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

November 21, 2013

SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT

DCA13MA120

A. ACCIDENT

Location:	San Francisco, CA
Date:	July 6, 2013
Time:	11:28 PDT
Aircraft:	Boeing 777-200ER

B. SYSTEMS GROUP

Chairman:	Adam Huray National Transportation Safety Board Washington, DC
Member:	Ken Fairhurst Federal Aviation Administration Renton, WA
Member:	John Herndon Federal Aviation Administration Houston, TX
Member:	Jung Ho Kim Aviation and Railway Accident Investigation Board Seoul, South Korea
Member:	Hae Seok Seo Asiana Airlines Seoul, South Korea
Member:	Dennis Asheim Boeing Seattle, WA

C. SUMMARY

On July 6, 2013 at 11:28 am Pacific daylight time, a Boeing 777, registration HL7742, operated by Asiana Airlines as flight 214, struck the seawall short of runway 28L at San Francisco International Airport. The airplane was destroyed by impact forces and fire. Three of the 291 passengers were fatally injured. The flight was a regularly scheduled passenger flight from Incheon International Airport, Seoul, Korea, and was operated under the provisions of *14 Code of Federal Regulations Part 129*. Visual meteorological conditions prevailed at the time of the accident.

D. DETAILS OF THE ON-SCENE INVESTIGATION

The aircraft was examined following the completion of the airport rescue and firefighting activities. There was no power on the aircraft during the on-scene investigation.

D.1 Flight Deck:

The flight deck was heavily sooted but generally did not exhibit thermal damage (see Figure 1). The Captain's and First Officer's rudder pedals appeared in a neutral position and moved together normally when either pedal set was moved. The tiller on both sides also moved when the pedal positions changed. The control yokes and columns demonstrated continuity and moved together normally when either side was moved. Head-up display systems were not installed on the aircraft.

Figure 1: Flight Deck

D.1.1 Switch Positions of Interest:

Heading Reference push button remained guarded and displayed “NORM”
Flap OVRD push button remained guarded and displayed only the white line
Gear OVRD push button remained guarded and displayed only the white line
Terrain OVRD push button remained guarded and displayed only the white line
Glideslope Inhibit push button returned to same state when pushed and indicator could not be viewed through the sooted/damaged face
Landing Gear handle was in the gear down position
Autobrake selector was in the “DISARM” position

Left seat VOR right and left switches up (VOR R and VOR L selected)
Left seat Display setting on MAP
Left seat Range set to 10
Left seat Radio/Mins/Baro select set to Baro
Left seat Baro select set to IN
Left seat FD switch down (OFF)
A/T ARM Left and Right switches were selected up (ARMED)

A/P Disengage Bar was up (not disengaged)
Bank Limit select set to “Auto”
Altitude select scale set to 1000
Right seat VOR right and left switches up (VOR R and VOR L selected)
Right seat Display setting on MAP
Right seat Range set to 20
Right seat Radio/Mins/Baro select set to Baro
Right seat Baro select set to IN
Right seat FD switch up (ON)

Alternate Pitch Trim levers full aft
Speedbrake handle full forward and in “DOWN” position
Throttles full aft “IDLE”
Reverser levers in the stowed position
Flap lever in 30 detent
Stabilizer Cutout Center and Right remained guarded and in normal position
Fuel Control Left and Right switches in “CUTOFF” position
Parking Brake was on
Left engine fire handle pulled (extended) and turned left
Right engine fire handle pulled (extended) and turned right

APU fire handle pulled (extended) and turned left
APU select set to “Off”
ADIRU push button displayed “On”

Seat belt sign turned on
Cargo Fire Arm FWD and AFT push-button indicators could not be viewed through sooted/damaged face but both were observed in the out (not depressed) position
Cargo Fire Discharge switch remained guarded and displayed a solid white line when guard was opened

D.2 Left Wing Observations:

Figure 2: Left Wing

D.2.1 Left Wing Krueger Flap:

Each wing has one Krueger flap located between the inboard leading edge slat and the engine pylon. The Krueger flap has two positions: retracted or extended. The Krueger flap will move to the extended position when the flap handle is moved to any position other than UP.

The left wing Krueger flap linkage arm was fractured. The surface was found in the extended position.

D.2.2 Left Wing Trailing Edge Flaps:

Each wing has 2 trailing edge flaps. The inboard flap is a double-slotted flap and the outboard flap is a single-slotted flap. At flap lever positions UP and 1, the flaps are fully retracted. The flaps are moved to a unique surface position for each flap lever detent position 5 through 30.

The left wing inboard flap outboard transmission assembly ballscrew and ballnut remained on the aircraft but were separated from the rest of the transmission assembly. The ballscrew measured 22.25 inches from the ballnut to the transmission interface. This measurement corresponded to a

flap surface position of 17 degrees and was an expected measurement for a flap lever positioned close to the 25 degree detent. The inboard flap inboard transmission assembly with the remaining section of inboard flap surface was located near the seawall. See section D.4.3.

The outboard flap surface and both transmission assemblies were separated from the wing. The flap surface was partially under the aft fuselage near the L3 door. The outboard flap outboard transmission assembly ballscrew measured approximately 16 inches from the ballnut to the transmission interface. This was an expected measurement for a flap lever placed in the 30 degree detent. The outboard flap inboard transmission assembly ballscrew measured approximately 18.5 inches from the ballnut to the transmission interface. This was an expected measurement for a flap lever placed in the 30 degree detent.

D.2.3 Left Wing Leading Edge Slats:

The airplane has seven leading edge slats on each wing. Six of the leading edge slats are outboard of the engine and one slat is inboard of the engine, between the engine and the fuselage. Each slat has an assigned number, from left to right, of 1 through 14. Each slat is part of a symmetrical pair, for example, slats 7 and 8. The slats have three positions: retracted (cruise), intermediate (sealed), and extended (gapped). The slats are at the sealed position when the flap lever is in the 1, 5, 15, or 20 detent. The slats are at the gapped position when the flap lever is in the 25 or 30 detent.

On the left wing, the three outboard slat surfaces (slats 1, 2, and 3) were separated from the wing structure with all drive mechanisms still attached to the wing except for the outboard drive mechanism for slat 1. This drive mechanism was separated from the wing and remained attached to the slat. Slats 4, 5, and 6 remained attached to the wing, were in line, and visually appeared to be in the gapped position.

Slat 7 (inboard most slat) did not appear to be damaged. The drive extension from the wing skin to the closest bolt measured approximately 14 inches for the outboard drive and approximately 12 inches for the inboard drive. These measurements corresponded to the slat surface being in the gapped position.

D.2.4 Left Wing Aileron:

The left wing aileron power control units (PCUs) were attached to the wing, but the control surface was damaged and only small portions of the surface were still attached to the PCUs. The underwing access panels were removed, and the PCUs were examined. In general, each of the compartments was clean with no foreign objects noted, and all wiring and hydraulic lines were intact and connected. The left aileron inboard and outboard actuator chrome extensions measured approximately 2.5 inches from the piston housing to the attachment pin. These measurements corresponded to a surface position of approximately 7.6 degrees trailing edge down.

D.2.5 Left Wing Spoilers:

The spoilers help the ailerons and flaperons control airplane roll about the longitudinal axis. They also supply speedbrake control to reduce lift and increase drag for descent and landing. There are seven spoilers on each wing. The five outboard spoilers are forward of the outboard flap. The two inboard spoilers are forward of the inboard flap. Each spoiler has an assigned number, from left to right, of 1 through 14. Each spoiler is part of a symmetrical pair, for example, spoiler pair 4 and 11.

For the left wing, spoilers numbered 1-5 were noted as attached to the wing and in the retracted position. For these spoilers, except spoiler 4, there was no extension of the spoiler actuators noted. Spoiler 4 is unique as it can be controlled manually through control cables or electrically as a speedbrake. The number 4 spoiler actuator chrome extension from the actuator housing to the attachment pin measured approximately 4 inches. This measurement corresponded to a spoiler surface position that was fully retracted.

The inboard spoilers (6 and 7) were not attached to the wing. See section D.4.2.

D.2.6 Left Wing Flaperon:

The flaperons are standard inboard ailerons which also operate as flaps. There is one flaperon for each wing located between the inboard and the outboard flaps on the wing trailing edge. When the flaps are extended, the ailerons and flaperons droop to increase the lift of the wing. The ailerons and flaperons of both wings move down. When drooped, the ailerons and flaperons are fully operational for roll control.

For the left wing, the flaperon surface was broken and both actuators remained attached to the wing and broken surface. For the inboard actuator, the chrome extension from the housing to the attachment pin measured 13.5 inches. This measurement corresponded to a surface position of approximately 24 degrees. For a flaps lever setting in the 30 detent, the corresponding flaperon full droop surface position is 31 degrees.

The outboard actuator was not measured due to localized structure damage.

D.2.7 Other Left Wing Observations:

The left main landing gear was separated from the left wing and was located along the debris path. The gear separated at the H-block fitting of the rear spar**.** The left wingtip light structure remained on the wing but the lens was broken.

D.3 Right Wing Observations:

Figure 3: Right Wing

D.3.1 Right Wing Krueger Flap:

The Krueger Flap was attached and the drive mechanism was intact. The surface appeared to be in the extended position.

D.3.2 Right Wing Trailing Edge Flaps:

The right wing inboard flap was severely damaged. The right wing inboard flap outboard transmission assembly ballscrew measured approximately 25 inches from the ballnut to the transmission interface. This was an expected measurement for a flap lever placed in the 30 degree detent. The right wing inboard flap inboard transmission assembly ballscrew measured approximately 25.5 inches from the ballnut to the transmission interface. This measurement was taken after the aircraft was moved to a recovery location. This was an expected measurement for a flap lever placed in the 30 degree detent.

The right wing outboard flap was attached to the wing and the canoe fairings remained intact. The right wing outboard flap outboard transmission assembly ballscrew measured approximately 16.5 inches from the ballnut to the transmission interface. This was an expected measurement for a flap lever placed in the 30 degree detent. The right wing outboard flap inboard transmission assembly ballscrew measured approximately 18.5 inches from the ballnut to the transmission interface. This was an expected measurement for a flap lever placed in the 30 degree detent.

D.3.3 Right Wing Leading Edge Slats:

All right wing slats remained attached to the wing and appeared to be in line. The drive extensions from the wing skin to the closest bolt were measured for the inboard and outboard drives for each slat. All slat drive measurements corresponded to the slat surfaces being in the gapped position (see Figure 4).

Slat Number	Inboard – skin to closest bolt	Outboard – skin to closest bolt
8	11.5 in.	13.5 in.
9	13 in.	13 ½ in.
10	14 ½ in.	15 ½ in.
11	16 in.	16 in.
12	16 ½ in.	16 ½ in.
13	16 in.	17 in.
14	17 ½ in.	18 ½ in.

Figure 4: Approximate Drive Measurements for the Right Wing Slats

D.3.4 Right Wing Aileron:

The right wing aileron power control units were attached to the wing and the control surface. The aileron surface was broken into two pieces at the location where the wing was bent downwards. The underwing access panels were removed, and the PCUs were examined. In general, each of the compartments was clean with no foreign objects noted, and all wiring and hydraulic lines were intact and connected. The right aileron inboard and outboard actuator chrome extensions measured approximately 3.5 inches from the piston housing to the attachment pin. These measurements corresponded to a surface position of approximately 12.2 degrees trailing edge up.

D.3.5 Right Wing Spoilers:

For the right wing, spoilers 9-14 were noted as attached to the wing and in the retracted position. For these spoilers, except spoiler 11, there was no extension of the spoiler actuators noted. Spoiler 11 is unique as it can be controlled manually through control cables or electrically as a speedbrake. The number 11 spoiler actuator chrome extension from the actuator housing to attachment pin measured approximately 4 inches. This measurement corresponded to a spoiler surface position that was fully retracted.

D.3.6 Right Wing Flaperon:

The flaperon remained attached to the wing but appeared to be in an overly retracted position. Flaperon actuator measurements were not taken because the PCUs were not accessible.

D.4 Components Found Separated From the Fuselage:

D.4.1 Stabilizer Trim Actuator:

The horizontal stabilizer jackscrew and drive assembly remained attached to the right horizontal stabilizer located on the runway. The ballscrew and internal safety rod were severed just below the ball nut. The detached section of the ballscrew measured 21 inches in length from the lower end stop to the fracture. The upper portion of the ballscrew measured 10.75 inches from the top of the attached ballnut to the upper stop. This measurement corresponded with a horizontal stabilizer surface position of -1.08 degrees leading edge down.

The Stabilizer Trim control components remained attached to the Section 48 structure that remained attached to the vertical stabilizer.

D.4.2 Inboard Spoiler Actuators:

The two left wing inboard spoilers (6 and 7) and the number 8 right wing inboard spoiler were identified along the debris path. The number 6 and number 7 spoiler actuator chrome extensions measured 4.5 inches from the stop to the attachment pin. These measurements corresponded to the spoilers being in the fully retracted position. The number 8 spoiler actuator chrome extension measurement could not be obtained due to the surrounding structure but appeared to be in the fully retracted position.

D.4.3 Flap Drive Unit:

A flap drive unit identified as PN 256W3318-2, SN 11270354 was found near the beginning of the debris path. It remained attached to flap support number 4 (left inboard flap, inboard drive). The measurement from the ballnut to the transmission interface was 25 inches. This was an expected measurement for a flap handle placed in the 30 degree detent.

D.4.4 Horizontal Stabilizers and Elevators:

The left and right horizontal stabilizers and attached elevators were located along the debris path on the runway. Both the left and right horizontal stabilizers were detached from the aircraft with only a small amount of structure remaining attached to the inboard ends.

The left elevator surface was not significantly damaged. There was no trailing edge at the outboard end of the horizontal stabilizer and there was no fuselage body at the inboard end of the elevator surface that would allow for a measurement of control surface deflection. The surface appeared to be in a faired position.

The right elevator surface was intact. The trailing edge at the outboard end with respect to the outboard tip of the horizontal stabilizer measured 1.25 inches elevator trailing edge up.

D.4.5 Rudder:

The vertical stabilizer and rudder remained connected to the top portion of Section 48 structure but was otherwise separated from other wreckage. The rudder control surface was broken and damaged and there was no trailing edge at the top of the vertical stabilizer. The access panels to the rudder power control units were removed. There was no visible damage noted to any of the power control units and no foreign objects were noted in any of the rudder power control unit compartments. All flight control wiring and hydraulic connections appeared intact.

D.5 Circuit Breakers:

The following circuit breakers (CB) were identified as being open, collared, or broken (note: only the panels listed below were inspected):

Panel ID	CB Location	Status	Label
P210	A-7	Open	SECT 2 THC R115AC
P210	C-1	Collared	SECT 1 PHA R115AC
P210	C-7	Collared	SECT 2 PHA R115AC
P210	D-23	Collared	UTILITY PHB R115AC
P210	F-16	Collared	SECT 2 R115AC
P210	G-16	Collared	SECT 2 R115AC
P210	J-13	Collared	R MAIN R28VDC
P210	H-18	Collared	SECT 2 PHA R115AC
P210	H-19	Collared	SECT 2 PHB R115AC
P210	H-20	Collared	SECT 2 PHC R115AC
P210	M-26	Collared	R MAIN R28VDC
P210	M-27	Collared	R MAIN R28VDC
P110	B-28	Collared	SECT 1 PHC L115VAC
P110	F-28	Collared	SECT 1 PHB L115VAC
P310	A-28	Open	DC STBY BUS 28VDC
P310	B-6	Open	BATT BUS SECT 2
P310	B-7	Open	BATT BUS SECT 2
P310	E-6	Open	CAPT FLT INSTR
P310	F-1	Open	CAPT FLT INSTR
P310	F-5	Open	CAPT FLT INSTR
P310	F-8	Open	CAPT FLT INSTR
P310	F-9	Open	CAPT FLT INSTR
P310	F-10	Open	CAPT FLT INSTR
P310	F-11	Open	CAPT FLT INSTR
P310	F-14	Open	CAPT FLT INSTR
P310	G-11	Open	CAPT FLT INSTR
P310	G-12	Open	CAPT FLT INSTR
P310	H-1	Open	CAPT FLT INSTR
P310	H-2	Open	CAPT FLT INSTR
P310	J-12	Open	HOT BATT BUS

P310	K-8	Open	HOT BATT BUS
P310	L-10	Open	HOT BATT BUS
P310	L-11	Open	HOT BATT BUS
P320	F-6	Open	GRD HANDLING 115VAC
P320	L-11	Open	GRD SVC DIST-2 PHC 115AC
P320	L-12	Open	GRD SVC DIST-2 PHC 115AC
P011-01	E-8	Collared	CAPT EFB
P011-01	D-6	Open	OPAS 1
P011-01	D-13	Open	RAT AUTO CTRL
P011-01	B-5	Open	EDP SUPPLY VALVE (LEFT ENGINE)
P011-02	E-21	Collared	F/O EFB
P011-02	B-20	Open	EDP SUPPLY VALVE (RIGHT ENGINE)
P011-02	A-17	Open	APU FUEL S/O VALVE
P011-02	A-18	Open	L ENGINE FUEL SPAR VALVE
P011-02	A-19	Open	R ENGINE FUEL SPAR VALVE
P011-02	A-23	Open	LANDING GEAR EXTD/RETR
P039	A-11	Open	CSC DC RT
P039	B-1	Open	PDU1L6L10L
P039	B-2	Open	PDU2L7L8C
P039	B-4	Open	PDU4L11L
P039	B-5	Open	PDU5L,8L,12L
P039	C-4	Open	PDU4R, 11R
P039	C-5	Open	PDU5R,8R,12R
P039	F-1	Broken	BULK EXT CARGO
P039	F-2	Open/Broken	SILL DOOR LIGHT
P039	F-3	Open/Broken	EXT DOOR LIGHT
P039	F-4	Open/Broken	EXT CARGO LIGHT
P039	F-5	Open/Broken	APU COMPT LIGHT
P039	F-6	Broken	A&BULK (INTERIOR CARGO LIGHT PANEL)
P039	F-7	Open	A&BULK (INTERIOR CARGO LIGHT PANEL)
P039	F-8	Open	A&BULK (INTERIOR CARGO LIGHT PANEL)
P039	G-1	Open	CARGO LIGHTING CONTROL/AFT

Figure 5: Circuit Breakers Identified as Open, Collared, or Broken

CB Location	Status	Label
A1	Open	ACE PWR
A3	Open	AIL PWR
A5	Open	FLPRN PCU
A7	Open	ELEV PCU
A9	Open	RUD PCU
B2	Open	STAB TRIM

Figure 6: Open Circuit Breakers on Flight Controls DC Power Supply Assembly P/N: 8-736-05, S/N: 1933, Rack: M24301

CB Location	Status	Label
A7	Open	ELEV PCU
A8	Open	RUD PCU
B2	Open	STAB TRIM

Figure 7: Open Circuit Breakers on Flight Controls DC Power Supply Assembly: P/N: 8-736-05, S/N: 1989, Rack: M24201

The P100 Left Power Panel, P200 Right Power Panel, the P300 Auxiliary Power Panel, and the P35 Cargo Bay Door Panel were all examined with no open, collard, or broken circuit breakers identified.

E. AUTOFLIGHT SYSTEM DESCRIPTION

E.1 Mode Control Panel:

The Mode Control Panel (MCP) is the primary interface between the pilot and the Autopilot Flight Director System (AFDS). Through the MCP, the pilot arms or engages the AFDS and the Thrust Management Computing System (TMCS), makes mode selections, and adjusts reference values. The MCP has dual redundant processing capability (A and B sides). Each push-button switch and toggle switch activation and release, as well as the illuminated annunciation on the push-button switches, is routed through each of the redundant processors through independent switch contacts. There are four liquid crystal displays on the MCP that show the following reference values:

- Indicated Airspeed or MACH
- Heading or Track
- Vertical Speed or Flight Path Angle
- Altitude

E.2 Autopilot Flight Director System Pitch Modes:

These AFDS pitch modes are available during climb, cruise and descent:

- Vertical Navigation
- Vertical Speed
- Flight Path Angle
- Flight Level Change
- Altitude Hold

Armed and engaged (active) AFDS pitch and roll modes are annunciated on the Primary Flight Display's Flight Mode Annunciations ("FMA"). Newly engaged modes are surrounded by a green box for ten seconds for emphasis.

The Vertical Navigation mode is a combination of throttle and elevator commands that control the airplane's vertical flight path and has several sub-modes. The vertical navigation commands come from the active flight management computing function based on navigation data and the active flight plan.

In the Vertical Speed/Flight Path Angle modes, the AFDS issues elevator commands to control to the MCP selected vertical speed or flight path angle. The pilot uses this mode to climb or descend to the altitude set in the MCP. In this mode, the pilot must set the engine thrust or engage the autothrottle to set the engine thrust necessary to maintain the target airspeed or Mach number. The airplane goes to and maintains the Vertical Speed or Flight Path Angle that is shown in the Vertical Speed/Flight Path Angle display on the MCP when these modes are engaged. The AFDS mode changes from Vertical Speed or Flight Path Angle to the Altitude Capture sub-mode then to Altitude Hold when the airplane reaches the target altitude. Altitude Capture is a sub-mode that controls the airplane pitch to capture the MCP selected altitude without overshooting the selected altitude. Altitude Capture and Altitude Hold are both annunciated as "ALT" on the Primary Flight Display FMA.

The Flight Level Change (FLCH) mode is a combination of thrust commands from the TMCS and elevator commands from the AFDS to change flight level. The pilot uses this mode to climb or descend to the altitude set in the MCP. The elevator commands from the AFDS maintain the speed/Mach that is shown on the MCP Indicated Air Speed/Mach display. This is informally referred to as a "speed-on-elevator" mode as the airplane speed is controlled by modifying the pitch of the aircraft through elevator movement instead of by the autothrottle. The airplane speed will stay within flap placard speeds, maximum operating velocity and Mach, and minimum speed limitations. The Thrust Management Computing Function supplies the engine thrust commands appropriate for a climb or descent to achieve a calculated vertical speed. The pilot must set a target altitude on the MCP before the FLCH mode can be set. With the FLCH mode active, the Flight Level Change light on the "FLCH" push-button switch will illuminate and "FLCH SPD" will be annunciated on the Primary Flight Display's FMA. The newly engaged FMA annunciation will be surrounded by a green box for ten seconds after being activated. The AFDS mode changes from FLCH to Altitude Capture then to Altitude Hold when the airplane reaches the altitude set on the MCP display.

The FLCH control laws are such that if a climb has been requested and there is insufficient energy to achieve both altitude and airspeed targets, FLCH will initially sacrifice airspeed in order to maintain altitude to prevent a descent when a climb is commanded. If airspeed decreases towards the lower amber band, FLCH will give up altitude in order to maintain minimum airspeed unless the AFDS is in flight director only operation and flaps are extended, in which case the flight director guidance will command a 2 feet per second climb to avoid terrain. As energy is added FLCH will revert to normal operation. The Autothrottle Automatic Engagement feature is not active in FLCH mode.

In Altitude Hold mode the airplane maintains the barometric altitude present when the pilot pushes the Altitude Hold push-button switch. When the engaged autopilot pitch mode is Vertical Speed, Flight Path Angle, or FLCH and the altitude selected on the MCP is captured, the AFDS pitch mode will change to Altitude Hold and the autothrottle mode will remain in or change to Speed mode.

E.3 Thrust Management Computing System Operation:

The Thrust Management Computing System is part of the Airplane Information Management System. The TMCS controls engine thrust in response to mode requests from the MCP, Flight Management Computing Function, and flight deck switches. The autothrottle (A/T) responds to commands by the TMCS and is armed by placing the A/T ARM switches on the MCP to the ARM position. The MCP includes the following push-button switches that can change the A/T function:

- Climb/Continuous (CLB/CON): selects the Climb thrust limit mode in the air or Continuous thrust limit mode in the air when one engine fails
- Autothrottle (A/T): If not already engaged, causes the A/T to engage in the appropriate mode for the current autopilot pitch mode. If the A/T is already engaged then pressing the push button will have no effect.
- Flight Level Change (FLCH): Activates the AFDS pitch mode Flight Level Change and A/T Thrust mode. Depending on the altitude set in the MCP, the A/T may transition to Hold mode. The A/T gives the thrust command necessary to achieve a calculated vertical speed, which differs based on the magnitude of the difference between the current altitude and the altitude set in the MCP.
- Vertical Navigation (VNAV): allows the throttles to operate with the Autopilot Flight Director System to control thrust or speed.

Under normal operation, when the A/T is armed, it will automatically engage with the selection of VNAV or FLCH on the MCP, or if the Takeoff/Go-Around switches are engaged. When operating in a VNAV mode, the A/T is under control of the VNAV Guidance function, which requests A/T modes and supplies speed or thrust targets as required to effect a coordinated control of the airplane in the vertical plane.

When the AFDS pitch mode Flight Level Change is activated, the A/T engages in the Thrust mode and advances the throttles if a climb is requested or retards the throttles if a descent is requested. The Thrust Management Computing Function sends A/T servo motor commands to

control engine thrust. At this time, the airspeed window will show the current or pilot selected airspeed. The Thrust Management Computing Function uses the difference between the present altitude and the MCP altitude to calculate a vertical speed to capture the MCP altitude. The A/T control laws command thrust which produces a vertical speed to complete the altitude change in 120 seconds or longer if required by the magnitude of the altitude change. The A/T is limited by the thrust limit at the forward range of throttle travel and by idle at the back range of travel. The A/T command cannot exceed the thrust limit mode. The A/T mode changes to Speed and the AFDS pitch mode changes to Altitude Capture then to Altitude Hold when the aircraft reaches the altitude set on the MCP display.

A newly engaged A/T mode will be surrounded by a green box for ten seconds on the Primary Flight Displays' FMA. Under normal operating conditions, the following A/T modes can appear on the Primary Flight Displays' FMA:

- Speed (SPD)
- Thrust (THR)
- Thrust Reference (THR REF)
- Hold (HOLD)
- Idle (IDLE)
- Test (TEST)

In Speed mode, the Thrust Management Computing Function sends the A/T servo motor commands to move the throttles to control the airplane speed. Two AFDS pitch modes are available for the Speed control law. They are VNAV Speed and MCP (A/T) Speed. The VNAV Speed mode uses a commanded true airspeed from the Flight Management Computing Function. The MCP Speed mode uses the speed in the Indicated Air Speed/Mach display on the MCP as command speed. Thrust limit, speed limit (Vmo/Mmo), and flap speed limit protection are active in Speed mode. The A/T Speed mode can operate with or without an autopilot pitch mode.

Thrust mode will engage when the Thrust Management Computing Function receives an A/T mode request and goes into VNAV descent, FLCH, or Go-Around thrust mode. The engine thrust will maintain an internally computed engine thrust target.

Thrust Reference mode will engage when the Thrust Management Computing Function receives a takeoff A/T request from the left or right Takeoff/Go-Around switch and commands the throttles to full takeoff thrust. THR REF shows for VNAV Climb or after a second push of the Takeoff/Go-Around switch.

HOLD occurs when the Thrust Management Computing Function removes excitation power from the A/T servo motors and the A/T system will no longer reposition the thrust levers. HOLD occurs in these autothrottle conditions:

- FLCH descent when the throttles reach the idle stop
- FLCH with pilot override
- Takeoff Thrust mode when computed air speed is more than 80 knots
- VNAV idle descent
- VNAV idle override

A pilot override occurs when a pilot manually moves the throttles to a position that differs from the A/T servo motor command by approximately eight degrees for 1.2 seconds. During a FLCH descent, HOLD mode will engage when the throttles reach the aft mechanical stop and the A/T servo motor continues to move or if the pilot overrides the autothrottle. During a FLCH climb, HOLD mode will engage only after a pilot override occurs. The autothrottle will remain in HOLD mode until (1) the airplane reaches the altitude selected on the MCP; (2) the pilot engages a new AFDS pitch mode or new A/T mode; (3) the A/T arm switches are turned off; (4) the thrust is manually commanded to increase past the thrust limit, or (5) the autopilot is disconnected and both flight director switches are turned off.

IDLE occurs when the Thrust Management Computing Function controls the throttle levers to the throttle lever aft stop. It can occur during a VNAV descent or during engine retard during flare for landing.

TEST occurs when a Thrust Management Computing System ground test is active.

The A/T may be overridden manually at any time by taking control of the throttle levers and placing them at a desired position. When the AFDS pitch modes FLCH or VNAV IDLE are engaged, the manual override causes the A/T mode to transition to HOLD, and the throttle levers will remain where they are positioned by the crew until one of the conditions listed in the pilot override paragraph above are met. Otherwise, in SPD, THR REF or THR autothrottle modes, the throttles remain active and when released will be returned automatically to the commanded position. Pushing the A/T disconnect switch on either throttle lever or moving the A/T arm switches to OFF will completely disconnect the system. If the A/T system is disconnected, the master caution light illuminates, the caution message “AUTOTHROTTLE DISC” appears on the EICAS display, and an aural caution alert sounds.

F. AIRSPEED AWARENESS AND STALL PROTECTION FEATURES

F.1 Airspeed Awareness:

The flight crew is primarily made aware of airspeed through displays on the Primary Flight Display. If airspeed decreases below the minimum maneuver speed, additional alerts and tactile forces are provided.

The Primary Flight Display includes a speed tape that displays the current airspeed, an airspeed trend vector, and the MCP selected airspeed on a continuous basis. The speed tape also includes visual displays for maximum and minimum allowable airspeeds (upper and lower barber poles), maximum and minimum operational airspeeds (upper and lower amber bands), takeoff and landing reference speeds, and flap maneuver speeds. For low speed operations, an amber band is displayed, which indicates the speed range between the minimum maneuvering speed (with 1.3 G maneuver capability) and the speed at which the stick shaker will activate. A red and black barber pole is displayed below the amber band and the top of this barber pole indicates the speed at which the stick shaker will activate. The margin to the stick shaker angle of attack is also displayed on the Primary Flight Display with the amber Pitch Limit Indicator. This provides a pitch attitude reference to the stick shaker activation.

If airspeed decreases below the top of the amber band, further nose up pitch trim is inhibited. As speed decreases within the amber band, the column forces increase as the angle of attack increases toward the stick shaker level. The pilot may still override the system with increased effort.

F.2 Low Airspeed Alert:

The Low Airspeed alert is a caution level alert. The alert occurs when airspeed decreases to less than 30% below the top of the amber band. The visual cues that accompany a Low Airspeed alert include turning the airspeed box on the Primary Flight Display amber, displaying an "AIRSPEED LOW" caution EICAS message, and illuminating the Master Caution lights on the glareshield. The Caution aural alert will also sound.

F.3 Stick Shaker:

The stick shaker is a warning level alert designed to warn the flight crew that the aircraft is approaching an aerodynamic stall. Stick shaker activation is determined based on the aircraft's angle of attack. The stick shaker activation point is the top of the barber pole. When the flaps are not retracted, or at slow speeds with the flaps retracted, the stick shaker activation point is also shown by the Pitch Limit Indication, an amber visual indication on the Primary Flight Display. The noise of the stick shaker motor shaking the columns provides an aural effect and the physical shaking of the column provides a tactile effect.

F.4 Autothrottle Automatic Engagement:

The autothrottle system has an optional Autothrottle Automatic Engagement feature (commonly referred to as "Autothrottle Wake Up") that was enabled on the accident aircraft. The Autothrottle Automatic Engagement feature will engage the autothrottle automatically if the airspeed is detected to be below a minimum threshold, if the AFDS is in a compatible pitch mode or no mode, if the autothrottle is armed but not activated in any of its modes, if the engine thrust is not already at its maximum limit, and if the aircraft is above 100 feet on approach or 400 feet on takeoff. Compatible AFDS pitch modes are all modes except FLCH and Takeoff/Go-Around. When the system automatically engages, the autothrottle will respond with the same functionality as it would if the autothrottle engage button was manually selected.

G. COMPONENT EXAMINATIONS

G.1 Mode Control Panel:

The Mode Control Panel (MCP) was examined by Rockwell Collins in the presence of the NTSB, FAA, Boeing, and Asiana. The examination was performed at the Rockwell Collins facility in Cedar Rapids, IA, from November 5-7, 2013.

Figure 8: Mode Control Panel Connected to the Test Bench

The label information from the MCP was as follows:

MFG: Rockwell Collins
Type: MCP-770C
Collins P/N: 822-1494-101
S/N: 471
MFD: 112005
MOD: No Mods Identified

G.1.1 Initial Observations:

The MCP was removed from a secure locker and removed from the packaging. A burnt odor was present from the unit. A visual inspection was performed and the unit appeared sooty on the front and top surfaces but was in good physical condition (see Figure 8). All cover screws were flush with the cover. The unit tamper seal located on the top of the unit was intact. The two test access tamper seals located at location J4 and J5 on the back of the unit were broken.

The J1, J2, and J3 wire connectors remained in place with the wires cut close to the connector. The connectors were checked using hand force and were secure. The connectors were removed and the pins appeared straight and clean.

G.1.2 Non-volatile Memory Download:

The soot on the 4 LCD displays on the front of the unit was lightly cleaned using glass cleaner. Power to ground short testing was performed and both A and B channels measured a resistance higher than the required 5 kOhms. The two test access panels at location J4 and J5 were removed. The connector pins appeared straight and clean.

The unit was connected to the Collins 777 Test Rack, P/N 676-3723-001, S/N EE01 with Mods 1-5 and 7. The non-volatile memory (NVM) was downloaded using PC Monitor software part number 829-7722 version 2.5.1.0.

The following faults were recorded in Channel A NVM:

Fault ID	Fault Description	Date/Time
3625	Speed Knob Dual Switch Contact Fault	11-08-01 19:59
3625	Speed Knob Dual Switch Contact Fault	11-10-03 03:09
3620	Altitude Knob Dual Switch Contact Fault	11-10-25 18:14
3625	Speed Knob Dual Switch Contact Fault	12-01-12 08:11
3620	Altitude Knob Dual Switch Contact Fault	12-01-17 04:19
3620	Altitude Knob Dual Switch Contact Fault	12-01-18 09:34
3620	Altitude Knob Dual Switch Contact Fault	12-01-21 21:38
3620	Altitude Knob Dual Switch Contact Fault	12-03-10 07:00
3620	Altitude Knob Dual Switch Contact Fault	12-05-05 07:36
3650	Altitude Select Auto/1000 Knob Fault	12-06-09 04:07
3620	Altitude Knob Dual Switch Contact Fault	12-11-04 05:04
3620	Altitude Knob Dual Switch Contact Fault	13-01-04 07:52
3650	Altitude Select Auto/1000 Knob Fault	13-03-20 08:08
3620	Altitude Knob Dual Switch Contact Fault	13-07-01 05:03

The following faults were recorded in Channel B NVM:

Fault ID	Fault Description	Date/Time
3455	Autothrottle Push Button Triplex Switch Single Contact Fault	11-03-23 04:19
3410	Localizer Push Button Triplex Switch Single Contact Fault	11-07-14 19:37
3625	Speed Knob Dual Switch Contact Fault	11-08-01 19:59
3625	Speed Knob Dual Switch Contact Fault	11-10-03 03:09
3620	Altitude Knob Dual Switch Contact Fault	11-10-25 18:14
3625	Speed Knob Dual Switch Contact Fault	12-01-12 08:11
3620	Altitude Knob Dual Switch Contact Fault	12-01-17 04:19
3620	Altitude Knob Dual Switch Contact Fault	12-01-18 09:34
3620	Altitude Knob Dual Switch Contact Fault	12-01-21 21:38
3620	Altitude Knob Dual Switch Contact Fault	12-03-10 07:00
3620	Altitude Knob Dual Switch Contact Fault	12-05-05 07:36

3650	Altitude Select Auto/1000 Knob Fault	12-06-09 04:07
3620	Altitude Knob Dual Switch Contact Fault	12-11-04 05:04
3620	Altitude Knob Dual Switch Contact Fault	13-01-04 07:52
3650	Altitude Select Auto/1000 Knob Fault	13-03-20 08:08
3620	Altitude Knob Dual Switch Contact Fault	13-07-01 05:03

Triplex switch single contact faults occur when one of three contacts in the switch disagrees with the other two contacts for a time period of 40 milliseconds. Dual switch contact faults occur when the two contacts in the switch disagree for a time period of 40 milliseconds. Fault 3650 occurs when the switch is in both the AUTO and 1000 positions simultaneously for a time period of 1 second. When fault 3650 occurs the switch logic default position is AUTO and the condition will reset when a valid switch position is detected.

The contacts for all toggle and push-button switches on the front panel of the MCP (including the left and right Flight Director switches and the Flight Level Change push-button switch) are monitored by the MCP. If a fault is identified for any contact it will be recorded in the unit's NVM.

G.1.3 Functional Test:

The unit was connected to Rockwell Collins test bench P/N 822-0733-123, S/N 123. Acceptance Test Procedure 827-4912-001, Rev D, section 6.3.5 Final Data Test Run was performed on the unit. The test confirmed that software version 227F-COL-AM1-02 was installed on the unit. Test block 810000 (Bezel Light Sensor Calibration) was not performed as the light sensor was covered in soot. The test included activation of all toggle switches, push buttons, and knobs on the front panel.

The unit passed all performed tests with the exception of test blocks 662100, 663700, 672100, and 673700. These four tests were considered failed because the bottom horizontal segment of the 100's digit in the Vertical Speed/Flight Path Angle LCD screen was missing. It was also noted during testing that the following push buttons would remain in the pressed position when pushed: left Autopilot, Autothrottle, Flight Level Change, Heading Hold, Vertical Speed/Flight Path Angle, Altitude Hold, Approach, right Autopilot, and Localizer. All push-button switches were heavily contaminated with soot. After brushing off some of the soot the switches were able to move more freely but still demonstrated hesitation.

G.1.4 Non-destructive Testing:

After the functional test was completed the back cover was removed. The top of the circuit cards were coated in soot. A 3 inch long piece of foreign object debris that ranged from 0.25 inches to 0.5 inches wide and that resembled a thin piece of tape was found balled up and pushed against the end plate within the cooling chamber. Wiring connectors J1 and J2 on the motherboard and J10 and J11 on the rear interconnect card were disconnected and the front panel was removed to gain visual access to the switch housings.

Industrial Computed Tomography (CT) was used to internally check the Flight Level Change, left Flight Director, and right Flight Director switches. Both Flight Director switches were placed in the OFF position for the scans. The FLCH push-button switch was in the disengaged/normal position for the CT scans. The scans were examined for evidence of foreign object debris and the integrity of the mechanical switch components. No anomalies were identified in any of these switches.

G.1.5 Vibration Testing:

The unit was reassembled and test block 930000 of the ATP was run to confirm that the front panel wiring was replaced correctly. The NVM was downloaded using the same procedure as in section G.1.2 to give a baseline prior to attempting additional testing. Software version 220C-COL-AM3-OC was loaded to the unit to support performing the additional testing. Acceptance Test Procedure 827-4912-001, Rev D, section 6.3.2 ESS "Environmental Stress Screening", vibration section only was performed. The vibration profile was changed and the profile used was from Boeing document D6-18926, Rev J, section 2.1.2.8. The Zone 1, Category C profile minus 8dB for 10 minutes in each axis was followed.

The unit parameters were set to the following for the duration of the test:

A/T left and right: armed
F/D left and right: on (engagement illuminated the A/T and APP push buttons)
A/T: illuminated
VS/FPA: illuminated
LOC: illuminated
APP: illuminated
Bank Angle Knob: Auto
Altitude Display Knob: 1000
AP: both flashing illuminated
IAS: 151kts
V/S: -700 ft/min
ALT: 3000 ft
HDG: 281
FLCH: was not illuminated

During the vibration testing the push-button switches on the front of the panel were monitored for illumination indicating an unexpected mode engagement. There were no unexpected mode engagements identified. One fault was recorded during the longitudinal testing portion of the test. It was labeled as fault 4150 and was recorded on the B channel only. The Environmental Stress Screening Procedure as defined by Rockwell Collins document 687-9579-343, Rev G, states the following under the vibration screen section:

"Nuisance Faults: Due to some limitations of the George Panel, some known nuisance faults may occur. These faults do not constitute a failure of this test and can be ignored. The nuisance fault codes are as follows: 3850, 3900, and 4150."

G.1.6 Service History:

Rockwell Collins repair history for this unit showed that it was repaired on 09/03/2010. The unit was returned due to the First Officer Flight Director not switching off. During the repair inspection, it was also noted that the Speed knob, Altitude knob, and Bank Angle knob were cracked. Both Flight Director switches and the selection knobs were replaced and the unit was returned to service.

G.2 Number 2 Proximity Sensor Electronics Unit:

The NTSB, FAA, Boeing, ARAIB, and Asiana representatives met at the Crane facility in Lynnwood, WA on August 26, 2013 for the examination of the Number 2 Proximity Sensor Electronics Unit (PSEU) removed from the event airplane. Crane acquired Eldec Corporation in 1996.

Figure 9: Proximity Sensor Electronics Unit

The label information from the PSEU was as follows:

MFG: Eldec Corporation
P/N: 80-778-01
S/N: 108252-221
MFD: 0601
MOD: A

G.2.1 Visual Examination:

The PSEU was removed from a secure locker and removed from the packaging. A visual inspection was performed. Soot was identified on some areas of the unit's surface but the overall physical condition of the unit was good (see Figure 9). All cover screws were flush with the cover. All connector pins appeared straight and the tamper seals were intact. The unit did not appear to have any loose internal components. "E4-1 M32025" was the rack location that was written with marker on the side of the unit.

G.2.2 Non-volatile Memory Download:

The PSEU was connected to test bench 38-596-02 (S/N 02) and the non-volatile memory was downloaded per Crane Document ESS80-777, Rev A, Paragraph 3.1.2. The EEPROM memory was downloaded in two separate files. One file contained BITE faults for the PSEU under test. See Attachment 1 of this report for a list of the BITE faults recorded on the day of the accident. The second file, labeled "Monitoring" file, contained faults related to parameters that are shared by both the Number 1 PSEU and the Number 2 PSEU. See Attachment 2 of this report for a list of the Monitoring faults recorded on the day of the accident.

A date/time stamp is recorded for each fault. The validity of faults with a time stamp of 000000000000 is unknown. Boeing confirmed that the aircraft was configured such that the cabin doors would have been monitored for an open condition by the Number 2 PSEU for the timeframe beginning at 18:27:48 and ending at 18:27:52.

G.2.3 Functional Test:

A functional test was performed on the unit per the manufacture's CMM 32-08-07, Rev 2, dated October 31, 2003, Task 32-08-07-150-801 Paragraph C. The unit was connected to test bench 38-504-01 (S/N 03). The unit passed all portions of the test.

G.2.4 Service History:

Crane had no service history related to this component.

ATTACHMENT 1
BITE FAULTS FOR PSEU S/N 108252-221

Flight Leg 8D.

FAULT ID	SHOP CODE	INTRMT COUNT	FLIGHT PHASE	DATE AND TIME	SHOP CODE NAME
8D00	00CF	7	Taxi_In	130706024119	LRU_Status_Invalid_Data_FED

Flight Leg 8E.

FAULT ID	SHOP CODE	INTRMT COUNT	FLIGHT PHASE	DATE AND TIME	SHOP CODE NAME
8D00	00CF	2	Taxi_In	130706053134	LRU_Status_Invalid_Data_FED

Flight Leg 8F.

FAULT ID	SHOP CODE	INTRMT COUNT	FLIGHT PHASE	DATE AND TIME	SHOP CODE NAME
8E50	01E8	0	Approach	130706182749	Tailstrike_Blade_Wiring_Or_Circuit_Breaker_2
D040	0086	0	Flare	130706182750	Opposite_Communication_Card_Failure
8CEC	00BD	0	Flare	130706182751	LRU_Status_Invalid_Data_E96
8D05	00D4	0	Flare	130706182752	LRU_Status_Invalid_Data_F83_CID_2
8D03	00D2	0	Flare	130706182752	LRU_Status_Invalid_Data_F83_CID_1
C580	01F3	0	Flare	130706182752	Sensor_Minus_Lead_Short_To_Ground_11
C560	01F3	0	Flare	130706182752	Sensor_Minus_Lead_Short_To_Ground_11
C540	01F3	0	Flare	130706182752	Sensor_Minus_Lead_Short_To_Ground_11
C520	01F3	0	Flare	130706182752	Sensor_Minus_Lead_Short_To_Ground_11
C480	01F3	0	Flare	130706182752	Sensor_Minus_Lead_Short_To_Ground_11
C440	01F3	0	Flare	130706182752	Sensor_Minus_Lead_Short_To_Ground_11
C420	01F3	0	Flare	130706182752	Sensor_Minus_Lead_Short_To_Ground_11

ATTACHMENT 2
MONITOR FAULTS FOR PSEU S/N 108252-221

Flight Leg 8D.

FAULT ID	SHOP CODE	INTRMT COUNT	FLIGHT PHASE	DATE AND TIME	SHOP CODE NAME
8D00	00CF	7	Taxi_In	130706024119	LRU_Status_Invalid_Data_FED

Flight Leg 8E.

FAULT ID	SHOP CODE	INTRMT COUNT	FLIGHT PHASE	DATE AND TIME	SHOP CODE NAME
8D00	00CF	3	Taxi_In	130706053134	LRU_Status_Invalid_Data_FED

Flight Leg 8F.

FAULT ID	SHOP CODE	INTRMT COUNT	FLIGHT PHASE	DATE AND TIME	SHOP CODE NAME
8DFE	0195	0	Approach	130706182748	R_MLG_Up_And_Locked2_Sensor_Target_True
8E50	01E8	0	Approach	130706182748	Tailstrike_Blade_Wiring_Or_Circuit_Breaker_2
D040	00A1	0	Approach	130706182748	Transmitter_Self_Shutdown
8CB9	009D	0	Approach	130706182748	Invalid_Label_Word_Error
D040	00A2	0	Approach	130706182748	CMSW_Transmitter_Shutdown
8CEE	00BF	0	Default	000000000000	LRU_Status_Invalid_Data_409
8CED	00BE	0	Default	000000000000	LRU_Status_Invalid_Data_408
C580	01F3	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
C560	01F3	3	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
C540	01F3	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
C520	01F3	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
C480	01F3	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
C440	01F3	3	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
C420	01F3	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
8D20	00D5	0	Default	000000000000	Opposite_Power_Supply_Reset
C4A0	01F3	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
CC20	01F3	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_11
DA80	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10

DA60	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
DA40	01F2	3	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
DC60	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
DC20	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D920	0031	2	Default	000000000000	Sensor_Short
DC40	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D9E0	0031	0	Default	000000000000	Sensor_Short
D9C0	0031	0	Default	000000000000	Sensor_Short
DC80	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
DA20	0031	0	Default	000000000000	Sensor_Short
D9C0	003F	0	Default	000000000000	Intermittent_Sensor_Channel_Fault
DC40	0031	0	Default	000000000000	Sensor_Short
DA00	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
DA60	0031	3	Default	000000000000	Sensor_Short
D9C0	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D9E0	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
DA40	0031	2	Default	000000000000	Sensor_Short
D980	0031	4	Default	000000000000	Sensor_Short
D960	0031	3	Default	000000000000	Sensor_Short
DC20	0031	0	Default	000000000000	Sensor_Short
D940	0031	3	Default	000000000000	Sensor_Short
DC80	0031	2	Default	000000000000	Sensor_Short
DC60	0031	0	Default	000000000000	Sensor_Short
DA80	0031	0	Default	000000000000	Sensor_Short
D980	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D960	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D940	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10

D920	01F2	2	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
DA20	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
8DF2	0189	0	Default	000000000000	Ldg_Gr_Control_Lever2_Switch_True
D960	003F	0	Default	000000000000	Intermittent_Sensor_Channel_Fault
D860	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D820	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D880	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D840	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D880	0031	0	Default	000000000000	Sensor_Short
D840	0031	0	Default	000000000000	Sensor_Short
D8A0	01F1	0	Default	000000000000	EPROM_Page_Fault
D900	0031	0	Default	000000000000	Sensor_Short
D8C0	0031	0	Default	000000000000	Sensor_Short
D8A0	0031	0	Default	000000000000	Sensor_Short
D8C0	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D900	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D8E0	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
D8A0	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10
C560	01F2	0	Default	000000000000	Sensor_Minus_Lead_Short_To_Ground_10