NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

Group Chairman's Factual Report – Airplane Systems and Powerplants

December 31, 2014

A. ACCIDENT DCA13MA081

Location:	Bagram Air Field, Afghanistan
Date:	April 29, 2013
Time:	1527 Local Time
Aircraft:	National Airlines flight 102, a Boeing 747-428BCF, registration N949CA

B. GROUP

Accident site documentation, May 3 – 12, 2013:

Chairman:	Tom Jacky National Transportation Safety Board Washington, D.C.
Member:	Steve Santangelo National Airlines Orlando, Florida
Member:	Rick Mayfield The Boeing Company Seattle, Washington

Wreckage Examination at NTSB Training Center, September 4-5, 2013:

Chairman:	Tom Jacky National Transportation Safety Board Washington, D.C.
Member:	Steve Santangelo National Airlines Orlando, Florida
Member:	Rick Mayfield The Boeing Company Seattle, Washington

Member: Eric West
Federal Aviation Administration
Washington, D.C.

Horizontal Stabilizer Jackscrew Assembly Examination at Boeing, January 15, 2014:

Structures Chairman: Pocholo Cruz
National Transportation Safety Board
Washington, D.C.

Systems Chairman: Tom Jacky
National Transportation Safety Board
Washington, D.C.

Member: Steve Santangelo
National Airlines
Orlando, Florida

Member: Rick Mayfield
The Boeing Company
Seattle, Washington

Member: Eric West
Federal Aviation Administration
Washington, D.C.

Elevator Power Control Units Examination at Parker, May 13-15, 2014:

Systems Chairman: Tom Jacky
National Transportation Safety Board
Washington, D.C.

Member: Steve Santangelo
National Airlines
Orlando, Florida

Member: Eric West
Federal Aviation Administration
Washington, D.C.

C. SUMMARY

On April 29, 2013, about 1527 local time, a Boeing 747-400, N949CA, operated as National Airlines flight 102, crashed shortly after takeoff from the Bagram Air Base (OAIX), Bagram, Afghanistan. All 7 crewmembers onboard were fatally injured and the airplane was destroyed from impact forces and post-crash fire. The 14 Code of Federal Regulations (CFR),

Part 121 Supplemental cargo flight was destined for Dubai World Central - Al Maktoum International Airport (OMDW), Dubai, United Arab Emirates.

The group met at the accident site from May 3 – 12, 2013 at Bagram Air Field to document the relevant airplane systems. In addition, the group also documented the 4 airplane power plants, manufactured by General Electric Snecma. Finally, on May 4, 2013 the group examined an exemplar National Airlines airplane located at Bagram Air Field.

During the investigation at the accident site, the National Transportation Safety Board removed the following airplane parts and components from the accident site for further examination:

1. Left Outboard Elevator Power Control Assembly
   Manufacturer: Bertea (Parker)
   Part Number: 234700-1005
   Serial Number: 2208
   Manufacture Date: 4th Quarter 2000

2. Left Inboard Elevator Power Control Assembly
   Manufacturer: Parker
   Part Number: 327400-9001
   Serial Number: 0363
   Manufacture Date: Unknown

3. Right Inboard Elevator Power Control Assembly
   Manufacturer: Parker
   Part Number: 327400-9001
   Serial Number: 0480
   Manufacture Date: 3rd Quarter 1992

4. Right Outboard Elevator Power Control Assembly
   Manufacturer: Bertea (Parker)
   Part Number: 324700-1005
   Serial Number: 0954
   Manufacture Date: Unknown

5. Circuit Card removed from Boeing Control Surface Position Digitizer (SPD)
   Part Number: 285U0034-201
   Serial Number D00133

6. Elevator Torque Tube with attached control cable segments (4), auto pilot input rods (3), elevator feel computer input rod, and segments of elevator push-pull tubes to elevator PCUs:
   Assembly Number: 251U2180-2
   Serial Number: LT A0692

7. Multiple miscellaneous segments of white (painted) hydraulic tubes including one section found on the runway near takeoff rotation

8. Two (2) segments of aft pressure bulkhead with flight control cable pass through's

9. Five (5) grommets for flight control cable pass through frames structure

10. Electronic Engine Control Unit (EEC) removed from Engine 1
Part Number: 07482S0CN1820M33P13
Serial Number: LMDD8545

11. Cargo Loading System Maintenance Computer Unit (Telair)

12. Flight Data Recorder (FDR) chassis

13. Two (2) segments of flight control cables removed from top of M-RAP vehicle

The Structures and Systems groups met at the National Transportation Safety Board Training Center in Ashburn, Virginia, from September 4-5, 2013 to further examine some of the components removed from the accident site. Included in the examination were the following components:

1. Left Outboard Elevator Power Control Assembly (see part documentation above)
2. Left Inboard Elevator Power Control Assembly (documented above)
3. Right Inboard Elevator Power Control Assembly (documented above)
4. Right Outboard Elevator Power Control Assembly (documented above)

5. Elevator Torque Tube with attached control cable segments (4), auto pilot input rods (3), elevator feel computer input rod, and segments of elevator push-pull tubes to elevator PCUs (documented above)

6. Horizontal Stabilizer Trim Drive Mechanism

The following items were removed from the wreckage at the Training Center for further examination at the NTSB Materials Laboratory:

7. Flight Data Recorder (FDR) chassis
8. Horizontal Stabilizer Upper Gimbal Forward Mount Plate

The group met at the Boeing Equipment Quality Analysis (EQA) Laboratory in Seattle, Washington on January 15, 2014 to examine the horizontal stabilizer jackscrew assembly as follows:

1. Horizontal Stabilizer Trim Drive Mechanism

2. Horizontal Stabilizer Upper Gimbal Forward Mount Plate
3. Small segment of airplane fuselage skin

The Systems Group met at the Parker Aerospace facility in Irvine, California from May 13-15, 2014 to examine the following components removed from the accident airplane:

1. Left Outboard Elevator Power Control Unit (documented above)
2. Left Inboard Elevator Power Control Unit (documented above)
3. Right Inboard Elevator Power Control Unit (documented above)
4. Right Outboard Elevator Power Control Unit (documented above)

At the conclusion of each group activity, all pertinent documentation and photographs were provided to each of the parties.

D. DETAILS OF INVESTIGATION

The airplane wreckage was located in an open field adjacent to Runway 03. The airplane was fragmented by impact forces and, in general, the airplane forward of the body station 2060, in section 47, was consumed by post-crash fire. Systems components in the areas of fire were damaged or consumed, which limited the group's ability to identify components. In addition, the airplane's powerplants were documented.

1. AIRPLANE SYSTEMS

During this phase of the investigation, the group identified and documented relevant systems of the airplane. Several system components were identified for further documentation and examination. The relevant airplane systems were documented according to the following categories:

A. Auto Flight

The 3 elevator auto pilot actuators were found in the aft section of the airplane, within a section of wreckage that contained the vertical stabilizer, rudder, and control cables. The units were identified as follows:

1. Actuator in Position B7081
   Manufacturer: Moog
   Part Number: A71720-2
   Serial Number: 0595

2. Actuator in Position B7082
   Manufacturer: Moog
   Part Number: A71720-2
   Serial Number: 0380

3. Actuator in Position B7083

Manufacturer:	Moog
Part Number:	A71720-3
Serial Number:	0761

The Elevator Feel Unit Assembly was located within a section of wreckage that contained the vertical stabilizer, rudder, and control cables. The unit was documented as follows:

Boeing Part Number:	65B81226-1
Serial Number:	219

Each of the 3 elevator auto pilot actuators appeared undamaged and connections to the elevator torque tube were intact. The Elevator Feel Unit Assembly also appeared undamaged and its connections to the elevator torque tube were intact.

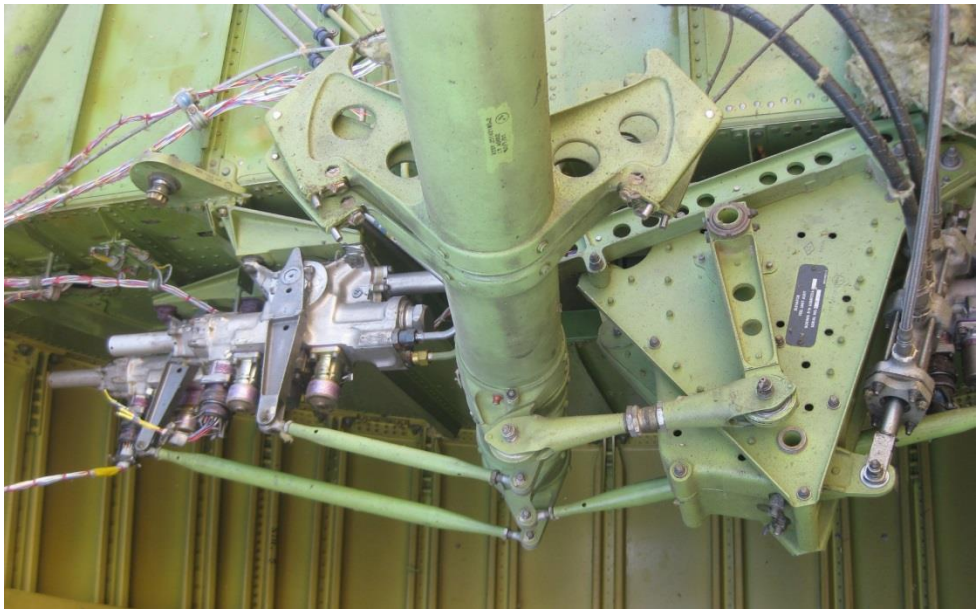

Figure 1 - Elevator Torque Tube, Elevator Auto Pilot, and Elevator Feel Unit Connections

Figure 2 - Elevator Torque Tube and Connections

B. Electrical Power

The P83, P84, and P85 electrical panels, connected to the E8 shelf, were located in the wreckage, near the initial impact zone and in an area of the debris field that was not subjected to post-impact fire. Each panel was bent, crushed and/or separated from the shelf, but did not exhibit any visual evidence of fire damage.

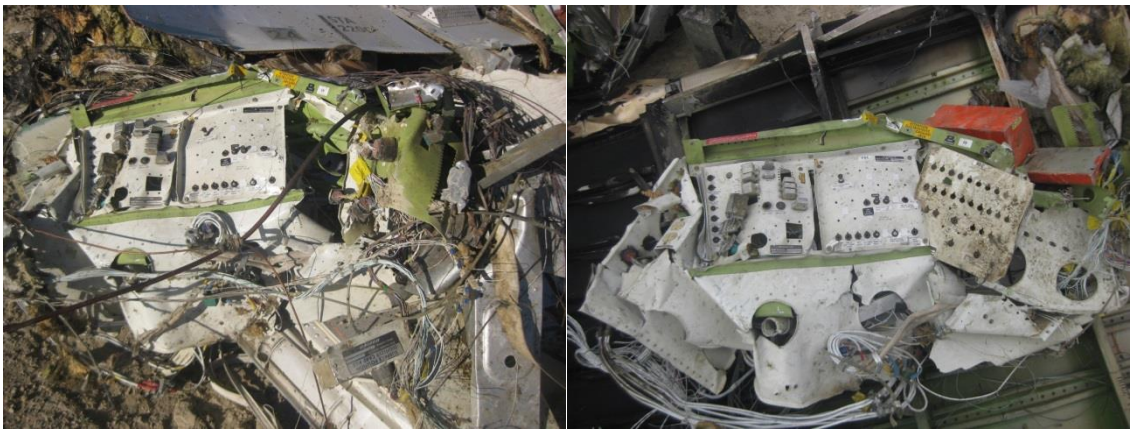

Figure 3 - E8 Shelf and associated electrical panels (Left) and partially-reconstructed E8 shelf (Right).

Each of the 4 wire bundles that pass through the aft pressure bulkhead was located in the wreckage. Several of the wire bundles were pulled out of the aft pressure bulkhead.

C. Equipment & Furnishings

(Note: See Structures Group Chairman Factual Report for information regarding the cargo floor and cargo system) The Telair main cargo system maintenance computer was located, as well as several of the cargo system display and local movement terminals. The cargo system computer was separated from the fuselage wall. The display screen on the Telair master cargo computer was fractured.

D. Flight Controls

Each of the primary and secondary flight control systems was examined to the extent possible, given the fire and impact damage. In general, the elevator and rudder flight control power control units (PCU) were not damaged by fire, while the aileron PCUs were.

D.1 Primary Flight Controls

D.1.1 Pitch Control System

Pitch attitude of the airplane is controlled by the elevators and the variable incidence horizontal stabilizer. The elevator control system is operated manually by movement of the control columns, which actuate the power control units in the horizontal stabilizer. The control columns are connected to the elevator power control units by a series of cables, pulleys, and torque tubes that run from the flight deck, along the top of the fuselage, to the elevators in the aft end of the airplane.

The elevator power control units are powered by the airplane's hydraulic systems as follows:

Left Outboard Elevator:	Hydraulic System 1
Left Inboard Elevator:	Hydraulic Systems 1 & 2
Right Inboard Elevator:	Hydraulic Systems 3 & 4
Right Outboard Elevator:	Hydraulic System 4

D.1.1.1 Examination of the Elevator Control System at Accident Site

Examination of the aft elevator torque tube (common aft elevator quadrant) noted that the tube was bent and the push rod attach bearings were damaged. In addition (as noted above), the three auto pilot servos and the elevator feel computer input rods were still attached to the torque tube. The push rods from the torque tube to the horizontal stabilizer were still connected to the tube but were severed at approximately the stabilizer bulkheads on each side. The tube could be moved through its assumed full range of travel (by hand). The torque tube was removed, with attaching push-pull rods and control cables still attached, from the wreckage and retained for further evaluation and reference.[1]

[1] In September, 2013 at the NTSB Training Center, a general visual examination of the aft elevator torque tube (common aft elevator quadrant) was accomplished with no additional visual damage noted from the on-scene examination.

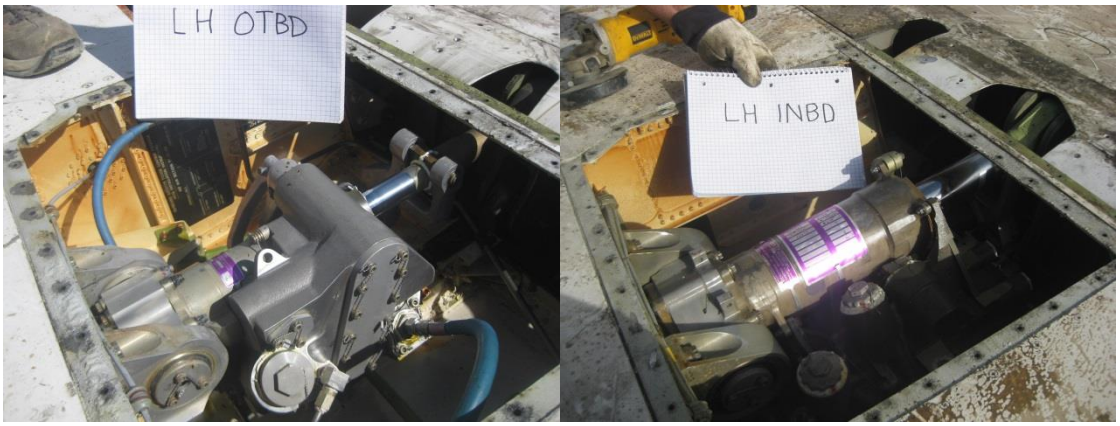

Figure 4 - Left Outboard PCU (Left) and Left Inboard PCU (Right), after access panels were removed.

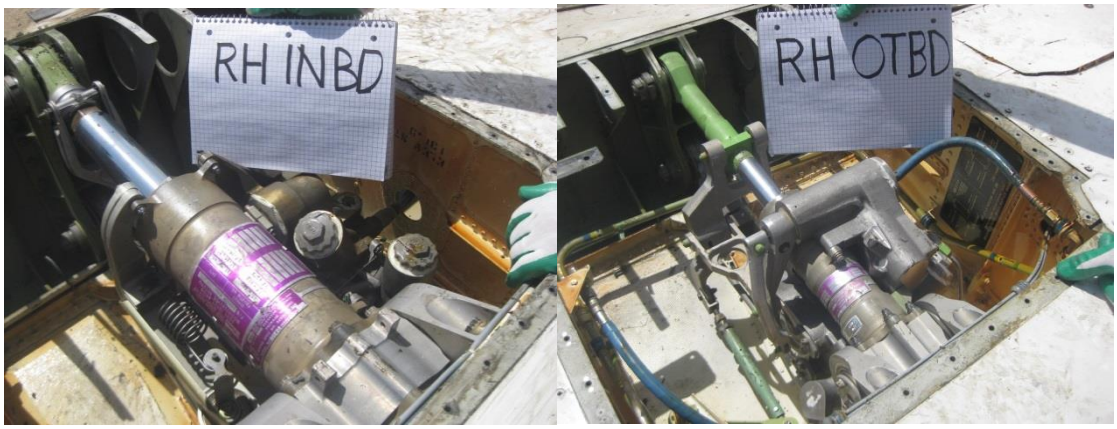

Figure 5 - Right Inboard PCU (Left) and Right Outboard (PCU) (Right) after the access panels were removed.

Five flight control cables were traced from the forward part of the wreckage to approximately the keel beam area of the wreckage. No attempt was made to identify each of the cables, but all appeared to be 1/8" diameter cable. Each of the cables was damaged – frayed, cut, and bent.

Within the section of wreckage that included the vertical stabilizer and rudder, the continuity of each of the 4 elevator cables from the aft elevator torque tube forward to the body station 2412 bulkhead was confirmed; the torque tube, elevator auto pilot actuators, and connecting flight control cables were contained in the section of wreckage. When fully extended, the control cables designated E2A and E2B (elevator) extended 32" and 28" beyond (airplane forward) the body station 2412 bulkhead, respectively. When fully extended the control cables designated E1A and E1B (elevator) extended 6" beyond and ~3" short of the body station 2412 bulkhead, respectively. Finally, the control cables designated RA and RB (rudder) extended 1" beyond the body station 2412 bulkhead and 1½" short of the body station 2436 bulkhead, respectively.

The elevator cable pulleys immediately aft of body station 2412 for elevator cables E2A, E2B, and E1A were broken with approximately half of each pulley missing. The pulley mount brackets were bent. The pulley corresponding to elevator control cable E1B was not noticeably broken.

The body station 2412 bulkhead flight control cable pass-through fairleads (grommets) were examined. Several of the grommets exhibited grooves or notches, including notches through the grommets material and into the bulkhead material.

For each of the body station 2412 pass through, the following assessment was made:

- E2A – Grommet removed
- E2B – No Grommet noted
- RB – No Grommet noted
- RA – Grommet removed
- E1B – Grommet removed
- E1A – No Grommet noted
- Loose Grommet found on structure, removed
- RA at body station 2436 – Grommet removed

In addition, the pressure seals on the cable pass thru at the aft side of the aft pressure bulkhead (body station 2360) were abraded on the upper side of each pressure seal.

Two lengths of control cable were found draped over the top of the aft most M-RAP (a MAT-V) in the wreckage. One segment, designated "X", was measured as 101½"; the other segment, designated "Y", was measured as 131". Each cable had a kinked or flat spot approximately 3/8" long that was similar; it appeared as the cables might have been snagged together. The flat spot was 67" down the length of cable X and 88" down the length of cable Y.

The horizontal stabilizer structure was found in the aft section of the airplane wreckage, clear of the area of post-impact fire. The assembly was aft of the vertical stabilizer, with the lower surface of the stabilizer and trailing edges of elevator contacting the ground. The surface position of the elevators was trailing edge down with respect to the horizontal stabilizer.

Using a crane, the horizontal stabilizer was hoisted from the ground and turned over to access the lower surfaces where the elevator PCU access panels were located. The access panels and fairings between the horizontal stabilizer and elevators were removed for visual examination of the elevator PCUs and elevators.

In general, a visual inspection of each of the 4 elevator power control assemblies did not reveal any physical damage. In addition, no foreign objects were noted in any of the elevator PCU access areas.

A visual examination of the elevator control surfaces revealed minor physical damage to the outer areas, and a minor deformation of the leading edge ribs of the left outboard assembly, and deformed trailing edges. Each of the 4 elevator surfaces could be moved by hand once the PCUs were removed. The severed elevator push-pull rods attached to the elevator torque tube, severed at the bulkheads, were intact from the bulkheads outboard, and operated smoothly when moved by hand. The push-pull rods would also hold the elevators in position until the inboard input rods and the slaved outboard rods were moved.


Figure 6 - Elevator and Horizontal Stabilizer segment as found (Left) and being overturned (Right)

The 4 elevator PCUs were removed from the airplane and retained by the investigation for further examination.

D.1.1.2 Examination of the Elevator Power Control Units at Parker

Prior to the examination, the 4 elevator PCUs were secured in the shipping crate. The crate was transported to the Parker Aerospace facility in Irvine, California. The crate was placed into secured storage. Upon the group's arrival, the shipping crate was moved from secured storage and the units removed from the crate. The part and serial numbers for the PCUs were confirmed and the PCUs were visually examined and photographed for documentation.

The appropriate functional test was conducted on each of the PCUs. For each PCU, the portion of the functional test related to proof pressure and duty cycle were not conducted because the tests are certification-level tests for newly-manufactured units and not applicable to in-service units, e.g. the accident airplane PCUs.

A hydraulic fluid sample was removed from each of the units, from the return port(s) prior to testing and sent to the Parker Materials & Processes Laboratory for contamination testing. The results of the contamination testing were not available during the group activity: Parker sent the results at a later date. The results of the contamination tests were included in Section D.1.1.2 **(5)** below.

The test results pages from each elevator PCU were scanned and provided to the participants electronically.

1. Examination of Left Outboard Elevator Power Control Unit

For this elevator PCU, Parker Aerospace had no record of return to Parker for repair.

A visual inspection was performed and the unit appeared in good condition. Safety wires were all in place. The PCU exhibited minor scratches and abrasions typical of an in-service unit.

The PCU was placed onto Parker Elevator Test Stand #016. The PCU was subjected to a functional test, conducted per Parker Component Maintenance Manual (CMM) 234700, Task 27-30-10-700-842-A01.

The test was accomplished on the Left Outboard PCU with no faults found except for Test Reference 9.A.(4) – Neutral Adjustment (the value was +0.007 inches outside specifications) and 9.A.(20).

2. Examination of Left Inboard Elevator Power Control Unit

Parker Aerospace indicated the elevator PCU had been returned to Parker for repair in April, 1998.

A visual inspection was performed and the unit appeared in good condition. Safety wires were all in place. The PCU exhibited minor scratches and abrasions typical of an in-service unit. Rubbing was noted on the external surface of the floating side of the external summing lever. The rubbing did not bind or freeze the linkage or the operation of the PCU. When the linkage was removed and opened, the staked bearing of the linkage was noted to be extended from its installed position, causing the floating side of the linkage to rub.

The PCU was placed onto Parker Inboard Elevator Test Stand #010. The PCU was subjected to a functional test, conducted per Parker Component Maintenance Manual (CMM) 234700, Task 27-30-09.

The test was accomplished on the Left Inboard PCU with no failures except for the 11.D Clearance Check (due to external summing lever rubbing), 11E. and F. Input/Output Rig Neutral test (rig was off in return direction), 11.L. Input Force (Extend force exceed max value), and 11.Q. (17) Actuator Stroke (in Extend direction).

3. Examination of Right Inboard Elevator Power Control Unit

Parker Aerospace indicated the elevator PCU had been returned to Parker for repair in November, 1998.

A visual inspection was performed and the unit appeared in good condition. Safety wires were all in place. The PCU exhibited minor scratches and abrasions typical of an in-service unit. Dirt was noted inside the return and pressure ports on the inboard side of the PCU.

The PCU was then placed onto Parker Inboard Elevator Test Stand #010. The PCU was subjected to a functional test, conducted per Parker Component Maintenance Manual (CMM) 234700, Task 27-30-09.

The test was accomplished on the Right Inboard PCU with no faults found except for Test 11.E. and F.(17) - Input/Output Rig Neutral (the main rig neutral exceeded maximum allowed rig from neutral).

4. Examination of Right Outboard Elevator Power Control Assembly

For this elevator PCU, Parker Aerospace had no record of return to Parker for repair.

A visual inspection was performed and the unit appeared in good condition. Safety wires were all in place, but there were no Parker witness seals on the safety wires. The PCU exhibited minor scratches and abrasions typical of an in-service unit.

The PCU was then placed onto Parker Elevator Test Stand #016. The PCU was subjected to a functional test, conducted per Parker Component Maintenance Manual (CMM) 234700, Task 27-30-10-700-842-A01.

The test was accomplished on the Right Outboard PCU with no failures noted.

5. Results of PCU Hydraulic Fluid Contamination Testing

Parker Materials & Processes Laboratory conducted contamination testing on each of the hydraulic fluid samples removed from the PCU units. Since a fluid was sampled from each return port, the outboard units had one sample (R) while the inboard units had 2 (R1 and R2). The results, compiled from the Parker M&P Laboratory Reports, are summarized as follows:

Left Outboard Elevator Power Control Assembly, Serial Number: 2208

PCU Serial Number 2208 - Hydraulic Fluid Contamination Report – Particle Count		
Micron Size Range	Maximum Allowable Particles (per 100 mL)	Return Particle Count
5 - 10	128,000	5,320
10 - 25	42,000	637
25 - 100	7,500	23
Greater Than 100	92	1

Left Inboard Elevator Power Control Assembly, Serial Number: 0363

PCU Serial Number 0363 - Hydraulic Fluid Contamination Report – Particle Count			
Micron Size Range	Maximum Allowable Particles (per 100 mL)	Return 1 Particle Count	Return 2 Particle Count
5 - 10	128,000	18,607	24,224
10 - 25	42,000	3,338	19,518
25 - 100	7,500	224	11,610
Greater Than 100	92	12	447

The particle count that exceeded the maximum allowable level is highlighted in yellow.

Right Inboard Elevator Power Control Assembly, Serial Number: 0480

PCU Serial Number 0480 - Hydraulic Fluid Contamination Report – Particle Count			
Micron Size Range	Maximum Allowable Particles (per 100 mL)	Return 1 Particle Count	Return 2 Particle Count
5 - 10	128,000	2,936	50,792
10 - 25	42,000	722	10,568
25 - 100	7,500	115	751
Greater Than 100	92	11	55

Right Outboard Elevator Power Control Assembly, Serial Number: 0954

PCU Serial Number 0954 - Hydraulic Fluid Contamination Report – Particle Count		
Micron Size Range	Maximum Allowable Particles (per 100 mL)	Return Particle Count
5 - 10	128,000	12,586
10 - 25	42,000	2,709
25 - 100	7,500	52
Greater Than 100	92	0 (zero)

D.1.2 Roll Control System

The primary roll control system was documented. The extensive fire damage to the wings and the severe fragmentation of the wings made it difficult to identify components of the roll control system.

Outboard aileron actuators were located on each wing. The left outboard PCU was identified as follows:

Bendix Part Number: 3170130-6
Specification: 60B00051-7
Serial Number: 8510120
No modification record

The unit was noted with the input linkage and output rod attached. Approximately 3-1/2" of exposed metal was noted.

D.1.3 Yaw Control System

The yaw flight control system was examined in the wreckage field.

The rudder PCU access panels on the vertical stabilizer were removed and the upper and lower rudder PCUs were identified and visually documented. No visual damage was noted on any of the PCUs, all connections were intact. There was no indication of fire damage. The lower PCU upper bearing appeared to have migrated down less than ¼-inch.

D.2 Secondary Flight Control Systems

D.2.1 Horizontal Stabilizer

D.2.1.1 Examination at the Accident Site

The horizontal stabilizer jackscrew and associated mounting structure and gearing were identified within the horizontal stabilizer segment of wreckage. The upper mount assembly was noted attached to the forward bulkhead of the horizontal stabilizer structure. The jackscrew mounts attaching the jackscrew to the forward side of the stab structure were bent and cracked. The upper yoke forward gimbal mount plate was gouged in two places on the forward surface. The plate was removed from the wreckage for further examination of differential metal and/or paint transfer.

Figure 7 - Horizontal Stabilizer jackscrew segments as found

The jackscrew was severed approximately 1 ½" above the drive assembly. A 4" crack (approximate) was noted from the bottom of the jackscrew fractured end which extended longitudinally "up" the jackscrew, towards the upper mount assembly. The jackscrew was covered with lubricant. The jackscrew drive assembly was located beneath the horizontal stabilizer structure. The drive assembly was aft of its normal location and was imbedded in the

lower horizontal stabilizer structure. The hydraulic drive motors were broken away from their housing and dislodged, but still connected to brackets and plumbing.

The following 2 measurements of the exposed jackscrew threads were made:

- Length of exposed threads, from upper mount collar to end of threads = 9 9/16”
- Length of exposed threads and connecting structure, from upper mount collar to end of internal tube/connecting structure = 15½”

The measurements were provided to Boeing for assessment of horizontal stabilizer position. Boeing indicated that the resultant horizontal position was consistent with a takeoff position.

A horizontal stabilizer control module assembly was documented as follows:

Part Number:	160200-303
Serial Number:	295
Assembly Date:	09/90

D.2.1.2 Examination at the NTSB Training Center

The horizontal stabilizer jackscrew, drive mechanism and associated mounting structure and gearing were removed from its shipping container and laid out on the floor of the NTSB Training Center. The segments of control assembly included the jackscrew, stabilizer mounting structure, jackscrew motor, and lower gimbal attachment mounting structure.

An NTSB Senior Materials Engineer, along with other group members, examined the trim drive mechanism. The engineer examined the jackscrew fracture faces, the drive mechanism, and attachment structure. A preliminary examination of the jackscrew indicated a potential bending fracture. According to the NTSB Senior Materials Engineer, the jackscrew fractures appeared to be overstress in nature with no indication of pre-existing cracking in any examined component.

After the group examination, the horizontal stabilizer jackscrew assembly was returned to its shipping container and then shipped to the Boeing Equipment Quality Analysis Laboratory in Seattle, Washington for further examination.

D.2.1.3 Examination at the Boeing Equipment Quality Analysis (EQA) Laboratory in Seattle, Washington

The group met at the Boeing Equipment Quality Analysis (EQA) Laboratory in Seattle, Washington on January 15, 2014 to further examine the horizontal stabilizer jackscrew assembly.

The group noted the following:

- Impact on the white structure on the base of the stabilizer mechanism appears as crush aft. The support structure did not exhibit any visual evidence of column impact in the vertical direction (as installed).
- Structural damage on the aft portion of the threaded portion of the jackscrew, in the area of the jackscrew fracture, is indicative of jackscrew impact.
- Given the length of the jackscrew and the as-found location and position of the jackscrew, if the bottom support structure of the horizontal stabilizer actuator was compromised and the structure moved aft, the jackscrew could impact the horizontal stabilizer structure.
- The jackscrew fracture suggests the jackscrew was bent aft at failure.

In addition, Boeing provided a Stabilizer Trim Mechanism Examination Reports, consisting of a Boeing Equipment Quality Analysis (EQA) Report and a Boeing Research and Technology (BR&T) Report. See Attachment 1, Boeing Stabilizer Trim Mechanism Examination Reports.

The Boeing reports revealed that the materials identified were verified to be correct, as specified on the manufactures engineering drawings. The examination further revealed that the fracture that separated the jackscrew into two pieces was consistent with a single overload event.

D.2.2 Wing Leading Edge Flaps and Slats

The leading edge flaps and slats for both wings were examined and documented. Due to the post-impact fire and fragmentation from impact, not all of the leading edge devices were accounted for; in addition, not all drive mechanisms from the 28 leading edge devices were accounted for.

From the area of the left wing wreckage, portions of 7 large scissor gear structures were located. Two leading edge flap drive mechanisms were located and four small leading edge drive mechanisms were found.

From the area of the right wing wreckage, approximately 6 leading edge devices were identified.

D.2.3 Flight and Ground Spoilers

All 8 flight spoiler actuators (4 on each wing) were found located aft of their respective wing structures. All the actuators were damaged by fire and no identification plate information was recognizable.

For the left wing, spoiler actuators 1, 2, and 4 (numbered from outboard in inboard) showed no exposed piston. Actuator number 3 was extended 2 ¼". For the right wing, none of the actuators showed exposed piston.

Only 2 ground spoiler actuators were located. Given the location in which they were found in the wreckage, the spoilers appeared to be numbers 5 and 8. The actuators appeared retracted.

D.2.4 Wing Trailing Edge Flaps

The wing trailing edge flaps were documented. Seven of the 8 wing trailing edge flap jackscrews were located in the wreckage. Only the number 4 jackscrew (corresponding to the left inboard flap, inboard jackscrew) was not located.

Each of the associated flap tracks for the located jackscrews was identified. In general, the flaptracks and jackscrews exhibited minor damage. The flap surfaces, if located in an area without fire damage, were fractured from impact damage. The majority of the flap surfaces located within the area of fire damage had been consumed by fire.

For the 7 found jackscrews, the gimbals were located in approximately the same positions. In addition, each of the measurements between upper stops and gimbal were approximately the same. The outboard jackscrews were located and the distance between the forward stops and the aft stops on the gimbal were all measured at approximately the same length.

The following flap jackscrew measurements were made:

Left Wing

- Jackscrew #1 - Outboard–outboard: 41 ¾”
- Jackscrew #2 – Outboard-inboard: 41 ¾”
- Jackscrew #3 – Inboard-outboard: 58 ½”
- Jackscrew #4 – Inboard-inboard: not identified

Right Wing

- Jackscrew #5 – Inboard-inboard: 57¼”
- Jackscrew #6 – Inboard-outboard: 58 7/16”
- Jackscrew #7 – Outboard-inboard: 41½”
- Jackscrew #8 – Outboard-outboard: 41 7/8”

The flap actuator measurements were provided to Boeing for conversion to flap setting. Based on the provided measurements, Boeing calculated that the trailing edge flap position was 10 degrees.

Of the flap transmissions located, only the outboard side of the #2 drive to torque tube connection had all three coupling screws missing.

Jackscrew #2 was identified as follows:

Part Number: 65681127-159
Serial Number: 4E0707

E. Hydraulic Power

The airplane has 4 functionally independent hydraulic systems that operate at a nominal 3,000 psi. Hydraulic power is used to actuate each flight control system except leading edge flaps. Hydraulic power is also used to extend and retract each of the airplane's landing gears. The main components for each of the 4 hydraulic systems are located in the nacelle area above and aft of each engine.

Following the accident, the United States Air Force recovered a segment of white hydraulic (return) tubing from Runway 03 in the area of Taxiway C (Charlie). Following an examination of the tubing, Boeing indicated that the tube was part of Hydraulic System #2 and was installed in the area aft of the aft pressure bulkhead.

Figure 8 - Piece of hydraulic line found on Runway 03

Figure 9 - Identification decal on hydraulic line

A number of pieces of hydraulic tubes of ¾" and 1" diameter, and of various lengths, were located in the aft section of the airplane wreckage. Each of the pieces were fractured, crushed or both. Several of these pieces were painted white. Boeing identified these pieces as white hydraulic tubes, installed aft of the aft pressure bulkhead.

Each hydraulic system, 1-4, is used by the elevator control system, rudder control, and horizontal stabilizer actuator. Therefore, each hydraulic system has components in the airplane's empennage, aft of the aft pressure bulkhead. Tubing for supply and return for each of the systems runs longitudinally below or near the main cargo deck flooring and through the aft pressure bulkhead to reach the components in the aft end of the airplane. Facing aft, the hydraulic tubing for system 1 pass through the bulkhead at the 5 o'clock position and the tubing for hydraulic system 2 passes through the aft pressure bulkhead in the 4 o'clock area of the aft pressure bulkhead. The hydraulic tubing for systems 3 and 4 pass through the aft pressure bulkhead in the area of 7 o'clock (see Figure 3).

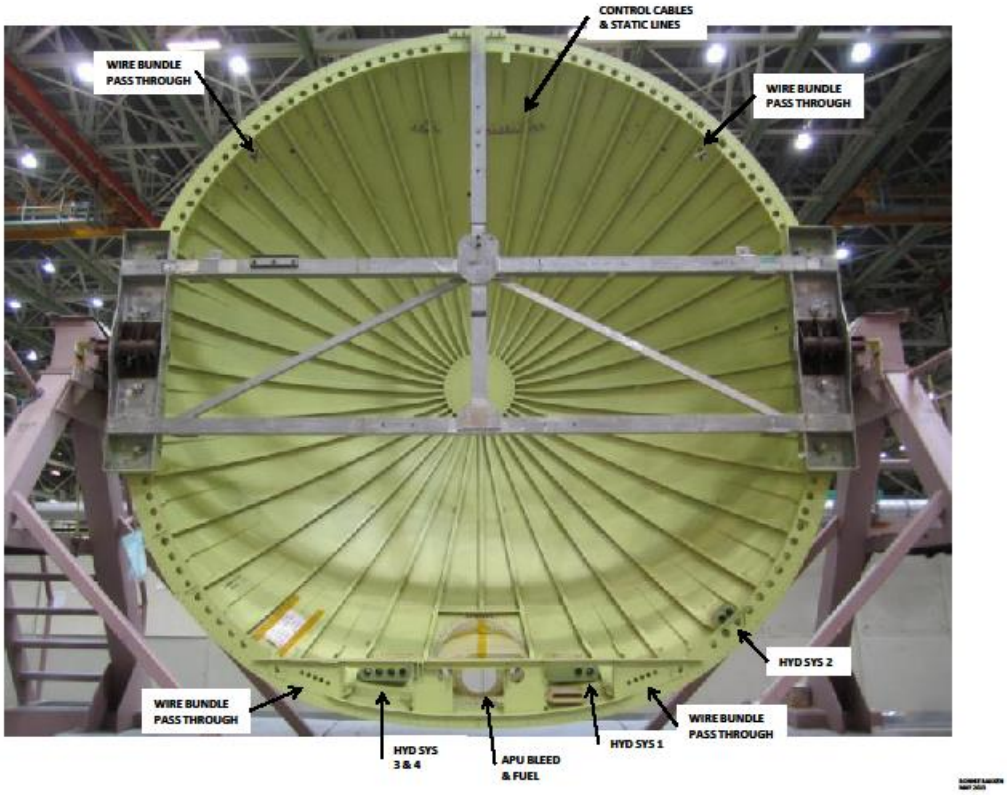

Figure 10 - Aft Pressure Bulkhead and Pass-Throughs, Looking Aft (Courtesy of Boeing)

The hydraulic tube continuity was confirmed from the entry into the horizontal stabilizer to the individual elevator power control assemblies.

F. Indicating/Recording Systems

The flight deck area was subjected to fire and impact damage. The majority of the switches, lights, and radio control panels could not be identified. However, the 6 flight deck electronic flight instrument system (EFIS) display units were accounted for in the cockpit wreckage. All of the units were severely damaged by fire (with internal components consumed). Identification of display units was based on the metallic outer case and chassis. No other flight deck instruments were identified in the wreckage.

The portion of the center pedestal was located in the area of the flight deck. Due to fire damage, only the metallic portions of the pedestal components were identifiable. The spoiler handle appeared to be in the stowed, or forward, position. When visually compared to exemplar photographs and schematics provided by Boeing, the remaining metallic portion of the flap handle was noted in the flaps 10 position (just aft and under the gate). The alternate stabilizer switches were observed but no position assessment could be made. The stabilizer cutout switches appeared to be in the "normal" position, but were thermally and physically damaged. For further information regarding the engine throttle position, please see Section 2, Airplane Powerplants.

A segment of one control column was found in the wreckage, fractured a few inches above the forward torque tube. It was not attached to the airframe.

Two segments of rudder pedals were found; neither was attached to the airframe.

The E-8 rack, which included the cockpit voice recorder (CVR), flight data recorder (FDR), and Flight Control Position Digitizer, was identified in the wreckage. The rack and its components were noted with impact damage. The CVR and FDR memory modules were located and removed by the United States Air Force personnel prior to the arrival of the group. The CVR chassis was not located in the wreckage, but the FDR chassis was identified. One side of the FDR chassis was punctured, and one of the M-RAP vehicles in the cargo was noted with an orange paint transfer of a color similar to the FDR chassis. The FDR chassis was retained for further examination.

The Flight Control Position digitizer had one card installed, which was removed for examination of the contents of its non-volatile memory. Further information from Boeing and the manufacturer of the digitizer confirmed that the card does not have non-volatile memory. No further examination of the digitizer was accomplished.

G. Landing Gear

The airplane was fitted with 5 landing gear assemblies as follows:

1. Nose Gear (operated by Hydraulic System 1)
2. Left Main Wing Gear (operated by Hydraulic System 4)
3. Left Main Body Gear (operated by Hydraulic System 1)
4. Right Main Wing Gear (operated by Hydraulic System 4)
5. Right Main Body Gear (operated by Hydraulic System 1)

Components from each of the 5 landing gear assemblies were located in the wreckage.

NOSE LANDING GEAR

A segment of the nose gear upper cylinder was identified in the wreckage. A small segment of a component, identified as Honeywell P/N 4061392-90, was found attached to the cylinder. According to Honeywell, the part number corresponds to a component of the Onboard Weight and Balance System, which was attached to the nose gear.

Figure 11 - Segment identified as Nose Gear Upper Cylinder

WING LANDING GEAR

Both wing landing gear assemblies were identified. Both were damaged by fire. However, as found, both of the retract actuators appeared extended. In addition, both of the wing landing gear assemblies were found positioned against their respective attach structures.

According to Boeing, the Wing Gear Retract Actuator (Part Number 65B01570) is retracted with gear down and extended with gear up.

BODY LANDING GEAR

Both body landing gear retract actuators were fragmented. In addition, both actuator pistons were detached from the cylinders. One body gear was broken into several pieces.

According to Boeing, the Body Gear Retract Actuator (Part Number 65B0150) is extended with gear down and retracted with gear up.

A body gear downlock assembly was documented as follows:

Part Number:	BAC 65B92558-10
Serial Number:	SHL-285

For this actuator, 4” of exposed shaft was measured, and a measurement of 5½” exposed shaft to the center of the attached linkage.

Several of the wheel trucks and brakes were identified in the wreckage. In general, most of the brake assemblies were subjected to fire damage. Each of the identified brake wear pins was longer than the minimum length, but several were melted. Due to the severity of the fire damage no attempt was made to identify the individual wheel trucks and/or brake assemblies.

H. Airborne Auxiliary Power

The auxiliary power unit (APU) was located in the wreckage. The unit was identified as follows:

Manufacturer:	Pratt & Whitney Canada
Model:	PW901A Gas Turbine Auxiliary Power Unit
Part Number:	391001-0
Serial Number:	PCE-9004

The APU was found in the wreckage field aft of the horizontal stabilizer. There was no visual evidence of fire damage noted. Visual examination of the internal rotating components did not reveal any rotational damage consistent with rotation at impact. A fracture was noted on the compressor. The APU mounts were severed.

The APU controller was located in the area of the E-8 rack.

2. AIRPLANE POWERPLANTS

The airplane was fitted with 4 powerplants, 2 mounted on the underside of each wing.

Each engine's identification plates were either too damaged by post-crash fire to be identified or were not located. Instead, the operator provided records to identify each engine as follows:

For each of the 4 engines:

Engine Manufacturer:	General Electric (GE) Snecma
Model:	Turbofan Engine
Part Number:	CF6-80C2B1F

For each specific engine:

a) Engine Number 1 Serial Number: 703151

b) Engine Number 2 Serial Number: 702644

c) Engine Number 3 Serial Number: 702432

d) Engine Number 4 Serial Number: 702571

Each of the four engines showed visual evidence of operation at impact. All noted rotating components exhibited damage typical of rotation at impact. In addition, each engine sustained severe damage from impact and post-crash fire. Each engine was fragmented, and components attached to or inside the engine were found separated, burnt, or crushed.

The area around the engine number 1 electronic engine control (EEC) was not damaged by fire. The unit's chassis was breached and several internal circuit cards dislodged. The unit was removed from the engine and retained for further examination. The Number 1 EEC was identified as:

Manufacturer:	BAE Systems
Part Number:	07482S0CN1820M33P13
Serial Number:	LMDD8545

Information received from GE, the engine manufacturer, indicated that the EEC would write information to non-volatile memory only when a normal flight leg is completed – landing, rollout and taxi to gate. Based on this information no further effort was made to query or download the information on the EEC.

The engine throttle on the center pedestal was located in wreckage, in the area of the flight deck. The pedestal was damaged by fire, but metallic portions of the engine power levers were noted as all full forward, with what appeared to be a slightly negative stagger from 1 to 4. The reverse levers were all stowed. The fuel switches were noted in the off position with exception of #3, which was in the on position. The flight deck area was damaged by fire.

Tom Jacky
Aerospace Engineer

ATTACHMENT 1

Boeing Stabilizer Trim Mechanism Examination Report