PHILIPPINES

Republic of the Philippines
DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
AIR TRANSPORTATION OFFICE
MIA Road Pasay City 1300

Aircraft Accident Investigation Board

Aircraft Accident Investigation Report

FEDERAL EXPRESS
N-581 FE
MD-11 AIRCRAFT
OCTOBER 17, 1999
SUBIC BAY INTERNATIONAL AIRPORT

AIRCRAFT ACCIDENT INVESTIGATION REPORT
N 581 FE MD-11 Aircraft

1. BASIC INFORMATION

Aircraft Registration	:	N 581 FE
Make and Model	:	MD-11
Owner and Operator	:	Federal Express Corporation
Address	:	FedEx Asia Pacific Hub Subic Bay Freeport Zone Olongapo City, Philippines
Pilot in Command	:	Capt. Michael Rooney
Date/Time of Accident	:	October 17,1999 On or about 1557 UTC
Phase of Operation	:	Landing
Type of Accident	:	Runway overshoot

1.1 HISTORY OF FLIGHT

On October 17, 1999, Federal Express (FedEx) flight 087 departed Shanghai, China at around 1300 UTC bound for Subic Bay International Airport in Olongapo City, Philippines.

At time 1524:53, as the airplane was in cruise flight just prior to descent, the Captain was heard on the cockpit voice recorder (CVR) stating: " let's see I got the indicated airspeed again. I've got no speed problem." At time 1531:45, Manila control gave instructions to the flight to descend to flight level 130 when ready which was acknowledged by the First Officer. The Captain was then heard on the CVR at time 1532:00 stating: "I'm gonna start it down now".

During the descent at time 1532:31, the First Officer (F/O) was heard stating: "you got the indicated again" to which the Captain replied: "it's been there" followed by sounds recorded in the CVR similar to Central Aural Warning

System (CAWS) autopilot disconnect warning for two cycles at time 1532:33 while the Captain stated: "it's been there for a few minutes."

At time 1532:51 the F/O was heard stating "ah look at this. Select elevator feel manual. Select flap limit override. This stuff was written up before" to which the Captain replied "yeah I'm gonna write it up again too."

At time 1533:44 the Captain stated "your indicated is in the red. mine's not." followed by several overspeed and autopilot disconnect warnings. The F/O appeared to be performing a checklist on SEL ELEV FEEL MAN and SEL FLAP LIM OVRD.

At time 1539:58 the Captain stated "I also got no autopilot" to which the F/O replied "well did you try resetting it." The Captain answered "I got a yellow".

At time 1540:44 Subic approach identified FedEx flight 87 to be four zero miles north northwest of Subic VOR and that it will be given vectors to Olong for a VOR DME zero seven approach.

At time 1542:16 the Captain stated "boy this speed's all over the place with this ... green arrow here."

At time 1543:57 the Captain stated: "ah yah. ... you can't get it when you've got a yellow thing up here. I did it. I tried it. See? That indicates that your autopilot's not available to you." The F/O replied "ok". The Captain then stated: "what I'm gonna need you to have you do is just ah set everything up there for me because I can't take...." -The F/O replied "I understand".

At time 1546:25 the F/O stated "you can slow to two fifty. Course you show it." The Captain replied " I show two twenty now.' The F/O said "I show two fifty five" to which the Captain replied "okay" and "I got the throttles al the way back".

At time 1548:45 the F/O stated: "I would say we could select another CADC... or something but I don't know whose is right". The Captain replied "yes" and " try to select yours on it and see what happens."

At time 1549:02 the F/O said "okay I'm on yours now." The Captain then replied "I got an autopilot." The F/O then stated "two oh five. Two oh five. Okay we seem to be back in business" at time 1549:31.

At time 1550:51 the Captain said "let's go gear down" to which the F/O replied "gear down" followed by sounds similar to gear handle movement and increased background noise.

The Captain then asked for a before landing check with the F/O asking for what brake setting to which the Captain replied "let's go ah we'll put em on medium right now" the F/O then continued with the checklist.

At time 1552:36 the F/O stated "okay fifteen hundred by six DME. Were inside six. Down to seven fifty." The Captain replied "put it on there" with the F/O answering "okay. Why doesn't it want to do it. Seven fifty".

At time 1552:59 the Captain stated "# speeds all over the place with this thing." and " well I mean it it's just jumping everywhere. The tape's jumping."

At time 1553:20 a Ground Proximity Warning Systems (GPWS) synthesized voice was heard stating: "one thousand"

At time 1553:34 the Captain stated: "flaps fifty." to which the F/O replied "flaps fifty " and "flaps coming to fifty".

At time 1554:01 the Captain was heard saying "I got the runway" and "going below MDA" followed by the sound similar to CAWS autopilot disconnect warning.

At time 1554:08 the Captain asked "flaps fifty. We got 'em?" with the F/O replying "flaps fifty. Oh no they're not working either. I'll bring them back up to thirty five" with the Captain saying "ok".

At time 1554:30 the Captain was heard saying "max braking. Braking max." the F/O replied "ok"

At time 1554:37 the GPWS synthesized voice sounded "five hundred" followed by "sink rate" with the F/O saying "keep her coming" and again followed by several sink rate warnings from the GPWS synthesized voice.

At time 1554:45 the GPWS synthesized voice was again heard stating several sink rate warnings followed by a "whoop whoop pull up" and altitude call outs till at time 1554:59 when the F/O stated: " get her down. Get her down" followed by the GPWS synthesized voice of "Ten" and the F/O saying "stop. stop. get on the runway" at time 1555:01.

At time 1555:04 a sound of increased background noise similar to touchdown was heard in the CVR. At time 1555:09 a sound similar to an increased engine RPM was heard with the F/O stating "put (it)/(her) all the way" and "max is it max?".

At time 1555:25 a sound similar to several impacts was heard in the CVR followed by the end of the recording.

The aircraft at this time overshot the runway impacting the localizer antenna and several approach lights before dropping onto a ledge and into the shore of Subic Bay. The crew managed to evacuate the aircraft with slight injuries and were eventually rescued.

1.1.1 Flight Crew Interview Information

The first flight crew interviews conducted by the ATO in Manila were attended by U.S. NTSB investigators. The flight crew was interviewed again in Memphis, Tennessee by U.S. investigators, and a written transcript of those interviews was provided to the ATO.

Information obtained from interviews with the captain indicated that the takeoff and climbout from Shanghai appeared normal with no airspeed discrepancies noted. The captain stated that he was well rested prior to the flight. The captain indicated that the airplane encountered clouds during the flight, but he did not perceive any precipitation. The captain stated that the autopilot disconnected several times during cruise near the top of descent, followed by an "IAS" annunciation of his primary flight display (PFD). He stated that the pitch bars on his PFD disappeared, and he remembered checking the stand-by attitude indicator at that time. He stated that he observed that the first officer's airspeed display to be higher that his airspeed display, so he slowed the airplane down. He stated that he decided to switch the first officer's air data computer (ADC) to his side based on his perception that his ADC was closest to being correct. He was not certain how many times he may have checked that standby airspeed indicator during the flight, nor did he recall checking the ground speed or true airspeed numbers on his PFD prior to switching the ADC. Once that selection was made, the autopilot became available for use.

The captain state that he did not perceive any problems during the approach, except the elevator felt a "little different", which he attributed to the select elevator feel manual alert that he had previously been presented. While on the approach, the autopilot and auto-throttles were used until the airport was acquired about 750 feet before passing the Subic VOR. He called for flaps 50-degrees and the first officer stated that there was a flap disagreement. She stated that she would return the flaps to the 35-degree position. He stated that he was not concerned with the flaps being unable to reach the 50-degree position because he believed that it did not hinder the approach. He then called for the selection of maximum autobrakes. The captain further stated that the sight picture "looked a bit higher" than he would normally expect during the final approach. He stated that the plane wanted to "float", and that he had to push forward to "put it [the airplane] on." He stated that he had no knowledge of a GPWS "pull up warning" during the approach. After touching down and exiting the runway into the water, the captain escaped out the cockpit window on his side as the water level reached the window level, while the first officer went out the window on her side. They both swam out into the fuel-soaked bay and climbed onto the right wing of the accident airplane until they were rescued by a boat.

The captain stated that he was aware that there are other sources for speed displayed on the PFD, such as the ground speed readout and wind indicator arrow. He stated that he did not notice these sources at the time of the airspeed anomalies. He also stated that he was previously aware of the MD-11 "Airspeed: Lost, Suspect, or Erratic" checklist, but he had never received training, initial or recurrent, on the use of this checklist. He also stated that the "IAS" (indicated airspeed) display does not direct the pilot to any checklist.

Information obtained from the interview with the first officer indicated that the takeoff and climbout from Shanghai appeared normal with no airspeed discrepancies noted. The first officer stated that she was well rested prior to flight. She also stated that she had flown into Subic Bay about 10 times prior to the accident, with some of the flights occurring while she was in the military. The last time she had flown into Subic Bay was about one month prior to the accident. The first officer stated that she had never seen as "IAS" displayed on a MD-11 PFD prior to the accident flight, and she had never received any training on that specific alert or any situation involving the MD-11 airspeed anomaly. She stated that she could not recall reading any airline information related to airspeed anomalies. She stated that she was aware of the "Airspeed: Lost, Suspect, or Erratic" checklist, but had never trained on it. She stated that she did not refer to this checklist during the accident flight because the problems went away after the air data computer (ADC) was selected to the captain's side. She also stated that she couldn't recall referring to the standby airspeed indicator during the accident flight, and that she had never used this instrument before while flying for Federal Express. She stated that she recalled hearing a GPWS "sink rate" warning during the approach; however, she stated that there was no GPWS "pull up" warning.

1.2 INJURIES TO PERSONS

Injuries	Flight Crew	Passengers	Other
Fatal	0	0	0
Serious	0	0	0
Minor	1	0	0
None	0	0	0
Total	1	0	0

1.3 DAMAGE TO AIRCRAFT

The aircraft was destroyed and broke into several pieces by its impact with the structures located after the end of runway 07 and the subsequent drop off a ledge until it finally came to rest on the shoreline of the airport.

1.4 OTHER DAMAGE

The Instrument Landing System's localizer antenna for Runway 07 was damaged including the approach lights for runway 25.

1.5 PERSONNEL INFORMATION

1.5.1 The Captain

The Captain, 53 years old, held an Airline Transport Pilot (ATP) certificate with ratings in single and multiengine land airplanes. He was also type rated in the Boeing B-727 and B-747, and the McDonnell Douglas MD-11. He had accumulated a total of about 14,000 hours of flight time, including about 3,000 hours as captain on the B-727 and MD-11. He had been flying as a MD-11 captain since April 1996. The Captain initially worked for Flying Tigers (which later merged with FedEx) in the mid- 1980s becoming a first officer on the DC-8 and the B-747 before becoming a captain on the B-727 in 1990.

Company records indicate that the captain had failed two transition training MD-11 simulator checks as captain, before passing on March 14, 1996. He completed MD-11 Initial Operating Experience as captain on April 4, 1996 and received an initial MD-11 Line Check on April 9, 1996. The captain had flown 1,430 hours on the MD-11 as captain with 205 landings based on records provided by his company.
The captain stated that he received about 10 hours of sleep during each of the first two overnights of the accident trip at Tokyo and Shanghai. His activities on the accident day included sightseeing at Shanghai with the first officer, and he stated that he felt rested at the start of the accident leg.

1.5.2 The First Officer

The First Officer, 43 years old, held an Airline Transport Pilot (ATP) certificate for multiengine land airplanes. She is type rated on the B-737 and MD-11 aircraft. The First Officer served for eight years in the U.S. Air Force with experience as a B-737 and C-5 military transport aircraft commander, she was hired by Federal Express in 1987as a B-727 flight engineer. She then became a DC-10 flight engineer in October 1999 followed by an upgrade to MD-11 first officer. As per company records she completed first officer MD-11 Initial training in the simulator on June 18, 1993. On July 10, 1993, she completed the Initial Operating Experience. She has accumulated a total flight time of about 5,700 hours. Based on company records, the First Officer had flown 2,300 hours as first officer on the MD-11 aircraft and recorded 198 landings.

The first officer stated that her sleep was normal prior to the accident.

1.6 AIRCRAFT INFORMATION

1.6.1 General Information

The aircraft, a McDonnell Douglas MD-11 with Serial No. 48419, was manufactured in 1991. It was acquired by American Airlines on May 28, 1991, and was then leased by FedEx on June 2, 1997 and was converted into a freighter. It was registered as N581FE with the Federal Aviation Administration. At the time of the accident, the airplane had a current Airworthiness and Registration Certificate. It was equipped with three (3) General Electric CF6-80C2 engine. At the time of the accident, the airplane had accumulated 30,278 flight hours and 5,817 cycles.

1.6.2 General Description of the MD-11 Pitot Static System

The MD-11 pitot static system gets pitot pressure input (from air that hits the front of the pitot tube head) and static air pressure input from the ambient air. These air pressures are sent through pneumatic lines to the central air data computers (ADCs) calculate important flight parameters (altitude and airspeed) from this air data.

The electronic instrument system gives the visual indication of the flight data (which are calculated from the air data). Also, the pitot static system supplies air data to the standby altimeter/airspeed indicator (SA/ASI) for use as an alternative visual indication.

The pitot static system includes the pitot tubes, static ports, pneumatic lines, and the SA/ASI. This system connects the air data system and the standby altimeter/airspeed to the pitot pressure. The pitot system has three pitot tube heads (and their pneumatic lines) below the aircraft's radome. As seen forward, the captain's pitot tube head is to the left, and the first officer's pitot tube head is to the right. The auxiliary pitot tube head is in the center. The three pitot tube heads have anti-ice heads and the pitot tubes can drain out their water via two drain holes mounted on each side of each head.

The pitot tube heads are in a position that puts the tubes open to, and in the direction of, the airflow that goes past the aircraft's nose. The air goes through the pitot tubes, pressurizes, and goes to the ADCs and the SA/ASI. The pressurized air that goes into the captain's pitot tube is sent to ADC-1. The pressurized air that goes through the first officer's pitot tube is sent to the ADC-2. The air pressure from the auxiliary pitot tube is sent to the SA/ASI.

There are four drains in the avionics compartment for the pneumatic lines of the pitot static system (one static line each and one pitot line drain each for the captain and the first officer's sides). The drains are used as reservoirs to collect water from the pneumatic lines. Each drain is a clear tube with a float ball in it. The float ball shows how much water is in the tube.

The MD-11 pitot-static system is nearly identical to the DC-10 pitot-static system. The pitot tube heads are mounted are mounted in the same positions on the nose of both airframes, and the heads are manufactured by Rosemont Aerospace.

1.6.3 Cockpit Indications Related to MD-11 Air Data Anomalies

The Boeing MD-11 indicated airspeed miscompares are displayed on the captain's and first officer's Primary Flight Displays (PFDs) to alert the flight crew to an indicated airspeed discrepancy. The indication appears as an amber "IAS" on the PFD. Data from the accident CVR and DFDR indicate that this indication was presented on the captain's PFD and recognized by the flight crew.

In the MD-11 Flight Crew Operating Manual (FCOM), Volume III, page 67 in the "Automatic Flight" section, a description of the "IAS" is as follows: "AUTOMATIC FLIGHT -- Control and Indicators – Failure Flags and Warnings (Sheet 1) – COMPARISON MONITOR ANNUNCIATION – Captain and FO PFD data is compared by the DEUs. If the difference limits are exceeded, a miscompare annunciation is shown in amber beneath the speed control window (upper left PFD). A NO COMPARE message indicates comparisons are not being done due to a crosstalk bus failure. Miscompare annunciators are: ATT – IRS pitch/roll; ALT – CADC altitude; RAD – radio altitude; HDG – IRS heading; LOC – localizer; IAS – CADC airspeed; G/S – Glideslope"

The Standby Altitude/Airspeed Indicator provides a means of evaluating whether the airspeed Discrepancy is on the captain's or first officer's side.

The "IAS" annunciation does not produce an "alert", and no additional information related to corrective actions are displayed.

According to Boeing, the crew is alerted or otherwise advised when:

- Any pilot heater system is inoperative (Level 1 Alert);
- The captain's and first officer's altitudes and/or airspeeds miscompare (annunciated on the PFDs)

- Airspeed CADC failures (airspeed, scale, and any associated "bugs" are removed from the PFD and a red X is drawn through the airspeed tape); and
- Altitude CADC failures (altitude, scale, and any associated "bugs" are removed from the PFD and a red X is drawn through the altitude tape).

According to Boeing, pitot static system source anomalies can occur for a variety of reasons, such as restrictions from tape, insects, insect nets, ice, fiberglass, and the operating environment.

1.6.4 MD-11 Aural/Visual Warning and Alerting System Description

The MD-11's aural/visual warning and alerting system consists of an Electronic Instrument System (EIS), Central Aural Warning System (CAWS) and Ground Proximity Warning System (GPWS). The EIS alerting system displays alerts and also their consequences (if any). Alerts are categorized into four levels (3, 2, 1, and 0). Alert levels have unique display characteristics to allow immediate crew recognition of the alert level.

Level 3 (red) alerts indicate emergency operational conditions requiring immediate crew awareness and immediate corrective or compensatory action by the crew. An example of a level 3 alert is ENGINE FIRE. Level 2 (amber) alerts indicate abnormal operational system conditions requiring immediate crew awareness and subsequent corrective or compensatory action by the crew. An example of a level 2 alert is SEL ELEV FEEL MAN. Level 1 (amber) alerts may require maintenance prior to takeoff, a logbook entry, or confirmation of desired system configuration. An example of a level 1 alert is BAT CHARGER INOP. Level 0 alerts are generally operational or aircraft systems status indications. An example of a level 0 alert is AUTO BRAKE TO.

According to Federal Express, there are 156 checklists in the Federal Express MD-11 Quick Reference Handbook (QRH) including 14 Level 3 emergency alerts and 71 Level 2 emergency abnormal alerts. Federal Express MD-11 crewmembers are trained on the philosophy behind the warning and alerting system and evaluated on the skills and knowledge required to accomplish associated checklists and procedures (including emergency non-alerts, abnormal non-alerts, supplemental procedures, system manual checklists, and MEL procedures).

One of the features of the MD-11 is that checklists associated with Level 3 emergency alerts and Level 2 emergency abnormal alerts are named according to their corresponding alert. When a warning or alert is displayed, and once aircraft control has been established, it is the captain's responsibility to determine the nature of the problem and call for the appropriate checklist by name (e.g., "ENGINE FIRE/SEVERE DAMAGE checklist" or "SEL ELEV FEEL MAN checklist").

1.6.5 Published Procedures for Erroneous Airspeed Indications

The MD-11 Flight Crew Operating Manual (FCOM) Vol. II expanded Emergency Non-Alert section contains a procedure titled "Airspeed: Lost, Suspect or Erratic". (This procedure was published by Boeing at the time of the Subic Bay accident; however, Federal Express had it listed in Abnormal Non-Alert of that time.) The checklist highlighted the following possible indications a malfunction in the pitot-static system:

- Indicated airspeed not consistent with normal pitch attitude and power setting for phase of flight.
- Indicated altitude different from actual altitude.
- "PITOT HEAT" alert.
- Many level 1 and 2 alerts such as "SEL ELEV FEEL MAN", "SEL FLAP LIM OVRD".
- IAS and/or ALT miscompare annunciation displayed on the PFD.
- Pressurization system problems.

A summary of the checklist is as follows:

1. AFS OVRD Switches ...OFF
2. Aircraft Pitch/ Thrust.....STABILIZE
3. Flight Director...........OFF
4. If practical Fly to Vmc At Earliest Possible Opportunity
5. After the Aircraft is Safety Established In Flight, Ensure Terrain Avoidance
6. Compare Pilot and Standby Flight Instruments
7. If Able to identify unreliable air data source
    a. CADC (Unreliable side)..............SELECT TO OTHER SIDE
    b. Static Source (Unreliable Side).......ALT
    c. Continue to monitor pitch thrust and airspeed to insure accuracy of selected instruments
8. In NOT Able to identify Unreliable air data source:
    a. Altitude and Thrust.....ADJUST
    b. Maintain normal pitch attitude and thrust for the phase of flight
    c. Use attached tables to determine thrust/pitch relation for remainder of flight

Data from the flight recorders and interviews with the accident flight crew indicate that the "SEL ELEV FEEL MAN" and "SEL FLAP LIM OVRD" alerts were annunciated during the descent for landing. The MD-11 FCOM contains separate checklist for each of these items; however, none of them provided a direct reference to a possible airspeed anomaly.

1.6.6 MAINTENANCE HISTORY OF THE ACCIDENT AIRCRAFT

1.6.6.1 Recent Routine Maintenance Checks of the Accident Plane

The most recent C-check (C-2) was accomplished on August 15, 1998, or months prior to the accident, and the next scheduled C-check was to occur on November 13, 1999, or 1 month after the accident. The most recent B-check (B-17) was accomplished about 2 weeks before the accident on September 1, 1999, and the next scheduled B-check was to occur about 1 week after the accident on October 21, 1999. The most recent A-check was accomplished on October 8,1999, and the next scheduled A-check was to occur on October 29, 1999.

1.6.6.2 Recent Maintenance Discrepancies Related to Airspeed Anomalies

An examination of the accident airplane's maintenance records beginning about 14 months prior to the accident revealed the following write-ups (summarized here for brevity and clarity) related to the pitot-static system:

April 9, 1999 ~ Autopilot and Autothrotles disengaged in stable cruise flight. An IAS MISCOMPARE light was observed, with a 6-knot airspeed split between the captain's and the first officer's display. ADC-2 was selected after the first officer's reading was closest to the stand-by airspeed. ACTION: Removed and replaced ADC-1 and performed pitot static leak check. System operationally checked ok.

April 13, 1999 ~ SEL ELV MAN and SEL FLAP LIMIT OVERIDE alerts came on several times. A 35-knot airspeed differential was noted, with an airspeed alert display ACTION: Purged first officer and captain's pitot line with dry nitrogen. Found captain's pitot line obstructed with water. Purged this line until dry. Performed low level leak check. Operational checked ok.

April 25, 1999 ~ Indicated airspeed disparity on both 1 and 6 display units. The disparity went away after airspeed display was selected to the ADC-2. ACTION: Restored ADC selection switch to original position. Both ADCs checked ok.

April 25, 1999 ~ Airplane received "Technical service Item" (TSI) treatment as a result of airspeed discrepancies. ACTION: ADC-2 removed and replaced as a precaution. Request to "watch for a few legs."

May 7, 1999 ~ TSI closed due to "no repeats" of airspeed discrepancies.

May 8, 1999 ~ On descent, an amber indicated airspeed disagree light was displayed, along with a 7-knot differential on localizer intercept. Autopilot and autothrottles failed to engage for both no.1 and no.2 FMAs. Airspeed differential grew to 19 knots between captain and first officer displays during approach. First officer's airspeed appeared to correct. Crew received SEL ELEV MAN and SEL

FLAP LIMIT OVRD alerts. ACTION: Realigned IRUs. Performed tests on both FCCs and ADCs; no anomalies noted. Checked ok.

May 9, 1999 ~ Airplane received another TSI treatment due to repeated write-ups of airspeed disagree. The following actions are requested: (1) Check writing at ADC-1, (2) Check continuity of total air temperature pins, (3) Check writing from selected connector pins, (4) Check TAT probe writing and replace TAT probe even if no faults found.

May 15, 1999 ~ Removed, tested and reinstalled ADC-1. No faults found. Total Air Temperature probe replaced. Airplane downgraded to CAT II CK III.

May 29, 1999 ~ TSI closed after "18 good legs" with no airspeed anomalies.

June 2, 1999 ~ During cruise, amber indicated airspeed alerts occurred simultaneously on both displays several times. Airspeed split was 3 - 4 knots between captain and first officer. ACTION: Fault found on FCC-1 removed and replaced. Checked ok. Also performed ADC-1 and ADC-2 tests; no faults found.

June 26, 1999 ~ During cruise amber indicated airspeed alerts occurred intermittently simultaneously on both displays several times. Airspeed did not fluctuate and appeared accurate with no other unusual indications. ACTION: ADC-1 test revealed fault code 1. Removed and replaced stall warning sensor. New sensor checked ok. (No other action taken, and ADC-1 remained in airplane)

June 26, 1999 ~ Amber indicated airspeed alerts on both captain and first officer's displays. Intermittent loss of autopilots and flight director pitch bars. Selected ADC on the other side, which seemed to fix the problem. Aircraft was in heavy rain and warm, temperatures. ACTION: FCC-1 shows faults for angle of attack (AOA) no.2 sensor. AOA sensor no.2 removed and replaced. Also purged and leak checked first officer's pitot system. Leak check ok.

July / August / September / October 1999 ~ No further known airspeed or pitot-static system related write-ups noted

A review of these maintenance records did not reveal any indication that the pitot tube drain holes had been inspected during these write-ups.

1.6.6.3 Federal Express Maintenance Program for Pitot-Static System

According to Federal Express representatives, the Federal Express maintenance program incorporated the following task related to the pitot-static system at the time of the accident:

- Drain Accumulated Water from Pitot System Every 4B (2,160 hrs)

• Check Air Data Switching	Every 4B (2,160 hrs)
• Inspect pitot Probes (from ground)	Every 4B (2,160 hrs)
• Leak Check Pitot/Static System	Every 2C (9,600 hrs)
• General Visual Inspection from Ground	Every Srvc. & A-check

1.7 METEOROLOGICAL INFORMATION

The following are the aerodrome weather as observed by the Air Traffic Service Facility at Subic International Airport on or about the time of the accident.

Wind Direction/Velocity	Calm
Visibility	6 Kilometers
Temperature	25 °C
Dew Point	24 °C
QNH	1008 Millibars
Scattered	1,800 ft.
Broken	7,000 ft.
Remarks	intermittent light rain

1.8 AIDS TO NAVIGATION

The aircraft was on a VOR/DME approach. VOR/DME and PAPI lights of both runways were reported to be on normal operation at the time of the accident.

1.9 COMMUNICATIONS

The flight was initially in contact with Subic approach control and was handed over to Subic tower for landing information and was in contact with the same until the accident. All communications equipment were reported to be in normal operation.

1.10 AERODROME INFORMATION

The accident happened at Subic Bay International Airport with the following particulars:

Runway Designation No.	:	07/25
Runway Bearing	:	068°/ 248°
Runway Dimension	:	2,744 meters x 45 meters
Runway 07/25 Stopway	:	0 / 0
Runway 07/25 Clearway	:	150 meters / 150 meters
Runway Strip	:	3,044 meters x 300 meters

Runway Strength	:	PCN 64 F / A / W / T
Runway Surface	:	First 456.9 m of runway 07 and First 549 m of runway 25 : Concrete, the rest asphalt

1.11 FLIGHT RECORDERS

The aircraft was equipped with a flight data recorder and a cockpit voice recorder with the following particulars:

a) Digital Flight Data Recorder
   Make/Model UFDR-Digital Flight Data Recorder/Allied Signal Avionics
   Serial no. 3233
b) Cockpit Voice Recorder
   Make/Model Fairchild A100a
   Serial no. 52852

Both recorders were brought to the National Transportation Safety Board (NTSB) Laboratories in Washington D.C. for the readout of the data.

1.12 WRECKAGE AND IMPACT INFORMATION

1.12.1 General Description of Accident Site

The airplane came to rest beyond the departure end of Runway 07 (length 9,003 feet, width 148 feet) at the Subic Bay International Airport (airport elevation is 56 feet msl, touchdown zone elevation is 40 feet). The airplane overran the end of Runway 07, impacted an instrument landing system (ILS) antenna site, and continued off a ledge that dropped about 30 feet onto a road located on the shoreline of the airport. The airplane then entered the water and initially came to rest at the following coordinates: North 14 degrees 47.97 minutes; East 120 degrees, 17.00 minutes.

Tire tracks were identified on runway 07 as light colored scuffmarks that appeared to "clean" the runway surface. The tracks began about 2,400feet from the departure end of the runway, and were predominantly on the right side of the runway centerline. No evidence of the initial touchdown location was found. Beyond the departure end of the runway, the tracks continued for about 265 feet, at which point the ground dropped in elevation about 30 feet over a horizontal distance of about 85 feet. A fence and a 15-foot tall light stanchion were located at this point and both were undamaged; however, the light structures mounted on the stanchions were damaged. An ILS antenna located approximately 200 feet from the end of the runway was damaged. The remaining portion of the ILS antenna was located 36.5 feet from the center of the nose gear track.

The ground immediately beyond the road toward the water exhibited an area of deep ground scarring that was similar in shape to the landing gear and engines. A swath of damaged trees was noted toward the outboard of the right main landing gear track. This swath path exhibited a distinct angle of descent toward another drop-off. This second drop-off was about 15 feet in elevation until it reached the water.

The majority of the airframe then drifted about 0.4 kilometers east of the final location and was tied down to the shoreline for salvage. Only the three engines (with pylons attached), tailcone sections, right main landing gear, and nose gear remained at the final impact site off the end of runway 07.

1.12.2 Wreckage Description

1.12.2.1 Fuselage

The fuselage had broken into two main pieces. The first piece was the nose section, which measured about 75 feet in length. The nose section had partially separated about Fuselage Station (FS) 999 on the left side of the aircraft (760 inches or 63.3 feet from the crest of the radome), and FS 1139 on the right side (beyond the 100 – inch plug, or 240 inches aft of the left side fracture.) The radome and the cockpit area of the nose section remained intact but were damaged. The nose of this section including the three pitot tubes, eventually sank to the bottom and was buried in about 12 inches of sand. The aft section of the fuselage remained relatively intact. The belly structure section immediately forward and aft of the center wing section was severely damaged. Both wings, the tail, the center landing gear and the left main landing gear remained attached to this section.

1.12.2.2 Wings

The right wing remained attached to the fuselage and was found in one piece. numerous fractures of the upper and lower skin, spars, and primary structure were noted. The right wing structure was more fragmented than the left wing structure. The No. 3 engine, engine pylon, and right main landing gear were separated from the right wing. The left wing also remained attached to the fuselage and was found in one piece. This wing was not as disintegrated as the right wing. Pieces of metal truss structure from the approach lights and chain link fence were found entangled in the left wing. The No. 1 engine pylon had separated from the left wing. The left main landing gear was separated from the trapezoidal panel and the left main landing gear attach fitting failed.

1.12.2.3 Tail Structure

The tail section, including the horizontal and vertical stabilizers, elevators, and rudder, remained attached to the fuselage. The stabilizer trim was found at about the seven-degree aircraft nose-up trim position (as per visual inspection of the index marks on the right side of the tail).

1.12.2.4 Landing Gear

The left main landing gear attaching structure failed and was completely severed from the aircraft, but remained with the left wing. The strut was still charged and one of the tires remained inflated (pressure unknown). The right main landing gear had separated from the right wing. The forward trunnion lug of the right main landing gear had no attach point hardware connected to it, indicating that the fuse pin sheared at one or possibly both grooves. The remaining tire tread varied from very acceptable to barely acceptable; no flat spots were visible. The truck (bogie beam assembly) appeared undamaged. No observations regarding the main landing gear braking system were recorded.

The nose gear remained attached to the trunnion fittings of the STA 595 bulkhead, which had separated from the fuselage and was found in the water near the end of the runway. The tires were punctured and deflated. The center landing gear had failed aft and pivoted aft and impacted the lower fuselage; it remained attached to the aircraft at the trunnion fittings.

1.12.2.5 Powerplants

1.12.2.5.1 Engine No. 1 (left)

The engine was a General Electric CF6-80C2. No evidence of fire damage was found. The engine remained attached to its pylon, which had separated from the wing. This engine exhibited more damage than the other two engines. The fan case was severely deformed and fractured. The fan inlet was missing. All of the fan blades were fractured near the hub and exhibited bending opposite the direction of rotation. The combustor sections exhibited severe impact damage and no longer retained its original shape. The Full Authority Digital Engine Controller (FADEC) had separated from the engine and found on the shoreline off the end of Runway 7. The thrust reversers and their associated actuators were found in the deployed position.

1.12.2.5.2 Engine No. 2 (center)

The engine was a General Electric CF6-80C2. No evidence of fire damage was found. The engine remained attached to its pylon, and the pylon was separated from the vertical stabilizer. This engine exhibited the least amount of damage in comparison to the two other engines. It remained mostly intact and cylindrical.

The bell mouth section remained attached and exhibited some impact damage. All of the fan blades of the compressor section were intact and attached to the hub; they all exhibited severe foreign object debris (FOD) damage. The combustor section was intact; grass and dirt was found inside. The FADEC remained attached to the engine and was removed by the investigators. The thrust reversers and their associated actuators were found in the deployed position.

1.12.2.5.3 Engine No. 3 (right)

The engine was a General Electric CF6-80C2. No evidence of fire damage was found. The engine remained attached to its pylon, which had separated from the wing. This engine exhibited less damage than the no.1 engine, and more damage than the no. 2 engine. The inlet was missing. Most of the fan blades were fractured and bent opposite the direction of rotation. The FADEC remained attached to the engine and was removed by investigators. The thrust reversers and their associated actuators were found in the deployed position.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Not done.

1.14 FIRE

There was no evidence of a pre nor post-impact fire .

1.15 SURVIVAL ASPECT

The accident was survivable since the structural integrity of the cockpit was not impaired, thus enabling the crew to exit through their emergency escape windows.

1.16 TESTS AND RESEARCH

1.16.1 Summary of Investigative Activities

The entire airframe and engine wreckage, including components associated with the pitot static system were visually examined and inventoried on-site on October 25 – 30, 1999, with the participation of a NTSB Aerospace Engineer. Three pitot tube heads, identified as the auxiliary, Captain's, and First Officer's, along with several pressure lines were examined at Boeing in Long Beach, California, on December 13-21, 1999. Non-volatile memory from all three Full Authority Digital Engine Controllers (FADECs) was extracted at the Lockheed Martin Control Systems in Binghamton, New York, on December 9, 1999. Non-volatile memory from the air data computers, and flight control computers was extracted at the Honeywell factory in Phoenix, Arizona, on August 9, 2000. Laboratory experiments to simulate airspeed anomalies during descent was conducted at the Honeywell factory in Phoenix, Arizona, on August 10, 2000.

1.16.2 On-Site Extraction and Examination of Pitot Tubes and Components

All three pitot tubes were removed from the airplane on October 26, 1999, while the nose section remained underwater near the seaplane ramp during the salvage effort. The three external screws holding down the head plates were removed, and the electrical lines and tubes immediately behind the heads were cut. A cursory review revealed that all of their drain holes were solidly obstructed with a granular substance. Water could flow through both ends of the Captain's and Auxiliary pitot heads, while the First Officer's tube was packed with sand. A sample of the sand where the tubes had impacted on the bottom of the seabed was taken for further examination.

After the nose section had been pulled up the seaplane ramp, the pitot and static lines of the blockage were excised, complete with moisture drains and lines. O obvious evidence of blockage was seen. The lines were compromised and impact damaged, exposing them to seawater. The glass moisture drains attached to these lines had an unknown amount of water in them; the mechanics who removed the drains reported that they had disconnected and reconnected the drains to remove the assembly, the emptied the trapped water from them in the process. The mating fitting to the static port into the ADC-1 was connected to these lines. It mated with the ADC-1 stud and had red torque stripe on it. About 20 inches of line immediately behind where the captain's and first officer's pitot head were previously mounted and also excised. There was a small amount of debris in the throat of this Captain's piece, and it appeared to be at the tip and very loosely packed. The material was similar in color (whitish) and consistency (loose, wet and granular) as debris that littered the area immediately behind the radome. Visual examination of the tips of the first officer's and auxiliary lines did not reveal any blockages. All of the excised lines were taped off and secured for further examination.

1.16.2 Laboratory Examination of Pitot Tubes

1.16.3.1 Gross Observations and Radiography

Three Pitot tube heads (part no. 851KD), identified as the Auxiliary, Captain's, and First Officer's, along with several pressure lines and a segment of the pitot static plate assembly, were examined by an NTSB investigator and U.S. advisors at the Boeing-Long Beach Division for evaluation. The pressure lines along with the three pilot tubes were radiographic-inspected to determine if any obstructions existed within the pitot tubes and pressure lines. The result of the radiographic inspection revealed no evidence of obstruction in the two drain holes of each pitot head.

1.16.3.2 Auxiliary Pitot Tube Head

No evidence of debris was observed within the forward portion of the tube or the two drain holes for the auxiliary pitot tube head. The pitot itself appeared to have evidence of water stains and corrosion. The 3-inch long forward tube portion of the pitot tube appeared to be blackened. The blackened region extended approximately halfway from the forward end. The subject part was cut lengthwise to expose the inner surfaces for examination. Visual and macroscopic examination revealed that the passageways of the pitot tube were unobstructed. A small amount of brownish-colored residues were observed along the inner corners of the pitot tube reservoir area. No fiberglass particles were found.

1.16.3.3 First Officer's Pitot Tube Head

The First Officer's pitot tube head appeared to have the same appearance of water stains and corrosion as the Auxiliary pitot tube head The same type and location of a blackened area along the forward portion of the 3-inch long forward tube of the pilot tube was also observed.

The right hand drain hole of the pitot tube head was found to be unobstructed.

The left-hand drain hole was plugged with a clear, crystalline particulate. Energy Depressive Spectrometry (EDS) analysis of this particulate revealed a high concentration of Silicon (Si), Aluminum (Al) along with smaller amounts of Oxygen (O), Sodium (Na), and Calcium (Ca).

The forward portion of the pilot tube was full of brown-colored sediment along with an aggregate of clear and white-colored crystalline particulates, small shells, and portions of an insect. The debris was filtered in the laboratory to separate the sediment from the particulates. Analysis of both the sediment and particulates revealed high concentrations of Si, Al, along with smaller amounts of O, Na and Ca, similar to what was found for the left hand drain hole. Small amounts of Potassium (K) were also detected within the particulates, and evidence of Iron (Fe) was detected within the sediment. The pitot tube was sectioned lengthwise to expose the inner surface. Visual and macroscopic examination of the inner surface revealed that the reservoir portion of the pitot tube was partially obstructed with material similar to the forward portion of the part. No fiberglass particles were found.

1.16.3.4 Captain's Pitot Tube Head

The Captain's pitot tube head appeared to have the same appearance of water stains and corrosion as the Auxiliary and First Officer's pitot tube heads. The location of the blackened area found on the Auxiliary and First Officer's forward portion of the 3-inch long forward tube portion of the pitot tube was observed; however, in this pitot tube, the location is somewhat at the middle of the forward tube.

The right-hand drain hole of the Captain's pitot tube head was plugged with a white and slightly greenish colored residue. Analysis of this residue revealed high concentrations of Nickel (Ni), Phosphorus (P), Sulfur (S), Si, Al, and Ca, along with smaller portions of O, Na, Magnesium (Mg), and K.

The left-hand drain hole of the pitot tube head was plugged with a brownish colored residue. EDS analysis of this residue revealed high concentrations of Si, Al, Ca, along with smaller portions of O, Na, Mg, P, S, Chlorine (Cl), K, and Ni.

The forward portion of the pitot tube was partially obstructed with brown colored sediment, along with an aggregate of clear and white-colored crystalline particulates, similar to the First Officer's pitot tube. The pitot tube was sectioned lengthwise to expose the inner surface. The inner surface revealed that the reservoir of the pitot tube was partially obstructed with this same sediment and particulates. The brownish-colored residue was found along the inner walls of the reservoir and also exhibited a greenish appearance. No fiberglass particles were found.

1.16.3.5 Sediment from the Floor of Subic Bay

A sample of the sediment from the floor of Subic Bay was submitted for analysis. The analysis revealed high concentrations of Si, Al, Cl, along with smaller amounts of O, Na, Mg, S, K, Ca, and Fe.

1.16.3.6 Base Material of the Pitot Tube

Analysis was performed on a pitot tube, the results indicated a high concentration of Copper (Cu). This is in conformance to the pitot tube material being a copper alloy (BeCu casting alloy C82500, AMS 4890). Analysis of an area along the outer surface of the strut portion of the pitot tube revealed a high concentration of Ni, along with smaller amounts of P, indicating that the strut portion was nickel-plated. This is in conformance to the requirements of the manufacturer (Rosemount Aerospace) that the strut portion of the pitot tube be electro-less nickel plated.

1.16.4 Air Data Computers and Associated Avionics

1.16.4.1 On-Site Observations

Air Data Computer No.1 (ADC-1) was extracted from the nose section while it rested underwater. Immediately upon recovery, the Group examined and photographed ADC-1 (Honeywell p/n 4059060-901; s/n 92050466). The upper surface of the Chassis had a 1.5-inch diameter hole in it, and the side of the chassis was deformed. The moisture drains had separated from the unit. Evidence that impact forces stripped off the line and fitting to the STATIC port was found. An assessment of the tightness of the STATIC fitting was impossible. The STATIC stud had torque stripe on it, but the mating fitting was missing. Evidence of metal was found in the threads of the stripped stud. The PITOT fitting was intact and slightly bent. The torque stripe on the fitting assembly was undamaged and intact, and the fitting nut was tight. ADC-1 was then placed back into fresh water for further analysis.

The Group later examined and photographed ADC-2 (Honeywell p/n 4059060-901; s/n 91010308) after it was able to be extracted from the airplane at the seaplane ramp (post-salvage) on October 30, 1999. The moisture drains were missing. Evidence that impact forces stripped off the line and fitting to the PITOT port was found. The STATIC fitting was intact. ADC-2 was then placed back into fresh water for further analysis.

1.16.4.2 Laboratory Testing of ADC's

Both ADC's were recovered from the crash site, and delivered to Honeywell Phoenix in drums of water. Upon removing the submerged ADC's from the drums of water that they were shipped in, they were moved to a lab for cleaning. The subassemblies were removed from the chassis, documented, and all were rinsed with water. Following rinse, a cleaning and two-day bake process was performed to prepare the circuit boards for non-volatile memory (NVM) extraction. Details of the extraction can be found in Attachment K. The extraction revealed the following:

No fault recordings were found for Captain side ADC on the last flight. An "Angle of Attack" (AOA) failure was recorded on the first officer's side ADC.

1.16.4.3 Flight Control Computer (FCC)

All cards from FCC box 1 were found to be operational except the A2 card. The data on card A2 is not significant with regard to airspeed monitoring. A known good card replaced the bad card and the NVM data was extracted. The FCC monitors detected numerous ADC discrepancies on the last flight leg, but it was not possible to determine which ADC was a fault or when they were logged. For FCC box 2, only the A2 card is operational. The three bad cards were replaced with known good cards and the NVM data was extracted. There were no faults recorded on the last leg by the A2 card.

1.16.4.4 Digital Electronic Units (DEU)

All data extraction from DEU memories was successful. Analysis of the data showed there was nothing recorded for the last flight leg.

1.16.4.5 Flight Management Computer (FMC)

There was no attempt at data extraction. The FMC data is not stored in NVM, but in battery-backed memory. Since the units had been in water since the accident, it was determined that the battery power had been depleted and all data subsequently lost.

1.16.4.6 Full Authority Digital Electronic Controls (FADECs)

- All three FADECs were examined at Lockheed-Martin Control Systems in Johnson City, New York. The results of the examination did not reveal any meaningful information regarding the accident flight..

1.17 Laboratory Experiments Related to Pitot Plumbing Anomalies

In an attempt to ascertain if pneumatic leaks or partial obstructions could cause the Captain side airspeed errors, representatives of Honeywell and Boeing, under the supervision of an FAA inspector and with NTSB concurrence, performed laboratory experiments determine if either of these anomalies could produce the airspeed effects that were similar to the indicated and actual airspeeds computed from accident flight performance data.

Static line experiments were deemed not required since recorded altitude indications during the accident flight were noted to be correct. It was determined that a pitot leak (to cabin pressure) at cruise altitude would cause a higher indicated airspeed. Since the indicated airspeed on the Captain's display was indicating lower than the actual airspeed during the accident flight, a pitot leak test was not performed.

For the pitot obstruction, an amount of water (sufficient to obstruct airflow) was introduced at cruise altitude. The water obstruction was found that adjusting the height of the "u"-shaped clear plastic tube (gravity influenced) formation and it was found that adjusting the height of the "u" varied the airspeed error. The tube was adjusted to produce a –12 knot error, which is the error value that was revealed in the accident airplane at the top-of-descent at 37,000 feet.

The orientation of the tube and other plumbing was retained throughout the descent profile. The hoses used were approximately the same inside diameter as the MD-11 aircraft plumbing they simulated. Two descent profiles were simulated using a Honeywell ADT-222C pressure controller and the airspeed error observed. The test results for one of these profiles is as follows:

13-inch Column H_2O (by volume)

Pressure Controller Output				
Altitude (Ft)	**Airspeed (kts)**	**Altitude (ft)**	**Airspeed (kts)**	**Error (kts)**
37,000	270	37013	257.5	-12.5
35,000	270	35014	250.1	-19.9
33,000	270	Not Recorded	243.7	-26.3
30,000	270	Not Recorded	243.7	-26.3
25,000	270	Not recorded	244.3	-25.7
25,000	240	Not recorded	217.3	-22.7
20,000	240	20003	210	-30
10,000	240	10,000	210.3	-29.7
10,000	170	10,000	137.6	-32.4
0	170	Not recorded	124.9	-45.1

1.18 Summary of Boeing DC-10/MD-11 Air Data Anomaly Corrective Maintenance Actions

According to Boeing, the following actions were taken as a result of reports from airlines related to airspeed anomalies:

- Late in 1974 Boeing (Douglas) received a report from a DC-10 operator of a 30-knot airspeed error, attributed to manufacturing residue blocking the pitot tube water drain holes. As a result of the operator report, Boeing (Douglas) campaigned the DC-10 fleet in late 1974-early 1975 for additional reports of block pitot tube water drain holes. Boeing (Douglas) then issued a DC-10 All Operator Letter AOL 10-758 on January 16, 1975, advising operators of the DC-10 incident which initiated the fleet campaign; and Douglas recommendations for inspecting the pitot tube drain holes for blockage.

- The MSG-2 (Maintenance Steering Group 2) DC-10 On Aircraft Maintenance Planning (OAMP) document was revised in 1975 to include a detailed inspection was made a Maintenance Review Board (MRB) requirement.

- The initial MD-11 OAMP (MSG-3) did not have a Boeing recommendation or an MRB requirement to perform detailed inspections of the pitot tube water drain holes.

- The MD-11 OAMP was revised in May of 1997, after the World Airways event, to recommend a detailed inspection of the pitot tube water drain holes on a 1C interval. This item has not yet been deemed a requirement by the MRB's industry steering committee.

- The MSG-3 DC-10 OAMP was developed in the mid- to late-1990's. The MSG-3 OAMP analysis differs from MSG-2 for the determination of which inspection items will be included in the OAMP. The DC-10 MSG-3 OAMP did not include a Boeing-recommended or MRB-required 1C-interval detailed inspection of the pitot tube water drain holes (until Boeing issued a temporary revision recommended the inspection on February 1, 2001).

- The work card (#5600) originally called for by the MD-11 OAMP had the drain hole inspection as a "general visual inspection." In December 2000, temporary revision was issued to the MD-11 OAMP to call for an improved work card (#1049) that specified a detailed inspection of the pitot drain holes.

- The MD-11 Structural repairs Manual (SRM) was revised in 1998 to insert warnings in the radome repair section to install pitot tube covers any time the radome was being repaired on the airplane.

- The OAMP's for the DC-10 MSG-2, DC-10 MSG-3 and MD-11 call for an MRB-required check for drain of accumulated water in the pitot-static systems moisture traps at 4A intervals. (The MD-10 does not have a moisture trap and therefore does not have this check.)

- In January and February of 2001 Boeing added the following note to the above 4A interval water drain check work cards that reads: "if moisture is found, check pitot heads (probes) drains for blockage per AMM 34-11-(airplane specific) pg. (airplane specific)."

- Boeing is in the process of adding the same note to the AMM pitot-static water trap drain procedures.

- Temporary revisions to the MSG-3 DC-10 OAMP and the MD-10 OAMP (MSG-3) were issued February 1, 2001 to recommend the IC detailed check of the pitot tube drain holes.

1.19 Airline Training and Information Dissemination Related for Airspeed Anomalies

When interviewed, the accident flight crew stated they could not recall any specific ground school and simulator training related to erroneous airspeed indications; however, they stated that they were aware of the "Airspeed: Lost, Suspect or Erratic" procedure from their review of the FCOM during their initial training.

Following a Boeing FCOM revision, FedEx issued a Company Flight Manual (CFM) revision on February 28, 1999, revising the "Airspeed: Lost, Suspect, or Erratic" checklist. The FCOM checklist revision incorporated the information from the August 1998 Boeing Flight Operators Bulletin. Company procedures documented in the Flight Operations Manual (FOM) direct that it is the crewmembers responsibility to obtain through publication distribution any revisions, bulletins, or notices that are applicable to flight operations. The MD-11 CFM further mandates that except as provided in the FARs, no crewmember may deviate from the provisions of the CFM.

According to Federal Express training documents, the Captain received training derived from the August 1998 Boeing Flight Operators Bulletin as an emphasis item during the "hot topics" portion of their annual recurrent training prior to the accident. Hot topic emphasis items are covered in the formal classroom instructor-led ground school training conducted in conjunction with the proficiency check. The hot topics session lasts about 1.5 hours during an 8-hour training period. This information was added to the recurrent ground training program in September 1998, the captain completed recurrent ground school training on February 16, 1999. The first officer completed recurrent ground school training on July 7, 1999.

1.20 FedEx MD-11 Flight Manual Procedure for GPWS Pull Up Warning

The Federal Express MD-11 Flight Manual Procedure for "GPWS Pull Up Warning" requires crews to perform the following:

> If the GPWS "Pull up" warning occurs during night or Instrument Meteorological Conditions (IMC) immediately execute the GPWS escape maneuver as follows:
>
> 1. Autopilot/Autothrottles...DISCONNECT
> 2. Airplane Attitude...+ 20 [degrees] OR GREATER
> 3. Throttles...FIREWALL POWER
> 4. Spoilers...Retract
> 5. ATC...Advise

According to information from the CVR, the GPWS Pull Up warning was sounded about six second before the GPWS synthesized voice indicated that the airplane was 100 feet above the ground as the airplane approached the runway. Sounds consistent with the airplane touching down on the runway were heard 25 seconds after the GPWS Pull Up warning.

1.21 Post-accident Corrective Actions

1.21.1 Boeing Revision to Flight Crew Operating Manual

On June 15, 2000, as a result of the Subic Bay incident and reports of airspeed anomalies by other MD-11 operators, Boeing revised the MD-11 Flight Crew Operating Manual to provide additional guidance to flight crews. The guidance states that if any two of the following alerts are displayed simultaneously, the crew should use these alerts as valid indications to immediately refer to the "Airspeed Lost, Suspect, or Erratic" checklist: "SEL ELEV FEEL MAN"; "SEL FADEC ALTN"; "SEL FLAP LIM OVRD." Federal Express adopted the Boeing checklist revisions.

1.21.2 Federal Express Training

After the incident, Federal Express implemented a dedicated training module with the objective of teaching "the flight crews to recognize air data failures and to safely operate the aircraft under these failure conditions." Federal Express now requires this training for all of their MD-11 flight crews. The airline also incorporated the training in their initial training for all new MD-11 pilots. The training involves a 30-minute briefing followed by a one-hour simulator session.

1.21.3 Summary of Boeing DC-10/MD-11 Air Data Anomaly Corrective Actions to Date

According to Boeing, the following is a partial historical summary of corrective action that have been issued by Boeing Flight Operations (Douglas) related to DC-10/MD-11 air data anomalies:

- Boeing gave a presentation to the IATA Safety Committee in February 1997 at Cartagena, Colombia, in the World Airways incident including cockpit indications and alerts, and corrective actions to date. The Safety Managers for several MD-11 operators were in attendance, including FedEx.

- In 1997, the MD-11 FCOM "Severely Damaged Radome and/or Suspect Airspeed Indication" procedure was modified and expanded into the "Airspeed: Lost, Suspect, and Erratic" procedure. The initial "Severely Damaged Radome..." procedure provided the flight crew with target pitch and power information for a variety of airspeeds, weights, and configurations.

- Flight Operations Bulletins entitled "Operation with Erratic Airspeed" and "Operation with Invalid or Suspect Airspeed" were released to all MD-11 operators by Boeing (McDonnell Douglas) on June 17, 1997, and August 27, 1998, respectively. Additionally, the July 1,1997 Trijet Flight Crew Newsletter, distributed to all DC-10 and MD-11 operators, contained the article "Invalid or Suspect Airspeed".

- Boeing developed a sample training module for air data malfunctions and offered the module to MD-11 operators via the August 1998 Flight Operations Bulletin described above, along with the recommendation that the operators incorporate the module in their recurrent training program. FedEx requested the module on October 8, 1998, and it was forwarded to FedEx on October 12, 1998.

- In December of 1998 Boeing elevated the "Airspeed: Lost, Suspect, and Erratic" procedure from an Abnormal Non-Alert procedure to an Emergency non-alert procedure after reports of an additional two air data incidents with symptoms similar to those described in the World event. (Federal Express did not elevate this change until after the Subic Bay accident)

- After the Subic Bay accident, Boeing revised the MD-10 and MD-11 SEL FADEC ALTN, SEL ELEV FEEL MAN, and SEL FLAP LIM OVRD procedures to refer the flight to the "Airspeed Lost, Suspect, or Erratic" emergency non-alert procedure (published on 15 June 2000).

- DC-10 and MD-11 operators have been advised several times over the years on the subject of anomalous airspeed indications. A brief review of Boeing (and McDonnell Douglas) Flight Operations correspondence showed the following partial listing of communications to operators (including those described previously):

    - February 15, 1972: Know your DC-10 letter #1A, "Flight Operation with Severely Damaged Nose Radome/Suspect Airspeed Indication"
    - May 1, 1975: Trijet Flight Crew Newsletter article: "Erroneous Airspeed Incident"
    - April 25, 1977: Know your DC-10 letter #55B "Operations with Suspect Erroneous Airspeed/Blocked or Frozen Pitot Static System"
    - June 17, 1997: Flight Operations Bulletin MD-11-97-04 "Operations with Erratic Airspeed"
    - July 1, 1997: Trijet Flight Crew Newsletter "Invalid or suspect Airspeed Indications"
    - August 27, 1998: Flight Operations Bulletin MD-11-98-06 "Operations with Invalid or Suspect Airspeed"

2.0 ANALYSIS

2.1 Sources of Airspeed Anomaly

According to data from the DFDR, and the analysis of that data, an indicated airspeed "miscompare" parameter began to appear on the DFDR about 43 minutes prior to the accident. This indication began at a time during which the DFDR recorded parameters consistent with an encounter with moderate turbulence and a mild upset. About 90 seconds after this parameter appeared, the first autopilot disconnect was noted on the DFDR as the airplane was cruising at 37,000 feet near top of descent. According to Boeing, the autopilot will disconnect if an airspeed miscompare is 12 knots or greater.

Attempts were made to compare the anomalous indicated airspeeds that were presented to the flight crew with the actual airspeed of the airplane during the descent. Due to lack of upper wind data, calculations to determine actual airspeed from DFDR data were not considered reliable due to the potential effects of significant winds at those altitude. However, comments from the flight crew relating to indicated airspeed were captured on the CVR and used to reconstruct actual versus indicated airspeed at altitude. As the airplane descended in close proximity to the airport surface, where the winds were reported (and assumed to be calm), airspeed calculations from DFDR data were considered to be accurate and useful. A compilation of the CVR and DFDR performance analysis provided the following data:

Altitude (DFDR)	Captain's Airspeed (DFDR)	First Officer's Airspeed (Actual)	Source of First officer's Airspeed	Airspeed Difference
8040	239	270	CVR at 1545:03	31
7610	231	260	CVR at 1545:32	29
5620	219	255	CVR at 1546:28	36
5070	205	238	CVR at 1548:22	33
3140	182	239	Calculated (DFDR)	57
820	172	217	Calculated (DFDR)	45
0 (touchdown)	151	196	Calculated (DFDR)	45

When the airspeed anomaly initially appeared during cruise, the captain's indicated airspeed differed by about 12 knots from the actual airspeed, and then gradually increased to about 45 knots as the airplane descended to sea level. This schedule of airspeed split versus altitude change is very similar to the schedule seen during a laboratory experiment (addressed in section 1.17 of this report) in which water was introduced into the pitot line of an air data computer, and the pressure was adjusted on the static side port to simulate a descent from 37,000 feet to sea level.

Laboratory examination of the captain's pitot tube head revealed blockages in both the left and right drain holes with an unknown substance. While it could not be determined if these blockages existed prior to impact, it is noteworthy that both drain holes on the auxiliary pitot head (middle mounted) had no solid blockages, and it sustained the same descent into water and impact with the sandy bottom as the captain's tube (For the first officer's pitot head, only the left hand drain hole was plugged with a clear crystalline particulate matter consistent with sand. Therefore, it is likely that both drain holes from the captain's pitot head were blocked prior to impact. This is consistent with the airspeed anomalies seen on the captain's side only.

Examination and follow-up testing of all electrical components associated with the pitot-static system did not reveal any evidence of avionics malfunction.

The airplane involved in the Subic Bay accident had a recent history of numerous airspeed anomalies. While numerous corrective actions were taken, including the purging of the pitot system, the anomalies continued to occur. None of the corrective actions involved a detailed inspection of the drain holes, which was probably the root of the problem.

2.2 MD-11 Alerts and Flight Crew Response

A review of the CVR entire transcript revealed no indications that the flight crew had checked the standby airspeed indicator, or had performed the MD-11 Flight Crew Operating Manual (FCOM) Vol. II Non-alert procedure titled "Airspeed: Lost, Suspect or Erratic". After the accident, the crew stated that they were aware of the procedure. The crew had also received ground training to emphasize the procedure prior to the accident. Additionally, the crew had accrued sufficient basic flight training and experience during their careers to be reasonably expected to check the standby airspeed indicator and/or perform the "Airspeed: Lost, Suspect or Erratic" procedure.

The flight crew could have been prompted to check the standby airspeed indicator, or perform the "Airspeed: Lost, Suspect or Erratic" procedure, if the MD-11 alerting scheme and checklists were developed with a more logical and intuitive approach to air data computer anomalies. Based on information from the cockpit voice recorder and crew statements, and a review of the published procedures in the airplane flight manual that were effective at the time of the accident, the crew did not receive cockpit indications that would have readily led them to the "Airspeed: Lost, Suspect, or Erratic" checklist. Additional research revealed that there is no dedicated alert to advise MD-11 crewmembers of subtle air data failures. Alerts displayed to the crew on the accident flight (i.e., SEL ELEV FEEL MAN, SEL FLAP LIM OVRD, and IAS miscompare annunciation on PFD) were symptoms of an air data failure and not the root cause of that failure. The crew responded to the alerts they observed and accomplished the checklists associated directly with the alerts. That action was consistent with the aircraft's warning and alerting scheme and the crew's training. At the time of the accident, checklists for air data failure symptom alerts (e.g., SEL ELEV FEEL MAN and SEL FLAP LIM OVRD) did not refer crews to the Abnormal Non-Alert Procedure – Airspeed: Lost, Suspect, or Erratic.

The Subic Bay accident and reports from previous incidents involving erroneous airspeed problems have demonstrated that if any two of the following alerts are displayed simultaneously, the crew should use these alerts as valid indications to immediately refer to the "Airspeed Lost, Suspect, or Erratic" checklist: "SEL ELEV FEEL MAN"; "SEL FADEC ALTN"; "SEL FLAP LIM OVRD." Boeing and Federal Express has since added this to the MD-11 Flight Crew Operating Manual (FCOM) as a result of the Subic Bay accident.

As the crew entered the approach environment (i.e., 5,000 feet and flaps 15) they identified that the problems may have been caused by a ADC malfunction. This is supported by the following excerpts from the CVR:

> 1548:45 HOT-2 (first officer) *"I would say we could select another CADC*...[sound similar to CAWS altitude alert]...*or something but I don't know whose is right."*
>
> 1548:49 UTC HOT-1 (captain) *"yes. Try to select yours on it and see what happens."*

Once the first officer switched her instruments to the captain's ADC, the alerts extinguished and the autopilot and autothrottles became available, giving the false impression the appropriate CADC had been selected. It is likely at this point the crew felt the problems had been resolved and that it was appropriate to commence the approach. This is supported by the following excerpts from the CVR:

> 1549:02 UTC HOT-2 (first officer) *"okay I'm on yours now."*
>
> 1549:03 UTC HOT-1 (captain) *"I got an autopilot"*.
>
> 1549:06 UTC HOT-2 (first officer) *"okay"*.
>
> 1549:24 UTC HOT-1 (captain) *"cleared for the VOR approach?"*
>
> 1549:24 UTC HOT-2 (first officer) *"okay you got it... yeah."*
>
> 1549:27 UTC HOT-1 (captain) *"Okay I'm gonna hit nav."*
>
> 1549:31 UTC HOT-2 (first officer) *"Two oh five. Two oh five* [comparing captains and first officer airspeeds] *okay we seem to be back in business."*

2.3 Continuation of Approach and Landing

As the airplane descended below 500 feet, cues and warnings were ignored by the flight crew that strongly suggested the approach could not be completed within acceptable parameters (e.g., multiple GPWS sink rate and pull up warnings, visual cues from the PAPI that the aircraft was high/long, and visual cues from the runway that the aircraft would land past the touchdown zone). The flight crew's failure to execute a missed approach despite receiving a GPWS Pull Up warning, at night, about 100 feet above the ground, and 25 seconds before the airplane touched down on the runway. This failure did not comply with the Federal Express MD-11 Flight Manual procedure for GPWS Pull Up Warning.

3.0 CONCLUSIONS

3.1 Findings

1.) The airplane was certificated, equipped, and dispatched in accordance with Federal regulations and approved FedEx procedures.

2.) The flight crew was properly certificated and qualified for the flight.

3.) Analysis of the data from the Digital Flight Data Recorder revealed that an indicated airspeed miscompare parameter began to appear about 43 minutes prior to the accident. This indication began at a time during which the DFDR recorded parameters consistent with an encounter with moderate turbulence and a mild upset.

4.) The examination and follow-up testing of all electrical components associated with the pitot-static system did not reveal any evidence of avionics malfunction.

5.) The airplane involved in the Subic Bay accident had a recent history of numerous airspeed anomalies. While numerous corrective actions were taken, including the purging of the pitot system, the anomalies continued to occur. None of the corrective actions involved a detailed inspection of the drain holes, which was likely the root of the problem.

6.) Laboratory examination of the captain's pitot tube head revealed blockages in both the left and right drain holes with an unknown substance. It is likely that both drain holes from the captain's pitot head were blocked prior to impact. This is consistent with the airspeed anomalies seen on the captain's side only.

7.) The schedule of airspeed split versus altitude change is very similar to the schedule seen during a laboratory experiment in which water was introduced into the pitot line of an air data computer, and the pressure was adjusted on the static side port to simulate a descent from 37,000 feet to sea level. This is consistent with blocked pitot tube drain holes that would allow water to accumulate inside the Captain's pitot line and interfere with air data computer computations.

8.) The first autopilot disconnect was noted on the DFDR as the airplane was cruising at 37,000 feet near the top of descent. This disconnect was related to an air data computer airspeed anomaly.

9.) A review of the entire CVR transcript revealed no indications that the flight crew had checked the standby airspeed indicator or had performed the MD-11 Flight Crew Operating Manual (FCOM) Vol. II Non-Alert Procedure titled " Airspeed: Lost, Suspect or Erratic."

10.) Data from the flight recorders and interviews with the accident flight crew indicate that the "SEL ELV FEEL MAN" and "SEL FLAP LIM OVRD" alerts were annunciated during the descent for landing. The MD-11 FCOM contains separate checklist for each of these items, however, none of them provided a direct reference to a possible airspeed anomaly.

11.) Both flight crew indicated that they received normal rest before the accident.

12.) The accident flight crew stated that they could not recall any specific ground school and simulator training related to erroneous airspeed indications; however, they stated that they were aware of the "Airspeed: Lost, Suspect or Erratic" procedure from their review of the FCOM during their initial training.

13.) Following a Boeing Flight Crew Operating Manual (FCOM) revision, FedEx issued a Company Flight Manual (CFM) revision on February 28, 1999, revising the "Airspeed: Lost, Suspect, and Erratic" checklist. The FCOM checklist revision incorporated the information from the August 1998 Boeing Flight Operators Bulletin. Company procedures documented in the Flight Operations Manual (FOM) direct that it is the crewmembers responsibility to obtain through publication distribution any revisions, bulletins, or notices that are applicable to flight operations. The MD-11 CFM further mandates that except as provided in the U.S. Federal Air Regulations, no crewmember may deviate from the provisions of the CFM.

14.) Training documents indicate that the captain would have received brief ground training derived from the August 1998 Boeing Flight Operators Bulletin as an emphasis item during the "hot topics" portion of his annual recurrent training prior to the accident. Hot topic emphasis items are covered in the formal classroom instructor-led ground school training conducted in conjunction with the proficiency check.

15.) The flight crew did not comply with Federal Express MD-11 Flight Manual procedure for GPWS Pull Up Warning after receiving a GPWS Pull Up warning at night, about 200 feet above the ground, and 25 seconds before the airplane touched down on the runway.

16.) The airplane touched down onto the runway with excessive airspeed.

3.2 PROBABLE CAUSE

The Aircraft Accident Investigation Board determines that the probable cause of the accident was the failure of the flight crew to properly address an erroneous airspeed indication during descent and landing, their failure to verify and select the correct airspeed by checking the standby airspeed indicator, and their failure to execute a missed approach. These failures led to an excessive approach and landing speed that resulted in a runway overshoot.

Contributing factors to the accident were clogged pitot tube drain holes, the MD-11's insufficient alerting system for airspeed anomalies, and the failure of the SEL ELEV FEEL MAN and SEL FLAP LIM OVRD checklists to refer the crew to the standby airspeed indicator,

3.3 RECOMMENDATIONS

1.) Require that all DC-10, MD-11, and MD-10 operators incorporate a detailed inspection of the pitot tubes, including the pitot tube drain holes, at appropriately frequent intervals.

2.) Notify DC-10, MD-10, and MD-11 operators about the circumstances of this accident and ensure that all pertinent training programs emphasize the importance of recognizing and correctly resolving erroneous airspeed indications; this training should specifically inform pilots that they should immediately reference the "Airspeed Lost, Suspect, or Erratic" checklist if more than one of the following alerts are displayed simultaneously: SEL ELEV FEEL MAN; SEL FADEC ALTN; SEL FLAP LIM OVRD .

3.) Require that operators' DC-10, MD-10, and MD-11 flight crew operating manuals include guidance referring the flight crew to the "Airspeed Lost, Suspect, or Erratic" checklist if more than one of the following alerts are displayed simultaneously: "SEL ELEV FEEL MAN"; SEL FADEC ALTN"; "SEL FLAP LIM OVRD."

4.) Require the Boeing Commercial Airplane Company to revise the annunciation of the indicated airspeed (IAS) caution annunciation so that the alert advises the crew to cross check the standby airspeed indicator.

BY THE AIRCRAFT ACCIDENT INVESTIGATION BOARD

SATURNINO B. DELA CRUZ	Chairman
REYNALD A. RAMOS	Vice-Chairman
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DANILO L. PANTALEON	Member
EDGARDO N. SALCEPUEDES	Member

Noted by:

M/GEN. ADELBERTO F. YAP (Ret)
Assistant Secretary

ATTACHMENTS

A.) Photographs

B.) DFDR plot with pertinent parameters

C.) CVR transcript

D.) FedEx MD-11 Checklist on Airspeed: Lost, Suspect or Erratic (prior to the Subic Bay Accident)

E.) FedEx MD-11 Flight Manual excerpt dated Dec. 30, 1993 related to Air Data System Description

F.) FedEx Management E-mail and Newsletter information related to MD-11 Airspeed Anomalies, issued before Subic Bay Accident

G.) Boeing/Douglas Flight Operations Bulletin and All-Operators letter regarding DC-10 and MD-11 Airspeed Anomalies (Issued before Subic Bay Accident)

H.) Post-Accident changes to FedEx MD-11 Flight Manual and Training related to operation with Erratic Airspeed

I.) Post-Accident changes to Boeing MD-11 Flight Manual related to Erratic Airspeed

J.) NTSB recommendation letter related to operation with Airspeed Anomalies (issued before Subic Bay Accident)

K.) NTSB Airworthiness Factual Report of Investigation

L.) Schematics of MD-11 Pitot-Static System

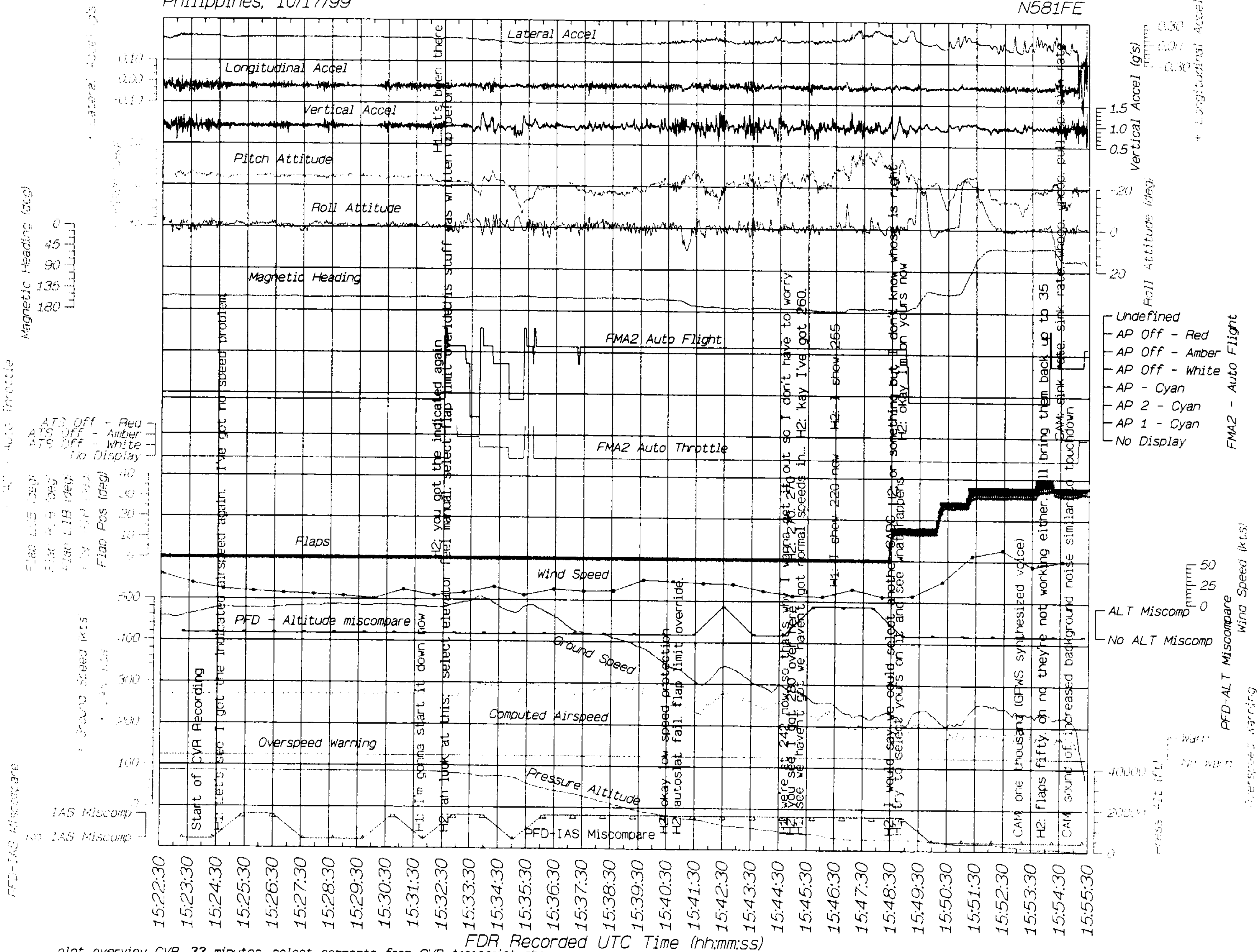
M.) All Boeing Telex Messages to MD-11 Operators Related to Subic Bay Accident and Pilot-Static Inspection Changes

N.) NTSB Aircraft Performance Plots: Airspeed and Altitude

FedEx MD-11 Subic Landing

Philippines, 10/17/99

N581FE



FDR Recorded UTC Time (hh:mm:ss)

plot_overview_CVR, 33 minutes, select comments from CVR transcript shown

Revised: December 30, 1999

Vehicle Recorders Division RE-40 - NTSB

National Transportation
Safety Board

Memorandum

Date: January 20, 2000

To: Greg Feith, U.S. Accredited Representative

From: Anna Cushman, CVR Group Chairman

Subject: CVR transcript - DCA00RA002

Enclosed is the CVR transcript (1 floppy disk and 1 printed) from the accident involving the Federal Express MD-11 (N581FE) at Subic Bay, Philippines on October 17, 1999 (NTSB ID: DCA00RA002). The CVR (Fairchild A100a, s/n 52852) was received packed in water and arrived with the ATO representative, Capt. Reynald Ramos. The tape was removed from the CVR, cleaned and successfully played (please refer to the 2 enclosed photos). After transferring the tape recording to a digital medium, the original tape was returned to Capt. Ramos. The CVR unit was returned to FedEx on November 5, 1999.

The CVR transcript was prepared during a group meeting with representatives from Federal Express, FedEx Pilots Association, Boeing, FAA, and the Philippine Air Transportation Office on October 26, 1999. The entire 30-minute and 22-second recording was transcribed and the timing was established using a correlation to the Flight Data Recorder. Specifically, the following CVR events were correlated to parameters from the FDR (and matched to the FDR's corresponding UTC time):

CVR Event	***FDR Parameter***
Air-to-Ground radio calls	VHF1 Keying
Auto-pilot disconnect warning	FMA2 Auto Flight (auto-pilot disconnect)
Flap/Slat handle movement	Slat Disagree, L2, R4, L4, R2
Flap/Slat handle movement	Flap Position
Gear Handle movement	Gear Down and Locked (1, 2, 3, 4)
GPWS altitude call-out	Radio Altitude

CVR events that could not be correlated to a specific FDR parameter (i.e. intra-cockpit conversation) were adjusted based on the relative time of the events and a linear interpolation between the times of the correlated events. Because these events cannot be correlated to a specific FDR parameter, their times are the best approximation to UTC time possible, but are relative, nonetheless.

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1524:07 **Start of Recording** 1524:07 **Start of Transcript**			
1524:18 HOT-2	what difference does that make?		
1524:20 HOT-1	well I I built it off of Subic is what I built it off of... ***...off of ah ***.		
1524:27 HOT-2	oh okay.		
1524:28 HOT-1	plus I don't know if the ahh the ahh...		
1524:29 HOT-2	I'll build it off.		
1524:30 HOT-1	...I think ah I probably copied the flight plan before I put it in so it's probably the same thing.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1524:36 HOT-1	if you ah put in a point outside of ah... go direct to a point and then build it if you want.		
1524:53 HOT-1	let's see I got the indicated airspeed again. I've got no speed problem.		
1524:58 HOT-2	***.		
1525:05 HOT-2	how do you know you're not getting the straight in instead of the. see I think you're getting the straight in approach and not the ahh...		
1525:13 HOT-1	say again?		
1525:16 HOT-2	fine let's try something else here.		
1525:17 HOT-1	see ah.		
1525:26 HOT-1	is there a SBA to ah ah transition?		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1525:30 HOT-2	up to. yeah I'm trying to get. I got it to come up before... let's see... why won't it let me do that?		
1525:44 HOT-2	I don't want that though.		
1526:08 HOT-1	* comes again.		
1526:25 HOT-2	okay that's it.		
1526:27 HOT-2	I put in the ah arrival too.		
1526:32 HOT-1	okay.		
1526:33 HOT-2	I can clear out (VILL).		
1526:40 HOT-2	direct to Subic.		
1526:42 HOT-1	go ahead and ah if you want to put it in the ah...		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1526:44 HOT-2	primary. okay.		
1526:45 HOT-1	...primary first and then ah.		
1526:49 HOT-2	okay... activate secondary...		
1526:57 HOT-2	...okay?		
1526:58 HOT-1	okay.		
1526:59 HOT-2	nav is avail I can read direct to Subic. it should be good.		
1527:07 HOT-2	okay nav's available.		
1527:08 HOT-1	nav's available Subic okay.		
1527:11 HOT-2	I lost your descent. what did you have in there?		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1527:15 HOT-1	That's okay it's it's showing me Subic and plus...		
1527:18 HOT-2	okay.		
1527:18 HOT-1	...six thousand. so that's okay.		
1527:21 HOT-2	okay six outbound on the one nine zero. turn back in. don't go below seven. let's see it's got three thousand. that's right.		
1527:31 HOT-1	say again? three yes.		
1527:32 HOT-2	don't go below three...		
1527:33 HOT-1	that's right.		
1527:34 HOT-2	...and you turn back inbound.		
1527:37 HOT-2	down course final fifteen hundred.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1527:47 **HOT-2**	that's right we're talking about this before er to someone else. there's no MDA on these...		
1527:54 **HOT-2**	... for some reason.		
1528:03 **HOT-1**	there's no MDA?		
1528:04 **HOT-2**	yeah notice that?		
1528:12 **HOT-1**	SBA seven hundred feet.		
1528:18 **HOT-2**	but there's none on the plate.		
1528:22 **HOT-1**	oh on the plate yeah. I don't know why it...		
1528:24 **HOT-2**	cause there should be a point where you have to be at seven hundred and you stay there until you get to the missed approach point if you don't have the runway and they don't have one.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1528:32 **HOT-1**	...well what...		
1528:34 **HOT-2**	neither VOR has that.		
1528:37 **HOT-1**	...they have a ah point here at three DME that crosses at seven fifty then it shows it going down from seven fifty.		
1528:43 **HOT-2**	but final. I meant final approach fix. I'm saying MDA.		
1528:45 **HOT-1**	oh oh okay.		
1528:46 **HOT-2**	like you would assume this would be a final approach fix but they don't call it that.		
1528:50 **HOT-1**	yeah.		
1528:51 **HOT-2**	and we don't have one at all in this. I'm sorry I didn't mean MDA.		
1528:55 **HOT-1**	no no problem.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1528:56 HOT-2	we have an MDA. we don't have a final approach fix to be there by.		
1529:01 HOT-1	well the missed approach point is the VOR.		
1529:03 HOT-2	yeah but you don't have a final approach fix. you normally you have to have that. that's you have to be at your. that's when you start your. oh let's see.		
1529:12 HOT-1	it's it's the VOR. you have to either decide to go down or you go around at the VOR.		
1529:16 HOT-2	no.		
1529:18 HOT-1	see you.		
1529:19 HOT-2	that's your missed approach point. you gotta be at your seven hundred feet prior to that.		
1529:26 HOT-1	you don't have to be.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1529:28 HOT-2	well you sure better be.		
1529:28 HOT-1	and that's that's you you you that's those are your minimums. you can go down to that. you can't go below that...		
1529:33 HOT-2	right but you sure better be.		
1529:34 HOT-1	... but ah but what they're saying is here you're showing you're coming down and then you're descending down. they didn't say your MDA is seven hundred feet. and you can go down when you when you start this approach. you can...		
1529:43 HOT-2	yep.		
1529:44 HOT-1	...go down on this approach from the time you get back turn around inbound you can start down you start the VOR you cross the VOR at six thousand go outbound make the turn and come back inbound. it says ten nautical miles three thousand down to two thousand and...		
1529:56 HOT-2	I know.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1529:57 HOT-1	...from two thousand you can go down to minimums on this one.		
1529:58 HOT-2	I know. but normally you should have a final approach fix.		
1530:02 HOT-1	it would be nice but you don't have to. on this approach you don't have one. there are some approaches where you don't.		
1530:15 HOT-1	what we'll what we'll do is we'll go ahead and nav it...		
1530:17 CAM	[sound similar to crewmember seat movement]		
1530:19 HOT-1	...and then ah I'm just going to ah ah prof it down and let it take it down and see what it does. if it doesn't stay on it I'll just click it off and I'll hand fly it. and I'll fly it on the FCP and just click it and run it on down.		
1530:30 HOT-2	oh it works good.		
1530:38 HOT-2	okay set in your side.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1530:42 HOT-1	okay.		
1530:54 HOT-2	I've got the.		
1531:06 HOT-1	sorry.		
1531:07 HOT-2	I was just going to say I have a VDP marked it's two point two from the runway.		
1531:16 HOT-1	yeah it's pretty tight in there well I usually just consider it to be the VOR. if I don't have it in sight I don't ah I just make a missed approach. I came in here one night and ah this airplane wasn't doing something right. anyway we had to make a missed approach cause they ah they what...		
1531:30 CAM	[sound similar to crewmember seat movement]		
1531:31 HOT-1	...they called the weather and ah our tailwind was too high so we had to pull up and go around. the Airbus ahead of us pulled up and went around and went into a hold at five thousand feet at the VOR. he requested five thousand...		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1531:41 HOT-2	oh.		
1531:42 HOT-1	...now I'm on a missed approach. got weather everywhere. what the hell am I supposed to go.		
		1531:45 CTR	FedEx eight seven when ready descend to flight level one three zero.
		1531:51 RDO-2	our discretion to one three zero. FedEx eight seven.
1531:55 HOT-2	I'll call the company.		
		1531:55 CTR	eight seven roger.
1531:56 HOT-1	okay.		
1531:57 HOT-2	one three oh.		
1532:00 HOT-1	I'm gonna start it down now.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
		1532:03 RDO-2	Manila FedEx eight seven's out of three seven oh for one three oh.
		1532:06 CTR	FedEx eight seven roger.
		1532:10 RDO-2	Subic ops FedEx eight seven.
		1532:14 RAMP	go ahead.
		1532:16 RDO-2	FedEx eight seven we should be there about five five past the hour.
		1532:21 RAMP	plan to park on gate seven.
		1532:24 RDO-2	gate seven. FedEx eight seven.
		1532:27 RDO	[sound similar to two microphone clicks on first officer's channel]
		1532:29 RDO-2	do we keep this airplane and take it on to Singapore?

INTRA-COCKPIT COMMUNICATION UTC SOURCE	CONTENT	AIRCRAFT-TO-GROUND COMMUNICATION UTC SOURCE	CONTENT
1532:31 HOT-2	you got the indicated again.		
1532:32 HOT-1	I I it's been there.		
1532:33 CAM	[sound similar to CAWS autopilot disconnect warning for two cycles]		
1532:34 HOT-1	it's been there for a few minutes.		
		1532:41 RAMP	negative.
		1532:45 RDO-2	understand we switch airplanes.
		1532:48 RAMP	yes ah gate number two.
1532:51 HOT-2	ah look at this. select elevator feel manual. select flap limit override. this stuff was written up before.		
1532:58 HOT-1	yeah I'm gonna write it up again too.		

INTRA-COCKPIT COMMUNICATION UTC SOURCE	CONTENT	AIRCRAFT-TO-GROUND COMMUNICATION UTC SOURCE	CONTENT
1533:01 HOT-2	I'm gonna get the book out here.		
		1533:04 RAMP	eight seven Subic Ops.
		1533:06 RDO-2	ah eight seven go ahead.
		1533:07 RAMP	ah it's gate two aircraft six one eight.
1533:08 CAM	[unidentified electrical high frequency sound]		
		1533:12 RDO-2	okay thanks.
		1533:13 RDO	[sound similar to two microphone clicks on first officer's channel]
1533:15 HOT-2	yeah we have to switch airplanes. okay.		
1533:16 HOT-1	good.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1533:17 HOT-2	good yeah that's true.		
1533:22 HOT-2	okay.		
1533:29 HOT-2	guess that's why the indicated airspeed was coming on. it wasn't matching right up here.		
1533:34 HOT-1	what wasn't?		
1533:36 HOT-2	we're gonna have to do this ah airspeed stuff I think.		
1533:41 HOT-2	select.		
1533:42 CAM	[sound similar to pages turning]		
1533:43 HOT-1	what's your indicated say? oh ...		
1533:44 HOT-2	elevator feel.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1533:44 **HOT-1**	...your indicated is in the red. mine's not.		
1533:46 **CAM**	[sound similar to a overspeed warning, autopilot disconnect warning, overspeed warning, autopilot disconnect warning, followed by eight overspeed warnings (continues until 1534:15)]		
1533:50 **HOT-1**	see there it goes. there. mine just mine just ran up.		
1533:55 **HOT-2**	okay.		
1533:56 **HOT-2**	select elevator feel manual. the electrical system is reverted to manual. the select manual switch should be pushed to lock the electrical system in manual. this alert will then be re...reset replaced by electric system manual alert.		
1534:14 **HOT-1**	#. come on here.		
1534:16 **HOT-2**	okay it all went away now.		
1534:18 **HOT-1**	I'm trying to slow it down but it wasn't doesn't want to slow down. * get the autothrottles off I'll do that but it just ah.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1534:29 HOT-2	here we have select...		
1534:29 HOT-1	do what you have to do on ah the check list there then @ and ah.		
1534:32 HOT-2	...well it all went away. select elevator...		
1534:41 HOT-1	make sure *.		
1534:42 HOT-2	...select electric system.		
1535:22 CAM	[sound similar to CAWS autopilot disconnect warning for two cycles]		
1535:25 HOT-1	#.		
1535:29 HOT-2	yeah I think the slower the better we start getting these warnings.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1535:31 HOT-1	that's what I'm doing. I'm trying select trying to get it back and it keeps going off on me.		
1535:42 CAM	[sound similar to CAWS autopilot disconnect warning for two cycles]		
1535:49 CAM	[sound similar to pages turning]		
1535:54 HOT-2	okay elevator feel manual. flap limit override.		
1535:59 HOT-2	elevator feel... manual. flap... limit.		
1536:30 CAM	[sound similar to pages turning]		
1536:32 HOT-2	okay select elevator feel manual. electrical feel selector. elevator feel selector... manual. config cue switch push.		
1536:47 HOT-2	okay you want me to * oh.		
1536:48 HOT-1	** pardon me?		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1536:50 HOT-2	it keeps going away but you want me to run it?		
1536:52 HOT-1	yeah just go ahead and do it.		
1536:54 HOT-2	okay elevator feel selector manual. elevator feel selector...pull for manual. 'kay. config cue switch... push.		
1537:08 HOT-2	okay we got our scale... position of elevator load feel speed bug is displayed. elevator feel selector high or low. rotate and hold elevator feel selector in high or low until ELF reference speed bug matches current indicated airspeed. continue to adjust as necessary. okay.		
1537:54 HOT-2	select flap limit override.		
1538:18 HOT-2	indicates both flap limiter channels have failed.		
1538:22 HOT-2	flap limit selector override one.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1538:32 HOT-2	okay after twenty seconds if flap limit disagree alert not displayed... do something. we have to wait twenty seconds here.		
1538:42 HOT-2	two.		
		1538:45 [CTR transmission to FedEx eight]	
1538:48 HOT-1	that's FedEx eight.		
1538:49 HOT-2	yeah.		
1539:02 HOT-2	'kay twenty seconds.		
1539:05 HOT-2	flap limit disagree alert. flap limit disagree alert... not displayed.		
		1539:12 CTR	FedEx eight. FedEx eight seven maintain flight level one three zero. contact Subic approach one one niner decimal one.

INTRA-COCKPIT COMMUNICATION UTC SOURCE	CONTENT	AIRCRAFT-TO-GROUND COMMUNICATION UTC SOURCE	CONTENT
		1539:19 RDO-2	one three zero. nineteen one. FedEx eight seven. good day.
		1539:23 CTR	good night.
1539:31 HOT-2	okay flap limit disagree alert. if flap limit disagree is not displayed. observe placarded flap extension speeds. we don't have protection. we just gotta make sure we don't overspeed the flaps. okay?		
1539:41 HOT-1	no problem.		
1539:48 HOT-2	did he say approach?		
1539:51 HOT-2	no autoland. windshear detect fail.		
1539:58 HOT-1	I also got no autopilot.		
1540:04 HOT-2	well did you try resetting it?		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1540:06 **HOT-1**	I got a yellow.		
		1540:11 **RDO-2**	Subic approach. FedEx eight seven passing sixteen point seven for one three zero with Papa.
		1540:17 **APR**	eight seven descend niner thousand. QNH one zero zero nine. expect VOR zero seven approach.
1540:20 **CAM**	[sound of clicking]		
		1540:23 **RDO-2**	one zero zero nine. down to nine thousand. FedEx eight seven. is that the procedure turn or the straight in VOR?
1540:29 **HOT-1**	procedure turn. we're gonna...		
1540:31 **HOT-2**	did he say that?		
1540:31 **HOT-1**	...yeah we're gonna do the procedure turn...		
		1540:32 **APR**	roger squawk. ident.

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1540:34 HOT-1	...* disregard. we're gonna do the procedure turn. we're gonna do the tear drop. we're gonna do the VOR approach. that's what we have to do from this side ah @.		
1540:43 HOT-2	okay low speed protection.		
		1540:44 APR	FedEx eight seven ah identified four zero miles north northwest of Subic VOR. fly heading ah one ah seven zero vectors to OLONG for VOR DME zero seven approach.
1540:58 HOT-1	vectors to OLONG okay.		
		1540:59 RDO-2	one seven zero. vectors to OLONG. FedEx eight seven.
1541:05 HOT-2	okay in range.		
1541:11 HOT-2	autoslat fail. flap limit override.		
		1541:13 APR	FedEx eight seven descend seven thousand.

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
		1541:17 RDO-2	seven thousand. FedEx eight seven.
1541:20 HOT-1	you'll have to change the approach too then.		
1541:24 HOT-1	descend to seven thousand is what he said. right? seven thousand		
1541:25 HOT-2	altimeters ten thirteen still...		
1541:27 HOT-1	ten thirteen set.		
1541:28 HOT-2	...let's see what's our new transition level's one three oh. we can go to... one zero zero eight. the altimeters.		
1541:49 HOT-2	okay I need to keep the config page up 'cause I need to get this... match the airspeed here.		
1541:56 HOT-2	okay that's *...in range check complete.		
1542:01 HOT-2	okay.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1542:10 CAM	[sound of click]		
1542:11 HOT-2	and one zero zero eight when you get a chance on the altimeter.		
1542:16 HOT-1	boy this speed's all over the place with this # green arrow here.		
1542:56 CAM	[sound of clicks]		
		1543:17 APR	FedEx eight seven check QNH one zero zero eight.
		1543:21 RDO-2	one zero zero eight. FedEx eight seven.
1543:23 CAM	[sound of two thumps]		
1543:24 HOT-2	passin ten.		
1543:29 CAM	[sound of click]		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1543:30 HOT-2	okay I got the straight in approach...		
1543:31 CAM	[sound of three clicks]		
1543:33 HOT-2	...OLONG three. twenty two fifty...		
1543:36 HOT-1	okay.		
1543:36 HOT-2	...fifteen hundred. seven fifty. seven hundred's still the baro.		
1543:41 HOT-2	same missed approach.		
1543:45 CAM	[sound similar to crewmember seat movement]		
1543:54 HOT-2	okay. did you try turning the autopilot on again?		
1543:57 CAM	[sound similar to crewmember seat movement]		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1543:57 HOT-1	** ah yah. @ you can't get it when you've got a yellow thing up here. I did it. I tried it. see? that indicates that your autopilot's not available to you.		
1544:03 HOT-2	okay.		
1544:05 HOT-1	what I'm gonna need you to have you do is just ah set everything up there for me because I can't take...		
1544:09 HOT-2	I understand.		
1544:10 HOT-1	...I'm gonna have to use my scan up here pretty much so you're gonna be setting all my ah.		
1544:13 HOT-2	do the autothrottles work?		
1544:15 HOT-1	nope. I've tried that a couple times too.		
1544:20 CAM	[sound similar to crewmember seat movement]		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1544:33 HOT-2	set seven hundred for you.		
1544:36 CAM	[sound of clicking]		
1544:36 HOT-1	set yeah I never did get finished with it. *.		
1544:47 HOT-2	okay we got seven hundred set.		
1544:51 HOT-1	I'm gonna go slats extend because I wanna get this thing slowed down and configured and I won't have to worry about it.		
1544:55 HOT-2	you gotta be careful of your speed.		
1544:57 HOT-1	yes I know.		
1544:59 HOT-1	we're at two ah forty two now. so that's why I wanna get it out so I don't have to worry about it.		
1545:01 CAM	[sound similar to CAWS altitude alert tone]		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1545:02 HOT-2	you see I got two eighty over here...		
1545:03 HOT-1	you got two eighty?		
1545:03 HOT-2	...two seventy. two seventy.		
1545:04 HOT-1	see we haven't got we haven't got normal speeds in...		
1545:05 HOT-2	eight for seven. we gotta level off.		
1545:06 HOT-1	...that's why I keep getting low speed protected.		
1545:08 HOT-2	yeah.		
1545:10 HOT-2	eight for seven.		
1545:11 HOT-1	roger.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1545:13 HOT-1	you may have to set the speed for me...		
1545:15 HOT-2	let's see.		
1545:15 HOT-1	...bug it for where I can see it over here to where ever. because we're getting a disagreement on this and you're not getting.		
		1545:20 APR	FedEx eight seven descend five thousand.
		1545:23 RDO-2	five thousand FedEx eight seven.
1545:27 HOT-2	five thousand.		
1545:27 HOT-1	five thousand.		
1545:32 HOT-2	'kay I've got two sixty.		
1545:33 HOT-1	see I keep getting I go down I keep getting a slow a low speed protection over here.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1545:37 CAM	[sound similar to crewmember seat movement]		
1545:40 HOT-2	okay you want slats extend?		
1545:42 HOT-1	slats extend please.		
1545:44 CAM	[sound similar to flaps/slats handle movement]		
1545:55 CAM	[sound of click]		
1545:58 HOT-1	I'm gonna have to have you give me headings and altitudes and I'm just flying this airplane ...		
1546:01 CAM	[sound similar to crewmember seat movement]		
1546:02 HOT-1	...so you're kind of flying the approach for my * my eyes on this approach.		
1546:04 HOT-2	okay.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1546:14 CAM	[sound of click]		
1546:17 CAM	[sound similar to CAWS altitude alert]		
1546:19 HOT-2	okay six for five.		
1546:20 CAM	[sound of clicking]		
1546:20 HOT-1	roger.		
1546:22 CAM	[sound of clicking]		
1546:25 HOT-2	you can slow to two fifty. course you show it.		
1546:27 HOT-1	I show two twenty now.		
1546:28 HOT-2	I show two fifty five.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1546:29 CAM	[sound similar to crewmember seat movement]		
1526:30 HOT-1	okay.		
1546:35 HOT-1	I got the throttles all the way back.		
1546:40 HOT-1	I got two fifteen now.		
1546:43 HOT-2	I think you'd * well.		
1546:48 HOT-2	***.		
1547:11 HOT-2	looking good here looking good.		
1547:15 CAM	[sound similar to CAWS altitude alert]		
1547:17 HOT-2	getting a little low.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1547:30 HOT-1	# these lights. get rid of that for me		
1547:32 HOT-2	it's just the config page keeps coming up.		
1547:50 HOT-1	why'd we get an altitude disagreement too?		
1547:58 HOT-1	I got an altitude over here. one oh zero zero eight is the altimeter?		
1547:56 HOT-2	yep.		
1547:58 HOT-1	is it three zero zero. what what he'd give it to us in millibars? what he give it to.		
1548:01 HOT-2	no we got it in.		
1548:02 HOT-1	say the altimeter.		
1548:03 HOT-2	I'll find out again.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
		1548:05 RDO-2	Subic approach FedEx eight seven. request altimeter setting.
		1548:09 APR	roger QNH one zero zero eight.
1548:11 HOT-1	one zero zero eight.		
		1548:12 RDO-2	one zero zero eight FedEx eight seven.
1548:20 HOT-1	what do you show on speed?		
1548:22 HOT-2	I show two thirty eight.		
1548:25 HOT-1	let's go flaps fifteen.		
1548:26 CAM	[sound similar to flaps/slats handle movement]		
1548:27 HOT-2	flaps fifteen.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1548:45 HOT-2	I would say we could select another CADC...		
1548:47 CAM	[sound similar to CAWS altitude alert]		
1548:47 HOT-2	... or something but I don't know whose is right.		
1548:49 HOT-1	yes.		
1548:57 HOT-1	try to select yours on it and see what happens.		
1549:00 CAM	[sound of clicks]		
1549:02 HOT-2	okay I'm on yours now.		
1549:03 HOT-1	I got an autopilot.		
1549:06 HOT-2	okay.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
		1549:09 APR	eight seven left ah one four zero descend three thousand. cleared VOR DME zero seven approach...
1549:15 HOT-1	heading one four zero.		
		1549:15 APR	...report OLONG commencing.
		1549:17 RDO-2	out of five for three thousand FedEx eight seven.
1549:22 HOT-2	I'll put it up on your side.		
1549:24 HOT-1	cleared for the VOR approach?		
1549:24 HOT-2	okay you got it... yeah.		
1549:27 HOT-1	okay I'm gonna hit nav.		
1549:31 HOT-2	two oh five. two oh five. okay we seem to be back in business.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1549:36 CAM	[sound of clicks]		
1549:57 HOT-1	we're how far outside of that are we? we got now.		
1550:00 CAM	[sound of clicks]		
1550:02 HOT-2	what do you mean?		
1550:04 HOT-1	I wonder what what that was for.		
1550:07 HOT-1	I don't want us to intercept this thing at a ninety degree angle is what I'm trying to say. flaps twenty eight.		
1550:12 HOT-2	flaps twenty eight.		
1550:14 CAM	[sound similar to flaps/slats handle movement]		
1550:20 CAM	[sound similar to CAWS altitude alert]		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1550:24 HOT-2	okay four for three. need to do approach check.		
1550:27 CAM	[sound similar to movement in cockpit]		
1550:32 HOT-2	briefing. altimeters one zero zero eight. minimums seven hundred baro. radios... I got Subic. approach check complete.		
1550:46 CAM	[sound of three thumps]		
1550:49 CAM	[sound of two thumps]		
1550:51 HOT-1	let's go gear down.		
1550:52 HOT-2	gear down.		
1550:53 CAM	[sound similar to gear handle movement followed by increased background noise]		
1550:57 HOT-1	before landing check.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1550:59 **HOT-2**	what kind of brakes you want?		
1551:00 **CAM**	[sound of snap possibly associated with spoiler handle movement]		
1551:01 **HOT-1**	let's go ah we'll put em on medium for right now.		
1551:07 **HOT-2**	okay course coming across		
1551:10 **HOT-2**	spoilers armed. autobrakes medium. gear down. four green.		
1551:13 **HOT-1**	flaps thirty five.		
1551:17 **CAM**	[sound similar to flaps/slats handle movement]		
1551:18 **HOT-2**	gear down. four green?		
1551:20 **HOT-1**	it's checked.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1551:21 HOT-2	standing by flaps. still want fifty?		
1551:23 CAM	[sound similar to movement in cockpit]		
1551:23 HOT-1	ah yes I do.		
1551:35 HOT-1	cross check my ah distances with me when we get...		
1551:36 HOT-2	okay... yep...		
1551:37 HOT-1	...up here so that we get the proper altitudes.		
1551:37 HOT-2	okay you're cleared below three thousand now. down to twenty two fifty.		
1551:39 HOT-1	okay		
1551:39 HOT-2	you're prof.		

INTRA-COCKPIT COMMUNICATION UTC SOURCE	CONTENT	AIRCRAFT-TO-GROUND COMMUNICATION UTC SOURCE	CONTENT
1551:41 **HOT-1**	prof... thank you.		
1551:41 **HOT-2**	prof.		
		1551:44 **RDO-2**	FedEx eight seven established on VOR seven.
1551:46 **HOT-1**	down to what?		
		1551:47 **APR**	FedEx eight seven continue approach...
1551:48 **HOT-2**	twenty two fifty.		
		1550:50 **APR**	... contact tower one one eight decimal two.
		1551:52 **RDO-2**	eighteen two FedEx eight seven.
1551:54 **HOT-2**	once you get inside here.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1551:56 HOT-1	we can go down to twenty two fifty now?		
1551:58 HOT-2	yeah.		
1551:59 HOT-1	it's not going down. that's why I've got prof on here for some reason.		
1552:03 HOT-2	okay. you can. you're cleared down to fifteen hundred now.		
1552:06 CAM	[sound similar to increasing and decreasing engine RPM]		
1552:07 HOT-1	I've got none of that. down to fifteen hundred now?		
1552:08 HOT-2	fifteen hundred.		
1552:12 CAM	[sound of click]		
		1552:16 RDO-2	Tower FedEx eight seven is on VOR seven.

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1552:16 CAM	[sound of snap]		
		1552:24 TWR	FedEx ah eight seven ah check gears. clear to land runway zero seven. wind calm.
		1552:32 RDO-2	wind calm Fed Ex eight seven.
1552:36 HOT-2	okay fifteen hundred by six. DME. we're inside six. down to seven fifty.		
1552:43 HOT-1	put it on there.		
1552:46 HOT-2	okaay. why doesn't it want to do it. seven fifty.		
1552:59 HOT-1	# speeds all over the place with this thing.		
1552:57 HOT-2	isn't the autothrottle working now?		
1553:00 HOT-1	well I mean it it it's just jumping everywhere. the tape's jumping.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1553:01 HOT-2	okay seven fifty til three DME.		
1553:06 CAM	[sound similar to activation of windshield wipers]		
1553:07 CAM	[sound of clicks]		
1553:07 HOT-2	okay I got lights up there.		
1553:10 CAM	[sound similar to windshield wiper motion continues until end of recording]		
1553:11 HOT-1	okay... thank you.		
1553:14 HOT-2	twelve hundred.		
1553:20 CAM	one thousand [GPWS synthesized voice]		
1553:23 HOT-1	one thousand feet CAT one.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1553:26 HOT-1	*.		
1553:27 HOT-2	okay down to seven hundred.		
1553:28 HOT-1	down to seven hundred.		
1553:33 HOT-2	we're standing by flaps.		
1553:34 HOT-1	flaps fifty.		
1553:35 HOT-2	flaps coming to fifty.		
1553:36 CAM	[sound similar to flaps/slats handle movement]		
1553:37 HOT-1	I want you to bug my heading around for me when we get up here.		
1553:41 HOT-1	so that you're gonna when you pick up the runway I'm staying on these gauges here for a little while.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1553:45 HOT-2	okay don't go below seven hundred.		
1553:46 HOT-1	I'm not gonna go below seven.		
1553:47 HOT-2	huh?		
1553:48 HOT-1	I'm not going below seven.		
1553:49 HOT-2	okay.		
1553:50 HOT-1	not til you pick up the runway.		
1554:01 HOT-2	okay I got the end of the runway.		
1554:01 HOT-1	I got the runway.		
1554:02 HOT-2	okay.		

UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1554:04 HOT-1	going below MDA.		
1554:05 CAM	[sound similar to CAWS autopilot disconnect warning]		
1554:08 HOT-1	flaps fifty. we got 'em?		
1554:09 HOT-2	flaps fifty. oh no they're not working either. I'll bring them back up to thirty five.		
1554:12 CAM	[sound similar to flaps/slats handle movement]		
1554:13 HOT-1	okay.		
1554:16 HOT-2	I reset the speed.		
1554:24 HOT-2	you got a thirteen cross from the right. winds are calm on the ground.		
1554:29 CAM	[sound of a clunk]		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1554:30 HOT-1	max braking. braking max.		
1554:33 HOT-2	okay.		
1554:37 CAM	five hundred [GPWS synthesized voice]		
1554:39 CAM	sink rate... [GPWS synthesized voice]		
1554:40 HOT-2	keep her coming.		
1554:40 CAM	... sink rate. sink rate. sink rate... [GPWS synthesized voice]		
1554:44 HOT-2	winds are calm.		
1554:45 CAM	... sink rate. sink rate. whoop. whoop. pull up. sink rate... [GPWS synthesized voice]		
1554:51 CAM	one hundred [GPWS synthesized voice]		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1554:52 CAM	... sink rate. [GPWS synthesized voice]		
1554:54 HOT-2	keep her coming		
1554:54 CAM	fifty [GPWS synthesized voice]		
1554:54 CAM	forty [GPWS synthesized voice]		
1554:55 CAM	thirty [GPWS synthesized voice]		
1554:57 CAM	twenty [GPWS synthesized voice]		
1554:59 HOT-2	get her down. get her down.		
1555:00 CAM	ten [GPWS synthesized voice]		
1555:01 HOT-2	stop. stop. get on the runway.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	CONTENT	UTC SOURCE	CONTENT
1555:04 CAM	[sound of increased background noise similar to touch down]		
1555:06 CAM	[sound similar to spoiler handle movement]		
1555:09 CAM	[sound similar to increased engine rpm]		
1555:10 HOT-2	*.		
1555:11 HOT-2	put (it)/(her) all the way		
1555:13 HOT-2	max. is it max?		
1555:16 HOT-2	god... help us.		
		1555:21 TWR	eight seven. right when able. taxi on charlie *.
1555:25 HOT-2	oh my god.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
UTC SOURCE	**CONTENT**	**UTC SOURCE**	**CONTENT**
1555:25 **CAM**	[sound similar to several impacts]		
1555:29 **End of Transcript**			
1555:29 **End of Recording**			

Unreliable airspeed/Mach, vertical speed and altitude information can be caused by pitot static system or air data computer (CADC) malfunctions. This may or may not be accompanied by Level 1 and Level 2 alerts, autopilot/autothrottle disconnects and/or instrument failure indications. These malfunctions can have several causes, including pitot-static blockage, volcanic ash, system damage, loss or damage to the radome, ice accumulation, and improper maintenance. Cases where all pitot-static-sources malfunctioned have occurred. When all systems are in error, comparisons are not available and the flight crews are unable to identify the errors.

During takeoff roll, pitot-static or CADC malfunctions may be recognized by abnormal indications at standard airspeed callouts such as "80 knots". In flight recognition occurs by normal monitoring of basic flight instruments and crew familiarity with pitch, power and airspeed relationships.

It is important that the flight crews recognize an unreliable airspeed condition in a timely fashion, and imperative that their initial action is to maintain aircraft control.

Air Data and pitot system malfunctions can result in different EIS alerting system displays or erroneous indications depending on the nature of the cause of the malfunction. Not all malfunctions will be readily obvious or result in specific alerts.

The following are some of the indications the flight crew might see if a malfunction occurs in the pitot-static system or in the CADC:

- Indicated airspeed not consistent with normal pitch attitude for phase of flight
- Indicated altitude different from expected actual altitude
- PITOT HEAT alert, indicating associated pitot heater is OFF
- Amber IAS, ATT, and/or ALT displayed on PFD
- Level 1 and Level 2 alerts such as SEL ELEV FEEL MAN, SEL FLAP LIM OVRD
- Engine FADEC and EPR messages
- Pressurization system problems

1. **AFS OVRD Switches** .... OFF

2. **Aircraft Pitch/Thrust** .... STABILIZE
   Disregard IAS/Flight Director pitch bar and high speed warnings. Use pitch attitude and thrust as the primary flight reference.

NOTE
With autopilot disconnected at altitude, control wheel may seem sensitive in pitch.

3. **Flight Director** .... OFF
   Disregard all alerts and warnings, except stick shaker, until after aircraft is stabilized and [illegible] operations achieved. Alerts and aural warnings can produce conflicting and disorienting [illegible]

NOTE
Initial concern is establishing control of the aircraft through pitch/thrust relation. Attention should not be directed towards responding to malfunction alerts until safe flight is assured.

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CAUTION

Under certain failures FPA and PLI may be unreliable. Check against primary flight references before using PLI or FPA.

4. **If Practical Fly To V_{MC} At Earliest Possible Opportunity.**

5. **After The Aircraft Is Safely Stabilized In Flight, Ensure Terrain Avoidance.**

NOTE

Approximately 10 degrees pitch attitude and MCT thrust will provide a safe initial climb condition if a climb is required.

6. **Compare Pilot And Standby Flight Instruments.**

7. **If Able To Identify Unreliable Air Data Source:**

   A. CADC (Unreliable Side) .... SELECT TO OTHER SIDE

   B. Static Source (Unreliable Side) .... ALT

   C. Continue to monitor pitch, thrust, and airspeed to insure accuracy of selected instruments. If air data returns to normal, select AFS OVRD OFF switches, autopilot and auto throttles as desired.

(End of Procedure)

8. **If NOT Able To Identify Unreliable Air Data Source:**

   A. Attitude and Thrust .... ADJUST

   B. Maintain normal pitch attitude and thrust for the phase of flight.

NOTE

The following information and displays can be considered reliable: PFD attitude, Ground speed readout, Engine N_1 and Stickshaker.

The following may or may not be reliable depending on the cause of lost or suspect airspeed (Radio NAV may be required when referring to these instruments): FPA, PLI, Low Speed Pitch Protection, IVSI, Altimeter, FMS NAV and Altitude reporting including TCAS.

The following will not be reliable: Auto Throttle Speed Protection, High Speed Pitch Protection, Overspeed Warning.

   C. Use the following AIRSPEED; LOST, SUSPECT OR ERRATIC tables to determine thrust/pitch relation for remainder of flight.

(CONTINUED)

NOTE

IAS and V_S values in the following table are approximate values.

FLIGHT PHASE	CONFIG	PRESSURE ALTITUDE	REF	WEIGHT (1000 LBS) 450	550	600	630
CLIMB	UP/RET	5000	PITCH	14	11.6	10.5	9.5
			IAS	250	275	288	299
Use max thrust (throttles to overboost bar)		FL 100	PITCH	12.5	10	8.5	8
			IAS	251	285	302	311
		FL 150	PITCH	10.5	8	7	6.5
			IAS	260	296	312	321
		FL 200	PITCH	8.5	6.5	5.5	5
			IAS	270	305	322	331
CRUISE	UP/RET	FL 100	PITCH	2	3	3	2.5
			N1	76.7	79.1	80.3	81.1
			IAS	330	330	330	330
Use N1 for thrust setting		FL 200	PITCH	2	2.5	3	3
			N1	83.6	86.1	87.4	88.3
			IAS	330	330	330	330
		FL 300	PITCH	2	2.5	3	3
			N1	89.2	92.4	94.3	95.6
			MACH/IAS	.827/.315	.827/315	.827/315	.827/315
		FL 350	PITCH	2	2.5		
			N1	91.3	93.7		
			MACH/IAS	.830/283	.830/283		
DESCENT	UP/RET	FL 350	PITCH	1			
			MACH/IAS	.768/260			
			VS	2030			
Use idle thrust		FL 300	PITCH	1.5	1.5	1.5	
			MACH/IAS	.693/260	.729/275	.760/287	
			VS	1920	2040	2140	
		FL 200	PITCH	1.5	2.5	2.5	
			MACH/IAS	260	260	273	
			VS	1760	1770	1850	
		FL 100	PITCH	2	2.5	2.5	
			MACH/IAS	250	267	281	
			VS	1500	1600	1680	

FLIGHT PHASE	CONFIG	PRESSURE ALTITUDE	REF	WEIGHT (1000 LBS) 350	400	450	480
ARRIVAL LVL FLT	UP/RET	5000	PITCH	5	5	5	5
			N1	58.9	62.3	65.5	67.3
			IAS	221	236	250	258
	0/EXT	3000	PITCH	8.5	8.5	8.5	8.5
			N1	61.5	65.1	68.4	70.3
			IAS	182	194	205	211
Use N1 for thrust setting	0/EXT	1500	PITCH	8.5	8.5	8.5	8.5
			N1	60.3	63.9	67.2	69.1
			IAS	[illegible]	194	205	211
	15/EXT	[illegible]	PITCH	6	[illegible]	6	6
			N1	63.5	67.[illegible]	70.6	72.3
			IAS	174	185	196	202
	28/EXT	1500	PITCH	4	4	4.5	4.5
			N1	68.9	72.8	76.2	78.1
			IAS	168	179	189	195
APPROACH IAS APPROX Vref + 15 Use N1 for thrust setting	35/EXT GEAR DOWN	DESCENT	PITCH	2.5	2.5	2.5	2.5
			N1	60.5	64	67.1	68.8
			IAS	153	162	171	176
			Maintain pitch and adjust power to maintain glide path.				
GO AROUND	28/EXT GEAR UP	SEA LVL	PITCH	20	20	19.5	18
			IAS	180	172	171	176
		5000	PITCH	20	18.5	16.5	15.5
			IAS	160	162	171	177

NOTE

IAS and V_S values in the following table are approximate values.

FLIGHT PHASE	CONFIG	PRESSURE ALTITUDE	REF	WEIGHT (1000 LBS) 450	550	600	630
CLIMB	UP/RET	5000	PITCH IAS	13 250	10.5 275	9.5 288	9 299
Use max thrust (throttles to overboost bar)		FL 100	PITCH IAS	11.5 251	9 285	8 302	7.5 311
		FL 150	PITCH IAS	9.5 260	7 296	6.5 312	6 321
		FL 200	PITCH IAS	7.5 270	5.5 305	5 322	4.5 331
CRUISE	UP/RET	FL 100	PITCH N1 IAS	2 70.5 330	3 72.9 330	3 74.1 330	3.5 74.8 330
Use N1 for thrust setting		FL 200	PITCH N1 IAS	2 77.7 330	2.5 80.2 330	3 81.5 330	3 82.3 330
		FL 300	PITCH N1 MACH/IAS	2 83.5 .862/.315	2.5 86.5 .862/315	3 88.6 .862/315	3 90.2 .862/315
		FL 350	PITCH N1 MACH/IAS	2.5 85.4 .830/283	3 88.5 .830/283		
DESCENT	UP/RET	FL 350	PITCH MACH/IAS VS	1.5 .768/260 1960	1.5 .782/265 2050		
Use idle thrust		FL 300	PITCH MACH/IAS VS	1.5 .693/260 1930	1.5 .729/275 2080	1.5 .760/287 2150	
		FL 200	PITCH IAS VS	1.5 260 1760	1.5 260 1810	1.5 273 1920	
		FL 100	PITCH IAS VS	2 250 1510	2.5 267 1620		

FLIGHT PHASE	CONFIG	PRESSURE ALTITUDE	REF	WEIGHT (1000 LBS) 350	400	450	480
ARRIVAL LVL FLT	UP/RET	5000	PITCH N1 IAS	5 55.2 221	5 58.3 236	5 61 250	5 62.5 258
	0/EXT	3000	PITCH N1 IAS	8.5 51 182	8.5 60 194	8.5 62.9 205	8.5 64.5 211
Use N1 for thrust setting	0/EXT	1500	PITCH N1 IAS	8.5 56.1 182	8.5 59.1 194	8.5 61.8 205	8.5 63.5 211
	15/EXT	1500	PITCH N1 IAS	6 58.5 174	6 61.7 185	6.5 64.8 196	6.5 66.4 202
	28/EXT	1500	PITCH N1 IAS	4 63.3 168	4 66.8 179	4.5 70.3 189	4.5 72.1 195
APPROACH IAS APPROX Vref + 15 Use N1 for thrust setting	35/EXT GEAR DOWN	DESCENT	PITCH N1 IAS	2.5 55.7 153	2.5 58.8 162	2.5 61.7 171	3 63.3 176
			Maintain pitch and adjust power to maintain glide path.				
GO AROUND	28/EXT GEAR UP	SEA LVL	PITCH IAS	20 175	20 168	18.5 171	17.5 176
		5000	PITCH IAS	20 158	18.5 162	16.5 171	15 176

(CONTINUED)

D. When ready for approach and landing,

- Maintain VMC.
- Establish landing configuration early.
- Use IRS ground speed and reported winds to verify airspeed.
- Use radar altimeter.
- Use a runway with electronic or visual glideslope.

(End of Procedure)

AIR DATA SYSTEM

GENERAL

The air data system consists of pitot and static air lines, two total air temperature (TAT) sensors, angle of attack (AOA) sensors, two central air data computers (CADC), and one standby altimeter/airspeed indicator.

NOTE

Federal Express has an optional third CADC installed as a backup to either the Captain's CADC or the First Officer's. The third CADC is not powered until selected with a selector on the maintenance panel. The third CADC is connected to the auxiliary pitot tube and the alternate static port.

Baroset data is received from the glareshield control panel (GCP). Wing tip fuel quantity data is received from the fuel quantity gauging system (FQGS) for VMO computation. The primary air data displays are part of the electronic instrument system (EIS).

Three pitot tubes (Captain's, First Officer's and auxiliary) sense aircraft pitot (impact) pressure and route it to the two CADCs and the standby altimeter/airspeed indicator.

The four static ports sense the static (outside air) pressure and route it to the two CADCs, standby altimeter/airspeed indicator and the avionics fan control pressure switch.

The TAT sensors (one per CADC) provide electrical resistance proportional to the outside air temperature to the CADCs. The CADCs then calculate the temperature.

The AOA sensors provide angle of attack data to the CADCs.

The GCP sends baroset data to the CADCs for the calculation of baro corrected altitude.

The FQGS sends wing tip fuel quantity data to the CADCs for calculation of VMO/MMO.

The CADCs compute and output airspeed, Mach number, altitude, maximum airspeed, vertical speed, TAT, static air temperature, AOA, TAS, and pressures (pitot, impact, and static).

Static source (position) errors and AOA effects air corrected in each CADC. TAT is corrected for anti-ice heater effects.

PNEUMATIC SYSTEM

The Captain's pitot tube is connected to CADC 1 and the First Officer's pitot tube is connected to CADC Td2. The auxiliary pitot tube is connected to the standby altimeter/airspeed indicator.

Two static plates with four static ports each are installed. The plates are symmetrically located on each side of the aircraft. A port from each side is provided for the Captain's static pressure system and the First Officer's static pressure system. The other ports are spares.

Each pilot port is cross connected to minimize errors caused by aircraft yaw. The Captain's ports are connected through the Captain's STATIC AIR selector to CADC 1. The First Officer's ports are connected through the First Officer's STATIC AIR selector to CADC 2.

The alternate static pressure system has two flush ports symmetrically located on each side of the aircraft at some distance from the static plates. The ports are cross connected to minimize errors and are connected to the standby altitude/airspeed indicator and both STATIC AIR selectors.

The STATIC AIR selectors allow the pilots to switch the source of static pressure for their respective CADCs from their normal ports to the alternate port.

AIR DATA SENSOR HEATER SYSTEM

The air data sensor heater system consists of integral heating elements within the pitot tubes, AOA sensors, and the TAT probe. Heaters are also mounted to the static pressure ports.

All of the heating elements are controlled by the miscellaneous systems controller (MSC). In addition the TAT probe heater circuit is wired to a ground/air sense relay which opens the circuit when the aircraft is on the ground.

Each pitot tube heater contains two elements which may be powered individually or in series. When on the ground, the elements are placed in series to reduce their power dissipation and prolong their life.

The TAT probe and AOA sensors each contain a single heating element. On the ground, the TAT probe heater is not powered and the AOA heaters operate from 28-volt ac. In the air, the AOA heaters operate from 115-volt ac.

All static pressure port heaters contain dual heater elements, one of which is controlled by an integral thermal switch.

The MSC controls the operation of the heaters, monitors heater currents, and provides appropriate alerts to the flight crew in case of heater malfunctions.

AIR DATA PARAMETERS

The following parameters are output by the CADCs:

- Standard altitude.
- Captain's baro-corrected altitude.
- First Officer's baro-corrected altitude.
- Computed airspeed.
- Mach number.
- Altitude rate.
- Maximum operating speed.
- True airspeed.
- Total air temperature.
- Static air temperature.
- Overspeed discrete.
- Total pressure.
- Static pressure.
- Impact pressure.
- Indicated angle of attack.
- Captain's baro-correction.
- First Officer's baro-correction.

The following aircraft systems use the CADC outputs:

- Flight control system.
- Flight management system (FMS).
- Electronic instrument system (EIS).
- IRUs.
- FADEC.
- ATC transponders.
- CAWS.
- GPWS.
- Cabin pressure controllers (CPC).
- Digital flight data acquisition unit

STANDBY ALTIMETER/AIRSPEED INDICATOR

A standby altimeter/airspeed indicator is installed on the standby instrument panel below the GEAR lever. It consists of two separate mechanisms housed in a singl sealed case.

The standby altimeter is an aneroid instrument and functions without electrical power.

The standby airspeed indicator is a pitot/static instrument connected to the auxiliary pitot system and operates without electrical power.

Altitude data is presented by means of a pointer reading against a circular dial and height counters. Ground pressure is shown by two counters, one in millibars and one in inches of mercury. They are visible through cutouts in the main dial.

A knob in the lower left hand corner of the case bezel provides the means of setting the ground pressure counter. It will simultaneously apply a correction to the altitude counter pointer.

Airspeed data is presented by means of a graduated drum reading against a fixed datum and visible through a cutout in the lower part of the main dial.

The instrument is integrally illuminated by lamps in a lamp board mounted behind the main dial.

STANDBY ATTITUDE INDICATOR

A standby attitude indicator is installed on the standby instrument panel below the GEAR lever. It is a self-contained, electrically-operated gyroscope that turns around a vertical axis. It operates on 22-volts ac 400-Hz power from a static inverter. An OFF flag comes into view when there is a power failure.

STANDBY COMPASS

A direct reading standby magnetic compass is installed in the cockpit. It is magnetically compensated to read within plus or minus 10 degrees error on all aircraft headings.

Attachment L:

FedEx Management E-mail and Newsletter information Related to MD-11 Airspeed Anomalies, Issued Before Subic Bay Accident

Flight Standards &Technical News

MD-11 NEWSLETTER

MD-11 Flight Manual
Revision 28 .... 30 June 1998
Bulletins 97-01
Temporary Revisions .... None

Flight Standards
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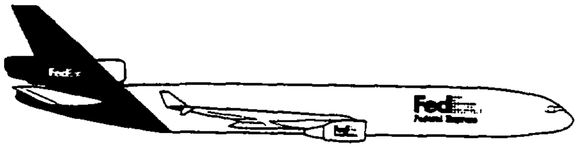
Flight Standards

Operation with Invalid or Suspect Airspeed

Recently Boeing, Long Beach Products Division, came out with a Flight Operations Bulletin that addresses some incidents that have occurred that resulted in operation with an invalid or suspect airspeed. The bulletin information will be added to Chapter 4 of the flight manual. The text of the bulletin follows:

Two MD-11 operators have reported incidents that resulted from contaminated or blocked pitot tubes. In addition, pitot-static problems are believed to have been casual factors in the recent loss of two transport aircraft, and may have contributed to the loss of a third. In the two MD-11 incidents above, investigators discovered that all three pitot systems were contaminated with water, and that the drain holes provided to allow drainage were plugged with debris; in both cases the airspeed displayed to the flight crew was considerably lower than the actual speed at which the aircraft was flying.

Unreliable airspeed, altitude and/or rate of climb indications, regardless of cause, will affect all aircraft systems that require air data input for normal operation. There is



no dedicated alert to tell the crew of air data failure. PFD changes, autoflight disconnects, unwarranted speed protection, speed/altitude miscompare signals and alerts from systems requiring valid air data input such as autotrim, elevator feel, GPWS, TCAS and pressurization may warn the crew that something is wrong, but do not establish exactly what system is the root fault. In fact, system alerts from erroneous air data can distract the crew from recognizing the primary reason for the display of the alerts.

It is important for the flight crew to recognize an unreliable airspeed quickly, and imperative that their initial action be to maintain aircraft control. Because the symptoms of pitot-static degradation may be different in each case, and because of the confusion caused by multiple, often conflicting alerts and warnings, the flight crew may not recognize an air data error or intuitively initiate a proper response.

As a result of the recent MD-11 events, Boeing has conducted an in-depth review of the flight characteristics and cockpit indications that the flight crew may experience following an air data malfunction, and has developed guidelines to help recognize erroneous airspeed, altitude and/or rate-of-climb indications. Recommendations that can dispel confusion and provide guidance for control of the aircraft follow:

-- Pitch attitude and thrust relationship is the key to recognizing air data problems. If air data presentation on the PFD is suspect, DISREGARD INDICATED AIRSPEED and verify that the aircraft pitch attitude and engine thrust are consistent with the phase of flight. When the PFD flight indications are not accurate, the pitch attitude will be different than expected for a given configuration. Indicated airspeed and/or vertical speed may not be realistic, overspeed warnings may occur during low power settings or stick shaker activation under conditions of high indicated airspeed. If the flight instruments are in error, disconnect the autopilot and autothrottles and manually establish the proper attitude and thrust. Flight crews should be familiar with the pitch/thrust relationship for their aircraft throughout the normal phases of flight.

-- Once it has been determined that the aircraft is in stable flight, make sure that the flight is clear of any possible terrain conflict. For the MD-11, 10 degrees nose up and MCT thrust will provide a positive climb gradient at all operating weights.

-- If practical, obtain VFR conditions.

-- With the aircraft stabilized and terrain clearance assured, refer to the existing AIRSPEED: LOST, SUSPECT OR ERRATIC checklist.

PLI and FPA: The Pitch Limit Indicator (PLI) is normally a good indication of the aircraft pitch attitude relative to stickshaker, and can assist crew awareness when flying at low airspeeds or high angles of attack. The PLI requires, however, an airspeed input from the CADC in computing its position on the PFD; if there is a miscompare between the Calibrated Air Speed (CAS) determined by CADC number 2, the PLI will be removed from the PFD. If both the Captain's and Copilot's CAS indicate the same, but are in error (equal damage or contamination of both pitots), the PLI will be displayed on the PFD, but will not indicate an accurate relationship between aircraft attitude and stickshaker activation.

The Flight Path Angle (FPA) can also be of help in establishing the aircraft's vertical track when reliable indicated airspeed is not available. The FPA requires vertical speed input from the CADC in order to compute the flight path angle, however, and an error in the vertical speed output from the CADC will cause a comparable error in the FPA.

Although both the PLI and the FPA can greatly assist the flight crew in monitoring aircraft performance, they must be cross checked against the primary references, i.e. pitch and thrust, to verify proper aircraft performance.

Tech Support

FMS POSITION, Part 3-Inertial Abnormals.

Nothing on the MD-11 is more fundamentally complicated than the inertial navigation system. Yet, nothing is so carefree and reliable. And, nothing can dig you into a hole with so little obvious warning. Let's review how to avoid FMS problems, and how to take care of the abnormals that may occur. Below is a summary of all the FMS position abnormals; read and compare all the messages, alerts, and other procedures that pertain to FMS position.

NOTE

This review is general background information only. Use only Flight Manual procedures in-flight.

PREFLIGHT

- Double-check correct FROM airport ICAO 4-letter on the F-PLAN INIT page.
- Check lat/long before you activate it at the INITIALIZE IRS * prompt.
- Enter something wrong? Get back to the INITIALIZE IRS * prompt with good data and reactivate. That may require turning off the IRUs and starting over. (See part 1.)
- Flight Plan check on the ND PLAN mode - Start by checking your aircraft symbol is sitting at the correct airport symbol before you slew through the Flight Plan.
- Before Start: "IRS" - "Aligned". Don't only look up at the IRS lights. Look down on the PFD for extra info. "0 Taxi" means IRUs are aligned, (NAV OFF lights OUT), and not drifting.
- Enter the takeoff runway in the MCDU. The FMS gets its Takeoff Update; the magenta steers you accurately to the course, and the Enhanced GPWS (TAWS) steers you away from the terrain (a new feature coming soon).

In-flight

- Radio Navaid Position Cross-Check (FMS Position vs. Raw Data)-A check before coast-out. Manually tune an off-track VOR, and enter it on the FIX page. Compare the ND raw data bearing/distance to the FMS FIX bearing/distance. Clear entries.
- Inertial Cross-Check - (IRUs vs. each other)-An optional check before coast-out. REF page: > POS REF. Page 1: FMS vs. IRS. Page 2: IRUs
- DESELECT Navaid-Prevent a Map Shift: Deselect an unreliable VOR so it can't be used for a Radio Navaid Update. From REF page, select NAVAID. Enter navaid ID in DESELECT box. FedEx permanently deselects (blackballs) historically troublesome VORs from the FMS (e.g., Subic Bay).
- MAP SHIFT-Navaid raw data disagrees with FMS data. (VOR bearing pointer doesn't point to VOR symbol. DME disagrees with ND range ring.) From REF page, select POS REF, page 2. Check for drifting IRU: REF page > POS REF, page 2.
- Regain situational awareness. Consider FMS Position Update (see flight manual chapter 4 procedure).

Below are all the FMS Position lights, messages and alerts in one place, to help you see the "big picture":

<u>NAV OFF lights</u>

Steady NAV OFF for:

- IRU is OFF.
- IRU is in Align Mode.
- IRU failure.

Flashing NAV OFF during alignment for:

- NO present position.
- BAD present position.
- MOVEment during initialization

Date: Monday, 14 September 1998 5:38pm ET
To: MD11-Hot-Topics, LCATOPICS-E-MD11
From: SWAH/RYAN
Subject: CAT I ILS Approach

What does a CAT I approach with the note "Special Aircrew and Aircraft Certification Required" mean?

ANSWER: For CAT I ILS approaches with lower minimums (i.e., minimums lower than normally used for the specific approach in question, not necessarily lower than 2400 RVR) labelled "Special Aircrew and Aircraft Certification Required", use of an autocoupled, monitored approach is mandatory. Autoland is recommended.

An example of this is Detroit ILS Rwy 21R. Normally the approach minimum is 250 feet with an RVR of 5000 required. There is a lower minima of 200 feet with an RVR of 2400 required with a note that states "Special Aircrew and Aircraft Authorization Required." All FedEx crews comply with this note and are allowed to fly to the lower minima.

Ryan Swah

Date: Monday, 14 September 1998 6:14pm ET
To: MD11-Hot-Topics, LCATOPICS-E-MD11
From: SWAH/RYAN
Subject: Operation with Invalid or Suspec

Recently Boeing came out with a Flight Operations Bulletin that addresses some incidents that have occurred that resulted in operation with an invalid or suspect airspeed. The bulletin information will be added to Chapter 4 of the flight manual and will be a SIA article. The text of the bulletin follows:

"Two MD-11 operators have reported incidents that resulted from contaminated or blocked pitot tubes. In addition, pitot-static problems are believed to have been casual factors in the recent loss of two transport aircraft, and may have contributed to the loss of a third. In the two Md-11 incidents above, investigators discoverd that all three pitot systems were contaminated with water, and that the drain holes provided to allow drainage were plugged with debris; in both cases the airspeed displayed to the flight crew was considerably lower than the actual speed at which the aircraft was flying.

Unreliable airspeed, altitude and/or rate of climb indications, regardless of cause, will affect all aircraft systems that require air data input for normal operation. There is no dedicated alert to tell the crew of air data failure. PFD changes, autoflight disconnects, unwarranted speed protection, speed/altitude miscompare signals and alerts from systems requiring valid air data input such as autotrim, elevator feel, GPWS, TCAS and pressurization may warn the crew that something is wrong, bu do not establish exactly what system is the root fault. In fact, system alerts from erroneous air data can distract the crew from recognizing the primary reason for the display of the alerts.

The Flight Path Angle (FPA) can also be of help in establishing the aircraft's vertical track when reliable indicated airpseed is not available. The FPA requires vertical speed input from the CADC in order to compute the flight path angle, however, and an error in the vertical speed output from the CADC will cause a comparable error in the FPA.

Although both the PLI and the FPA can greatly assist the flight crew in monitoring aircraft performance, they must be cross checked against the primary references, i.e. pitch and thrust, to verify proper aircraft performance."

Ryan Swah
Manager, MD11 Flight Standards/Technical Support
901/224-5360
———(end of letter)——————————

Date: Tuesday, 15 September 1998 1:57pm ET
To: MD11-Hot-Topics, LCATOPICS-E-MD11
From: SWAH/RYAN
Subject: penalty for carrying extra fuel

How much fuel do you burn to carry fuel? Here is a simple formula that provides the answer.

4% per 1000 pounds per hour equals amount of fuel burned to carry a given amount of fuel.

For example, if you add 10,000 pounds of extra fuel and your flight is 8 hours long, you will burn 3200 pounds of fuel to carry the extra fuel.

4% times 10,000 equals 400 times 8 hours equals 3200 pounds.

Ryan Swah
Manager, MD11 Flight Standards/Technical Support
901/224-5360
———(end of letter)——————————

January 16, 1975
C1-750-08/COM PROGRAMS
10-34-00-01
AOL 10-758

TO: All DC-10 Operators

SUBJECT: DC-10 ROSEMOUNT PITOT TUBES, P/N 851DK, PERIODIC INSPECTION AND CLEANING

APPLICABLE TO: All Series DC-10 Aircraft

REFERENCE: C1-750-TWX-452/COM PROGRAMS dated 12-20-74

Gentlemen:

We have received a report from a DC-10 operator of one occurrence of a 30-knot airspeed error displayed on the Captain's mach/airspeed indicator during descent from 26,000 feet to 7,000 feet through a rain squall. The problem was subsequently traced to rain water accumulation in the No. 1 pitot system piping induced by blockage of the pitot tube water drain holes. The unit was returned to Douglas where the problem was identified as a manufacturing anomaly where silver braze material was inadvertently deposited around the drain hole during vendor production. A visual inspection of the drain hole will not determine whether this condition exists.

Douglas transmitted a request by the referenced TWX to all DC-10 operators requesting a fleet inspection as early as possible for this condition. The results of this inspection to date have shown that in addition to the one discrepant pitot tube originally reported by one operator, we have reports of eleven additional pitot tubes with plugged water drain holes. However, in each of these instances, the blocked water drain holes were caused by an accumulation of debris from the aircraft operating environment and were cleared by applying reverse air pressure through the pitot tube. Douglas, therefore, recommends a periodic inspection and cleaning of DC-10 pitot tubes during "C" maintenance checks to be performed as follows:

PERIODIC PITOT TUBE DRAIN HOLE CHECK

1. Ensure that pitot anti-ice heater is "OFF" if unit is installed on aircraft and that the pitot tube is not "HOT".

2. Connect air pressure source of 5 PSI/maximum/or pitot static test set, 450 knots/maximum.

3. Adjust air pressure as noted in Step 2 and check for air flow out of each drain hole by placing a finger alternately over each hole.

All DC-10 Operators

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Page 2

4. Alternate method for pressure check is to attach 9/16 inch inside diameter hose/approximately 3 feet long/to open end of pitot tube. Blow into opposite end of hose and check for air flow out of drain hole as described in Step 3.

   Pitot tubes with suspect or blocked drain holes should be cleared using the following procedure:

   (a) Using a #30 safety wire carefully clear the obstruction from the drain holes.

   (b) Purge the affected pitot system as follows:

      (1) Disconnect pitot terminating lines from affected CADC, EPR transducer and/or standby airspeed indicator and cap fittings.

      (2) Connect purging nitrogen source to pitot line at affected CADC or standby airspeed indicator if no third CADC is installed. Caution: Secure flexible pressure lines to prevent whipping movement when pressure is applied.

      (3) Apply dry nitrogen purge for a period of three minutes, regulate pressure to 25 PSI and do not exceed 30 PSI.

      (4) Check for flow out of each drain hole by placing a finger alternately over each hole.

      (5) If blockage is cleared conclude purging operation, return system to normal configuration.

      (6) If blockage or suspected blockage persists, remove and replace the pitot tube.

5. Perform system leak test on applicable pitot system.

   NOTE: If removed pitot tubes with blocked drain holes show evidence of oil or grime residue, the unit should be soaked in "Stoddard" solvent and should then be purged with high pressure (45 PSI maximum) air applied to the drain holes and outlet strut. This procedure should be repeated as necessary to clear the tube of blockage.

Douglas requests that DC-10 operators keep us advised, on a continuing basis, of any pitot tube blockage problems encountered.

All DC-10 Operators

January 16, 1975
C1-750-08/COM PROGRAMS
10-34-00-01
AOL 10-758
Page 3

The procedures for inspection and cleaning of pitot tubes described in this AOL will be incorporated into the next revision of the DC-10 Maintenance Manual scheduled for April 1, 1975.

Very truly yours,

McDonnell Douglas Corporation

R. H. Luke, Director
Product Support
Commercial Programs
Douglas Aircraft Company

JFT:dhs

MCDONNELL DOUGLAS

Douglas Aircraft Company

Flight Operations Bulletin

June 17, 1997
ATA: 11-34-11-00,
Bulletin No. MD-11-97-04

Applicable to: *All MD-11 Aircraft*

Subject: OPERATION WITH ERRATIC AIRSPEED

One MD-11 Operator has reported an occurrence during which all cockpit Indicated Airspeed Indications (IAS) became erroneous, accompanied by airframe vibration, incorrect/inappropriate Primary Flight Director (PFD) pitch guidance information, and anomalous Alerts and Aural Warnings. The cause of this phenomena was traced to incorrect output information from both Air Data Computers (ADCs) resulting from contaminated pitot static systems. The vibration was due to an airspeed in excess of the flap/slat configuration limit speed. When erratic and or invalid indications affect all cockpit airspeed instrumentation, they may also impact Total Pressure (TP), Static Pressure, Pressure Altitude, and Total Air Temperature indications.

Any discussion on erratic airspeed must include the following questions:

(1) What is the effect on aircraft operations?

(2) What are the recommended flight procedures?

(3) Does the effect on aircraft operation differ from "SEVERELY DAMAGED... RADOME AND/OR SUSPECT AIRSPEED INDICATION" procedure currently in use?

Invalid airspeed can occur from a variety of causes: contaminated pitot static system, plugged static ports, internal system leaks, foreign object damage, etc. The quality of pitot static input to the ADCs, and the resultant impact on airspeed indications can vary greatly depending on the type and degree of damage or malfunction, on the number of pitot static systems compromised, and the vertical movement of the aircraft at the time the damage/malfunction occurred. Indications to the flight crew may be confusing and contradictory, often accompanied by alerts, autoflight disconnects, unusual flight director information, apparently anomalous engine performance and

[redacted]

[redacted]

other indications that may add to the difficulty of evaluating the problem. The recent loss of two aircraft and damage to a third may be attributable to this type of failure.

Pitot static problems may cause erroneous outputs or complete failure from one or more ADCs. When an ADC fails, the associated Primary Flight Displays will display a red "X", indicating that the displayed information is unusable: under these conditions, selecting another ADC will resolve the display problem.

Erroneous ADC outputs are more complex since no clear indication of valid versus invalid data is presented to the crew. With an erroneous output from a single ADC, the crew can usually determine which ADC is faulted by comparing its information against that of the standby instruments. The faulted ADC may then be deselected. However, if more than one ADC, or an ADC and the standby instruments are unreliable, the crew will have trouble deciding which data are correct.

Because of the variety of conditions and effects of pitot static problems, a detailed listing of all possible permutations is not practical. Consequently, the descriptions provided below are generalizations, and may not pertain to all situations. Since the flight crew may not recognize the specific cause for erroneous ADC information, but is able to determine that "something is wrong", the suggested procedures must fit virtually all suspected invalid airspeed situations.

P & W Engines: The FADEC uses Pressure Altitude, Total Air Pressure, and Total Air Temperature from the ADCs in computing engine thrust. When ADCs show conflicting data, or when a primary air data parameter is not available, the FADEC compares the "local" FADEC probe with the ADC. A discrepancy between local (TP) data and ADC data reverts the FADEC to the ALTERNATE mode. Although EPR may be lost or become unreliable, and the use of autothrottles is lost, the engines will continue to perform satisfactorily.

GE Engines: GE engines do not use Total Pressure for thrust computation: Pressure Altitude and Total Air Temperature are used. Even though the FADEC may not be affected within its normal operating range, differences between ADCs and/or indicated airspeeds could cause the FADECs to revert to the ALTERNATE mode. Over boost protection may be lost. The overboost bar will still reflect MCT. Autothrottles may or may not remain operational. Speed on thrust compares the indicated airspeed with the target speed and, with or without autopilot/autothrottle disconnect, may react to an incorrect airspeed.

Cockpit displays: Indicated airspeed will not conform to normal airspeed for the existing combination of aircraft attitude and thrust. "IAS" may appear in the upper left portion of the PFD, indicating a comparitor mis-match between pilot and copilot airspeeds. The autopilot and autothrottles may disconnect. "SELECT FADEC ALTN", "SEL ELEV FEEL MAN", and "SEL FLAP LIM OVRD" alerts may appear. Flight Director bars may bias from view. The speed tape display may be in error, or may disappear if invalid airspeed information is available to the associated ADC. The Pitch Limit Indicator (PLI) is Mach compensated at higher airspeeds, and may default to a lesser compensation factor. At higher actual airspeeds, the PLI position, relative to the aircraft symbol on the PFD, may differ from a normal display. Auto Flap Limit, stab trim speed, LSAS, Elevator Load Feel and other FCC functions that use speed/pressure input will be affected.

FMS Horizontal NAV should remain accurate regarding track and ground speed, however, the display of current winds will be in error. Vertical navigation may be affected depending on the validity of altitude input to the ADC.

Speed Protection: Speed protection includes Autothrottles and LSAS. The PLI indicates the relationship between Angle-of-Attack and Stick Shaker Activation with the Stick Shaker continuing to provide valid warning of an approaching stall. Aural alerts also warn of an overspeed condition. Basically, low speed protection uses indicated airspeed for thrust (autothrottle) and Angle-of-Attack for pitch (LSAS). At higher airspeeds, .5 Mach and above, both the PLI and Stick Shaker are Mach compensated and, with an error in airspeed data, may default to a lesser Mach number. *At lower airspeeds, the PLI indication and Stick Shaker activation are accurate regardless of air data error.* When indicated airspeed is below actual airspeed, autothrottles off, low speed thrust protection could command thrust advance, (IAS, VMIN) even when the aircraft is actually at a safe air speed. Neither LSAS nor Stick Shaker will activate if the actual angle-of-attack is well below the stall angle of attack. High speed pitch/thrust protection, including aural warnings, reacts to indicated airspeed regardless of the actual airspeed. With flaps and/or slats extended, configuration limit speeds may be exceeded, accompanied by aircraft vibration, even though the IAS indicates operation below the limit speeds. When indicated airspeed is above the actual airspeed, LSAS low speed pitch protection and stick shaker will function normally based on Alpha regardless of the high indicated airspeed. Aural overspeed warning may occur, and the throttles may retard if the indicated airspeed reaches VMAX. Thus, with invalid indicated air speeds, conflicts can occur between airspeed indications, speed protection responses and aural warnings.

SEVERELY DAMAGED RADOME/SUSPECT AIRSPEED PROCEDURE COMPARISON: Both aspects have too many variables to draw specific conclusions; such as degree of airstream disruption, extent of pitot blockage, number of pitots affected, integrity of pitot static system, time and type of problem, pilot awareness, etc. Therefore, generic suggested procedures are presented below.

Suggested Procedures: To assess pilot action, first determine what he/she has to work with:

Consider invalid or suspect: Indicated Airspeed, high speed protections including flap limits, pitch bar (except GS and FPA), altitude, low speed thrust protection, speed tape (VMIN, foot) versus indicated airspeed, EPR and wind display.

Consider valid: PLI (below 15,000 feet/250 knots), Engine N1, PFD attitude display, vertical speed, FPA, LSAS low speed protection (pitch), stick shaker, ground speed readout.

With a suspected invalid airspeed indication, *the first action is aircraft stabilization through pitch/thrust.* Once safely stabilized, a problem evaluation and the appropriate procedures can be determined.

1. Disconnect the autopilot and autothrottles. Establish a "normal" pitch/thrust relation, (FPA symbology placed on the horizon will provide altitude hold).

2. Disregard airspeed indication/Flight Director pitch bar and high speed warnings: do not chase airspeed.

3. Check that the PLI is above the aircraft symbol on the PFD. If not, adjust the attitude with pitch and/or thrust as appropriate. The PLI will provide accurate Alpha (pitch limit) information below 15,000 feet/250 knots.

At this point the aircraft should be in stable flight, and the crew can take the second action: *evaluate the situation.*

4. Check the opposite pilot's displays and the standby indication to determine system validity. If, for example, the captain's airspeed is significantly different from that of the first officer's (FO) and the FO's matches the standby, consider the FO airspeed valid. Captain should select CAPT CADC ON 2 and re-engage autoflight.

5. Check terrain and maneuver as necessary. MCT thrust (overboost bar) and 10 degree pitch attitude should provide a safe initial climb condition if a climb is required. When the aircraft is stable and terrain clearance assured, *plan the remainder of the flight.*

6. Refer to Volume 1, SEVERELY DAMAGED NOSE RADOME &/OR SUSPECT AIRSPEED INDICATION, for thrust/pitch attitude/FPA relation. Monitor PLI below 15,000 feet.

NOTE: If it has been determined that the indicated airspeed is significantly higher than the actual airspeed, disregard possible high speed aural warning. Flaps/slats may be less than the selected setting 175/280 knot limits; verify flap/slat position. Elevator Load Feel may not be valid, resulting in a difference in maneuvering "feel".

If indicated airspeed is less than actual airspeed, and there is no indication of comparitor difference between pilot and copilot airspeeds, low speed protection may provide undesired thrust advance; in that case, consider placing the AFS Override switches to OFF to inhibit throttle advance due to undesired low speed thrust protection.

SUMMARY:

Loss of pitot static information, or invalid input from the pitot static system for whatever reason, can produce conflicting and disorienting cues to the flight crew. Confusion may also be compounded by alerts and aural warnings that do not accurately represent the actual flight condition. *The relation of pitch attitude and thrust on aircraft performance remains a constant, and reference to non-ADC driven displays, such as PLI, FPA, and ground speed, can help establish safe flight conditions.*

T. J. Melody
Senior Manager/Chief Test Pilot
Experimental Flight Operations
& Customer Service

FJG:csl

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Long Beach Products Division

Flight Operations Bulletin

August 27, 1998
ATA: 3600, Performance
Bulletin No. MD-11-98-06

Applicable to: *All MD-11 Aircraft*

Subject: OPERATION WITH INVALID OR SUSPECT AIRSPEED

Two MD-11 operators have reported incidents that resulted from contaminated or blocked pitot tubes. In addition, pitot-static problems are believed to have been causal factors in the recent loss of two transport aircraft, and may have contributed to the loss of a third. In the two MD-11 incidents above, investigators discovered that all three pitot systems were contaminated with water, and that the drain holes provided to allow drainage were plugged with debris; in both cases the airspeed displayed to the flight crew was considerably lower than the actual speed at which the aircraft was flying.

Unreliable airspeed, altitude and/or rate of climb indications, regardless of cause, will affect all aircraft systems that require air data input for normal operation. There is no dedicated alert to tell the crew of air data failure. PFD changes, autoflight disconnects, unwarranted speed protection, speed/altitude miscompare signals and alerts from systems requiring valid air data input such as autotrim, elevator feel, EPR, GPWS, TCAS and pressurization may warn the crew that something is wrong, but do not establish exactly what system is the root fault. In fact, system alerts from erroneous air data can distract the crew from recognizing the primary reason for the display of the alerts.

It is important for the flight crew to recognize an unreliable airspeed quickly, and imperative that their initial action be to maintain aircraft control. Because the symptoms of pitot-static degradation may be different in each case, and because of the confusion caused by multiple, often conflicting alerts and warnings, the flight crew may not recognize an air data error or intuitively initiate a proper response.

SEL ELEV FEEL MAN

Consequence:

NONE

"SEL FADEC ALTN" AND/OR "SEL FLAP LIM OVRD" AND/OR "IAS COMPARATOR MONITOR" ALSO DISPLAYED

NO

Refer to Emergency Non-Alert Procedure – AIRSPEED: LOST, SUSPECT OR ERRATIC.

[End of Procedure]

ELEV FEEL Selector. . . . . MANUAL

Pull ELEV FEEL selector out for manual operation. Observe "ELEV FEEL MANUAL" alert replaces "SEL ELEV FEEL MAN" alert.

ELF Speed . . . . SET AS REQUIRED

Rotate and hold ELEV FEEL selector in HI or LO (1 or 2) as required.

NOTES

When ELEV FEEL is in MANUAL, ELF speed is displayed on CONFIGURATION synoptic.

Slew ELF reference speed bug to maintain approximate agreement with aircraft indicated airspeed.

[End of Procedure]

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SEL FLAP LIM OVRD

Consequence:

NONE

NOTE

FLAP LIMIT MANUAL light will be illuminated

"SEL FADEC ALTN" AND/OR "SEL ELEV FEEL MAN" AND/OR "IAS COMPARATOR MONITOR" ALSO DISPLAYED

NO

Refer to Emergency Non-Alert Procedure – AIRSPEED: LOST, SUSPECT OR ERRATIC.

[End of Procedure]

FLAP LIMIT Selector . . . . OVRD 1

Rotate FLAP LIMIT selector to OVRD 1 and observe "FLAP LIMIT OVRD" alert is displayed.

After 20 seconds,

"FLAP LIMIT DISAG" ALERT DISPLAYED

NO

FLAP LIMIT Selector. . . . . OVRD 2

Rotate FLAP LIMIT selector to OVRD 2.

After 20 seconds,

"FLAP LIMIT DISAG" ALERT DISPLAYED

NO

Flap extension may be limited.

[End of Procedure]

Observe placarded flap limit speed.

[End of Procedure]

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FLIGHT INSTRUMENTS

EMERGENCY NON-ALERTS

(2-12A-2-1)

AIRSPEED: LOST, SUSPECT OR ERRATIC

Unreliable airspeed/Mach, vertical speed and altitude information can be caused by pitot static system or air data computer (CADC) malfunctions. This may or may not be accompanied by Level 1 and Level 2 alerts, autopilot/autothrottle disconnects and/or instrument failure indications. These malfunctions can have several causes, including pitot-static blockage, volcanic ash, system damage, loss or damage to the radom, ice accumulation, and improper maintenance. Cases where all pitot-static-sources malfunctioned have occurred. When all systems are in error, comparisons are not available and the flight crews are unable to identify the errors.

During takeoff roll, pitot-static or CADC malfunctions may be recognized by abnormal indications at standard airspeed callouts such as "80 knots". In flight recognition occurs by normal monitoring of basic flight instruments and crew familiarity with pitch, power and airspeed relationships.

It is important that the flight crews recognize an unreliable airspeed condition in a timely fashion, and imperative that their initial action is to maintain aircraft control.

Air Data and pitot system malfunctions can result in different EIS alerting system displays or erroneous indications depending on the nature of the cause of the malfunction. Not all malfunctions will be readily obvious or result in specific alerts.

The following are some of the indications the flight crew might see if a malfunction occurs in the pitot-static system or in the CADC:

- Indicated airspeed not consistent with normal pitch attitude and power setting for phase of flight.
- Indicated altitude different from actual altitude.
- "PITOT HEAT" alert.
- "WSHEAR DET FAIL" alert.
- "SEL FADEC ALT" alert.
- Many level 1 and Level 2 alerts such as "SEL ELEV FEEL MAN", "SEL FLAP LIM OVRD".
- IAS and/or ALT miscompare annunciation displayed on PFD
- Pressurization system problems.

PROCEDURE

The following information and displays can be considered reliable: PFD attitude, NAV display, ground speed, engine N_1 and stickshaker.

AFS OVRD Switches . . . . OFF

Aircraft Pitch/Thrust . . . . STABILIZE

Establish a normal pitch/thrust relation.

(CONTINUED)

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OPERATION WITH ERRATIC AIRSPEED

TRAINING OBJECTIVE

Several industry hull loses have occurred due to pitot icing and other failures of the air data system. The objective of this training is to teach the flight crews to recognize air data failures and to safely operate the aircraft under these failure conditions.

BRIEF (30 MIN)

Failure of air data can stem from many different causes, the most common being icing of the pitot-static system, contamination of the system from air or ground contaminants, volcanic ash, damage to tubes and sensors, disrupted airflow over the pitot tubes and AOA vanes, failure within the CADC, and improper maintenance.

Air data failure will effect the autoflight system, speed protection, pressurization system, fuel system, engines, navigation and flight controls in addition to presenting the cockpit with unreliable indicated airspeed, altitude, and vertical speed.

Recognition

A CADC receives primary information from pitot-static, TAT, AOA and inertial inputs. It then outputs information to all systems that use air data information.

While inaccurate CADC output may result from failure within the CADC itself, such output is usually the result of input error to the CADC. Because of the numerous ways that air data can be corrupted, the flight crew should immediately recognize the fact of air data failure and not necessarily the cause of that failure.

Dual CADC failure

(1) TOTAL FAILURE results in red "X" on both PFD air data (IAS and ALT) tapes. No IVSI display. Autopilot and autothrottles will disconnect. PLI and FD are removed from the PFD. Vertical speed is not selectable on the FCP. FPA is not available. FMS NAV is no longer available, and manual tuning of VORs is required.

The following alerts may be displayed:

SEL FLAP LIM OVRD
WSHSR DET FAIL
AUTO SLAT FAIL
GPWS FAULT SEL ELV MANUAL
CAWS FAULT
NO NAV
NO AUTOLAND
TCAS FAIL
CABIN PRESS RELIEF
TANK FEED FORWARD
FLAPS DISAGREE

(2) INVALID OUTPUT from both CADCs will reflect the alerts shown above except that the air data tapes on the PFD will show blank rather than the red "X".

(3) INACCURATE BUT VALID OUTPUT from both CADCs may or may not be reflected by the pilot's instruments, system alert or aircraft operation, depending on the degree of split between the two CADCs, the acceptance range or comparison requirements for air data by the user systems.

Total CADC failure or invalid data output can be easily recognized by the flight crew. Inaccurate but valid data may be difficult to detect (e.g., equal icing on #1 and #2 pitot tubes, partial blockage of both static ports).

Single or dual CADC failure is recognized by red "X"s in the PFD air data tapes and the number of alerts generated by systems that require data from the CADC. Incorrect but valid output from the CADC would first be noticed by the flight crew when the normal pitch attitude of the aircraft is not consistent with the IAS and IVSI display in the cockpit, and/or when unreasonable over/under speed alerts occur.

Review AIRSPEED: LOST, SUSPECT, OR ERRATIC checklist in CFM chapter 2-12 (Flight Instruments).

- **With Captain flying; Fail pitot system 2 (Malf Index, Flight Instruments, Pitot System Fail)**

Issue a descent clearance to 10,000 feet:
The PF should:

(1) Recognize:
Airspeed split
IAS comparator alert
AP and ATS disconnect and unavailable

(2) Accomplish the Airspeed: Lost, Suspect, or Erratic checklist

NOTE

The FCCs are designed to prevent damage to the aircraft by the autoflight system when a difference in data from the CADCs is sensed. Therefore, the AP and ATS will disengage and amber AP and ATS OFF boxes will be displayed on the PFD.

The pilot must determine which CADC is functioning properly by running the Airspeed: Lost, Suspect, or Erratic checklist and selecting the appropriate SISP CADC switch. The FCCs assume that the pilot selected the appropriate CADC and the AP and ATS may now be engaged. However, the AP and ATS will engage even if the wrong CADC selection is made and the available (white AP and ATS OFF) indications may falsely lead credence to the inappropriate SISP CADC selection.

Attachment O:

Post-Accident Changes to Boeing MD-11 Flight Manual Related to Erratic Airspeed

AIRSPEED: LOST, SUSPECT OR ERRATIC

Unreliable airspeed/Mach, vertical speed and altitude information can be caused by pitot static system or air data computer (CADC) malfunctions. This may or may not be accompanied by Level 1 and Level 2 alerts, autopilot/autothrottle disconnects and/or instrument failure indications. These malfunctions can have several causes, including pitot-static blockage, volcanic ash, system damage, loss or damage to the radom, ice accumulation, and improper maintenance. Cases where all pitot-static-sources malfunctioned have occurred. When all systems are in error, comparisons are not available and the flight crews are unable to identify the errors.

During takeoff roll, pitot-static or CADC malfunctions may be recognized by abnormal indications at standard airspeed callouts such as "80 knots". In flight recognition occurs by normal monitoring of basic flight instruments and crew familiarity with pitch, power and airspeed relationships.

It is important that the flight crews recognize an unreliable airspeed condition in a timely fashion, and imperative that their initial action is to maintain aircraft control.

Air Data and pitot system malfunctions can result in different EIS alerting system displays or erroneous indications depending on the nature of the cause of the malfunction. Not all malfunctions will be readily obvious or result in specific alerts.

The following are some of the indications the flight crew might see if a malfunction occurs in the pitot-static system or in the CADC:

(CONTINUED)

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AIRSPEED: LOST, SUSPECT OR ERRATIC (Continued)

- Indicated airspeed not consistent with normal pitch attitude and power setting for phase of flight.
- Indicated altitude different from actual altitude.
- "PITOT HEAT" alert.
- "WSHEAR DET FAIL" alert.
- "SEL FADEC ALT" alert.
- Many level 1 and Level 2 alerts such as "SEL ELEV FEEL MAN", "SEL FLAP LIM OVRD".
- IAS and/or ALT miscompare annunciation displayed on PFD.
- Pressurization system problems.

Procedure

NOTE: The following information and displays can be considered reliable: PFD attitude, NAV display, ground speed, engine N_1 and stickshaker.

AFS OVRD Switches .... OFF

Aircraft Pitch/Thrust .... STABILIZE

Establish a normal pitch/thrust relation.

(CONTINUED)

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AIRSPEED: LOST, SUSPECT OR ERRATIC (Continued)

Disregard IAS/Flight Director pitch bar and high speed warnings. Use pitch attitude or thrust as the primary flight reference. Should stick shaker be encountered, lower nose to horizon and increase thrust. Resume pitch/thrust reference after the stick shaker ceases.

NOTE: With autopilot disconnected at altitude, control wheel may seem sensitive in pitch.

Flight Director . . . . OFF

Disregard all alerts and warnings, except stick shaker, until after aircraft is stabilized and safe operations achieved. Alerts and aural warnings can produce conflicting and disorienting cues.

CAUTION: Under certain failures FPA and PLI may be unreliable. Check against primary flight references before using FPA or PLI.

NOTE: Establish control of the aircraft through pitch/thrust relation. Respond to malfunction alerts after safe flight is assured.

If practical fly to VMC at earliest possible opportunity.

After the aircraft is safely stabilized in flight, ensure terrain avoidance.

NOTE: Approximately 10 degrees pitch attitude and MCT thrust will provide a safe initial climb condition if a climb is required.

Pilot and Standby Flight Instruments . . . . COMPARE

ABLE TO IDENTIFY UNRELIABLE AIR DATA SOURCE

NO

CADC (Unreliable Side) . . . . .SELECT TO OTHER SIDE

Static Air Switch (Unreliable Side) . . . . ALT

AIR DATA RETURNS TO NORMAL

NO

(CONTINUED)

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AIRSPEED: LOST, SUSPECT OR ERRATIC (Continued)

ABLE TO IDENTIFY UNRELIABLE AIR DATA SOURCE

NO

(CONTINUED)

AIR DATA RETURNS TO NORMAL

NO

(CONTINUED)

AFS OVRD OFF Switch
(Reliable Side) .... NORMAL POSITION

Use autopilot and autothrottles associated with the reliable ADC.

NOTE: The following information and displays may or may not be reliable: FMC (unreliable side) data associated with air data and TAS & WIND on ND (unreliable side).

Continue to monitor pitch, thrust, and airspeed to insure accuracy of selected instruments.

[END]

Attitude and Thrust .... ADJUST

Maintain normal pitch attitude and thrust for the phase of flight.

NOTES: The following information and displays can be considered reliable: PFD attitude, NAV display, ground speed, engine N_1 and stickshaker.

The following may or may not be reliable depending on the cause of lost or suspect airspeed: FPA, PLI, low speed pitch protection, IVSI, altimeter, altitude reporting and TCAS. FMS NAV function may be inoperative.

(CONTINUED)

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AIRSPEED: LOST, SUSPECT OR ERRATIC (Continued)

The following will not be reliable: Flight director pitch bar autothrottle speed protection, high speed pitch protection and overspeed warning.

Use the following AIRSPEED: LOST, SUSPECT OR ERRATIC tables to determine thrust/pitch relation for remainder of flight.

NOTE: IAS and Vertical speed (VS) values in the following tables are approximate.

General Electric CF6-80C2 Engines

FLIGHT PHASE	CONFIG	PRESSURE ALTITUDE	REF	WEIGHT (1000 LB) 450	550	600	630
CLIMB	UP/RET	5000	PITCH	14.0	11.6	10.5	9.5
			IAS	*250*	*275*	*288*	*299*
Use max thrust (throttles to overboost bar)		FL 100	PITCH	12.5	10.0	8.5	8.0
			IAS	*251*	*285*	*302*	*311*
		FL150	PITCH	10.5	8.0	7.0	6.5
			IAS	*260*	*296*	*312*	*321*
		FL 200	PITCH	8.5	6.5	5.5	5.0
			IAS	*270*	*305*	*322*	*331*
CRUISE	UP/RET	FL 100	PITCH	2.0	3.0	3.0	2.5
			N_1	76.7	79.1	80.3	81.1
			IAS	*330*	*330*	*330*	*330*
		FL 200	PITCH	2.0	2.5	3.0	3.0
			N_1	83.6	86.1	87.4	88.3
			IAS	*330*	*330*	*330*	*330*
Use N_1 for thrust setting		FL 300	PITCH	2.0	2.5	3.0	3.0
			N_1	89.2	92.4	94.3	95.6
			MACH	.827	.827	.827	.827
			IAS	*315*	*315*	*315*	*315*
		FL 350	PITCH	2.0	--	--	--
			N_1	91.3	--	--	--
			MACH	.830	--	--	--
			IAS	*283*	--	--	--

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ENG__RPM LO (Continued)

Observe engine parameters on EAD.

Observe EGT, N_1, N_2, and fuel flow for possible flameout or failure.

EGT AND FUEL FLOW NORMAL

NO

Continue engine operation.

Assume defective RPM source.

[END]

RESTART DESIRED

NO

Refer to Abnormal Non-Alert Procedure - ENGINE RESTART IN FLIGHT.

[END]

Refer to Abnormal Non-Alert Procedure - ENGINE SHUTDOWN IN FLIGHT.

[END]

SELECT FADEC ALTN

Consequences:

NONE

(CONTINUED)

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SELECT FADEC ALTN (Continued)

"SEL FLAP LIM OVRD" AND/OR "SEL ELEV FEEL MAN" AND/OR "IAS COMPARATOR MONITOR" ALSO DISPLAYED

NO

Refer to Emergency Non-Alert Procedure – AIRSPEED: LOST, SUSPECT OR ERRATIC.

Autothrottles .... DISENGAGE

Push ATS disconnect switch and observe ATS OFF displayed on PFD.

Associated Throttle .... REDUCE AT LEAST 20% BELOW MCT

NOTE: When N_1 is reduced at least 20% below MCT, engine overboost will be prevented when ALTN mode is selected.

Illuminated FADEC MODE Switch .... PUSH

Open cover and push illuminated FADEC MODE switch. Observe SELECT light extinguishes and ALTN light remains illuminated.

Associated FADEC MODE Switch .... PUSH AGAIN

Open cover and push associated FADEC MODE switch. Observe ALTN light extinguishes.

NOTE: First push selects FADEC ALTN mode. Second push attempts to return FADEC to normal mode.

"SELECT FADEC ALTN" ALERT EXTINGUISHES

NO

Autothrottles .... ENGAGE

[END]

(CONTINUED)

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SELECT FADEC ALTN (Continued)

Illuminated FADEC MODE Switch . . . . PUSH

Open cover and push illuminated FADEC MODE switch. Observe SELECT light extinguishes and ALTN light remains illuminated.

Associated Throttle . . . . SET AS DESIRED

Increase thrust to re-establish N_1 equal to highest N_1 of remaining engines.

Remaining Engines
(One at a Time). . . . . REDUCE THRUST/SELECT ALTN

NOTE: Selecting FADEC ALTN mode for remaining engines realigns thrust levers.

Autothrottles . . . . ENGAGE

Push AUTO FLIGHT switch and observe ATS OFF is no longer displayed on PFD.

[END]

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SEL ELEV FEEL MAN

Consequences:

NONE

"SEL FADEC ALTN" AND/OR "SEL FLAP LIM OVRD" AND/OR "IAS COMPARATOR MONITOR" ALSO DISPLAYED

NO

Refer to Emergency Non-Alert Procedure – AIRSPEED: LOST, SUSPECT OR ERRATIC.

ELEV FEEL Selector. . . . . MANUAL

Pull ELEV FEEL selector out for manual operation. Observe "ELEV FEEL MANUAL" alert replaces "SEL ELEV FEEL MAN" alert.

ELF Speed . . . . .SET AS REQUIRED

Rotate and hold ELEV FEEL selector in HI or LO (1 or 2) as required.

NOTES: When ELEV FEEL is in MANUAL, ELF speed is displayed on CONFIGURATION synoptic.

Slew ELF reference speed bug to maintain approximate agreement with aircraft indicated airspeed.

[END]

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SEL FLAP LIM OVRD

Consequences:

NONE

NOTE: FLAP LIMIT MANUAL light will be illuminated

"SEL FADEC ALTN" AND/OR "SEL ELEV FEEL MAN" AND/OR "IAS COMPARATOR MONITOR" ALSO DISPLAYED

NO

Refer to Emergency Non-Alert Procedure – AIRSPEED: LOST, SUSPECT OR ERRATIC.

FLAP LIMIT Selector .... OVRD 1

Rotate FLAP LIMIT selector to OVRD 1 and observe "FLAP LIMIT OVRD" alert is displayed.

After 20 seconds,

"FLAP LIMIT DISAG" ALERT DISPLAYED

NO

FLAP LIMIT Selector .... OVRD 2

Rotate FLAP LIMIT selector to OVRD 2.

After 20 seconds,

"FLAP LIMIT DIAG" ALERT DISPLAYED

NO

Flap extension may be limited.
[END]

(CONTINUED)

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SEL FLAP LIM OVRD (Continued)

"FLAP LIMIT DISAG" ALERT DISPLAYED

NO — (CONTINUED)

"FLAP LIMIT DIAG" ALERT DISPLAYED

NO — (CONTINUED)

Observe placarded flap limit speed.

[END]

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General Electric CF6-80C2 Engines

FLIGHT PHASE	CONFIG	PRESSURE ALTITUDE	REF	WEIGHT (1000 LB)			
				450	550	600	630
DESCENT	UP/RET	FL 350	PITCH	1.0	--	--	--
			MACH	.768	--	--	--
			IAS	*260*	--	--	--
			VS	2030	--	--	--
		FL 300	PITCH	1.5	1.5	1.5	--
			MACH	.693	.729	.760	--
Use idle thrust			*IAS*	*260*	*275*	*287*	--
			VS	1920	2040	2140	--
		FL 200	PITCH	1.5	2.5	2.5	--
			IAS	*260*	*260*	*273*	--
			VS	1760	1770	1850	--
		FL 100	PITCH	2.0	2.5	2.5	--
			IAS	*250*	*267*	*281*	--
			VS	1500	1600	1680	--

(CONTINUED)

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AIRSPEED: LOST, SUSPECT OR ERRATIC (Continued)

General Electric CF6-80C2 Engines

FLIGHT PHASE	CONFIG	PRESSURE ALTITUDE	REF	WEIGHT (1000 LB) 350	400	450	480
ARRIVAL LVL FLT	UP/RET	5000	PITCH	5.0	5.0	5.0	5.0
			N_1	58.9	62.3	65.5	67.3
			IAS	*221*	*236*	*250*	*258*
	0/EXT	3000	PITCH	8.5	8.5	8.5	8.5
			N_1	61.5	65.1	68.4	70.3
			IAS	*182*	*194*	*205*	*211*
Use N_1 for thrust setting	15/EXT	3000	PITCH	6.0	6.0	6.5	6.5
			N_1	64.7	68.4	71.8	73.7
			IAS	*174*	*185*	*196*	*202*
	28/EXT	3000	PITCH	4.0	4.0	4.5	4.5
			N_1	70.1	74.0	77.5	79.4
			IAS	*168*	*179*	*189*	*195*
APPROACH *IAS* APPROX V_{REF} + 15 Use N_1 for thrust setting	35/EXT GEAR DOWN	DESCENT	PITCH	2.5	2.5	2.5	3.0
			N_1	62.1	65.6	68.7	70.5
			IAS	*153*	*162*	*171*	*176*
	Maintain pitch and adjust power to maintain glide path.						
GO AROUND	28/EXT GEAR UP	SEA LVL	PITCH	20.0	20.0	19.5	18.0
			IAS	*180*	*172*	*171*	*176*
		5000	PITCH	20.0	18.5	16.5	15.5
			IAS	*160*	*162*	*171*	*177*

When ready for approach and landing,

- Maintian VFR conditions.
- Establish landing configuration early.
- Use IRS ground speed and reported winds to verify airspeed.
- Use radar altimeter.
- Use a runway with electronic or visual glideslope.

[END]

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NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C.

August 28, 2001

AIRWORTHINESS
FACTUAL REPORT OF INVESTIGATION

A. ACCIDENT

LOCATION:	Subic Bay, Philippines
DATE:	October 17, 1999
AIRCRAFT:	McDonnell Douglas MD-11 U.S registration N581FE; Serial no. 48419
OPERATOR:	Federal Express
NTSB Case No .:	DCA00RA002

B. U.S. ADVISORS

US Accredited Rep (Airworthiness)	Jeff Guzzetti U.S. National Transportation Safety Board Washington, DC
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Advisor	Joseph Martin Honeywell, Inc. (Engineer, Air Data Systems) Phoenix, Arizona
Advisor	John T. Faulks Lockheed Martin Control Systems (Product Support Engineer) Johnson City, New York

C. SUMMARY

On October 17, 1999, at 1557 UTC, a McDonnell Douglas MD-11F, N581FE, operated by Federal Express as a cargo flight from Shanghai, China, to Subic Bay, Philippines, overshot the runway and impacted water while landing on runway 07 at Subic Bay International Airport. The captain and first officer, the sole occupants, received minor injuries. The airplane was destroyed. Night and visual meteorological conditions prevailed at the time of the landing.[1] According to crewmember statements, cockpit flight recorder (CVR) and digital flight data recorder (DFDR) information, and information from representatives of the Philippine government, differences in airspeed indications between the captain's and first officer's instruments were presented to the crew during the descent for landing.

The following engineering activities occurred under the supervision of the NTSB as a result of this investigation:

[1] Overcast skies and drizzle prevailed at the time of the landing; however, the crew indicated that they had the airport in sight prior to reaching the Minimum Descent Altitude (MDA).

- The airframe and engine wreckage, including components associated with the pitot-static system, were visually examined and inventoried on-site on October 25-30, 1999.

- Three pitot tubes heads, identified as the Auxiliary, Captain's, and First Officer's, along with several pressure lines were examined at Boeing in Long Beach, California, on December 13-21, 1999.

- Non-volatile memory from all three Full Authority Digital Engine Controllers (FADECs) was extracted at the Lockheed Martin Control Systems in Binghamton, New York, on December 9, 1999.

- Non-volatile memory from the air data computers and flight control computers was extracted at the Honeywell factory in Phoenix, Arizona, on August 9, 2000.

- Laboratory testing to simulate airspeed anomalies during descent was conducted at the Honeywell factory in Phoenix, Arizona, on August 10, 2000.

- Research into the previous and current maintenance procedures associated with the DC-10 and MD-11 pitot static system.

This memorandum provides a summary of all findings related to the airworthiness aspects of this incident. Supporting data is attached.

D. DETAILS OF THE INVESTIGATION

1.0 Accident Site and Wreckage Distribution

The airplane entered the water just off the departure end of Runway 7 (length 9,003 feet, width 148 feet) at the Subic Bay International Airport (airport elevation 56 feet msl, touchdown zone elevation 40 feet). The airplane overran the end of Runway 7, impacted concrete approach light stanchions, and continued off a ledge that dropped about 30 feet onto a road located on the shoreline of the airport. The airplane then entered the water and initially came to rest at the following coordinates: North 14 degrees, 47.97 minutes; East 120 degrees, 17.00 minutes.

The majority of the airframe then drifted about 0.4 kilometers east of the final impact location and was tied down to the shoreline for salvage. Only the three engines (with pylons attached), tailcone sections, right main landing gear, and nose gear remained at the final impact site off of the end of Runway 7 at the time of the Airworthiness Group's arrival. Additional documentation of the accident site, including runway markings, ground scars, and tree strikes, was performed by the Aircraft Performance Group.

No evidence of an in-flight fire or in-flight structural failure was found.

2.0 Structural Damage

2.1 Fuselage

The fuselage had broken up into two main pieces. The first piece was the nose section, which measured about 75 feet in length. The nose section had partially separated about Fuselage Station (FS) 999 on the left side of the aircraft (760 inches or 63.3 feet from the crest of the radome), and FS 1139 on the right side (beyond the 100-inch plug, or 240 inches aft of the left side fracture.) The radome and cockpit area of the nose section remained intact but were damaged. The nose of this section, including the three pitot tubes, eventually sank to the bottom and was buried in about 12 inches of sand. The aft section of the fuselage remained relatively intact. The belly structure section immediately forward and aft of the center wing section was severely damaged. Both wings, the tail, the center landing gear and the left main landing gear remained attached to this section. Cargo pallets were found inside and attached to the loading system.

2.2 Wings

The right wing remained attached to the fuselage and was found in one piece. Numerous fractures of the upper and lower skin, spars, and primary structure were noted. The right wing structure was more fragmented than the left wing structure. The no. 3 engine, engine pylon, and right main landing gear were separated from the right wing. Upper wing skin and stringers are severed from the No. 3 pylon at the front spar inboard at 45-degree angle to the No. 2 tank fuel tank access cover. The upper skin was found severed at the rear spar inboard of the right main landing gear fitting doubler extending forward about 24 inches. The lower wing skin, aft panel, was found severed just inboard of the right main landing gear fitting doubler. The right rear spar was found severed between the right main landing gear attach fitting and the trapezoidal panel.

The left wing also remained attached to the fuselage and was found in one piece. This wing was not as disintegrated as the right wing. Two areas of the leading edge (outboard of the engine pylon area) were crushed inward in a rectangular pattern that measured about three feet in length and two feet in depth. The front spar was severed in these locations. Pieces of metal truss structure from the approach lights and chain link fence were found entangled in the left wing. The no. 1 engine and pylon had separated from the left wing. The left main landing gear was separated from the trapezoidal panel and left main landing gear attach fitting failed. The left main landing gear was found about 90-degrees from its normal orientation and had twisted aft and upward.

2.3 Tail Structure

The tail section, including the horizontal and vertical stabilizers, elevators, and rudder, remained attached to the fuselage. The stabilizer trim was found at about the seven-degree aircraft nose-up trim position (as per a visual inspection of the index marks on the right side of the tail).

2.4 Landing Gear

The left main landing gear attaching structure failed and was completely severed from the aircraft, but remained with the left wing. The strut was still charged and one of the tires remained inflated (pressure unknown). The right main landing gear (Douglas p/n NRG6719-501, rev D, BF Goodrich s/n 501018) had separated from the right wing. The forward trunnion lug of the right main landing gear had no attach point hardware connected to it, indicating that the fuse pin sheared at one or possibly both grooves. The forward section of the right main landing gear fuse pin remained in the intact forward lug of the right main landing gear attach fitting. The aft lug of the right main landing gear has the trunnion pin attached along with sections of both main landing gear attach fitting aft lugs. Trunnion lugs exhibited evidence of contact with adjacent structure outboard (main landing gear attach fitting). The upper and lower folding diagonal brace remained attached to the gear. The fixed side brace and pillow block attach point were not located. All tires remained inflated. The main landing gear appeared to still have a nitrogen charge (pressure unknown) and was not leaking fluid. The remaining tire tread varied from very acceptable to barely acceptable; no flat spots were visible. The truck (bogie beam assembly) appeared undamaged. No observations regarding the main landing gear braking system were recorded.

The nose gear remained attached to the trunnion fittings of the STA 595 bulkhead, which had separated from the fuselage and was found in the water near the end of the runway. The outer cylinder was cracked along approximately 80% of its length on the forward side, and the gland nut was stripped from the cylinder, releasing nitrogen and strut hydraulic fluid. The tires were punctured and deflated.

The center landing gear had failed aft and pivoted aft and impacted the lower fuselage; it remained attached to the aircraft at the trunnion fittings.

3.0 Powerplants

3.1 Engine No. 1 (Left)

The engine was a General Electric CF6-80C2. No evidence of fire damage was found. The engine remained attached to its pylon, which had separated from the wing. This engine exhibited more damage than the other two engines. The fan case was severely deformed and fractured. The fan inlet was missing. All of the fan blades were fractured near the hub and exhibited bending opposite the direction of rotation. The combustor sections exhibited severe impact damage and no longer retained it's pre-impact cylindrical shape. The Full Authority Digital Engine Controller (FADEC) had separated from the engine and found on the shoreline off the end of Runway 7. The thrust reversers and their associated actuators were found in the deployed position.

3.2 Engine No. 2 (Center)

The engine was a General Electric CF6-80C2. No evidence of fire damage was found. The engine remained attached to its pylon, and the pylon was separated from the vertical stabilizer. This engine exhibited the least amount of damage in comparison to the other two engines. It remained mostly intact and cylindrical. The bell mouth section remained attached and exhibited some impact damage. All of the fan blades of the compressor section were intact and attached to the hub; they all exhibited severe foreign object debris (FOD) damage. The combustor section was intact; grass and dirt was found inside. The FADEC remained attached to the engine and was liberated by investigators. The thrust reversers and their associated actuators were found in the deployed position.

3.3 Engine No. 3 (Right)

The engine was a General Electric CF6-80C2. No evidence of fire damage was found. The engine remained attached to its pylon, which had separated from the wing. This engine exhibited less damage than the no. 1 engine, and more damage than engine no. 2. The inlet was missing. Most of the fan blades were fractured and bent opposite the direction of rotation. The FADEC remained attached to the engine and was liberated by investigators. The thrust reversers and their associated actuators were found in the deployed position.

4.0 Pitot Static System

4.1 General Description of the MD-11 Pitot-Static System

The MD-11 pitot static system gets pitot pressure input (from air that hits the front of the pitot tube head) and static air pressure input from the ambient air. These air pressures are sent through pneumatic lines to the central air data computers (ADCs). The ADCs calculate important flight parameters (altitude and airspeed) from this air data.

The electronic instrument system gives the visual indication of the flight data (which are calculated from the air data). Also, the pitot static system supplies air data to the standby altimeter/airspeed indicator (SA/ASI) for use as an alternative visual indication.

The pitot static system includes the pitot tubes, static ports, pneumatic lines, and the SA/ASI. This system connects the air data system and the standby altimeter/airspeed to the pitot pressure. The pitot system has three pitot tube heads (and their pneumatic lines) below the aircraft's radome. As seen forward, the captain's pitot tube head is to the left, and the first officer's pitot tube head is to the right. The auxiliary pitot tube head is in the center. The three pitot tube heads have anti-ice heads and the pitot tubes can drain out their water via two drain holes mounted on each side of each head.

The pitot tube heads are in a position that puts the tubes open to, and in the direction of, the airflow that goes past the aircraft's nose. The air goes through the pitot tubes, pressurizes, and goes to the ADCs and the SA/ASI. The pressurized air that goes through the captain's pitot tube is sent to ADC-1. The pressurized air that goes through the first officer's pitot tube is sent to the ADC-2. The air pressure from the auxiliary pitot tube is sent to the SA/ASI.

There are four drains in the avionics compartment for the pneumatic lines of the pitot static system (one static line each and one pitot line drain each for the captain and the first officer's sides). The drains are used as reservoirs to collect water from the pneumatic lines. Each drain is a clear tube with a float ball in it. The float ball shows how much water is in the tube.

The MD-11 pitot-static system is nearly identical to the DC-10 pitot-static system. The pitot tube heads are mounted in the same positions on the nose of both airframes, and the heads are manufactured by Rosemont Aerospace.

4.2 On-site Extraction and Examination

All three pitot tube heads were removed from the airplane on October 26, 1999, while the nose section remained underwater near the seaplane ramp during the salvage effort. The three external screws holding down the head plates were removed, and the electrical lines and tubes immediately behind the heads were cut.[2] A cursory review revealed that all of their drain holes were solidly obstructed with a granular substance. Water could flow through both ends of the Captain's and Auxiliary pitot heads, while the First Officer's tube was packed with sand. A sample of the sand where the tubes had impacted on the bottom of the seabed was taken for further examination.

After the nose section had been pulled up the seaplane ramp, the pitot and static lines of the ADC-1 system were excised, complete with moisture drains and lines. No obvious evidence of blockage was seen. The lines were compromised and impact damaged, exposing them to seawater. The glass moisture drains attached to these lines had an unknown amount of water in them; the mechanics who removed the drains reported that they had disconnected and reconnected the drains to remove the assembly, and emptied the trapped water from them in the process. The mating fitting to the static port into the ADC-1 was connected to these lines. It mated with the ADC-1 stud[3] and had red torque stripe on it. About 20 inches of line immediately behind where the captain's and first officer's pitot head were previously mounted was also excised. There was a small amount of debris in the throat of this Captain's piece, and it appeared to be at the tip and very loosely packed. The material was similar in color (whitish) and consistency (loose, wet and granular) as debris that littered the area immediately behind the radome. Visual examination of the tips of the first officer's and auxiliary lines did not reveal any blockages. All of the excised lines were taped off and secured for further examination.

The static ports on the left side of the airplane were damaged. It is unknown how much of the damage was related from impact and/or from the salvage. The static lines running along the left side of the nose section (above the wheel well) were intact from the ADC-1 area to FS 595 (nose

[2] This activity was performed by a U.S. NTSB investigator after receiving permission from representatives of the ATO. Attempts to seal the pitot tubes upon removal were unsuccessful due to the underwater extraction and aircraft position. It should also be noted that a salvage diver had previously rubbed the tip of the pitot tube heads with his gloved finger after the nose of the airplane had been lifted up from the bottom of Subic Bay prior to towing to shore. This was captured on video.

[3] The mating ADC-1 stud had been previously identified during the on-scene phase of the investigation, and it addressed later in this report.

landing gear bulkhead). The primary static port plates from the left side of the airplane was excised and retained.

4.3 Laboratory Examination of Pitot Tubes

4.3.1 Gross Observations and Radiography

Three pitot tube heads (part no. 851KD), identified as the Auxiliary, Captain's, and First Officer's, along with several pressure lines and a segment of the pitot static plate assembly, were examined by an NTSB investigator and U.S. advisors at the Boeing-Long Beach Division for evaluation. The pressure lines along with the three pitot tubes were radiographic-inspected to determine if any obstructions existed within the pitot tubes and pressure lines. The results of the radiographic inspection revealed no evidence of obstruction in the two drain holes of each pitot head.

4.3.2 Auxiliary Pitot Tube Head

No evidence of debris was observed within the forward portion of the tube or the two drain holes for the auxiliary pitot tube head. The pitot tube itself appeared to have evidence of water stains and corrosion. The 3-inch long forward tube portion of the pitot tube appeared to be blackened. This blackened region extended approximately halfway from the forward end. The electrical connector for this pitot tube did not appear to be bent. The pressure line appeared to be bent slightly in the forward direction.

The subject part was cut lengthwise to expose the inner surfaces for examination. Visual and macroscopic examination revealed that the passageways of the pitot tube were unobstructed. A small amount of brownish-colored residues were observed along the inner corners of the pitot tube reservoir area.

4.3.3 First Officer's Pitot Tube Head

The First Officer's pitot tube head appeared to have the same appearance of water stains and corrosion as the Auxiliary pitot tube head. The same type and location of a blackened area along the forward portion of the 3-inch long forward tube of the pitot tube was also observed. The electrical connector for this pitot tube did not appear to be bent. The pressure line appeared to be bent slightly in the in the aft direction.

The right hand drain hole of the pitot tube head was found to be unobstructed. The left hand drain hole was plugged with a clear, crystalline particulate. Energy Dispersive Spectrometry (EDS) analysis of this particulate revealed a high concentration of Silicon (Si), Aluminum (Al) along with smaller amounts of Oxygen (O), Sodium (Na), and Calcium (Ca). The forward portion of the subject part was full of brown-colored sediment along with an aggregate of clear and white-colored crystalline particulates, small shells, and portions of an insect. The debris was filtered in the laboratory to separate the sediment from the particulates. Analysis of both the sediment and particulates revealed high concentrations of Si, Al, along with smaller amounts of O, Na and Ca, similar to what was found for the left hand drain hole. Small amounts of Potassium (K) were also detected within the particulates, and evidence of Iron (Fe) was detected within the sediment. The pitot tube was sectioned lengthwise to expose the inner surface. Visual and macroscopic examination of the inner surface revealed that the reservoir portion of the pitot tube was partially obstructed with material similar to the forward portion of the part.

4.3.4 Captain's Pitot Tube Head

The Captain's pitot tube head appeared to have the same appearance of water stains and corrosion as the Auxiliary and First Officer's pitot tube heads. The location of the blackened area found on the Auxiliary and First Officer's forward portion of the 3-inch long forward tube portion of the pitot tube was observed; however, in this pitot tube, the location is somewhat at the middle of the forward tube. The electrical connector for this pitot tube head did not appear to be bent. The pressure line appeared to be bent slightly in the in the aft direction.

The right-hand drain hole of the Captain's pitot tube head was plugged with a white and slightly greenish colored residue. Analysis of this residue revealed high concentrations of Nickel (Ni), Phosphorus (P), Sulfur (S), Si, Al, and Ca, along with smaller portions of O, Na, Magnesium (Mg), and K. The left-hand drain hole of the pitot tube head was plugged with a brownish colored residue. EDS analysis of this residue revealed high concentrations of Si, Al, Ca, along with smaller portions of O, Na, Mg, P, S, Chlorine (Cl), K, and Ni. The forward portion of the pitot tube was partially obstructed with brown colored sediment, along with an aggregate of clear and white-colored crystalline particulates, similar to the First Officer's pitot tube. The pitot tube was sectioned lengthwise to expose the inner surface. The inner surface revealed that the reservoir of the pitot tube was partially obstructed with this same sediment and particulates. The brownish-colored residue was found along the inner walls of the reservoir and also exhibited a greenish appearance.

4.3.5 Sediment from the Floor of Subic Bay

A sample of the sediment from the floor of Subic Bay was submitted for analysis. The analysis revealed high concentrations of Si, Al, Cl, along with smaller amounts of O, Na, Mg, S, K, Ca, and Fe.

4.3.6 Base Material of the Pitot Tube

Analysis was performed on a pitot tube, the results indicated a high concentration of Copper (Cu). This is in conformance to the pitot tube material being a copper alloy (BeCu casting alloy C82500, AMS 4890). Analysis of an area along the outer surface of the strut portion of the pitot tube revealed a high concentration of Ni, along with smaller amounts of P, indicating that the strut portion was nickel-plated. This is in conformance to the requirements of the manufacturer (Rosemount Aerospace) that the strut portion of the pitot tube be electro-less nickel plated.

4.4 Air Data Computers

4.4.1 On-Site Observations

Air Data Computer No. 1 (ADC-1) was extracted from the nose section while it rested underwater. Immediately upon recovery, the Group examined and photographed ADC-1 (Honeywell p/n 4059060-901; s/n 92050466). The upper surface of the chassis had a 1.5-inch diameter hole in it, and the side of chassis was deformed. The moisture drains had separated from the unit. Evidence that impact forces stripped off the line and fitting to the STATIC port was found. An assessment of the tightness of the STATIC fitting was impossible. The STATIC stud had torque stripe on it, but the mating fitting was missing. Evidence of metal was found in the threads of the stripped stud. The PITOT fitting was intact and slightly bent. The torque stripe on the fitting assembly was undamaged and intact, and the fitting nut was tight. ADC-1 was then placed back into fresh water for further analysis.

The Group later examined and photographed ADC-2 (Honeywell p/n 4059060-901; s/n 91010308) after it was able to be extracted from the airplane at the seaplane ramp (post-salvage) on October 30, 1999. The moisture drains were missing. Evidence that impact forces stripped off the line and fitting to the PITOT port was found. The STATIC fitting was intact. ADC-2 was then placed back into fresh water for further analysis.

4.4.2 Laboratory Testing of ADCs

Both ADCs were recovered from the crash site, and delivered to Honeywell Phoenix in drums of water. Upon removing the submerged ADCs from the drums of water that they were shipped in, they were moved to a lab for cleaning. The subassemblies were removed from the chassis, documented, and all were rinsed with water. Following rinse, a cleaning and two-day bake process was performed to prepare the circuit boards for non-volatile memory (NVM) extraction.

The identification of the DADCs and respective subassemblies was as follows:

Assembly Name	Assembly HPN	Assembly s/n
ADC, LRU, **Captain Side**	4059060-901ModA	92050466
Static Pressure Sensor (A1)	4040831-901	20577128
Total Pressure Sensor (A2)	4040831-901	20575133
Freq.-to-Digital Conv. Card (A3)	4040813-902	G2035255
Analog-to-Digital Conv.Card (A4)	4047985-903	G2015254
Power Supply (A5)	4040815-901	2034967
ARINC Interface Card (A6)	4066263-901	G2015304
Central Processor Unit Card (A7)	4066276-901	G2046586

The captain side ADC appeared to be the more damaged of the two, with an almost 1-inch diameter puncture hole toward the rear of the top cover. This puncture was noted near the two circuit cards, where several microcircuits had their tops popped off.

Assembly Name	Assembly HPN	Assembly s/n
ADC, LRU, **First Officer Side**	4059060-901ModC	91010308
Static Pressure Sensor (A1)	4040831-901	01162659
Total Pressure Sensor (A2)	4040831-901	10163715
Freq.-to-Digital Conv. Card (A3)	4040813-902	G0115086
Analog-to-Digital Conv.Card (A4)	4047985-903	G0115096
Power Supply (A5)	4040815-901	0113943
ARINC Interface Card (A6)	4066263-901	G0125139
Central Processor Unit Card (A7)	4066276-901	G0105674

Following clean and bake, the subassemblies were reassembled into their respective ADCs. The ADCs were taken to the Air Data Laboratory and attempts were made to power-up the units on the MD-11 ADC Manual Test Set. Neither of the two ADCs showed any response to test fixture power and initial conditions; they were pronounced "dead at the LRU level". Each of the recovered CPU cards (A7) which contains the flight failure memory, was installed into a previously verified MD-11 ADC. In both cases, the CPU cards were not functional, such that no response was given by the previously verified ADC. The next step was to use best practices to remove the flight failure memory devices and install them onto the CPU card of the previously verified ADC. This process was successful for both the Captain and First Officer side recovered ADCs. The resulting stored flight fail codes were as follows:

Captain Side Fail codes

03 29 27
05 00 27

First Officer Side Fail codes

01 01 27	03 01 27	05 27 01	08 29 01
01 00 29	03 00 29	05 00 29	08 00 27
02 01 27	04 01 27	06 29 01	09 29 01
02 00 29	04 00 29	07 01 27	09 00 27

The first two digits represent the flight number, where 01 is the most recent, and 09 is the 8^{th} previous flight. The next four digits represent two, two digit Built In Test (BIT) fail codes. The descriptions of the identified fail codes for the accident flight are as follows:

Captain Side Fail codes

No failures

First Officer Side Fail codes

00 No failure

01 Angle of Attack (AOA) Input Failure: Indicates AOA #1 $\sin^2\theta + \cos^2\theta = 1$ test fails, OR AOA #1 ac Reference is invalid.

27 AOA Comparison Failure: Indicates that AOA #1 and #2 comparison was greater than limits set in Aircraft Calibration Memory (4 degrees) when airspeed greater than 75 knots.

29 Indicated AOA Failure: Indicates failure of one of two tests depending on the state of the ADC's AOA Unique/Average input configuration;
Unique – indicates the "onside" AOA input is invalid as in fail code 01
Average – indicates failure of either "onside" OR "offside" OR fail code 27.

No fault recordings were found for Captain side ADC on the last flight. An AOA failure was recorded on the first officer's side ADC. According to Boeing, AOA failures are "fairly common", and are due to tight Built-In-Test tolerances relative to the MD-11 flight operations. Additionally, Boeing stated that an AOA failure could not cause the magnitude of airspeed error that occurred in the accident.

The ADC pressure sensors were powered in a verified ADC to determine if they were operational, and if so, what failures existed. The response of each sensor (value and BIT failures) was as follows, with the pneumatic input open to room atmosphere:

Captain Static Pressure - No display, (likely due to an electrical short), diaphragm resonating

Captain Total Pressure - 3.691 in. Hg , resonating, fails Ps = Pt by .080 in. Hg comparison test (sensor value shift)

First Officer Static Pressure - 3.691 in. Hg , resonating, fails Ps = Pt by .080 in. Hg comparison test (sensor value shift)

First Officer Total Pressure 3.691 in. Hg, not resonating, fails 15V Power supply test & AOA related BIT tests 27 and 29

According to Boeing and Honeywell data, the operation of the pressure sensors reported above could not have been the situation at the time of the accident; the 3.691 inches Hg would indicate over 50,000 feet if a static Sensor, or negative airspeed if a Total sensor.

4.5 Flight Control Computer (FCC)

Part Number	4059001-907	Serial Number	93060580
	4059001-907		Unreadable

All cards from FCC box 1 were found to be operational except the A2 card. The data on card A2 is not significant with regard to airspeed monitoring.

A known good card replaced the bad card and the NVM data was extracted. The FCC monitors detected numerous ADC discrepancies on the last flight leg, but it was not possible to determine which ADC was at fault or when they were logged.

For FCC box 2, only the A2 card was operational. The three bad cards were replaced with known good cards and the NVM data was extracted. There were no faults recorded on the last leg by the A2 card.

Each FCC monitors both air data computers so it was decided that the extra effort to lift the NVM chips off the boards and place them onto good boards for FCC box 2 would not be beneficial. No evidence was found to indicate that there would be different data than that provided by FCC box 1.

4.6 Digital Electronic Units (DEU)

Part Number	4059011-911	Serial Number	91060359
	4059011-901		92?30537
	4059011-901		Unreadable

All data extraction from DEU memories was successful. Analysis of the data showed that there was nothing recorded for the last flight leg.

4.7 Centralized Fault Display Unit

Part Number	4059040-905	Serial Number	96070444

There was no attempt to extract data from this unit; it was determined that there was no useful information contained in this unit.

4.8 Flight Management Computer (FMC)

Part Number	4059050-911	Serial Number	90044185
	4059050-911		9?0451?3

There was no attempt at data extraction. The FMC data is not stored in NVM, but in battery-backed memory. Since the units had been in water since the accident, it was determined that the battery power had been depleted and all data subsequently lost.

5.0 ADC Failure Mode & Effects Analysis (FMEA) and Fault Tree Analysis (FTA)

A review of the ADC's Failure Mode and Effect Analysis (FMEA) and the Fault Tree Analysis (FTA) documents was performed to determine if any failure modes could have the effect of a below nominal airspeed error, which increases on descent. The FMEA review focused on the Total Pressure Sensor up to the Frequency-to-Digital Converter Multiplexer circuitry due to their function in the ADC design. For the airspeed error undetected by the ADC's continuous Built In Test monitors, the FMEA identified the following two specific Sensor piece parts:

Piece Part Name	Failure Mode	Failure Rate (per million operating hrs)
Sensor Diaphragm	Resonant Frequency Changes	0.537×10^{-6}
Sensor Magnet	Weak Solder Connection	0.00004×10^{-6}

According to Boeing and Honeywell, these failures are not likely to have been involved in the accident for the following reasons:

Sensor Diaphragm Failure – The FMEA is not specific in how long it takes the failure to reach detection levels by other means; i.e. crosschecking airspeed in the flight deck. Honeywell's experience has been for this failure to occur very slowly over months or years, rather than a single flight.

Sensor Magnet Failure – Extremely low failure rate.

The FTA lists the ADC's undetected airspeed failure rate to be the sum of the two Piece Part failure rates listed above; therefore validating that these are the only failure modes contributing to an undetected airspeed error identified in the two analyses.

6.0 FADECs

All three FADECs were examined at Lockheed-Martin Control Systems in Johnson City, New York. The purpose of this event was to capture any FADEC memory that may have been recorded for the accident flight in order to compare the independent FADEC pressure and airspeed sources with the erroneous sources from ADC-1 that was captured on the DFDR. This data would aid in characterizing the error by comparing (FADEC) airspeed source with the air data computer airspeed source.

Engine 1 FADEC --- Good data was extracted, but only from previous flights. Apparently, no data was stored for the accident flight, because the FADEC is designed to store data into a buffer upon normal engine spool down time, and this engine took a substantial hit from the approach light stanchion which likely caused power to be immediately interrupted.

Engine 2 FADEC -- Good data from memory, with faults recorded from the event flight. The faults appear to capture data as the airplane is on the ground during the initial impact sequence. There is good static pressure (14.50 psi) and airspeed data (Mach 0.33) associated with one of the faults; however, this data was not meaningful to the investigation because it was recorded at the very end of the accident flight while the airplane was on the ground.

Engine 3 FADEC -- No useful data was able to be extracted. Both CPU subassemblies would not power up normally. Channel A devices in an engineering CPU did allow data extraction, but appeared as if one device had data corruption (possible incomplete write). Channel B devices in the engineering board still exhibited a power up problem and NVM data was not extracted. Evidence of white deposits and corrosion on the ECU and subassemblies were found on this FADEC.

7.0 Laboratory Experiments Related to Pitot Plumbing Anomalies

In an attempt to ascertain if pneumatic leaks or partial obstructions could cause the Captain side airspeed errors, representatives of Honeywell and Boeing, under the supervision of an FAA inspector and with NTSB concurrence, performed laboratory experiments to determine if either of these anomalies could produce the airspeed effects that were similar to the indicated and actual airspeeds computed from accident flight performance data.

Static line experiments were deemed not required since recorded altitude indications during the accident flight were noted to be correct. It was determined that a pitot leak (to cabin pressure) at cruise altitude would cause a higher indicated airspeed. Since the indicated airspeed on the Captain's display was indicating lower than the actual airspeed during the accident flight, a pitot leak test was not performed.

For the pitot obstruction, an amount of water (sufficient to obstruct airflow) was introduced at cruise altitude.[4] The water obstruction was introduced in a "u"-shaped clear plastic tube (gravity influenced) formation and it was found that adjusting the height of the "u" varied the airspeed error.[5] The tube was adjusted to produce a -12 knot error, which is the error value that was revealed in the accident airplane at the top-of-descent at 37,000 feet.

The orientation of the tube and other plumbing was retained throughout the descent profile. The hoses used were approximately the same inside diameter as the MD-11 aircraft plumbing they simulated. Two descent profiles were simulated using a Honeywell ADT-222C pressure controller and the airspeed error observed. The test results are as follows:

[4] It should be noted that the same symptoms of anomalous airspeed indications can be duplicated by obstructions from a variety of sources, not just blocked pitot head water drain holes. For example, nests, screws, insects, sand, residue from an extended shop visit with pitot covers removed, etc., may obstruct the pitot sensing systems anywhere from the pitot head to the ADC connector.

[5] Similar to a manometer.

16.5-Inch Column of H_2O

Pressure Controller Output		Air Data Computer Indications		
Altitude (ft)	Airspeed (kts)	Altitude (ft)	Airspeed (kts)	Error (kts)
37,000 (cruise)	270	37013	258	-12
35,000	270	35011	249.6	-20.4
33,000	270	33008	242.4	-27.6
30,000	270	30006	230	-40
25,000	270	25004	227	-43
25,000	240	25003	197	-43
20,000	240	20004	188	-52
10,000	240	9997	190	-50
10,000	170	9997	101	-69
0	170	-3	89	-81

13-Inch Column of H_2O

Pressure Controller Output		Air Data Computer Indications		
Altitude (ft)	Airspeed (kts)	Altitude (ft)	Airspeed (kts)	Error (kts)
37,000	270	37013	257.5	-12.5
35,000	270	35014	250.1	-19.9
33,000	270	Not recorded	243.7	-26.3
30,000	270	Not recorded	243.7	-26.3
25,000	270	Not recorded	244.3	-25.7
25,000	240	Not recorded	217.3	-22.7
20,000	240	20003	210	-30
10,000	240	10,000	210.3	-29.7
10,000	170	10,000	137.6	-32.4
0	170	Not recorded	124.9	-45.1

According to CVR and DFDR information from the accident flight, and an aircraft performance analysis of airspeed and pressure data performed by the Safety Board, the schedule of airspeed differential noted during the descent of the accident airplane closely matched the results of the 13-Inch Column test listed above.

8.0 Maintenance History of the Accident Airplane

8.1 Recent Routine Maintenance Checks of the Accident Airplane

At the time of the accident, the airplane had accumulated 30,278 flight hours and 5,817 cycles. The most recent C-check (C-2) was accomplished on August 15, 1998, or 14 months prior to the accident, and the next scheduled C-check was to occur on November 13, 1999, or 1 month after the accident. The most recent B-check (B-17) was accomplished about 2 weeks before the accident on September 1, 1999, and the next scheduled B-check was to occur about 1 week after the accident on October 21, 1999. The most recent A-check was accomplished on October 8, 1999, and the next scheduled A-check was to occur on October 29, 1999.[6]

8.2 Recent Maintenance Discrepancies Related to Airspeed Anomalies

An examination of the accident airplane's maintenance records beginning about 14 months prior to the accident revealed the following write-ups (summarized here for brevity and clarity) related to the pitot-static system:

April 9, 1999 – Autopilot and Autothrottles disengaged in stable cruise flight. An IAS MISCOMPARE light was observed, with a 6-knot airspeed split between the captain's and first officer's display. ADC-2 was selected after the first officer's reading was closest to the stand-by airspeed. ACTION: Removed and replaced ADC-1 and performed pitot static leak check. Systems operationally checked ok.

April 13, 1999 – SEL ELV MAN and SEL FLAP LIMIT OVERIDE alerts came on several times. A 35-knot airspeed differential was noted, with a airspeed alert display. ACTION: Purged first officer and captain's pitot line with dry nitrogen. Found captain's pitot line obstructed with water. Purged this line until dry. Performed low level leak check. Operational checked ok.

April 25, 1999 – Indicated airspeed disparity on both 1 and 6 display units. The disparity went away after airspeed display was selected to the ADC-2. ACTION: Restored ADC selection switch to original position. Both ADCs checked ok.

April 25, 1999 – Airplane received "Technical Service Item" (TSI) treatment as a result of airspeed discrepancies. ACTION: ADC-2 removed and replaced as a precaution. Request to "watch for a few legs."

May 7, 1999 – TSI closed due to "no repeats" of airspeed discrepancies.

May 8, 1999 – On descent, an amber indicated airspeed disagree light was displayed, along with a 7-knot differential on localizer intercept. Autopilot and autothrottles failed to engage for both no. 1 and no. 2 FMAs. Airspeed differential grew to 19 knots between captain and first officer displays during approach. First officer's airspeed appeared to correct. Crew received SEL ELEV MAN and SEL FLAP LIMIT OVRD alerts. ACTION: Realigned IRUs. Performed tests on both FCCs and ADCs; no anomalies noted. Checked ok.

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[6] According to Federal Express representatives, the C-check interval for the MD-11 is 455 days or 4,800 flight hours. The B-check interval is 540 hours. The A-check interval is 250 hours. The service interval is every 7 days.

May 9, 1999 – Airplane received another TSI treatment due to repeated write-ups of airspeed disagree. The following actions are requested: (1) Check wiring at ADC-1, (2) Check continuity of total air temperature pins, (3) Check wiring from selected connector pins, (4) Check TAT probe wiring and replace TAT probe even if no faults found.

May 15, 1999 – Removed, tested, and reinstalled ADC-1. No faults found. Total Air Temperature Probe replaced. Airplane downgraded to CAT II CK III.

May 29, 1999 – TSI closed after "18 good legs" with no airspeed anomalies.

June 2, 1999 – During cruise, amber indicated airspeed alerts occurred simultaneously on both displays. Airspeed split was 3 – 4 knots between captain and first officer. ACTION: Fault found on FCC-1. FCC-1 removed and replaced. Checked ok. Also performed ADC-1 and ADC-2 tests; no faults found.

June 26, 1999 -- During cruise, amber indicated airspeed alerts occurred intermittently simultaneously on both displays several times. Airspeed did not fluctuate and appeared accurate with no other unusual indications. ACTION: ADC-1 test revealed fault code 1. Removed and replaced stall warning sensor. New sensor checked ok. (No other action taken, and ADC-1 remained in airplane)

June 26, 1999 – Amber indicated airspeed alerts on both captain and first officer's displays. Intermittent loss of autopilots and flight director pitch bars. Selected ADC on the other side which seemed to fix the problems. Aircraft was in heavy rain and warm temperatures. ACTION: FCC-1 shows faults for angle of attack (AOA) no. 2 sensor. AOA sensor no. 2 removed and replaced. Also purged and leak checked first officer's pitot system. Leak check ok.

July / August / September / October, 1999 -- No further airspeed or pitot-static system related write-ups noted

A review of these maintenance records did not reveal any indications that the pitot tube drain holes had been inspected during these write-ups.

8.3 Federal Express Maintenance Program for Pitot-Static System

According to Federal Express representatives, the Federal Express maintenance program incorporated the following task related to the pitot-static system at the time of the accident:

• Drain Accumulated Water from Pitot System	3410-201	Every 4B (2,160 hours)
• Check Air Data Switching	3410-301	Every 4B (2,160 hours)
• Inspect Pitot Probes (from ground)	3410-501	Every 4B (2,160 hours)
• Leak Check Pitot/Static System	3410-601	Every 2C (9,600 hours)
• General Visual Inspection from Ground		Every Srvc. & A-check

According to Federal Express representatives, the program did not incorporate the MD-11 On-Aircraft Maintenance Planning (OAMP) task 3404-110, which was added in 1998 by Douglas into the OAMP as a recommendation only. This task is entitled "Detailed Inspection – Pitot Tubes Drain Hole" and recommended that the drain holes on each pitot head be inspected for blockages at every C-check. The recommendation was made as a result of an MD-11 incident that occurred in Argentina and is addressed later in this report. Federal Express did not incorporate this task because it was recommended only, and not a required task listed in the MD-11 Maintenance Review Board (MRB) document.

Additional information related to Federal Express maintenance procedures for the MD-11 pitot-static system, including revisions that were made after the Subic Bay accident, can be found in section 11.0. The work cards for the procedures are attached.

9.0 Previous DC-10 / MD-11 Incidents Involving Anomalous Airspeed Indications

9.1 World Airways

On November 6, 1996, about 1619 Eastern standard time, World Airways flight 201, N271WA, a McDonnell Douglas MD-11, overran runway 11 at Ezeiza International Airport in Buenos Aires, Argentina.[7] The airplane received minor damage. There were no injuries to the 269 passengers and 16 crewmembers. The investigation revealed that the crew landed long and fast as a result of erroneous airspeed indications. It was determined that these indications were caused by water in the pitot tubes as a result of blocked pitot tube head drain holes. Laboratory analysis of the debris blocking the drain holes revealed fiberglass shards, which may have entered the uncovered pitot tubes as a result of on-airplane radome repairs.

According to representatives at World Airways, a review of World Airways MD-11 fleet history disclosed five instances of similar alerts and anomalies prior to the Argentina incident. Two of these reports occurred on N273WA, two were reported on N280WA, and one was reported on N275WA. In two cases, the airline determined that the pitot tube drain holes were clogged. In two other cases, replacement of the air data computers corrected the malfunction. The cause of the fifth occurrence was not determined. As a result of these reports, prior to the Argentina incident, a fleet campaign directive was accomplished on all aircraft, inspecting the drain holes and clearing as necessary. However, at that time, the airline was not convinced that clogged drain holes was the cause of these incidents, but believed that entrapped water may have been the cause. To reduce this

[7] This incident was investigated by airworthiness authorities in Argentina. The NTSB provided technical assistance. The NTSB case no. is DCA97WA006.

possibility, the airline chose to increase the frequency of performing task 34-11-01 which involved draining any accumulated water from the pitot system, from the required 1,800-hour interval down to a 450-hour interval. Further investigation immediately after the Argentina incident revealed that the proposed interval was never implemented in the airline's maintenance program for unknown reasons.

It was noted during the Argentina incident investigation that the MD-11 Aircraft Maintenance Manual (AMM) contains a procedure for checking and cleaning the pitot head drain holes; however, the original Maintenance Steering Group–3 (MSG-3) MD-11 On-Aircraft Maintenance Planning document (OAMP) did not have a recommendation or requirement for checks of the pitot head drain holes. Thus, it was not incorporated into the World Program during the start up of the MD-11 program.

Boeing received reports from another MD-11 operator in late 1997 of two different MD-11s experiencing air data anomalies during arrival into the same South American destination. Examinations of the pitot tubes revealed insect and/or other environmental debris blocking the pitot tube drain holes.

9.2 DC-10 Incidents

On January 16, 1975, Douglas issued an All Operator Letter (AOL 10-758, attached) advising DC-10 operators of an incident in which a 30-knot airspeed difference between instruments was experienced during descent in heavy rain. Subsequent investigation revealed blocked pitot head drain holes.

The results of a Douglas-requested DC-10 fleet inspection revealed 11 additional pitot tubes with one or more blocked water drain holes (attributed to an accumulation of debris from the airplane's operating environment).

From 1975 to the present, Boeing has received additional reports of DC-10 air data anomalies. For example, Boeing service history data from 1995 to the present revealed 17 reported DC-10 airspeed anomalies. Of those 17 anomalies, 6 involved faulty airspeed indicators; 4 involved faulty air data computers; 3 involved pitot tube (not pitot tube drain holes) blockages from sand, insects, and in one case, a screw; 2 involved loose pitot or static line connectors; and 2 involved the removal and replacement of both an airspeed indicator and an air data computer as corrective action. For the same time period, according to Boeing, there were 21 reported MD-11 airspeed anomalies (not including the Subic Bay accident). Of those 21 anomalies, 5 involved insects/dirt/nests/fiberglass in the pitot tube(s), blocking pitot head drain holes or the pitot lines themselves (some of the reports were not very specific); 4 involved air data computers (the computers were removed and replaced); 4 involved causes that were unknown or unidentified; 3 involved loose or nonexistent pitot or static line connections; 2 involved debris in the static port(s) or lines; one reported that corrective action was the removal and replacement of the static and pitot hoses; one involved a reported FMC fault; and one reported that corrective action consisted of blowing out the pitot line and removing and replacing an air data computer.

10.0 Summary of Boeing DC-10/MD-11 Air Data Anomaly Corrective Maintenance Actions

According to Boeing, the following actions were taken as a result of reports from airlines related to airspeed anomalies:

- Late in 1974 Boeing (Douglas) received a report from a DC-10 operator of a 30-knot airspeed error, attributed to manufacturing residue blocking the pitot tube water drain holes. As a result of the operator report, Boeing (Douglas) campaigned the DC-10 fleet in late 1974-early 1975 for additional reports of blocked pitot tube water drain holes. Boeing (Douglas) then issued a DC-10 All Operator Letter AOL 10-758 on January 16, 1975, advising operators of the DC-10 incident which initiated the fleet campaign, the additional 11 pitot tubes with blocked water drain holes from environmental debris reported to Douglas during the fleet campaign; and Douglas recommendations for inspecting the pitot tube drain holes for blockage.

- The MSG-2 (Maintenance Steering Group 2) DC-10 On Aircraft Maintenance Planning (OAMP) document was revised in 1975 to include a detailed inspection of the pitot tube water drain holes at every 1C maintenance check, per AOL 10-758. This inspection was made a Maintenance Review Board (MRB) requirement.

- The initial MD-11 OAMP (MSG-3) did not have a Boeing recommendation or an MRB requirement to perform detailed inspections of the pitot tube water drain holes.

- The MD-11 OAMP was revised in May of 1997, after the World Airways event, to recommend a detailed inspection of the pitot tube water drain holes on a 1C interval. This item has not yet been deemed a requirement by the MRB's industry steering committee.

- The MSG-3 DC-10 OAMP was developed in the mid- to late-1990's. The MSG-3 OAMP analysis differs from MSG-2 for the determination of which inspection items will be included in the OAMP. The DC-10 MSG-3 OAMP did not include a Boeing-recommended or MRB-required 1C-interval detailed inspection of the pitot tube water drain holes (until Boeing issued a temporary revision recommending the inspection on February 1, 2001)

- The work card (#5600) originally called for by the MD-11 OAMP had the drain hole inspection as a "general visual inspection." In December 2000, a temporary revision was issued to the MD-11 OAMP to call for an improved work card (#1049) that specified a detailed inspection of the pitot drain holes.

- The MD-11 Structural Repair Manual (SRM) was revised in 1998 to insert warnings in the radome repair section to install pitot tube covers any time the radome was being repaired on the airplane. (According to Boeing, the DC-10/MD-10 SRM's will be revised to include the same warning via the September 2001 update package.)

- The OAMPs for the DC-10 MSG-2, DC-10 MSG-3 and MD-11 call for an MRB-required check/drain of accumulated water in the pitot-static systems moisture traps at 4A intervals. (The MD-10 does not have a moisture trap and therefore does not have this check).

- In January and February of 2001 Boeing added the following note to the above 4A interval water drain check work cards that reads: "If moisture is found, check pitot heads (probes) drains for blockage per AMM 34-11-(airplane specific) pg. (airplane specific)."

- Boeing is in the process of adding the same note to the AMM pitot-static water trap drain procedures.

- Temporary Revisions to the MSG-3 DC-10 OAMP and the MD-10 OAMP (MSG-3) were issued February 1, 2001 to recommend the 1C detailed check of the pitot tube drain holes.

11.0 Summary of Federal Express MD-11 Pitot-static System Maintenance Procedures and Corrective Actions

According to representatives of Federal Express, as a result of the Subic Bay accident, the airline has called out detailed instructions to inspect the pitot head drain holes during the "General Visual Inspection from Ground", which they perform at every service and A-check interval. The airline has also adopted the "Detailed Inspection – Pitot Tube Drain Hole" inspection that had only been recommended in the MD-11 OAMP as a 1-C check..

The following chart provides an overview of the Federal Express maintenance actions related to the MD-11 pitot static system. Items in bold indicate revisions that have been implemented as a result of the Subic Bay accident:

Spec. #	Specified Action	FedEx Maint. Card	Frequency.	Notes	Comments
0500-002	Service Check - GVI of Probes and Static Ports for condition and security	Service Check (Step 5.E)	Daily not to Exceed 7 Days		Pitot tubes inspected from **ground** only.

0500-003	**FX A-Check - (Revised Nov. 2000) Added GVI of Pitot Probes and Static Ports for condition and security and Drain holes for obstructions.**	**A-Check (Step 23)**	**250 Flt. Hrs.**	**Drain Hole inspection new since N581FE incident.**	**Pitot tubes inspected with ladder and flashlight. Inspection task is good, purging procedure is questionable. Review required.**
3410-201	Drain any accumulated water from the Pitot System.	34B1401	4B = 2160 Flt Hrs		Water drained from inspection tube at ADC does NOT require system purge or pitot head inspection.
3410-202	Drain any Accumulated water from Static System.	34B1401	4B = 2160 Flt Hrs		Water drained from inspection tube at ADC does NOT require system purge or pitot head inspection.
3410-301	Perform an Operational Check of the Air Data Switching.		4B = 2160 Flt Hrs		
3410-302	Perform an Operational Check of the Static Port Heaters.		4B = 2160 Flt Hrs		
3410-501	Perform a General Visual Inspection of the Pitot Probes.	53B0201 (Step 1.D)	4B = 2160 Flt Hrs		Pitot tubes inspected from ground only, limited value now that A-check does inspection on ladder.
3410-502	Perform a General Visual Inspection of the Static Port.	53B0201	4B = 2160 Flt Hrs		Static ports inspected from ground only.
3410-503	Inspect the Static Port Plate assemblies for waviness. Use the Static Port contour check fixture for the standard.		36 Months	RVSM requirement	
3410-601	Perform a Functional Check of the Pitot and Static System for leakage.	34C1301	2C = 9600 Flt Hrs or 30 Months		Does not do physical inspection of pitot head as part of functional check.

3411-501	**Perform a Detailed Inspection of the Pitot tubes, including the drain holes IAW OAMP. Added new to FX C check Oct. 2000.**	**34C1501**	**1C = 4800 Flt Hrs or 15 Months**	**New FX requirement since N581FE incident.**	**Pitot tubes inspected with ladder and flashlight.**

12.0 Cockpit Indications and Operational Issues Related to DC-10 and MD-11 Air Data Anomalies

MD-11 Indicated airspeed miscompares are displayed on the captain's and first officer's Primary Flight Displays (PFDs) to alert the flight crew to an indicated airspeed discrepancy. The indication appears as an amber "IAS"on the PFD. Data from the accident CVR and DFDR indicate that this indication was presented on the captain's PFD and recognized by the flightcrew.

The Standby Altitude/Airspeed Indicator provides a means of evaluating whether the airspeed discrepancy is on the captain's or first officer's side.

According to Boeing, the crew is alerted or otherwise advised when:

- any pitot heater system is inoperative (Level 1 Alert);
- the captain's and first officer's altitudes and/or airspeeds miscompare (annunciated on the PFDs);
- Airspeed CADC failures (airspeed, scale, and any associated "bugs" are removed from the PFD and a red X is drawn through the airspeed tape); and
- Altitude CADC failures (altitude, scale, and any associated "bugs" are removed from the PFD and a red X is drawn through the altitude tape).

Since pitot static system source[8] anomalies can occur for a variety of reasons, a dedicated alerting system that can accurately and reliably report leaks, restrictions (from tape, insects, insect nests, ice, fiberglass, operating environment, etc.), and other air data source errors has not yet been devised.

The MD-11 Flight Crew Operating Manual (FCOM) Vol. II expanded Emergency Non-Alert section contains a procedure titled "Airspeed: Lost, Suspect or Erratic". This procedure was published at the time of the Subic Bay accident. The checklist highlighted the following possible indications of a malfunction in the pitot-static system:

[8] Defined for these purposes as the pitot probe, static ports, and tubing to the air data computers and standby airspeed/altitude indicators.

- Indicated airspeed not consistent with normal pitch attitude and power setting for phase of flight.
- Indicated altitude different from actual altitude.
- "PITOT HEAT" alert.
- "SEL FADEC ALTN" alert.
- Many Level 1 and Level 2 alerts such as "SEL ELEV FEEL MAN", "SEL FLAP LIM OVRD".
- IAS and/or ALT miscompare annunciation displayed on the PFD.
- Pressurization system problems.

Data from the flight recorders and interviews with the accident flight crew indicate that the "SEL FADEC ALTN", "SEL ELEV FEEL MAN", and "SEL FLAP LIM OVRD" alerts were annunciated during the descent for landing. The MD-11 FCOM contains separate checklists for each of these items; however, none of them provided a direct reference to a possible airspeed anomaly.

On June 15, 2000, as a result of the Subic Bay incident and reports of airspeed anomalies by other MD-11 operators, Boeing revised the MD-11 Flight Crew Operating Manual to provide additional guidance to flight crews. The guidance states that if any two of the following alerts are displayed simultaneously, the crew should use these alerts as valid indications to immediately refer to the "Airspeed Lost, Suspect, or Erratic" checklist: "SEL ELEV FEEL MAN"; "SEL FADEC ALTN"; "SEL FLAP LIM OVRD."

13.0 Summary of Boeing Flight Operations-related Actions for DC-10/MD-11 Air Data Anomaly Events

According to Boeing, the following is a partial historical summary of corrective actions that have been issued by Boeing (Douglas) related to DC-10/MD-11 air data anomalies:

- Boeing gave a presentation to the IATA Safety Committee in February 1997 at Cartagena, Colombia, on the World Airways incident including cockpit indications and alerts, and corrective actions to date. The Safety Managers for several MD-11 operators were in attendance, including FedEx.
- In 1997, the MD-11 FCOM "Severely Damaged Radome and/or Suspect Airspeed Indication" procedure was modified and expanded into the "Airspeed: Lost, Suspect or Erratic" procedure. The initial "Severely Damaged Radome..." procedure provided the flight crew with target pitch and power information for a variety of airspeeds, weights, and configurations.
- Flight Operations Bulletins entitled "Operation with Erratic Airspeed" and "Operation with Invalid or Suspect Airspeed" were released to all MD-11 operators by Boeing (McDonnell Douglas) on June 17, 1997, and August 27, 1998, respectively. Additionally, the July 1, 1997 Trijet Flight Crew Newsletter, distributed to all DC-10 and MD-11 operators,

contained the article "Invalid or Suspect Airspeed". (FedEx republished the "Operation with Invalid or Suspect Airspeed" Flight Operations Bulletin in its entirety in the company's professional monthly publication to crewmembers in October 1998.)

- Boeing developed a sample training module for air data malfunctions and offered the module to MD-11 operators via the August 1998 Flight Operations Bulletin described above, along with the recommendation that the operators incorporate the module in their recurrent training program. FedEx requested the module on October 8, 1998, and it was forwarded to FedEx on October 12, 1998.
- In December of 1998 Boeing elevated the "Airspeed: Lost, Suspect, or Erratic" procedure from an Abnormal Non-Alert procedure to an Emergency Non-Alert procedure after reports of an additional two air data incidents with symptoms similar to those described in the World event.
- After the Subic Bay accident, Boeing revised the MD-10 and MD-11 SEL FADEC ALTN, SEL ELEV FEEL MAN, and SEL FLAP LIM OVRD procedures to refer the flight crew to the "Airspeed Lost, Suspect, or Erratic" emergency non-alert procedure (published on 15 June 2000).
- Heritage Douglas Aircraft operators have been advised several times over the years on the subject of anomalous airspeed indications. A brief review of Boeing (and McDonnell Douglas) Flight Operations correspondence showed the following communications to operators (including those described previously):
    - January 3, 1972: Know Your DC-8 letter #46A, "Unreliable Airspeed Indications"
    - February 15, 1972: Know Your DC-10 letter #1A, "Flight Operation with Severely Damaged Nose Radome/Suspect Airspeed Indication"
    - February 16, 1975: Know Your DC-8 letter #51, "Operation with Suspect Erroneous Airspeed"
    - May 1, 1975: Trijet Flight Crew Newsletter article: "Erroneous Airspeed Incident"
    - May 2, 1975: DC-9 All Operator Letter C1-270-CLS-L437 "Operation with Erroneous Airspeed"
    - October 18, 1976: DC-9 All Operator Letter C1-270-CLS-L1018 "Operation with Suspect Erroneous Airspeed"
    - April 25, 1977: Know Your DC-10 letter #55B "Operation with Suspect Erroneous Airspeed/Blocked or Frozen Pitot Static System"
    - August 2, 1982: Know Your DC-8-70 letter #1 "Airspeed Indication Drop/Ice Accumulation in the Pitot Lines"
    - July 22, 1983: Know Your DC-8-70 letter #2 "Operation with Suspect Erroneous Airspeed"
    - June 17, 1997: Flight Operations Bulletin MD-11-97-04 "Operation with Erratic Airspeed"
    - July 1, 1997: Trijet Flight Crew Newsletter "Invalid or Suspect Airspeed"

- September 1, 1997: Twinjet Flight Crew Newsletter "Invalid or Suspect Airspeed Indications"
- August 27, 1998: Flight Operations Bulletin MD-11-98-06 "Operation with Invalid or Suspect Airspeed"

Jeffrey B. Guzzetti
Aerospace Engineer

SYSTEM SCHEMATIC

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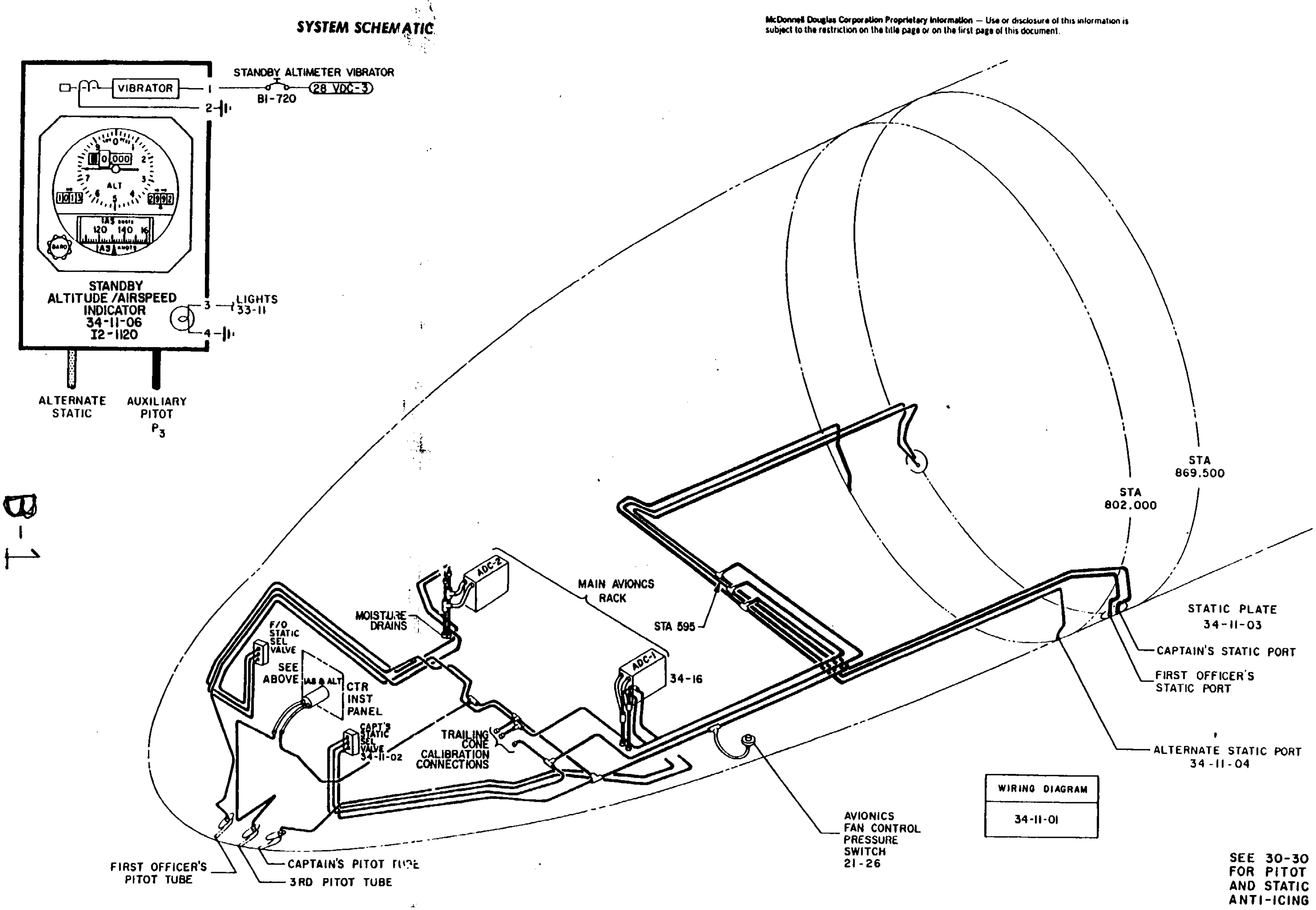

B-1

WIRING DIAGRAM
34-11-01

SEE 30-30 FOR PITOT AND STATIC ANTI-ICING

ALL CUSTOMERS WITH 2 CADC

34-11-0
CODE 100

TITLE PITOT-STATIC SYSTEM	DOUGLAS	CHG A	CODE IDENT NO. 88277	MD-11	34-11-0
P. BORISY		D. RODRIGUEZ		A. LOZANO	DATE 05-20-91

SYSTEM BLOCK DIAGRAM

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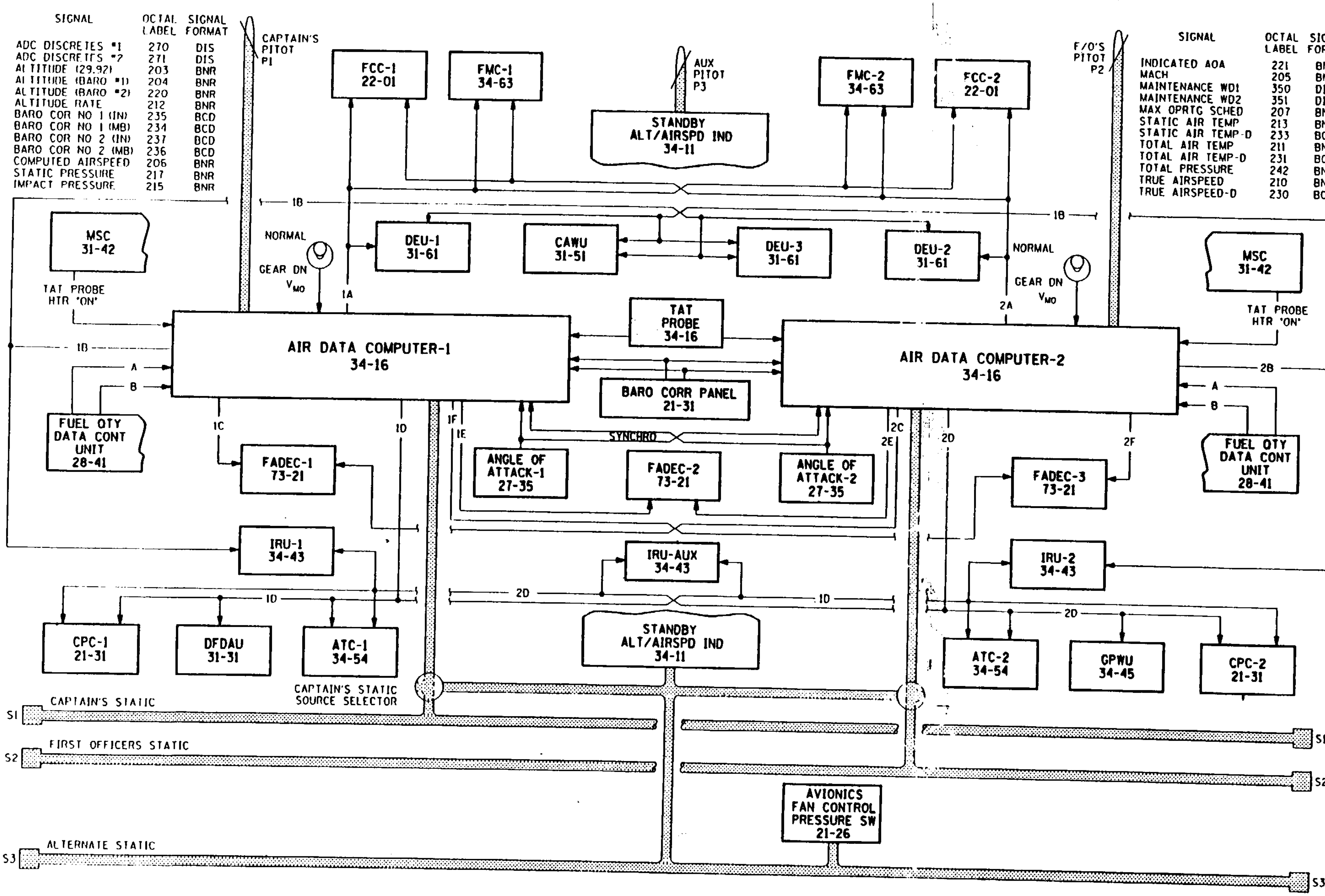
SIGNAL	OCTAL LABEL	SIGNAL FORMAT
ADC DISCRETES #1	270	DIS
ADC DISCRETES #2	271	DIS
ALTITUDE (29.92)	203	BNR
ALTITUDE (BARO #1)	204	BNR
ALTITUDE (BARO #2)	220	BNR
ALTITUDE RATE	212	BNR
BARO COR NO 1 (IN)	235	BCD
BARO COR NO 1 (MB)	234	BCD
BARO COR NO 2 (IN)	237	BCD
BARO COR NO 2 (MB)	236	BCD
COMPUTED AIRSPEED	206	BNR
STATIC PRESSURE	217	BNR
IMPACT PRESSURE	215	BNR

SIGNAL	OCTAL LABEL	SIGNAL FORMAT
INDICATED AOA	221	BNR
MACH	205	BNR
MAINTENANCE WD1	350	DIS
MAINTENANCE WD2	351	DIS
MAX OPRTG SCHED	207	BNR
STATIC AIR TEMP	213	BNR
STATIC AIR TEMP-D	233	BCD
TOTAL AIR TEMP	211	BNR
TOTAL AIR TEMP-D	231	BCD
TOTAL PRESSURE	242	BNR
TRUE AIRSPEED	210	BNR
TRUE AIRSPEED-D	230	BCD



ALL CUSTOMERS
WITH 2 ADCS & W/O ADAS

34-10
CODE 100

TITLE					
AIR DATA SYSTEM	DOUGLAS	CHG	CODE IDENT NO. 88277	MD-11	34-10
	APPR P. BORISY	CHKR VU LE	DRAWN BY J. MARTINEZ	DATE 07-06-91	

SYSTEM SCHEMATIC

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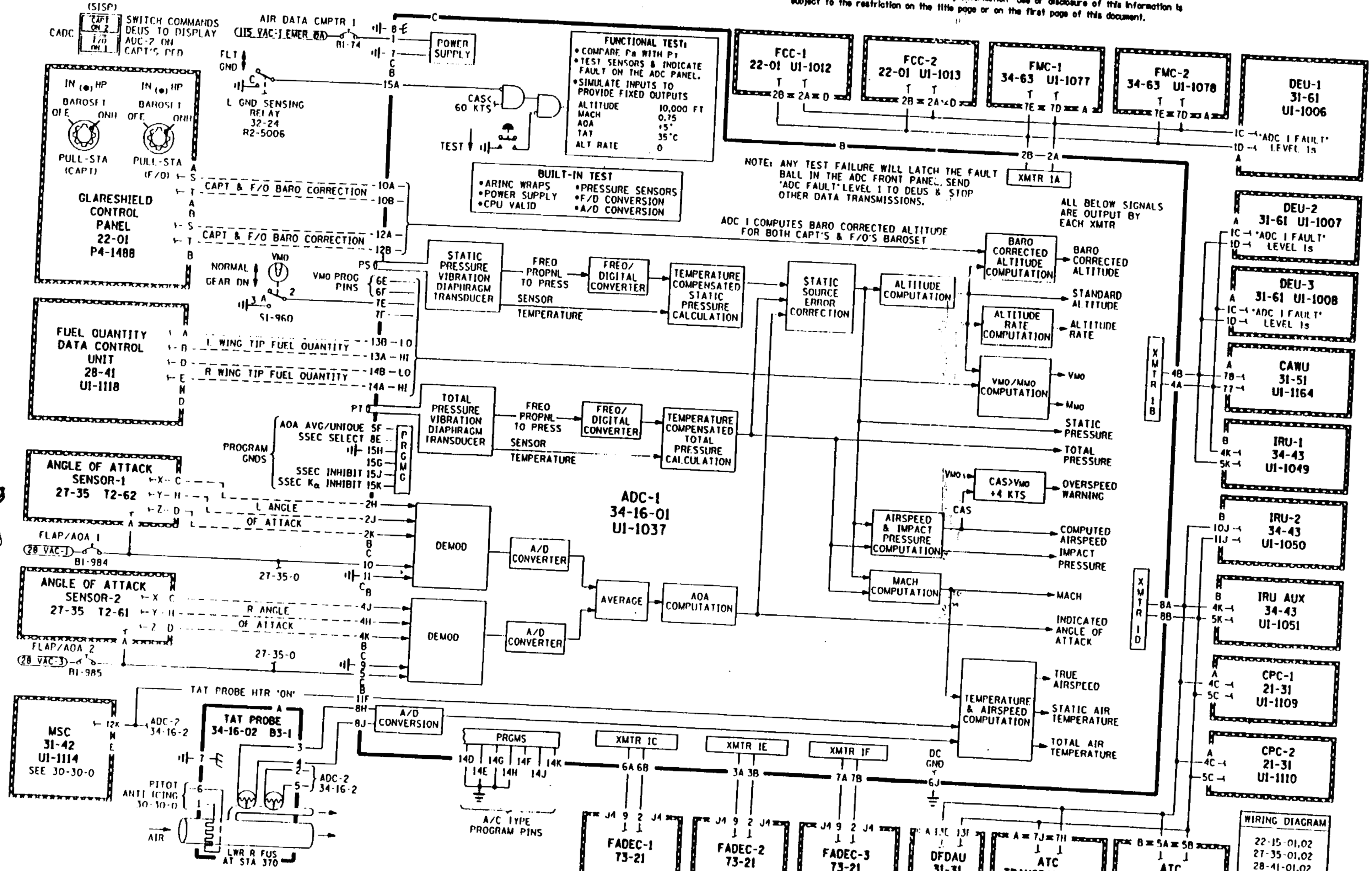

AA OZ Z4 Z9
GA WT Z8

34-16-1
CODE 100

TITLE					
AIR DATA COMPUTER-1	DOUGLAS	CHG	CODE IDENT NO. 88277	MD-11	34-16-1
	APPR P. BORISY	CHKR PETER LIU	DRAWN D. JOHNSON	DATE 02-21-91	

FedEx MD-11 Subic Bay, Philippines
17 October 1999