including the accident aircraft, and 2 DC-10 aircraft. EWA maintenance personnel totaled 309 full time mechanics, 18 part-time mechanics, 38 casual mechanics, and 34 contract mechanics.

EWA performed scheduled and unscheduled maintenance using maintenance personnel employed both by EWA and by various contractors, as appropriate to the type of maintenance to be performed. As part of this maintenance program, EWA established various line maintenance stations at the stations serving its scheduled routes. The line maintenance stations were classified as Class I, II, and III.

1.17.1.1.1 EWA's routine maintenance program

EWA personnel typically performed the following DC-8 maintenance checks: Transit Check, Terminating Check, Service Check, and B Check. The B Checks were the most in-depth level of maintenance that EWA employees performed, and were accomplished at specific stations where EWA maintenance personnel were assigned. The heavy maintenance C and D Checks were accomplished by FAR Part 145 FAA-approved repair stations. Any such repair station used by EWA was required to meet the qualifications of EWA's Substantial Maintenance Program and be listed on EWA Operations Specification D91.

C Checks differ from B Checks since C Checks are high level checks to insure the integrity and airworthiness of the airframe, check fluid quantities, check the security of components, perform operational checks of specified components, change filters, perform lubrication, overhaul specific components, check systems, and check the accomplishment of the CPCP. The C Check is accomplished every twenty-four calendar months.

D Checks are also defined as high level checks to include all of the same checks as described in the C Checks and, in addition, the "overhaul of the aircraft". The D Check is accomplished every twelve calendar years. All the work required in a C Check is always accomplished when a D Check is performed. (EWA MPPM chpt. 4, p. 188).

In 1998, EWA changed from a "block" B Check system to a "segmented" B Check system. In a block B Check, all items in the B Check are performed at each B Check inspection. In a segmented B Check, the items on a B Check are distributed among several smaller, sequential B Checks (B-1, B-2, B-3 and B-4). A segmented B Check occurs each 136 flight hours unless an intervening C Check was accomplished. The shorter 136-hour interval between each segmented check is such that all of the segmented B Checks are performed over the same time interval as the block B Check.

The EWA B-1 and B-3 Checks involved the lubrication of certain parts of the elevators. Work cards B013 (used on B-1 Check) and B018 (used on B-3 Check) indicate several external lubrication points for the elevator tab hinges (seven per side), outboard elevator hinges (five per side), elevator geared tab link attach joints (two per side), and the inboard elevator hinge (one per side). The Douglas DC-8 Maintenance Manual, Chapter 12, General Servicing 12-82-1, pages 318 and 319 were used to establish the instructions on the EWA B-1 and B-3 work cards for the elevator lubrication task. (See Ex. 11H at 4). No panel or fairing is required to be removed in order to perform these tasks. (Ex. 11H at 4).

The B-2 Check included two work cards for inspections of the aft fuselage and empennage area. Work card B008 called for an inspection that primarily involved the aft fuselage and empennage. Work card B009 involved an inspection of the right-hand and left-hand horizontal stabilizer external surfaces. Work card B009 directed the mechanic to conduct an external surface inspection as follows: "Inspect external surface of RH and LH horizontal stabilizers for signs of damage, deformation, fluid leakage, and security of attachment. Inspect static dischargers for general condition and security." (Ex. 11I). The card also directed the mechanic to conduct an elevator and tab inspection as follows: "Visually inspect elevators and tabs for general condition, corrosion, leakage, and security of attachment. Inspect static dischargers for general condition and security." (Ex. 11I).

Boeing states that "<u>[t]he Manufacturer's Recommended Program (MRP) work cards published by the Douglas Aircraft Company and as specified by the On Aircraft Maintenance Planning (OAMP) document do not call for removal of the inboard control tab fairing during the B check. The inboard control tab fairing is not removed until the D and E checks.</u>" (Doc. No. 195 at 1 of Enclosure to letter (emphasis added)). The Boeing response goes on to say that "<u>the Emery B-2 inspection work card B009 …would be consistent with an MRP B check external inspection ..., that is, an inspection to be accomplished without removing access or inspection panels, fairings, or the like.</u>" (Doc. No. 195 (emphasis added)).

1.17.1.1.2 EWA's classes of stations

Class I line maintenance stations were staffed with EWA employees and were equipped with the mechanics, facilities, equipment, and parts necessary to perform both scheduled and unscheduled maintenance on all aircraft normally operating into the station. Class I stations were designed around having a B Check capability. Class I stations were located at Austin, Texas; Vandalia, Ohio; and Portland, Oregon.

Class II stations were staffed with EWA personnel, but did not necessarily have full facilities, equipment, and parts to perform all scheduled or unscheduled maintenance. There were twenty-one Class II stations located throughout the United States, and one station in Mexico.

Class III stations were staffed with on-call maintenance personnel to perform both scheduled and unscheduled maintenance on all EWA aircraft normally operating to the station. There were seven Class III stations located in the United States and Mexico. All work performed at a Class III station was scheduled and controlled by EWA Line Maintenance Control.

1.17.1.1.3 Maintenance manuals

EWA managed control of its Continuous Airworthiness Maintenance Program (CAMP) by use of an FAA-approved and/or -accepted maintenance manuals system. (Ex. 17A at 3). Maintenance manuals included in the EWA CAMP were: Maintenance Policy and Procedures Manual, Weight and Balance Manual, Aircraft Maintenance Manual, Fueling Manual, and Minimum Equipment List. (EWA MPPM, chpt. I, p. 1, sec. I.A.). Together, these manuals made up the EWA CAMP and supported other EWA maintenance-related programs in compliance with FAR Parts 121 and 43.

In addition, numerous manuals were incorporated into the EWA Maintenance Manual by reference. Among these were the Douglas Aircraft Maintenance Manuals, including appropriate revisions, the Douglas Aircraft Overhaul Manual, the Douglas IPC, previous operators' manuals, and FAA-approved Supplemental Type Certificate (STC) holder and Original Equipment Manufacturer (OEM) Maintenance Manuals. (Ex. 17A at 3-4). Since United Airlines (UAL) was one of the previous operators of EWA aircraft, the UAL DC-8 Maintenance Manual and the UAL IPC, series 60/70, were included in the list of FAA-approved maintenance manuals for certain EWA DC-8 aircraft. (Ex. 17A at 3).

EWA's Maintenance Policy and Procedures Manual (MPPM) is one of the most critical manuals in EWA's maintenance program. The following excerpts are from the EWA MPPM:

> Contract Agency personnel will follow all the applicable EMERY WORLDWIDE AIRLINES procedures when completing the required paperwork as detailed within this chapter and other applicable chapters of the Maintenance Manuals. Contract Agency/Vendor personnel will follow the same procedures as those called-out for EMERY WORLDWIDE AIRLINES mechanics unless noted otherwise. (EWA MPPM, chpt. 4, p. 32, sec. III.A.2).
>
> * * * *
>
> If the Mechanic or Inspector must leave a job or inspection before they have completed all the work or inspection specified by a sign-off item, they will write a Discrepancy Item to indicate the status of the work with a reference to the form and item number containing the original instructions. After the Discrepancy Item is written, the Mechanic or Inspector will enter the Discrepancy item number following the sign-off block

on the original maintenance or inspection form. (EWA MPPM, chpt. 3, p. 65, sec. X.B.1.b).

* * * *

When a Mechanic or Inspector must leave a job or inspection before all the work outlined in a Manual procedure is completed, a Discrepancy Item must be written to indicate the status of the job. (EWA MPPM chpt. 3, p. 66, sec. X.B.3.a).

1.17.2 Tennessee Technical Services (TTS)

TTS is an FAA-approved Part 145 repair station, Air Agency Certificate Number T64R1640. The repair station's capabilities listing included the DC-8-70 series.

1.17.3 Contractor maintenance arrangement between EWA and TTS

FAR § 121.373(a) requires that each air carrier "establish and maintain a system for the continuing analysis and surveillance of its inspection program and the program covering other maintenance, preventive maintenance, and alterations and for the correction of any deficiency in those programs, regardless of whether those programs are carried out by the certificate holder or by another person."

1.17.3.1 Selection of TTS to be a contract maintenance provider to EWA

In 1998, EWA made a business decision to find additional Heavy Maintenance Providers. Prior to selection by EWA, each prospective facility was visited and evaluated by EWA officials. TTS was one of the Part 145 repair stations considered by EWA. EWA officials reviewed TTS's facility, manuals, staff, and management to verify compliance with applicable FAR, industry standards, and EWA's standards. In addition, EWA's Director of Heavy Maintenance visited and evaluated TTS. (Ex. 17FF at 6). The Director of Heavy Maintenance's evaluation included an explanation of the general ability of the repair station to support a DC-8 heavy maintenance program.

In addition, EWA used a standard format for an inspection and audit of prospective vendors that had been developed by the aviation industry. This is known as a Coordinating Agency for Supplier Evaluation (CASE) audit. The CASE audit is accepted by the FAA and has been approved as an acceptable means of selecting maintenance and repair providers in accordance with FAR § 121.373(a). (EWA Operations Specifications Manual, rev. 4, chpt. 1, p. 16).[20]

[20] An excerpt from the EWA Operations Specifications Manual addressing the CASE Audit is attached as Attachment "D".

EWA performed its first CASE audit of TTS on September 29, 1998. (Ex. 17LL). Although the audit revealed some inadequacies, (Ex. 17LL at 6-8, 11-13, and 15), all of these inadequacies were addressed by TTS and EWA management prior to submitting to the FAA an Operations Specifications change to add TTS to EWA's FAA-Approved List of Substantial Maintenance Providers. As part of the CASE audit, EWA reviewed TTS's Training Program and found it to be in compliance with industry standards.

Based on the CASE audit and on a visit to, and inspection of, TTS by EWA representatives, EWA selected TTS to act as a contract overhaul facility. (Ex. 17FF at 6). As a requirement for use of TTS, EWA required that TTS obtain EWA approval of all TTS inspectors that performed inspector duties for EWA aircraft. (Ex. 17V at 47).

EWA used TTS to perform B Checks starting in November of 1998, and C Checks starting in January of 1999. N8079U was the first aircraft EWA provided to TTS for the performance of a D Check. At the time EWA used TTS to perform D Checks, TTS was an FAA-approved repair station, with appropriate FAA approvals to conduct D Checks on DC-8 aircraft.

1.17.3.2 TTS Use of EWA manuals and work cards

EWA provided to TTS, and TTS had possession of, and access to, all EWA manuals necessary to perform all tasks associated with performing contract maintenance for EWA. (Ex. 17V at 41).

TTS officials, including the President of TTS, testified that the work cards supplied by EWA were adequate to perform the maintenance for C and D Checks. (Ex. 17X at 45-46).

1.17.3.3 TTS's Repair Station Inspection Procedures Manual (IPM)

TTS's IPM states the following with respect to documentation of maintenance turnover procedures for interrupted maintenance activities:

> A status book will be provided in the hangar and each shop in which a status report will be entered by each of the lead mechanics informing the next shift of the status of work in progress. Its purpose is to assure a continuing maintenance responsibility for work in progress. (TTS IPM Rev. 7, 12/30/99, sec. V, p. 12).

To maintain continuity of inspection responsibility, the TTS IPM provides:

> A status book will be provided for inspectors in which a status report will be left by each of the inspectors leaving the job before completion of a project, for information to the succeeding

inspector. Its purpose is to assure a continuing inspection responsibility for in-progress work inspections. (TTS IPM Rev. 7, 12/30/99, sec. V, p. 2).

With respect to non-routine work cards, the TTS IPM says that "[t]he Non-Routine Work Form 26 is used to record discrepancies and/or work to be accomplished that is not part of the customer's routine work package. On a limited basis it may be used to record and track labor expended for a specific task or group of tasks when deemed necessary by Planning." (TTS IPM, rev. 8, 08/11/00, sec. VI, p. 15). The TTS IPM also says that the non-routine supplement Form 84 is used "to provide supplemental (additional) items to Routine and Non-Routine. Generally used when sufficient space is not available on the above documents." (TTS IPM, rev. 7, 12/30/99, sec. VI, p. 23).

1.17.3.4 EWA training of TTS inspectors

EWA provided training to all TTS inspectors that were to perform inspector duties on EWA aircraft. (Exs. 17V at 47; 17W at 5-6). EWA trained TTS inspectors on the EWA maintenance policies and procedures necessary to provide contract maintenance on EWA's behalf. TTS officials testified that this training was adequate. (Ex. 17W at 6; Doc. No. 136 at 247-252). As part of this training, TTS Inspectors attended several training classes at the TTS facility by EWA personnel. This training included training on EWA's MPPM, inspection program, and CPCP program. EWA also provided TTS with training material produced by EWA in the form of Maintenance Service Letters (MSL's).[21] EWA did not provide maintenance training with respect to specific maintenance tasks with which FAA-certificated mechanics should be familiar, or training necessary to maintain the qualification currency of employees to perform work on a specific aircraft. TTS's President confirmed that Emery was not expected to provide DC-8 specific maintenance training to personnel at TTS and that TTS did not rely on EWA to train TTS's mechanics on how to accomplish DC-8 maintenance, other than matters specific to EWA's manuals. (Ex. 136 at 247-252).

1.17.3.5 EWA ongoing oversight of TTS

After initiating use of TTS, EWA continued to conduct regular audits and inspections of TTS. The audits included bi-annual audits using the CASE standard audit format and CPCP audits prior to the completion of all C and D Checks. The inspections included regular site visits. In addition, the management of both EWA and TTS maintained open lines of communication for the discussion of issues designed to improve the overall TTS repair product.

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[21] These MSL's were part of EWA's Maintenance Training Program designed to train its staff, outside of formal classroom training, and to inform its staff of changes to the MPPM or other pertinent information as deemed necessary by EWA's management.

The work cards issued for each aircraft sent to TTS for C or D Checks were reviewed three times. The first review was conducted by EWA's Quality Assurance personnel prior to submitting the cards to TTS to ensure that all cards included all tasks necessary to comply with the FAR and EWA's maintenance and inspection program requirements. TTS Quality Assurance personnel conducted the second review after the completion of the check on the aircraft to ensure that all required FAR and EWA maintenance and inspection program requirements had been fulfilled. EWA Quality Assurance personnel conducted the third review after the check was completed in order to ensure, from a records perspective, that all required FAR and EWA maintenance and inspection program requirements had been fulfilled.

1.17.4 FAA Oversight of EWA

From 1987 through December of 1999, FAA oversight of EWA's operating certificate was assigned to the FAA's San Jose, California, Flight Standards District Office (FSDO). During the time that the San Jose FSDO oversaw EWA's certificate, EWA's operations grew from a fleet of 6 DC-8 aircraft and 318 airline personnel in 1990, to 43 DC-8 aircraft and 1,065 airline personnel in 1998.

In 1999, EWA requested that oversight of EWA's certificate be transferred to the FAA Great Lakes Region. This request was based on EWA's desire for increased oversight and more comprehensive surveillance from the FAA. (Exs. 17BB at 12, 58; Doc. No. 192 at 49). As a result of this request, the oversight was transferred to the FAA Great Lakes Region in December 1999. The FAA Great Lakes Region assigned oversight of EWA to the Cincinnati, Ohio FSDO, which was the closest FSDO to EWA's corporate offices and main base of operations in Dayton, Ohio.

1.17.4.1 RASIP and NASIP inspections

During the nearly eleven years that EWA was operational, the FAA used National Aviation Safety Inspection Program (NASIP) inspections and Regional Aviation Safety Inspection Program (RASIP) inspections to determine if air carriers were in compliance with the FAR, approved company procedures, and other written FAA guidelines. (Ex. 11A; Ex. 17JJ). EWA received five NASIP/RASIP investigations during its existence.

A NASIP or RASIP inspection team is usually formed of individuals that are not from the Flight Standards District Office that is responsible for the inspected air carrier's certificate. While this provides a "fresh look" at the air carrier, it also means that NASIP and RASIP inspectors are typically not familiar with the air carrier they are inspecting, or the programs used by that air carrier.

The NASIP/RASIP team executes the inspection, which may last for as long as three weeks. At the end of the inspection, the NASIP/RASIP team prepares a report for delivery to the certificate-holding FSDO. This report usually lists certain initial "findings" made by the inspection team. These initial findings are subject to inquiry and resolution, and are broken down into different areas, including operational or airworthiness / maintenance areas. Each initial finding is also classified into one of three categories:

- Category A or I – Represents a possible non-compliance with the FAR.
- Category B or II – Represents a possible failure to adhere to guidance developed by the certificate holder, including FAA-approved or -accepted company procedures, such as manual procedures.
- Category C – Represents systemic deficiencies that could cause non-compliance with regulatory requirements. Not all NASIP and RASIP inspections use Category C.

Only Category A initial findings may eventually be determined to constitute non-compliance with the FAR. Even if a Category B initial finding is substantiated, the circumstances would still fall short of representing non-compliance with the FAR.

The findings are turned over to the certificate-holding FSDO, which did not participate in the inspection. The FSDO, working in conjunction with the relevant FAA Region, is responsible for processing the findings, and working with the air carrier to determine which findings have merit and which do not. This is a necessary step, since the NASIP/RASIP inspection team, which prepared the findings, is not necessarily aware of all of the circumstances involved. (See Ex. 17CC at 35 (FAA Principal Maintenance Inspector (PMI) stating that "there is no way as a new inspector you could come into this carrier and be 100 percent correct at all times, so that is why we go over the write-ups and they explain to us, show us the documentation and in a lot of cases, some documentation was missed"). The FSDO will usually investigate the NASIP/RASIP findings further and give the air carrier (or repair station) the opportunity to respond to each finding. Quite often, the air carrier satisfactorily demonstrates to the FSDO that the air carrier is in compliance with the cited provision and that the NASIP/RASIP inspectors either misunderstood what they were seeing or were unaware of relevant circumstances. In many cases, the air carrier simply did not have the opportunity to address the NASIP/RASIP team during its investigation in order to short circuit what would turn out to be unfounded findings.

Typically, many of the initial Category A or I NASIP/RASIP findings are determined by the certificate-holding FSDO not to represent a violation of the FAR. In other cases, the FSDO will indicate that the matter has been corrected by the air carrier and not pursue the matter further. In still other cases, the FSDO may downgrade a Category A or I finding to a Category B or II finding.

On the other hand, the FSDO may concur with a Category A or I NASIP/RASIP finding and open an enforcement investigation. In these latter cases, the discussion about whether or not the circumstances constitute a violation of the FAR continues through the normal due process mechanisms available to an air carrier in an enforcement proceeding under the FAA's Compliance and Enforcement Program. In some cases, during the enforcement proceeding the matter is determined not to represent non-compliance with the FAR.

The FAA conducted NASIP/RASIP inspections of EWA at the following times preceding the accident:

- *June 8-26, 1992* – FAA Western-Pacific Region conducted a NASIP inspection of EWA.
- *June 12-23, 1995* – FAA Western-Pacific Region conducted a RASIP inspection of EWA.
- *February 1-5, 1999* – the FAA Western-Pacific Region conducted a RASIP inspection. This was a focused RASIP inspection, with an emphasis on cargo handling procedures at EWA.
- *January 18-28, 2000* – the FAA Great Lakes Region conducted a RASIP inspection of EWA. This inspection was intended to evaluate EWA's condition at the time EWA's certificate was transferred from the FAA Western-Pacific Region to the FAA Great Lakes Region.
- *October 16, 2000 to November 2, 2000* – the FAA Great Lakes Region conducted a RASIP inspection of EWA.

1.17.4.2 Interim and Final Settlement Agreements

On August 13, 2001, the FAA and EWA signed an Interim Settlement Agreement (ISA) stipulating, among other things, that EWA would immediately cease all commercial air carrier operations conducted under FAR Parts 119 and 121 and not resume operations until all issues raised by the FAA were fully resolved in keeping with a plan to be negotiated by the FAA and EWA. (Ex. 17L).

On September 17, 2001, the FAA and EWA signed a Final Settlement Agreement (FSA). (Ex. 17L). In this agreement, the FAA and EWA agreed to work together to address issues outlined in the agreement and that EWA would not be allowed to resume operations until meeting requirements set by the FAA. (Ex. 17L). In executing both the ISA and the FSA, EWA did not admit to any violations based on the FAA allegations. FAA officials also testified that these matters were only allegations, since no enforcement action had been initiated for most of them. (Ex. 17CC at 36). Subsequently, EWA and the FAA entered into an Amendment to Final Settlement Agreement, dated December 4, 2001, in which EWA and the FAA agreed that EWA would not resume commercial air carrier flight operations. (Ex. 17L).[22]

1.17.5 FAA Oversight of TTS

The FAA's oversight of TTS's Part 145 repair station certificate was implemented through its FAA Certificate Holding District Office (CHDO), which managed the certificate. (Ex. 17DD). As part of the oversight, EWA's FAA Principal Maintenance Inspector (PMI) performed "spot" inspections of the TTS facility to ensure that TTS was performing inspections in accordance with the DC-8 maintenance manual and the work cards. The results of these "spot" inspections were relayed to both TTS and EWA. (Ex. 17DD at 29).

From February 14-18, 2000, the FAA conducted a RASIP inspection of TTS to ensure TTS was operating in compliance with applicable FAR and internal TTS Policies and Procedures. (Exs. 17X at 11). All findings were administratively closed. (Ex. 17DD at 7).

2. ANALYSIS

The statement by the accident flightcrew to Air Traffic Control (ATC) that the flightcrew believed it was experiencing a CG problem led to speculation early during the investigation that either improper cargo loading or cargo shifting could be a factor in this accident.

2.1 Weight and Balance and Cargo Issues

An analysis of the data obtained from the DFDR indicates that the basic stability of the aircraft during the accident flight is consistent with a CG that is within the aircraft's CG limits. (Ex. 13A at 26). The stability is inconsistent with an aft shift of the CG. (Ex. 13A at 26).

Additional information documented by the NTSB about the weight and loading of cargo on Flight 17 indicates that the cargo was well within limits for weight and center of gravity. An analysis of this information follows.

2.1.1 Aircraft loading

Since the Weight and Balance/Load Manifest for the accident flight indicated a ZFW CG of 27.1%, and since the aircraft's aft ZFW CG limit was 33.6%, (Ex. 2G), the aircraft was well within the aircraft CG limits.

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22 There was also a second amendment to the FSA, dated May 13, 2002.

2.1.1.1 The aircraft was properly loaded.

All of the testimony and other evidence supports the conclusion that all cargo was properly loaded aboard the aircraft.[23] There is uniform and uncontroverted testimony by employees of both EWW, the ground-based, freight-handling affiliate of EWA, and MAS, the contract ground handler at MHR, that the aircraft was properly loaded. Moreover, even if there had been significant loading errors, it would have been virtually impossible for those errors to lead to the aircraft control difficulties that preceded the accident. There is no evidence that the aircraft was loaded in any manner other than as planned for in the LPS. The LPS itself was signed by an MAS Load Planner, who indicated that he had "determined that the cargo is secure in the positions described in this load planning sheet." (Ex. 2F).

2.1.1.1.1 The topside cargo was loaded in the same sequence as planned on the LPS.

The testimony of the experienced cargo handlers responsible for loading the aircraft confirms the routine nature of the loading in accordance with the LPS. The MAS Ramp Supervisor said that the aircraft load was normal and that the positions were loaded in accordance with the LPS. (Ex. 2B at 2).

Even if there had been an error in the loading sequence (in other words, if the cargo handlers had loaded a pallet or ULD into a different position than specified on the LPS), it is extremely unlikely that the error would have resulted in an aircraft that was more tail heavy than planned, for the following reasons:

- *All eighteen positions had cargo in them.* Because all of the topside cargo positions were loaded, a single pallet or ULD could not have been positioned farther aft than planned without some other pallet or ULD being positioned farther forward than planned. This would minimize the effect of any shift aft in the CG.

- *It would have been virtually impossible to misload the pallets so that the CG would be farther aft.* The LPS called for the heaviest of the four pallets to be loaded in position 18, the position farthest aft. Any misloading of this pallet would have resulted in the CG being farther forward than planned, rather than farther aft. In fact, if we assume that the pallet planned for position 1 was actually loaded in

[23] For additional details and analysis supporting the conclusion that neither cargo loading nor cargo shifting was involved in this accident, see Consideration of Cargo Issues As a Causal Factor in the Accident of Flight EB017, June 16, 2000, attached as Attachment "E", which is incorporated herein by reference.

that position, (See Ex. 2B at 23)[24], then the remaining pallets, in positions 17 and 2, were loaded with the heaviest pallet being placed the farthest aft. Any misload would result in the CG being farther forward than on the LPS, rather than farther aft.

- *It would be virtually impossible for any pallets to have been interchanged with any ULDs.* Standard procedures call for positions 1, 2, and 18 to contain only pallets. Given this standard loading practice, it is inconceivable that ULDs were placed in these positions. Testing has confirmed that the physical dimensions of the fuselage, as it narrows toward the rear of the aircraft, would make it impossible to load a ULD in position 18. The specific testimonial evidence by the EWW RNO Operations Manager makes it extremely unlikely that ULDs could have been interchanged with the pallet planned to be loaded at position 17. (Ex. 2B at 46).

- *The chance of the CG being further aft than planned due to ULD misloading is remote.* The LPS indicates that several of the heavier ULDs were to be loaded aft. (Exs. 2F and 2B at 11). In fact, of the fourteen ULDs aboard the aircraft, the heaviest was planned to be located in position 16, the furthest aft available position. Four of the five heaviest ULDs were planned to be loaded in positions 12, 13, 15, and 16, the furthest aft available positions other than position 14. Any misloading involving these ULDs would have shifted the CG further forward than planned.

- *The remaining ULDs contained relatively light loads, such that if misloaded, the difference in the CG would have been relatively minor.* The heaviest of the remaining ULDs in positions 3 through 11 weighed only 3,600 pounds. While there is no reason to believe that any of these pallets were misloaded, even if they were, their lower weight would have resulted in a minimal change in the CG.

2.1.1.1.2 Eyewitness observations confirm that the CG was not further aft than it normally would be.

If the aircraft had been tail heavy, there would have been many telltale signs. However, firsthand accounts of the accident aircraft's attitude prior to takeoff indicate that these telltale signs did not exist. All eyewitness accounts indicate that the aircraft was *not* tail heavy prior to departure:

- *The tailstand was never lower to the ground than it would be with normal aircraft loading.* Four witnesses confirm that the height of

[24] Since the pallet that was planned to be loaded in position 1 contained hazmat, it would have been extremely unlikely that the pallet could have been loaded improperly without being detected.

the tail of the accident aircraft was normal at all times during aircraft loading, including when the tailstand was installed and removed. (Ex. 2B at 7, 12, 15, 19, and 20).

- *The air start receptacle was not hard to reach.* The air start receptacle of a tail heavy DC-8 would be noticeably difficult to reach. However, an MAS Cargo Technician testified that he only had to reach up to a normal height to disconnect the air start hose. (Ex. 2B at 20).

- *The nose strut was normally compressed.* If an aircraft were tail heavy, the nose strut would be extended more than normal. One EWA mechanic testified that the nose strut was extended only six to eight inches. (Ex. 2B at 44). He also said that he would normally notify the captain only if the nose strut were extended more than ten or twelve inches.

- *The crew stairs were normally aligned.* The crew stairs aboard a tail heavy DC-8 would not have been aligned properly with the passenger door. However, the MAS supervisor testified that there was no problem with the alignment of the crew stairs and the passenger door. (Ex. 2B at 56). Additionally, the crew did not report a problem with the alignment.

- *The aircraft appeared normal during taxi.* There are no indications that the aircraft did not taxi normally.

Thus, the LPS, all eyewitness accounts, and all investigation evidence leads to the conclusion that the aircraft was properly loaded.

2.1.1.2 Even the worst possible scenario involving improper cargo loading would not have caused the control difficulties encountered by the flightcrew.

Even though the possibility that the accident aircraft had a CG aft of the aircraft's limits is extremely remote, the NTSB conducted testing in the simulator to understand the extent to which an aft CG could affect the aircraft's controllability. (See section 1.16.1, above).

The simulator test demonstrated that the improper loading of a DC-8 could not result in a normal rotation followed by the onset of control problems once airborne. The control problems that result from a CG that is too far aft would manifest themselves long before the aircraft rotated. The DC-8 simulator showed that it is doubtful that a DC-8 with an aft CG could even take off. At a minimum, the flightcrew would very likely recognize the problem immediately upon the application of power. It would be virtually impossible not to recognize such a problem during the elevator check at 80 knots because the aircraft behavior and responses to control inputs would have been abnormal. This simulator testing indicates that improper loading could not be the cause of the aircraft accident. Even the impossible-to-achieve worst-case scenarios for improper cargo loading would not lead to the controllability difficulties encountered by the accident aircraft.

2.1.2 Cargo shifting

The NTSB also explored the possibility that cargo shifted aboard the aircraft to such an extent that it caused sudden aircraft controllability problems.

A review of the evidence indicates that it would have been virtually impossible for the cargo to shift significantly. Further, even a significant shift in the cargo would not likely have resulted in the control difficulties encountered by the flightcrew.

2.1.2.1 Inability of the cargo load to shift significantly

All eighteen of the positions capable of holding topside cargo on the accident aircraft were loaded with either pallets or ULDs. Positions 1, 2, 17, and 18 were loaded with pallets, and the remaining positions were loaded with ULDs. (Ex. 2F and 2D at 47). The belly was loaded with cargo in compartments "A" and "C." No cargo was loaded in compartments "B" or "D." There is no evidence supporting a theory that the cargo shifted.

2.1.2.1.1 DFDR evidence does not support a cargo-shifting theory

Any cargo shift significant enough to cause aircraft controllability problems would be evidenced by an accompanying change in the longitudinal acceleration parameter on the DFDR readout. However, the DFDR readout data shows no indication of any "spike" or "bump" in the longitudinal acceleration that would support a cargo-shifting theory.

2.1.2.1.2 The sound spectrum analysis does not support a cargo-shifting theory

The acoustic evidence from the two audio tests reveals that the source of the ratchet noise detected on the CVR is not likely to be a cargo load rolling in the rollers within the cargo area of the aircraft.

2.1.2.1.3 Verification of the securing of topside cargo

Testimony given to the NTSB by Cargo Technicians that worked on the accident aircraft is uniform and uncontroverted that all pallets and ULDs were properly locked into position. (Ex. 2B at 4, 7, 8, 14, 17-18, and 25).

2.1.2.1.4 The securing of topside cargo

The testimony also indicates that the cargo aboard the pallets and ULDs was secure. Normally, cargo is secured on pallets by the use of five locks on the long side, and four locks on the short side for attaching the nets. Again, uniform and uncontroverted testimony by the MAS Cargo Technicians and EWW and EWA employees indicates that all cargo was well secured in place aboard the pallets and ULDs. (Ex. 2B at 25, 5, and 46-47).

2.1.2.1.5 The inability of the cargo to shift, even if unrestrained

Even had the cargo locks not been in place, or even had the locks failed to restrain the pallets or ULDs, it is unlikely that the cargo could have shifted to such a degree as to cause control difficulties. This is because the ability of the cargo to shift would have been limited in several ways, even had the locks or restraints failed.

For instance, while there was an unoccupied space aft of position 18 ("position 19"), the NTSB eliminated the possibility that a pallet in position 18 could shift to position 19. The rigid stops and the contours of the fuselage would have made this impossible, since the fuselage rapidly narrows, like a funnel, aft of position 18. Similarly, the NTSB noted that ULDs loaded in position 17 may only shift aft approximately four to six inches before movement is limited by contact with the aircraft fuselage.[25]

The physical impossibility for cargo loaded in position 18 or 17 to move aft would, in turn, make it impossible for cargo loaded in other positions to move aft. Once the cargo in position 18 or 17 is secured in place, and assuming that there are no empty cargo positions, the minimal room that exists between each contiguous pallet or ULD would cause each successive pallet or ULD to act as a stop for the movement of contiguous pallets or ULDs. As a result, the likelihood of any shift in the topside cargo that would affect the aircraft's controllability is extremely remote, if not impossible.

2.1.2.2 Possible shift of cargo in the belly

Compared to the topside cargo hold, the belly of the DC-8 holds relatively little cargo. In fact, according to the LPS, cargo was loaded only in compartments "A" and "C" of the accident aircraft. Additionally, EWA used compartments "B" and "C" to transport some company material. As a result, compartment "A" contained 1,090 pounds of cargo, compartment "B" contained 474 pounds of company materials, and compartment "C" contained 1,600 pounds of cargo, and an additional 1,310 pounds of company material. Compartment "D" was empty.

The cargo in compartment "A" originated at RNO, and was not taken off the aircraft in MHR. (Ex. 2B at 7). One MAS Cargo Technician testified that he connected the net in compartment "A," and locked the pit door. (Ex. 2B at 13).

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[25] Id. at 11 (summary of Group Aircraft and Loading Area Observation Activities).

Another testified that the compartment was full, making it unlikely that there could have been any significant shift of the cargo in that compartment.

The cargo in compartment "C" included several pieces of long freight and some mail. (Ex. 2B at 11-12). MAS Cargo Technicians testified that they loaded the long freight aft of the door and secured the netting, (Ex. 2B at 15).

Taken together, these facts demonstrate that there could not have been any shift in cargo loaded in the belly of the accident aircraft significant enough to affect the aircraft's CG or the aircraft's controllability.

2.1.2.3 The risk of control difficulties resulting from cargo shifting

In addition to the calculations addressed earlier about whether there was a possibility that any cargo was improperly loaded, the potential effect on the aircraft CG of various hypothetical conditions involving shifts in the cargo was calculated.

Whereas Condition 1 assumed that the aircraft was loaded in accordance with the LPS, Condition 4 tested the shift aft of a single pallet or ULD by one position, by determining the CG of the aircraft by assuming that the 4,400 pounds loaded in position 18 were loaded in position 19, even though this condition is not physically possible. The result of this shift in the single position of cargo aft by one position was to move the CG aft to 27.8%. This is a very small shift from the original CG of 27.1%, and would likely be virtually imperceptible to the crew.

Condition 5 assumed that all of the cargo in positions 6 through 18 shifted back one position to occupy positions 7 through 19; again, a condition not physically possible. In this case, the final CG was 33.9%, or very close to the aircraft's aft CG limits.

Only when using the scenario where the entire load is shifted aft by one position (Condition 6) was the aft CG limit exceeded, resulting in a CG of 36.2% (which exceeded the technical aircraft CG limits by 2.6%). Although this condition is physically impossible, the resulting CG of 36.2% is still within the controllability limits of 38% established in the simulator.

In sum, none of the tested loading conditions exceeded the 38% CG that marked the limits of controllability of the aircraft in the simulator test, even though it would have been physically impossible for many of these conditions to occur. Even the shifting of all topside cargo aft by one position, the worst possible configuration tested (and one that would not have been physically possible), would have resulted in an aircraft CG that would ultimately have been within the aircraft's controllability limits.

2.2 DFDR Trace

2.2.1 Aircraft controllability during the accident flight and the flight preceding the accident flight

Review of the DFDR data indicated that the elevator movement in the airplane nose-down direction was restricted. At no time during the accident flight did the elevator travel below the neutral position. This occurred despite the fact that the control column was being pushed in a nose down (forward) direction.

The Airplane Performance Study, (Ex. 13A), enabled the NTSB to identify, using DFDR data and the Kinsurf program, the point in time when the pitch control anomaly first appeared:

> A control anomaly has been identified about 8 1/3 minutes before landing at Sacramento. The control extraction showed that the stabilizer moved trailing edge up (airplane nose up) when the pilot pushed the airplane over to resume the descent after a brief pause. This is opposite to the airplane nose down trim one would expect at this point. A kinematic extraction shows a control tab split began at the time of the anomaly. This tab split was easily controllable with the stabilizer trim motion returning the aircraft to trim and the elevator remaining responsive to pilot input. (Ex. 13A, page 25).

The fact that the elevator remained responsive to pilot input during the flight preceding the accident flight, despite the developing anomaly, is borne out by statements by the first officer on the flights from DAY to RNO and from RNO to MHR. (Ex. 2R at 2). During his interview, referring to these flights preceding the accident flight, the first officer that: "the airplane flew well and there were no problems with it." (Ex. 2R at 2). Regarding the flight from RNO to MHR, the first officer stated that he watched the accident captain closely and considered him to be a really good pilot. (Ex. 2R at 2). The first officer's comments about the captain's flying during the flight immediately preceding the accident flight, all of which appeared to be normal for a completely controllable aircraft, indicate that the amount of control tab asymmetry was small.

Using the corrected DFDR elevator data and findings from the Airworthiness Group, NTSB staff began modeling the effects of an elevator control tab split on Flight 17. The DFDR data indicates that the elevator was trailing edge up, in other words, airplane nose up, for the entire flight. The DFDR data for the control column showed a nose-down command.

The working left-hand control tab was at the trailing edge up stop of eight degrees for almost the entire flight—the maximum airplane nose-down elevator possible. Because the elevators are designed with much greater travel in the airplane nose-up direction, the left-hand control tab would not be able to overcome the greater deflection and authority of the disconnected right-hand control tab. This is compounded by the effects of the gear tabs, which would add to the authority of the disconnected right-hand control tab in keeping the elevator trailing edge up.

2.2.2 The accident flightcrew had no indication of malfunction during its preflight walk-around inspection

Regarding EWA's manuals and procedures relating to the walk-around inspection, Captain Gentile testified (Doc. No. 136 at 72):

> Q. During the course of the investigation, have you become familiar with Emery's operating procedures as they were contained in the DC-8 Aircraft Operating Manual, Volume I?
>
> A. Somewhat.
>
> Q. You mentioned that operators did either one or two walk-around checks of the elevator, one with the gust lock engaged, one with it disengaged.
>
> Can you tell us what –do you remember what Emery's procedure was?
>
> A. Yeah. Emery's was a very thorough walk-around procedure with both the gust lock engaged first and then with the gust lock disengaged and describing the requirements for the gust lock disengaged and – engaged for the flight engineer or second officer.

Due to the apparently small control tab asymmetry that existed during the last 8 1/3 minutes of the flight preceding the accident flight, the accident flightcrew would not have been able to detect this problem during the preflight walk-around inspection in MHR prior to the accident flight.

2.2.3 The accident flightcrew had no indication of malfunction during the control rollout check

During the taxi out on the accident flight, the crew was required to perform a control rollout check. The purpose of this check is to determine that the control surfaces, ailerons, rudder and elevator, are operating normally. The ailerons and rudder on the DC-8 are controlled through hydraulic "packs". These hydraulic packs provide pressure to the ailerons and rudder. The control rollout check for these controls is accomplished by monitoring hydraulic pressure while exercising the ailerons and rudder through full travel. The elevator is not hydraulically boosted. The elevator is aerodynamically boosted through the use of control tabs. The pilot controls the elevator via the control tabs by pushing and pulling the control column fore and aft. Only at the very extremes of control column travel does the pilot actually move the elevator.

Since the pilot normally moves only the control tabs via the control column, the pilot would feel that he or she had a good control check with a fully functioning elevator even if the elevator was jammed. After a series of DC-8 accidents and incidents where it was found this was the case, the FAA mandated an Elevator Position Indicator (EPI) by an FAA Airworthiness Directive (AD) in 1977. In May of 1977 the Douglas Aircraft Company published "Know Your DC-8" Letter 53A, (Ex. 17GG), describing the EPI and its markings and outlining the use of the EPI in conducting the elevator portion of the control rollout check. The markings on the face of the EPI include UP, DN and NEUT. The NEUT marking was a white band that extended from 0 to 5 degrees trailing edge up (TEU). Letter 53A states, in pertinent part, "followed by applying full down elevator control to the column stop, and checking that the needle on the elevator position indicator moves down into or transitions through the white band on the indicator." (Ex. 17GG at 1). This letter remained in effect until June of 2001, approximately 16 months after the accident.

The DFDR trace from the accident flight chronicles the elevator portion of the control rollout check in the data from 19:42:28 to 19:42:30 (EX. 10F, page 2). During that time, the elevator moved to a position of between 2.8 and 3.8 degrees trailing edge up (TEU). The data clearly shows that the needle of the EPI moved down into the white band.

Captain Gentile testified as follows:

> Q. All right, sir. Can you tell us what the range of that neutral zone is?
>
> A. It's about 5 degrees – it's about a 5 degree range in – in the neutral zone.
>
> Q. And does it go from zero to minus five or zero to plus five?
>
> A. I don't recall.
>
> Q. All right, sir. In 2-Q, in the Ex., there is a graphic of the EPI. It's on Page 1.
>
> A. Right. It's zero to five.
>
> Q. Five up?
>
> A. Yeah.
>
> Q. And again going back to Letter 53-A, that would have been an acceptable control roll-out check under the existing guidance?
>
> A. Correct. (Doc. No. 136 at 76).

In June of 2001 the Boeing Company issued a Flight Operations Bulletin No. DC-8-01-02 (Ex. 2Q). The purpose of this bulletin was, again, to describe the use of the EPI when conducting the control rollout check. In this version the pertinent language was changed to read:

> followed by full down elevator to the column mechanical stop and verifying that the <u>needle moves through the faired position to a point below the white band</u>. (Ex. 2Q at 1 (emphasis added)).

2.2.4 The accident flightcrew had no indication of malfunction during the 80 knot check

The "Know Your DC-8" Letter 53A states, in pertinent part, that:

> If it should not be possible to make the elevator control check with the aircraft turned into the wind, the following optional procedure may be used. During the initial takeoff roll (60 – 80 knots), check response of the aircraft to small up and down elevator inputs. The optional procedure should not be used when the takeoff is made on wet or icy runways or when moderate crosswind conditions exist. (Ex. 17GG at 2).

EWA required the optional 80-knot check be made on all takeoffs unless the runway was wet or icy or moderate crosswind conditions existed. The crew did perform an 80-knot check during the accident takeoff. The results of that 80-knot check can be seen in the DFDR data from 19:48:50 and 19:48:51. (EX. 10J, page 1 (II-9)). That data clearly shows that, concurrent with the elevator being pushed forward, nose down, the aircraft pitch changed from positive 0.2 degrees to negative 0.6 degrees. Captain Gentile testified (Doc. No. 136 at 83-84):

> Q. Okay. If we go to Ex. 10-J … this would be the 80 knot check on the accident flight. If we look again in the far left-hand column at time 19:48:50, and we go three columns to the right, we have pitch attitude in degrees. You'll notice that the pitch in that particular – from there to the next plot, which is at 19:48:51, the pitch went from a positive .2 degrees to a negative .6 degrees.
>
> A. Correct.
>
> Q. That's a nose-down pitch?
>
> A. Correct.
>
> Q. Is that a pitch that, in your experience on the airplane, that would be noticeable to the crew?
>
> A. Yes.
>
> Q. Would that be an acceptable 80 knot check if – if an operator required an 80 knot check?
>
> A. Yes.

2.3 Loss of Bolt Connecting the Right-Hand Elevator Pushrod to the Elevator Control Tab Crank Fitting

2.3.1 Detailed examination of elevator pushrod assembly

Based on the anomaly in the DFDR beginning approximately 8 1/3 minutes before landing on the flight preceding the accident flight, the NTSB conducted a detailed wreckage inspection, see section 1.12.3, focusing on elevator system components. In particular, the inspection focused on the differences between the left-hand and right-hand elevator pushrods and related attachment points.

Whereas the pushrod for the left-hand elevator control tab had been heavily damaged by impact forces, the pushrod for the right-hand elevator control tab, including both ends, was found intact and undamaged. This, combined with the fact that neither the bolt that attaches the pushrod to the control tab nor the associated nut and cotter pin were found, indicates that the pushrod was not attached at the time of impact due to the bolt having been missing.

This was confirmed by additional investigation. For instance, the bushings in the clevis lugs showed no visible signs of internal damage or deformation, as they would have had the bolt been in place at the time of impact. Further, the fact that the rod end bearing through which the missing bolt would have passed showed no deformation or smear marks confirms that the bolt was missing at the time of impact. Finally, the head of the clevis revealed no evidence that the bolt head or washer was up against the outer surface of the clevis. Had the bolt and washer been present at the time of the accident, markings should have been detectable.

This may be contrasted with the forward end of the right-hand pushrod. When the bolt was removed after the accident, the surface of the rod revealed evidence of a circular pattern, indicating the presence of the bolt and washer at the time of impact.

Further confirmation comes from a comparison of the left-hand and right-hand elevator control rod. Whereas the aluminum housing for the left-hand elevator control rod was found broken, the housing for the right-hand elevator control rod was intact, indicating that there had been no forced separation.

In addition to the other clear evidence that the bolt was missing at the time of impact, the many nicks and scrapes on the forward edge of the clevis and on the end of the right-hand control rod indicate contact between the two and a jamming of the control tab, which is consistent with a missing bolt.

2.3.2 Elevator flight control system

The results of the DFDR analysis (see section 2.2) and the detailed wreckage inspection (see sections 1.12.3 and 2.3.1) indicate that the bolt connecting the aft end of the right-hand elevator pushrod to the elevator control tab crank fitting was missing at the time of impact. The possible causes of the bolt to be missing include either a missing nut (and cotter pin) or a shearing of the bolt. Since there is no evidence of a shearing of the bolt, it is likely that no nut was on the bolt and that the bolt backed itself out of its position before the accident.

The only way the bolt could back itself out of position under these circumstances is for either the nut not to have been properly installed or the cotter pin not to have been properly installed, causing the nut to back itself out of position over a period of time, and eventually fall off the bolt, thereby leaving the bolt unrestrained and allowing it to back out of its position.

In either case, it is clear that the unrestrained bolt backed itself out of its position. Further, the missing bolt left its position approximately 8 1/3 minutes prior to the landing at MHR on the flight immediately preceding the accident flight. However, the aircraft remained controllable through the landing at MHR.

At some point prior to the accident takeoff, most likely during the control rollout check immediately preceding the accident flight, the now-disconnected right-hand elevator pushrod became jammed in such a manner as to place the right-hand control tab at its full (25 degrees) TED position. The travel limits for the elevator control tabs are 8 degrees TEU and 25 degrees TED. At that time, the left-hand elevator control tab became the only control tab responding to pilot input. By design, the left-hand elevator control tab was limited to 8 degrees TEU. It therefore became impossible for the crew to control the elevator to the degree necessary to enable them to recover from the extreme nose-up attitude the aircraft had attained.

Since the bolt was missing at the time of impact, it is clear that the either the cotter pin, or the nut and cotter pin, were not properly installed at some point when maintenance was performed on the right-hand control tab. For these reasons, the NTSB investigated all maintenance preceding the accident that had been performed on the right-hand elevator and control tab, or in the immediate vicinity of those components, that could have lead to any of the hardware being missing at the time of the accident.

2.3.3 Maintenance performed by EWA subsequent to the D Check

The NTSB investigated all maintenance performed on the aircraft by EWA subsequent to the D Check performed by TTS to determine if any EWA mechanic had access to the right-hand elevator and control tab. As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing.

A review of the logbook pages, routine work cards and non-routines for this aircraft while in service after the D Check, as well as the other evidence, shows that no EWA mechanic opened the Control Tab Fairing and that no maintenance, either routine or non-routine, was performed on the right-hand control tab pushrod subsequent to the D Check. Therefore, no EWA mechanic either had access to, or the ability to view, the relevant hardware, such that an EWA mechanic could have contributed to the absence of, or have detected, any of the missing components. A breakdown of all times that EWA mechanics performed maintenance in the vicinity of the right-hand elevator includes the B-1, B-2, and B-3 Checks and one maintenance action that resulted in the swapping of the elevator dampers.

2.3.3.1 Elevator damper swap

Besides the B-1, B-2, and B-3 Checks, there was only one other time when EWA employees were known to have been near the elevator of N8079U subsequent to the D Check. This involved the pilot report regarding the abnormal elevator back pressure that led the EWA mechanics to return the elevator dampers to their proper position eight days after TTS had released the aircraft as airworthy following completion of the D Check with the dampers in the incorrect position.

Several EWA mechanics were involved in this maintenance, including: an EWA Supervisor, the Lead Mechanic, and several other mechanics on each of two shifts. Testimony from all of those individuals indicates that the elevator dampers were discovered in the wrong positions during a visual inspection, and that the EWA mechanics swapped the dampers back to the correct positions. During this maintenance: (i) there was no reason for an EWA mechanic to remove the Control Tab Fairing at any time, and (ii) at no time during the elevator damper swap did any EWA mechanic remove the Control Tab Fairing. As noted above, access to the missing bolt, nut, or cotter pin can occur only through the Control Tab Fairing.

Therefore, any failure of TTS to install the bolt, nut, and cotter pin correctly during the D Check could not have been discovered by EWA personnel during the damper swap.

2.3.3.2 B-1 Check

Neither the B007 nor the B013 work card, nor any other work card used in connection with the B-1 Check, called for the removal of the Control Tab Fairing. As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing. Both Boeing and EWA confirm that no fairings or panels are required to be removed during performance of any B-1 Check inspection or lubrication work card. There is no evidence indicating that the Control Tab Fairing was removed at any point during the B-1 Check. The maintenance log and testimony confirm that at no time during the B-1 check did EWA mechanics perform any maintenance in the area of the Control Tab Fairing.

As a result, there is no evidence that any EWA mechanic either had access to, or the ability to view, the bolt, nut, or cotter pin, such that they could have detected the absence of any relevant piece of hardware during the B-1 Check. Therefore, any failure of TTS to install the bolt, nut, and/or cotter pin correctly during the D Check could not have been discovered by EWA personnel during the B-1 Check.

2.3.3.3 B-2 Check

Neither the B009 work card nor any other work card used in connection with the B-2 Check called for the removal of the Control Tab Fairing. As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing. Both Boeing and EWA confirm that no fairings or panels are required to be removed during performance of any B-2 Check inspection work card. There is no evidence indicating that the Control Tab Fairing was removed at any point during the B-2 Check. The maintenance log and testimony confirm that at no time during the B-2 check did EWA mechanics perform any maintenance in the area of the Control Tab Fairing.

In addition, the testimony by the mechanics that performed this task and interviews of them by the NTSB and EWA uniformly indicated that no panels or fairings were removed from the area of the right-hand elevator during the B-2 Check.

As a result, there is no evidence that any EWA mechanic had either access to, or the ability to view, the bolt, nut, and/or cotter pin, such that they could have detected the absence of any relevant piece of hardware during the B-2 Check. Therefore, any failure of TTS to install the bolt, nut, and cotter pin correctly during the D Check could not have been discovered by EWA personnel during the B-2 Check.

2.3.3.4 B-3 Check

Neither the B011 nor the B018 work card, nor any other work card used in connection with the B-3 Check, called for the removal of the Control Tab Fairing. As noted above, the only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing. Both Boeing and EWA confirm that no fairings or panels are required to be removed during performance of any B-3 Check inspection or lubrication work card. There is no evidence indicating that the Control Tab Fairing was removed at any point during the B-3 Check. The maintenance log and testimony confirm that at no time during the B-3 check did EWA mechanics perform any maintenance in the area of the Control Tab Fairing.

Thus, there is no evidence that any EWA mechanic either had access to, or the ability to view, the bolt, nut, or cotter pin, such that they could have detected the absence of any relevant piece of hardware during the B-3 Check. Therefore, any failure of TTS to install the bolt, nut, and/or cotter pin correctly during the D Check could not have been discovered by EWA personnel during the B-3 Check.

2.3.4 Maintenance performed by TTS during the D Check

2.3.4.1 TTS's duties during the D Check required TTS employees to install the right-hand control tab and associated hardware in an airworthy condition

As part of the D Check, work card 3504D directed TTS to install the right-hand elevator assembly. (Ex. 7K). The notes on the work card provided instructions directing TTS and its mechanics to use the applicable DC-8 maintenance manual, which referred TTS and its employees to the complete EWA Maintenance Manual system, including the United DC-8 Maintenance Manual and the Douglas DC-8 Overhaul Manual. Work card 3504D also directed that an inspector check the elevator assembly for proper installation. (Ex. 7K at steps 11-12).

In keeping with the work scope, TTS was obligated to provide the labor necessary to perform the inspection or work as agreed upon and to document all work accomplished per FAR § 145.59(a). In sum, TTS was contractually responsible for returning N8079U to service in an airworthy condition at the conclusion of the D Check.

At the public hearing, TTS's President testified and summarized TTS's responsibilities: (i) TTS was FAA-approved to perform substantial maintenance on DC-8 aircraft, (ii) TTS had been required to demonstrate to the FAA that it had a workforce of "maintenance personnel specifically trained to work on DC-8 aircraft to gain that approval", (iii) EWA's D Check work cards were all FAA-approved, (iv) it was TTS's responsibility to perform maintenance and inspect the maintenance that it performed, (v) it was TTS's responsibility to install the aircraft elevator and its component parts correctly, (vi) it was TTS's responsibility to correctly install and inspect the bolt, nut, and cotter pin on the elevator pushrod assembly, and (vii) it was TTS's responsibility to ensure that the parts installed on the aircraft were in an airworthy condition. (Ex. 136 at 247-252). FAA-certificated airframe and powerplant mechanics are formally trained that any castellated nut or bolt with a drilled hole in it should be secured with a cotter pin to ensure that the component is in an airworthy condition.[26]

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[26] See e.g., FAA Advisory Circular (AC) 65-9A, Airframe & Powerplant Mechanics: General Handbook, at 126 (addressing castellated nuts), 132 (addressing the safetying of bolts and nuts), and 135 (addressing the installation of cotter pins in castellated nuts). A copy of AC 65-9A is attached as Attachment "F".

In sum, TTS was solely responsible for ensuring that the right-hand elevator assembly, including all necessary hardware, was properly installed during the D Check.

2.3.4.2 TTS failed to comply with required procedures related to work performed on control tab pushrod and elevator damper during the D Check

The lack of documentation of the work performed by the 19 TTS mechanics that performed maintenance on work card 3504D during the D Check made the investigation more difficult. For instance, there is no evidence of what reference material was used by TTS to complete work card 3504D.

Both the EWA MPPM and the TTS IPM outlined specific procedures to accomplish any inspection task. In the event of a work stoppage or interruption, the procedures called for the individual to enter a discrepancy to identify where the stoppage occurred during the execution of the task. The only proper methods for entering these discrepancies are the completion of a TTS non-routine Form 26 or the completion of a TTS non-routine supplement Form 84. There is no evidence that any non-routine Form (either Form 26 or 84) was completed during the maintenance performed to complete work card 3504D. This is despite the fact that 19 TTS mechanics worked on the task over a period of more than a month, during which time various components, including the control tabs and associated hardware, were being installed, safetied, and rigged.

As a result, there is no way of determining conclusively which TTS mechanics were involved in the maintenance that should have included installing the bolt, nut, and cotter pin, or at what point this maintenance took place. However, the procedures used by TTS mechanics during the work on this work card evidenced substandard performance of procedures related to the maintenance tasks.

One example of substandard performance was the improperly documented temporary installation of the fairing for the control tab clevis. One TTS Inspector testified that the fairing is "temporarily installed" before the rigging takes place. (Doc. 17W at 36). However, the DC-8 maintenance manual does not call for the temporary installation of the fairing for the elevator control tab clevis. If the fairing was temporarily installed, it should have been documented on either a TTS Form 26 or 84, since it is not part of the routine maintenance. It is particularly troubling that this undocumented maintenance was performed on precisely the area from which the bolt was eventually missing.

Another example involves testimony by a TTS inspector, which suggests that TTS did not follow the approved procedures for installing the elevator damper and control tab pushrod. The TTS Inspector testified that he would not be able to tell whether the dampers were installed backwards during a "walk up" visual inspection. (Ex. 17W at 44). The TTS Inspector also testified that a copy of the applicable maintenance manual was made for every task and that this copy was used as the task was being performed. The United DC-8 Maintenance Manual required that TTS mechanics take the following two steps: "Connect the control tab drive rod to the drive crank on the elevator control tab torque tube. … Safety nut with cotter pin," and "Connect the link on the inboard elevator damper to the fittings installed in the trailing edge of the horizontal stabilizer. Safety nuts with cotter pins. Make sure the damper allows full travel." The fact that such clear guidance is in the appropriate maintenance manual, and the fact that the TTS Inspector testified that maintenance would have been performed in accordance with a copy of the maintenance manual that would have been used as the task was performed, contrast sharply with the TTS Inspector's testimony that he would be unable to tell whether the dampers were installed backwards during a "walk up" visual inspection and the fact that the dampers are known to have been incorrectly installed. This strongly suggests that the TTS Inspector either did not have the manual procedures with him, in violation of TTS procedures, or that the Inspector did not follow the United DC-8 Maintenance Manual procedures that he had with him.

The same Inspector that signed for the inspection of the reversed damper installation also signed for the inspection of the work to safety the elevator control tab pushrod. The Inspector's inability to correctly identify an incorrect damper installation, with or without a maintenance manual reference, raises questions about whether the inspection was actually performed, and also calls into question all of the inspections that this individual signed for, including the inspection of the control tab pushrods.

2.3.4.3 Condition of elevator components prior to installation by TTS

Since the elevator and its major components, including the tabs, were received by TTS in an overhauled condition, (Ex. 7S), the NTSB considered and investigated whether the absence of the cotter pin, or nut and cotter pin, at the time TTS received the overhauled components could have contributed to their eventual absence at the completion of the D Check.

TTS noted no discrepancies during the receiving inspection for the elevator, control tabs, and gear tabs, and found the components to be in an airworthy condition and serviceable for installation on the aircraft. There is no evidence that any TTS employee detected any incorrect installation of these parts or that the dampers or associated hardware were installed incorrectly. In addition, if any parts were received by TTS in an unairworthy condition, there is no evidence that this condition was noted by any TTS employee at any time during the three month-long D Check, despite the fact that most, if not all, relevant panels and fairings are opened at some point during the D Check.

More importantly, even though TTS received the components in an overhauled condition, the nut, bolt, and cotter pin were not installed at the time the overhauled components were received by TTS, since the elevator, control tabs, and gear tabs were each received as individual units. (EWA Receiving Report[27]). This would be the normal circumstance whenever the components are shipped as individual units, as they were in this case. It is the responsibility of the repair station to assemble the components properly and install them on the aircraft in an airworthy manner.

Besides its failure to detect any discrepancies with respect to the control tab, TTS also failed to detect the improper installation of the dampers during the receiving inspection, with the result being that TTS mechanics later installed the elevator damper link arms incorrectly to accommodate the reversed dampers. In addition, the TTS Inspector failed to discover the incorrect installation of the elevator and dampers on the horizontal stabilizer.

Because the components were packaged separately when received by TTS, TTS necessarily performed the connection of the right-hand elevator pushrod to the control tab crank fitting. There was ample opportunity for TTS employees to detect this unairworthy condition before TTS released the aircraft as airworthy and safe for flight at the end of the D Check. TTS failed to do so.

2.3.4.4 TTS's general compliance with EWA and TTS manuals

TTS failed in many ways to comply with the EWA and TTS manuals through its inability to follow its own internal procedures for documenting work. These internal errors were impossible for EWA to detect during the performance of the maintenance without providing oversight that would be virtually one-on-one. There is no evidence that any other air carrier using TTS detected these shortcomings, and it is doubtful whether any air carrier would have been able to detect them. EWA had the opportunity to review the documentation in this detail only because it was obtained and reviewed in the context of an accident investigation. In short, TTS mechanics failed to follow internal TTS turnover procedures. Examples of these failures follow.

In the case where a work card contains multiple steps, and/or the task will be accomplished over a long period of time, it is crucial that an accurate record be made of the work accomplished to date and by whom. The 3504D work card is such a card. The maintenance manual lists a number of steps required to install the elevator and, in the case of the D check on N8079U, the card was open for over a month with 19 TTS mechanics having had some involvement with the elevator

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[27] The EWA Receiving Report, showing receipt of the individual components, is attached as Attachment "G". The report shows various components, including the "RH Elev Tab", the "Control Tab", and the "Elevator gear Tab", as being received in different boxes. The Receiving Report incorrectly refers to elevator assemblies as elevator tab assemblies. Thus, the part number for the "RH Elev Tab" indicates that the component is actually the right-hand elevator (part number 5644420-506). (See also Ex. 7S).

installation. To provide a complete and accurate record of maintenance performed, both the EWA MPPM and the TTS IPM provide a non-routine form and instructions for its use.

The EWA MPPM states that if there is a work stoppage, a discrepancy item must be made to identify where the maintenance action was stopped. The discrepancy item should also include any outstanding items, temporary installations or other steps taken by maintenance that are not documented in any other place. (EWA MPPM, chpt. 3, p. 65-66). Discrepancies are considered non-routine items, and there are only a few documents used by TTS to document non-routine items: (i) the logbook, (ii) the TTS Non-routine Form 26, or (iii) the TTS Non-routine Form 84. In the D Check package, there were no non-routine items entered in the logbook or TTS non-routine Form 26 or 84's used to document any work stoppage, temporary installation, or any other items relative to the maintenance performed during the 37-day period that the 19 TTS mechanics were working on the right-hand elevator control tab.[28]

It is clear that these 19 TTS mechanics could not have continually worked on the installation of the elevator components for the entire 37-day period. Therefore, there must have been at least one work stoppage, which should have been documented on a TTS Form 62. EWA would not normally receive this documentation following a D Check. At the Technical Review Meeting, TTS provided the NTSB with a copy of all Form 62s generated during the D Check. A review of these documents revealed only one TTS Daily Status Report, TTS Form 62, that showed a work stoppage during the elevator tab installation. That document was unsigned and indicated only that the tabs were "on but not torqued."[29]

Despite the explicit guidance in the IPM regarding how to document work stoppages, the evidence shows that TTS mechanics actually followed an entirely different procedure. One TTS Inspector testified about the process actually used by TTS employees. He said that mechanics would use a copy of the maintenance manual to track the work as it was completed. (Doc. No. 135 at 153, lines 16-21). This is despite the fact that the TTS IPM outlines the approved process for tracking work, which is through the use of a TTS Form 62. (TTS IPM, sec. VI).

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[28] As noted earlier, the TTS IPM called for the use of non-routine Forms 26 or 84 to document discrepancies. Despite the fact that the non-routine Form 26 was used approximately 2,173 times and the non-routine supplemental Form 84 was used 42 times, none of these non-routine forms were used to document the work performed by the 19 TTS mechanics that performed maintenance in connection with work card 3405D over the course of 37 days of maintenance.

[29] A copy of this TTS Daily Status Report, Form 62, is attached as Attachment "H".

The problems inherent in the use of this informal, undocumented procedure to track the task completions on work card 3504D were further exacerbated when TTS deviated from the maintenance manual by temporarily installing the Control Tab Fairing, (Ex. 17W, p. 36, line 15), which covers the nut, bolt, and cotter pin on the right-hand elevator control tab pushrod. Such a step increases the likelihood that a mechanic will, at a later date, see the Control Tab Fairing installed, and assume that all work now hidden by the fairing has been accomplished.

Even assuming that TTS used this informal, unapproved turnover procedure, it does not appear that TTS employees used it consistently. When EWA, in the course of the accident investigation, reviewed the data package received by EWA for the D Check, this review revealed only one maintenance manual section that was attached to a work card for the entire D Check. The maintenance manual section was for a functional check of a hydraulic pump. A review of this maintenance manual section showed that there were no signatures or initials or any other identifiable notation that would indicate who performed the task or if all the tasks were performed.

In sum, TTS deviated from the procedures set forth in the EWA MPPM and TTS IPM by using an informal, undocumented process of tracking completed tasks by initialing pages from the maintenance manual. There is no reference to this process in any EWA or TTS manual. Further, TTS produced no initialed maintenance manual pages to substantiate its claim that this process was used to document the work accomplished in connection with the 3504D work card.

Had the TTS mechanics followed TTS's correct internal turnover procedure, it is probable that they would have detected the problem with the installation of the bolt, nut, and cotter pin.

2.3.5 EWA maintenance program

EWA's maintenance program is an FAA-accepted and/or -approved program that had been in use for over ten years at the time of the accident. EWA's maintenance program complied with applicable FAR, FAA Advisory Circulars and FAA Directives. The maintenance program included a Continuous Airworthiness Surveillance System (CASS). EWA's maintenance program was under constant improvement based upon reliability data and input from line maintenance, heavy maintenance, Boeing, the FAA and other industry sources, including heavy maintenance providers such as TTS.

There is no evidence to indicate that EWA's maintenance program or any EWA mechanic contributed in any way to the missing bolt, nut, or cotter pin.

2.4 EWA selection of, guidance to, training of, and general oversight of TTS

Like many air carriers, including major air carriers, and as permitted by the FAR, EWA contracted with repair stations for the performance of many maintenance tasks. In keeping with the FAR, EWA used FAA-approved repair stations, and provided the oversight required by the FAR.

2.4.1 Selection of TTS by EWA

EWA followed appropriate procedures when first selecting TTS to perform heavy maintenance and when increasing the types of heavy maintenance that TTS could perform.

The process followed by EWA in selecting TTS to provide heavy maintenance is the standard practice for the industry. The CASE audit provides a consistent means with which to evaluate repair facilities. The CASE audit and additional inspections under the direction of the Director of Heavy Maintenance clearly indicated that TTS would be an appropriate contract maintenance provider.

Although the CASE audit revealed some minor discrepancies, (Ex. 17LL), all of these inadequacies were addressed by TTS and EWA management prior to EWA's submitting to the FAA an Operations Specifications change to add TTS to the FAA-Approved List of Substantial Maintenance Providers.

2.4.2 Guidance to TTS from EWA

EWA initially provided to TTS several complete sets of all maintenance manuals, supplemental maintenance manuals, wiring diagrams, illustrated parts catalogs, overhaul manuals and in-house manuals required to perform the task of B, C and D Checks, as well as any "drop-in" maintenance. In order to better supply its own personnel with proper documentation, TTS requested additional copies of the manual sets; these additional sets were provided at no cost to TTS.

As a result, TTS had in its possession all of the maintenance manuals required to perform any and all tasks associated with the D Check. The EWA manuals adequately provided procedures and guidance to TTS to enable TTS to perform any DC-8 heavy maintenance function on behalf of EWA, including the installation of the elevator and related components, the identification of the hardware necessary to install those components, and the release of the aircraft as airworthy with those components installed.

2.4.3 Training of TTS and TTS personnel by EWA regarding EWA policies and procedures

EWA trained TTS inspectors with respect to the particular policies and procedures used by EWA, (Ex. 136 at 247-252), including training on EWA's MPPM, inspection program, and CPCP program. EWA did not, and was not responsible to, provide maintenance training with respect to specific maintenance tasks with which FAA-certificated mechanics should be familiar. TTS's President confirmed that TTS did not expect EWA to train TTS's mechanics on how to accomplish DC-8 maintenance, except for matters specific to EWA's manuals. (Ex. 136 at 247-252).

TTS was responsible for training and maintaining the qualification currency of all employees that performed work on a specific aircraft. This training related to the systems and components listed on the TTS Operations Specifications for that aircraft. As part of the CASE audit, EWA reviewed TTS's Training Program and found it to be in compliance with industry standards.

2.4.4 EWA's ongoing oversight of TTS

EWA provided appropriate ongoing oversight of TTS. After initiating use of TTS, EWA continued to conduct regular, scheduled audits and inspections of TTS. The use of periodic CASE-type audits is a standard industry practice for providing oversight of contract maintenance facilities. EWA also conducted regular CPCP audits prior to the completion of all C and D Checks. In addition, EWA officials conducted inspections during regular site visits, and both EWA and TTS freely communicated with each other between audits and inspections.

The work cards issued for each aircraft sent to TTS for C or D Checks were reviewed three times: (i) first, so EWA could ensure that the cards being sent to TTS included all necessary tasks, (ii) second, so TTS could ensure that the completed cards fulfilled all FAR and EWA maintenance and inspection program requirements, and (iii) third, so that EWA could ensure that the completed cards fulfilled all FAR and EWA maintenance and inspection program requirements.

The obligation of EWA to oversee TTS did not require EWA employees to look over the shoulders of each TTS mechanic who was working on an EWA aircraft. The FAR do not, and should not, require air carriers to provide this level of oversight in connection with the performance of contracted maintenance. Such a labor-intensive system would defeat the purpose of the repair station system currently in place under the FAR, and would make contract maintenance inefficient and impractical.

In sum, EWA provided oversight over TTS that was both proper and standard within the industry, and there is no evidence that EWA's oversight over TTS caused or contributed to the accident in any way.

2.5 FAA Oversight of EWA

In seeking to have its certificate transferred to the Great Lakes Region, EWA was seeking closer oversight by the FAA. It was EWA's desire to undergo critical and timely observation and review by the FAA to ensure that it was compliant with the FAR.

The use of the so-called "findings" from NASIP or RASIP inspections to gauge the performance of an air carrier is neither meaningful nor practical. The findings are really best characterized as preliminary allegations yet to be investigated for substantiation. They are just the start of a process that will eventually determine whether aspects of an air carrier's programs are in compliance with the FAR. In the case of EWA, this process never reached its conclusion. The discourse over the merits of each particular finding in the relevant FAA inspections was mooted by the Final Settlement Agreement and the cessation of EWA's operations, and that discourse was never completed.

In the wake of the accident, EWA was subjected to extensive and microscopic FAA scrutiny. While these inspections obviously contributed to the FAA's insistence on EWA's cessation of operations, all such inspections that occurred post-accident are entirely irrelevant to the facts and circumstances of the EWA Flight 017 accident.

3. CONCLUSION

3.1 Proposed Findings

EWA proposes that the NTSB adopt the following findings:

1. The EWA flightcrew was properly certificated, trained, and in compliance with all applicable FAR.

2. The EWA flightcrew was properly trained for all foreseeable circumstances they faced during the accident flight.

3. EWA provided adequate opportunities for the crew to begin the flight well rested.

4. There was no evidence that any preexisting medical condition affected the flightcrew's performance.

5. There was no evidence that drug or alcohol usage affected the performance of the flightcrew, the mechanics, the cargo technicians, or any other individual involved in this accident in a way that caused or contributed to the accident.

6. Weather was not a factor in the accident.

7. All EWA mechanics who performed work on the aircraft during the course of the swap of the elevator dampers or the B-1, B-2, or B-3 Check, were properly certified and trained to perform their duties.

8. The accident aircraft was certified and equipped in accordance with federal regulations and approved procedures.

9. There is no evidence that any aircraft structural failure caused or contributed to the accident.

10. The flightcrew followed all appropriate procedures from the time of their preflight through impact.

11. The impending loss of flight control during the accident flight was not detectable by the flightcrew during either the walk around inspection, taxiing, or 80-knot check.

12. All load planning by EWA, EWW, and MAS employees was properly performed.

13. All cargo was loaded in accordance with the Load Planning Sheet.

14. The aircraft CG was within limits from the time of loading through the time of the accident.

15. The cargo did not shift at any time from the time of taxi through the accident in any way that caused or contributed to the accident.

16. EWA provided adequate oversight over MAS.

17. EWA appropriately handled all hazmat that was aboard the accident aircraft.

18. There were no hazmat issues related to the accident.

19. At the time of the accident, the bolt connecting the right-hand elevator pushrod to the control tab crank fitting was missing.

20. The first effect of the missing bolt occurred approximately 8 1/3 minutes prior to the landing of the accident aircraft at MHR on the flight immediately preceding the accident flight.

21. The aircraft remained controllable during the flight preceding the accident flight due to the aerodynamic loads on the elevator, which tended to keep it in trim.

22. Although the missing bolt during the flight immediately preceding the accident flight was detectable on the DFDR, the effect of the missing bolt during that flight was small enough that it could not be recognized by the flightcrew of that flight.

23. At some point during the control rollout check, or less likely, during the 80-knot check, the elevator control tab pushrod became jammed in such a manner as to force the right-hand control tab to its full (25 degrees) trailing edge down position.

24. The jammed right-hand control tab resulted in a restricted elevator movement, aerodynamically driving the elevator to a full trailing edge up position.

25. The restricted elevator movement resulted in a loss of effective response of the elevators to input from the control column and an inability to control the nose up tendency of the aircraft.

26. The missing bolt resulted from TTS's failure to install either the cotter pin, or the nut and cotter pin, during the D Check.

27. At the time of its selection by EWA to perform heavy maintenance, TTS held a Part 145 certificate.

28. The FAA approved EWA's use of TTS as a provider of heavy maintenance.

29. EWA's initial audit of TTS was appropriate and complied with FAA requirements.

30. EWA's periodic auditing of TTS was appropriate and complied with FAA requirements.

31. EWA's continuing oversight of TTS was appropriate and complied with FAA requirements.

32. TTS performed work on the right-hand elevator control tab during the D Check.

33. TTS personnel did not comply with EWA's MPPM when they failed to generate a non-routine write-up.

34. TTS personnel did not comply with TTS's IPM when they failed to generate a Form 26 or 84 to indicate the status of any incomplete work.

35. The only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing.

36. Between the time that the overhauled elevator components were delivered to TTS and the accident, the only time that work was accomplished in the immediate vicinity of the bolt connecting the

right-hand elevator pushrod to the control tab crank fitting was during the D Check by, and at, TTS.

37. Due to the poor documentation of the work performed by the TTS repair station mechanics, the Maintenance Manuals used to complete work card 3504D are not identified in the TTS D Check documentation.

38. Due to the failure of TTS personnel to complete documentation evidencing non-routine maintenance tasks, including any incomplete maintenance tasks during the D Check, it is impossible to determine exactly what work was accomplished by each of the 19 TTS mechanics that performed work installing the control tab on the right-hand elevator during the D Check.

39. At the completion of TTS's installation of the right-hand elevator control tab during the D Check, either the connecting cotter pin, or the nut and cotter pin, was missing.

40. TTS mechanics failed to install the cotter pin, or the nut and cotter pin, during the installation of the right-hand elevator control tab during the D Check.

41. No TTS mechanic detected the missing cotter pin, or missing nut and cotter pin, before the Control Tab Fairing was closed during the D Check.

42. The TTS inspector failed to detect the missing cotter pin, or missing nut and cotter pin, during the inspection for work card 3504D during the D Check.

43. No TTS employee detected the missing cotter pin, or missing nut and cotter pin, at any time prior to releasing the aircraft as airworthy during the D Check.

44. During the D Check, TTS released N8079U as airworthy when there was no cotter pin, or no nut and cotter pin, installed on the bolt connecting the right-hand elevator pushrod to the control tab crank fitting.

45. TTS's management failed to detect the breakdowns in the execution of TTS's procedures.

46. EWA provided to TTS all manuals necessary to determine the proper hardware, including the bolt, nut, and cotter pin, to use during the installation of the right-hand elevator and control tab.

47. FAA-certificated airframe and powerplant mechanics are formally trained that any castellated nut or bolt with a drilled hole in it should be secured with a cotter pin.

48. EWA provided to TTS the proper manuals, adequate instruction, and sufficient oversight to permit TTS to conduct a correct D Check on N8079U.

49. EWA provided proper training to TTS and TTS employees on EWA's MPPM, inspection program, and CPCP program.

50. EWA was not required to, and did not, provide maintenance training with respect to specific maintenance tasks with which FAA-certificated mechanics should be familiar.

51. EWA's oversight over TTS complied with all regulatory requirements.

52. Between the time that the Control Tab Fairing was closed by TTS during the D Check and the accident, no maintenance performed by EWA called for the removal of the Control Tab Fairing.

53. Between the time that the Control Tab Fairing was closed by TTS during the D Check and the accident, the Control Tab Fairing was never removed.

54. At the time the elevator dampers were received by TTS, they had been improperly installed.

55. TTS's receiving inspection failed to detect the improperly-installed dampers.

56. TTS improperly installed the elevators with the dampers in the reversed position.

57. TTS improperly installed the damper link arms to accommodate the reversed dampers.

58. During the elevator damper swap performed by EWA mechanics, the Control Tab Fairing was not removed.

59. During the elevator damper swap performed by EWA mechanics, EWA employees were not in an area that would permit them to detect the missing cotter pin, or missing nut and cotter pin.

60. The only way to access or view the bolt that connects the right-hand elevator pushrod to the control tab crank fitting is by removing the Control Tab Fairing.

61. At no time following the completion of the D Check by TTS did any maintenance procedure undertaken by EWA require the removal of the Control Tab Fairing.

62. The aircraft manufacturer has confirmed that the Control Tab Fairing is not removed during any B Check inspection or lubrication.

63. At no time following the completion of the D Check by TTS was the Control Tab Fairing removed.

64. During the B-1 Check performed by EWA mechanics, no maintenance procedures called for the removal of the Control Tab Fairing.

65. During the B-1 Check performed by EWA mechanics, the Control Tab Fairing was not removed.

66. During the B-1 Check performed by EWA mechanics, EWA employees were not in an area that would permit them to detect the missing cotter pin, or missing nut and cotter pin.

67. During the B-2 Check performed by EWA mechanics, no maintenance procedures called for the removal of the Control Tab Fairing.

68. During the B-2 Check performed by EWA mechanics, the Control Tab Fairing was not removed.

69. During the B-2 Check performed by EWA mechanics, EWA employees were not in an area that would permit them to detect the missing cotter pin, or missing nut and cotter pin.

70. During the B-3 Check performed by EWA mechanics, no maintenance procedures called for the removal of the Control Tab Fairing.

71. During the B-3 Check performed by EWA mechanics, the Control Tab Fairing was not removed.

72. During the B-3 Check performed by EWA mechanics, EWA employees were not in an area that would permit them to detect the missing cotter pin, or missing nut and cotter pin.

73. Any FAA oversight, inspection, or enforcement action related to EWA after the accident is irrelevant to determining the cause(s) of this accident.

3.2 Proposed Probable Cause

EWA proposes that the NTSB adopt the following statement of probable cause:

The National Transportation Safety Board determines that the probable cause of the accident was the loss of elevator control that resulted from the loss of the bolt connecting the right-hand elevator pushrod to the elevator control tab crank fitting. The loss of the bolt was due to the failure of the TTS mechanics conducting the D Check to install the cotter pin, or the nut and cotter pin, to safety the bolt properly.

Contributing to the accident was the failure of the TTS Inspector to identify the missing hardware at the time that the work on the elevator control tab installation was completed during the D Check.