AIRCRAFT ACCIDENT REPORT

BHNL/2016/02/03/F

Accident Investigation Bureau

Report on the Accident involving a Bristow Helicopters (Nigeria) Limited Sikorsky S76C++ Helicopter with nationality and registration marks 5N-BQJ which occurred at 77 NM offshore from Murtala Muhammed Airport on Radial 139º on 3rd February 2016

This report was produced by the Accident Investigation Bureau (AIB), Murtala Muhammed Airport, Ikeja, Lagos.

The report is based upon the investigation carried out by Accident Investigation Bureau, in accordance with Annex 13 to the Convention on International Civil Aviation, Nigerian Civil Aviation Act 2006, and Civil Aviation (Investigation of Air Accidents and Incidents) Regulations.

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of aircraft accident/serious incident investigations to apportion blame or liability.

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As the Bureau believes that safety information is of great value if it is passed on for the use of others, readers are encouraged to copy or reprint for further distribution, acknowledging the Accident Investigation Bureau as the source.

Recommendations in this report are addressed to the Regulatory Authority of the State (NCAA). It is for this authority to ensure enforcement.

Printed in Nigeria for the Accident Investigation Bureau (AIB)

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AC	Alternating Current
ADD	Air Data Display
ADIs	Attitude Director Indicators
ADs	Airworthiness Directives
AHRS	Attitude and Heading Reference System
AIB	Accident Investigation Bureau (The Bureau)
AMSL	Above Mean Sea Level
AOL	All Operators Letter
ASCB	Avionics Standard Communications Bus
AP	Auto Pilot
ATIS	Automatic Telecommunications Information Service
BEA	Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile
BHNL	Bristow Helicopters Nigeria LTD
CDRE	Crash Damaged Recovery Equipment
CRM	Crew Resource Management or Cockpit Resource Management

CRT	Cathode Ray Tube
CVR	Cockpit Voice Recorder
DAFCS	Digital Automatic Flight Control System
DG	Directional Gyro
DNMM	Murtala Muhammed Airport, Lagos
ECU	Engine Control Unit
EFIS	Electronic Flight Information System
EGPWS	Enhanced Ground Proximity Warning System
ELT	Emergency Locator Transmitter
EOP	Emergency Operating Procedure
FAA	Federal Aviation Administration
FAERITO	Flight Anomalous Event Recorder
FDR	Flight Data Recorder
FPM	Feet Per Minute
FPSO	Floating Production Storage Off loading
h	Hour(s)
HDG	Heading
HSIs	Horizontal Situation Indicators

HUMS	Health and Usage Management System
ICAO	International Civil Aviation Organisation
ICS	Intercommunication system
IFR	Instrument Flight Rule
IRCS	Instrument Remote Controllers
Kt	knot
kVA	Kilo-volts-ampere
kW	Kilowatt
LAG	Lagos
MAN SYN	Manual Synchronization
MPFR	Multi-Purpose Flight Recorder
MR	Main Rotor
MTBF	Mean-Time-Between Failures
MTOW	Maximum Take Off Weight
NCAA	Nigerian Civil Aviation Authority
NE-E	North East-East
Nig.CARs	Nigerian Civil Aviation Regulations
NTSB	National Transportation Safety Board

OPC	Operator Proficiency Check
PAX	Passengers
PF	Pilot Flying
PM	Pilot Monitoring
rpm	Revolutions per minute
SAR	Search And Rescue
SAS	Stabilization Augmentation System
SBs	Service Bulletins
shp	Shaft horse power
STBY ATT	Standby Attitude Indicator
STG	Sea Trucks Group
TCAS	Traffic Collision and Avoidance System
TD	Technical Directives
TR	Tail Rotor

Aircraft Accident Report No.:	BHNL/2016/02/03/F
Registered Owner and Operator:	Bristow Helicopters (Nigeria) Limited
Aircraft Type and Model:	Sikorsky S76C++
Manufacturer:	Sikorsky Aircraft Corporation, USA
Year of Manufacture:	2007
Nationality and Registration Marks:	5N-BQJ
Serial No.:	76065
Location:	77 NM offshore from Murtala Muhammed Airport on Radial 139°
Date and Time:	3rd February, 2016 at about 10:25 h *(All times in this report are local time, equivalent to UTC+1 unless otherwise stated)*

SYNOPSIS

On the 3rd of February, 2016, Accident Investigation Bureau was notified of the accident by the Nigerian Civil Aviation Authority through a phone call and investigation commenced same day. All relevant stakeholders were notified.

A Sikorsky S76 C++ helicopter with nationality and registration marks 5N-BQJ, a domestic charter flight operated by Bristow Helicopters Nigeria Ltd departed Murtala Muhammed Airport Lagos (DNMM) with 11 passengers and 2 crew for Erha Floating Production Storage Off loading (FPSO) helideck. The Captain was the Pilot Flying (PF) while the First Officer was Pilot Monitoring (PM) on this leg of the flight.

The take-off and climb-out was normal. A few minutes into the flight, the Captain observed an unusual vibration of the aircraft and made a remark about this to the First Officer. About fifteen minutes later, the crew also reported that the Digital Auto Flight Control system (DAFCS) and TRIM FAIL lights illuminated twice and were reset. The No.1 autopilot decoupled on both occasions. Also, according to the PM, a passenger seated in the middle row reported perceiving a burning smell. However, the aircraft continued to destination and landed. On ground Erha, the Captain conducted visual checks but could not ascertain the source of the burning smell earlier reported.

Instrument Meteorological Conditions prevailed at the time and Instrument Flight Rules (IFR) flight plan was filed.

At 09:50 h, 5N-BQJ departed Erha FPSO for Lagos on the second leg of the flight with nine passengers and two crew on board, the First Officer was the PF; estimating LAG 10:40 h and endurance of one hour plus thirty-five minutes maintaining an altitude of 3,000 ft above mean sea level (AMSL).

Fifteen minutes into the flight, there were repeated illuminations of 'TRIM FAIL' and Digital Automatic Flight Control System (DAFCS) indications. The Emergency

Operating Procedure (EOP) was consulted and it recommended that the helicopter be flown hands and feet on the control.

At 10:08 h, about 75 NM from LAG, initial contact was made with Lagos Approach. The Pilot Flying (PF) complained of the collective being heavy and the autopilot decoupling. There was loss of power, high rate of descent and decreasing altitude.

The Captain observed a slight turn to the right and asked the PF to check heading and the PF reported that there was problem with the compass.

The instrument readings were inaccurate and inconsistent, and the aircraft started drifting to the right.

At about 66 NM on radial 145° from LAG, the Captain made a distress call "MAY DAY, MAY DAY, MAY DAY" on the Approach frequency. Afterwards, the aircraft stabilized at an altitude of 1,500 ft AMSL on a NE-E heading and the Captain briefed the passengers that they would have to ditch the aircraft.

At about 10:19 h, 5N-BQJ made a controlled landing on water at approximately 77 NM on radial 139° of 'LAG VOR'. Coordinates of the position was 05°45′43" N, 004°13′54" E.

The investigation identified the following causal and contributory factors:

Causal Factor

The crew switched the Compass to "FREE" DG mode for Landing on the helideck at Erha FPSO, and did not return to the "SLAVE" mode after take-off which caused the trim fail to cut off consistently which in turn disengaged the autopilot as a result of the unsynchronised heading inputs.

Contributory Factors

1) Non-adherence to Company Operations Manual (Part B checklist) as it relates to after take-off checks.
2) The crew did not disengage the autopilot to fly the aircraft manually.

Four Safety Recommendations were made.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On the 3rd of February 2016, a Sikorsky S76C++ helicopter with nationality and registration marks 5N-BQJ belonging to Bristow Helicopters (Nigeria) Ltd. departed Murtala Muhammed International Airport Lagos (DNMM) for Erha (FPSO) with 11 passengers and two crew. The Captain was the Pilot Flying (PF) while the First Officer was the Pilot Monitoring (PM) on this leg of the flight.

The take-off and climb-out was normal but a few minutes into the flight, the Captain observed an unusual vibration of the aircraft and made a remark about this to the First Officer. About fifteen minutes later, the crew also reported that the Digital Auto Flight Control system (DAFCS) and TRIM FAIL lights illuminated twice and were reset. The No.1 autopilot decoupled on both occasions.

According to the CVR transcript, on approach to land in Erha, the Captain executed a go-around and came back for a second approach and landed. On ground, the Captain remarked to the First Officer, "After a month Oomo[1], I need OPC[2]."

Also, according to the PM, a passenger seated in the middle row reported perceiving a burning smell. However, the aircraft continued to destination and landed. On landing at Erha, the Captain conducted visual checks but could not ascertain the source of the burning smell earlier reported.

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[1]Oomo - Local slang for exclamation

[2]OPC - Operator Proficiency Check

At 09:50 h, 5N-BQJ departed Erha for Lagos on the second leg of the flight with nine passengers and two crew on board, estimating LAG 10:40 h and endurance of one hour plus thirty-five minutes maintaining an altitude of 3,000 ft above mean sea level (AMSL). According to the Captain, fifteen minutes into the flight, there were repeated illuminations of 'TRIM FAIL' and Digital Automatic Flight Control System (DAFCS). The Emergency Operating Procedure (EOP) was consulted and it recommended flying the helicopter hands and feet on the controls.

At 10:08 h, about 75 NM from LAG, initial contact was made with Lagos Approach. The Pilot Flying (PF) complained of the collective being heavy and auto-pilot decoupling. These resulted in loss of power, high rate of descent and decreasing altitude. Furthermore, the Captain observed a slight turn to the right and asked the PF to check heading and the PF reported that there was problem with the compass.

At about 66 NM on radial 145^{o} from LAG, the crew again complained of high rate of descent and instruments readings being inconsistent and inaccurate. As a result, the Captain made a distress call "MAY DAY, MAY DAY, MAY DAY" on the Approach frequency. Afterwards, the aircraft stabilized at an altitude of 1,500 ft AMSL on a NE-E heading. The Captain then briefed the passengers on the status of the aircraft and her intention if need be for ditching. The Co-pilot informed the Captain about the inaccuracy of the compass and said, "holding wings level - it's funny". Thereafter, the captain declared the intention to ditch the aircraft. The Captain also noticed that the Cyclic control was not responding to lateral movement.

At about 10:19 h, 5N-BQJ made a controlled landing on water (ditching). The Co-pilot stated as follows: "The life-raft on the left was not fully deployed. This led to most passengers and crew utilizing the life raft on the right side. This initiated a tilt of the helicopter and eventually led to overturning on its belly after all passengers and crew had exited." The occupants were then rescued by a boat in the vicinity of the accident.

5N-BQJ ditched at an approximately 77 NM on radial 139° of 'LAG VOR'. Coordinates of the position was 05°45′43" N, 004°13′54" E.

The accident occurred in daylight and Visual Meteorological Conditions prevailed.

1.2 Injuries to Persons

Injuries	**Crew**	**Passengers**	**Total in the aircraft**	**Others**
Fatal	Nil	Nil	Nil	Nil
Serious	Nil	Nil	Nil	Nil
Minor	Nil	Nil	Nil	Nil
None	2	9	11	Nil
Total	2	9	11	Nil

1.3 Damage to Aircraft

The aircraft was substantially damaged.

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 Captain

Nationality:	Nigerian
Age:	35 years
Gender:	Female
Licence Type:	ATPL (H)
Licence Validity:	26th January 2019
Aircraft Ratings:	S76C+, S76C++, AS332L2
Instrument Rating Validity:	3rd December, 2016
Medical Validity:	4th July, 2016
Licence Proficiency Check:	3rd June, 2016
Operator Proficiency Check:	3rd June, 2016
Annual Line Check:	August 2016
Total flying time:	3,174 h
On type:	2,497.45 h
On type (PIC):	199 h
Last 90 Days:	59.45 h
Last 28 Days:	Nil
Last 24 hours:	Nil

The Captain's FAA Commercial Pilot License with ratings on Rotorcraft-Helicopter and Instrument Helicopter was issued on the 29th of December, 2008 and converted on the 1st of September, 2009. The Captain's FAA Airline Transport Pilot Certificate was issued on the 16th of September 2013 and converted to the Nigerian ATPL on 3rd of April 2014.

From her training records, her first operator proficiency training was on 16th December, 2012 but there was no detail of procedures carried out.

On 15th April, 2013 operator proficiency check was done and Autopilot/Flight Director malfunction emergency procedures were carried out.

On 28th of March, 2014 operator proficiency check; Autopilot/Flight Director malfunction emergency procedure was carried out.

On 3rd October, 2014 operator proficiency check; Autopilot/Flight Director Malfunction emergency procedure was not carried out.

On 8th December, 2014 operator proficiency check; Autopilot/Flight Director Malfunction emergency procedure was carried out.

On 23rd August, 2015 operator proficiency check; Autopilot/Flight Director Malfunction emergency procedure was carried out.

On 4th December, 2015 operator proficiency check; Autopilot/Flight Director Malfunction emergency procedure was not carried out.

On 22nd June, 2016 (after the accident) operator proficiency check; Autopilot/Flight Director Malfunction emergency procedure was carried out.

On 2nd November, 2016 (after the accident), operator proficiency check; Autopilot/Flight Director malfunction emergency procedure was carried out.

On 14th January, 2017 operator proficiency check; Autopilot/Flight Director Malfunction emergency procedure was carried out.

On 8th August, 2017 operator proficiency check; Autopilot/Flight Director Malfunction emergency procedure was carried out.

From the company records, operator proficiency check (Autopilot/Flight Director malfunction procedure) was carried out once in 2013, twice in 2014 and none in 2015. After the accident, operator proficiency check (Autopilot/Flight Director malfunction procedure) was carried out twice in 2016 and 2017 respectively.

1.5.2 The First Officer

Nationality:	Nigerian
Age:	31 years
Gender:	Male
License Type:	ATPL (H)
License Validity:	16th December, 2018
Medical Validity:	5th November, 2016
License Proficiency Check:	17th July, 2016
Operator Proficiency Check:	17th July, 2016
Annual Line Check:	May 2016
Aircraft Ratings:	S76C+, S76C++
Instrument Rating Validity:	17th January, 2017
Total flying time:	1,088 h
On type:	852 h
Last 90 Days:	68:56 h
Last 28 Days:	13:25 h
Last 24 hours:	2:35 h

The First Officer's FAA Commercial Pilot License with ratings on Rotorcraft-Helicopter and Instrument Helicopter was issued on the 11th of April, 2013 and was converted to Nigerian Commercial Pilot License on the 18th of December, 2013.

His first operator proficiency check was on the 26th of January, 2014. Among the exercises carried out was Emergency/Abnormal Procedures (Autopilot/Flight Director Malfunction). From the training records, these exercises were supposed to be carried out every 36 months.

The next operator proficiency check was on 13th July, 2014 and the Autopilot/Flight Director Malfunction emergency procedure was not carried out.

On 16th January, 2015 operator proficiency check was carried out and Autopilot/Flight Director Malfunction emergency procedure was included.

On 19th July, 2015 operator proficiency check was done and Autopilot/Flight Director Malfunction emergency procedure was carried out.

On 18th January, 2016 operator proficiency check was done and Autopilot/Flight Director Malfunction emergency procedure was not carried out.

From the company records, the operator proficiency check (Autopilot/Flight Director Malfunction procedure) was carried out twice in 2014 and 2015 respectively and once in 2016.

1.6 Aircraft Information

The Sikorsky S76 C++ is a medium-size helicopter manufactured by the Sikorsky Aircraft Corporation, USA. It is fitted with twin turbo shaft engines, retractable landing gear, and four bladed main and tail rotors. This aircraft has a capacity of carrying 12 passengers and two crew. It has a Maximum take-off weight (MTOW) of 5,307 Kg (11,699.93 lb).

The aircraft is equipped with the following Avionic equipment: Combine CVR/FDR, Auto Flight Control System, Weather (WX) Avoidance Radar, 4 Tube Electronic Flight Information System (EFIS), Passenger briefing System, Sky Tracker System (with phone), Enhanced Ground Proximity Warning System (EGPWS), 406 MHz Emergency Locator Transmitter (ELT), Moving Map, Audio Control Panel with ICS (Intercommunication system) and TCAS (Traffic Collision and Avoidance System).

1.6.1 General Information

Type:	S76C ++
Manufacturer:	Sikorsky Aircraft Corporation, USA
Date of Manufacture:	March, 2007
Serial No.:	760656
Registered Owner/Operator:	Bristow Helicopters (Nigeria) Ltd.
Registration Number:	5N-BQJ
Certificate of Airworthiness Validity:	24th April, 2016
Certificate of Insurance Validity:	1st April, 2016

Certificate of Registration:	11th April, 2013
Noise Certificate:	Issued on 23rd April, 2013
Total Airframe time:	6,867 h (As at 02/02/2016)
Total Hours since new:	6,867 h
Cycles Since New (CSN):	12,560
Category:	Transport

1.6.2 The Aircraft Electrical Power System

Electrical Power

The electrical system consists of both AC and DC power systems.

DC Power

The DC power system provides electrical power from the battery, the generators, or an external power unit. A 24-volt battery provides engine starting and backup power.

Two engines mounted with a 28-volt DC starter-generator furnish generator power. Either generator is capable of supplying DC power to all essential and primary buses.

An external power unit supplies external power for starting and system operation through a receptacle on the right aft fuselage.

DC power is distributed through seven DC buses. The master switch panel and circuit-breaker panel are located in the cockpit control and provide circuit protection for the DC electrical power. Caution lights on the WCA monitor the DC system operation.

AC Power

The main AC generator is a 10-kVA generator driven by the main rotor at 107%. The AC generator supplies AC power for the windshield heating system.

The main AC generator is on the right side on back of the main gearbox.

AC power is distributed through a single AC Bus. The master switch panel in the cockpit provides control protection of the AC electrical power system. Caution lights on the WCA monitor the AC system operation.

1.6.3 Power plant

The Arriel 2S2 engine is a turbo-shaft engine with a single-stage axial compressor, a single-stage centrifugal compressor, an annular combustion chamber, a single stage high-pressure turbine, a single stage power turbine, and a reduction gearbox with a nominal output at 6,400 rpm. The engine is rated 923 shp (688 kW) at takeoff power and 833 shp (629 kW) at maximum continuous power. The ignition system includes one high-energy generator, two injectors, and two igniters.

No. 1

Engine Type:	Arriel
Manufacturer:	Turbomeca
Model:	Arriel 2S2
Serial No.:	42066
Date of Manufacture:	October, 2006
Total Time Since New:	5,950:43 h

Total Time Since Overhaul:	N/A
Cycles:	N/A

No. 2

Engine Type:	Arriel
Manufacturer:	Turbomeca
Model:	Arriel 2S2
Serial No.:	42024
Date of Manufacture:	December, 2015
Total Time since New:	6,305:19 h
Total Time since Overhaul:	N/A
Cycles:	N/A

Type of fuel used is Jet A1.

1.6.4 Engine Control Unit (ECU)

The ECU (Engine Control Unit) is a dual module computer that performs fuel regulation and engine parameters management. On both modules, failure blocks, and according to the failures some parameters, are stored in a non-volatile memory component for maintenance purposes.

1.6.5 The Main Rotor (MR) and Tail Rotor (TR) Systems

The S76 C++ main rotor systems provide the aerodynamic forces that enable the aircraft to fly. The system includes the drive shaft which is attached to the main transmission gearbox and main rotor head, and four main rotor blades installed on the hub. Three actuators (forward, aft and lateral) control the movement of the swash plate, which changes the pitch angle of the blades.

The tail rotor system is used to control torque (that is the tendency of an aircraft with a single main rotor system to turn in the opposite direction of the main rotor rotation). The tail rotor system includes a drive shaft, an intermediate gear box, a tail rotor gear box and four tail rotor blades. The tail rotor drive shaft is attached to the main transmission gearbox.

1.6.6 Flight Control Systems

1.6.6.1 Cyclic, Collective and Tail Rotor Control Systems

The aircraft was equipped with cyclic, collective and tail rotor pedal control. Moving the cyclic forward or aft results in the helicopter pitching up or down, moving the cyclic left or right results in the helicopter to roll in the direction commanded. Raising or lowering the collective causes simultaneous increase or decrease, respectively, in the lift produced by the main rotor blades. Moving the tail rotor pedals positions the tail rotor blades to cause the helicopter to yaw. Either of the pilots can control the cyclic, collective, and tail rotor pedal control system.

1.6.7 Aircraft Avionics Systems

The aircraft is equipped with an SPZ-7600 integrated flight control system.

System Description

The SPZ-7600 Integrated Flight Control System consists of the following subsystems:

- *DFZ-760 Digital Automatic Flight Control System (DAFCS)*
- *EDZ-7O5 Electronic Flight Instrument System (EFIS)*
- *Attitude and Heading Reference System (AHRS)*

The SPZ-7600 Integrated Flight Control System consists of a combination of subsystems that provide features especially suited for IFR helicopter operations and search and rescue (SAR).

The SAR Features can be included at installation or added later.

The dual DFZ-760 DAFCS combines autopilot and flight director functions for aircraft stabilization and automatic flight path control.

For SAR, its four-axis control provides automatic approach to hover and automatic climb capability in addition to typical flight director modes.

Integration with an optional Doppler radar and an optional long-range Navigation (Nav) system adds fully automatic approaches to pilot designated targets terminating at a hover with Doppler-based velocity hold.

The dual EDZ-705 EFIS accepts inputs from attitude, heading, Navigation, and flight director sources to provide cathode ray tube (CRT) ADI and HSI displays. Nav information and source switching is also provided to the flight directors by EFIS. Weather information from the PRIMUS@ 700, 701, or 870 Weather Radar System and

LSZ-850 Lightning Sensor System can be displayed with Nav information on the Electronic HSI (EHSI).

DFZ-760 Digital Automatic Flight Control System (DAFCS)

The DFZ-760 DAFCS consists of the following components:

- *FZ-706 Digital Flight Control Computer*
- *PC-700 Autopilot Controller*
- *MS-700 Flight Director Mode Selector*
- *AZ-649 Air Data Sensor*
- *AL-300 Air Data Command Display*

The DFZ-760 DAFCS is a fully coupled, four-axis (pitch, roll, yaw and Collective) flight control system designed specifically for helicopters.

In the S-76, it is a dual system configuration for redundancy and fail-operational performance.

In addition to stabilization and automatic flight path control, basic system features include the following:

- *Auto trim*
- *Heading hold*
- *Radar altitude hold*
- *Velocity hold (accelerometer based)*
- *Automatic turn coordination*
- *Autolevel*

The system also incorporates optional search and rescue (SAR) features consisting of:

- *Mark-on-target*

- *Two-stage automatic approach-to-hover*
- *Doppler-based velocity hold*
- *Automatic climb*

Two identical, interchangeable FZ-706 Digital Flight Control computers perform all autopilot and flight director functions. These computers are designated No. 1 and No. 2 with respect to their installation location in the aircraft. Either computer can be designated the master while the other is the slave.

This relationship is established by the selection of the active Flight director using the PC-700 Autopilot Controller FDSEL button.

At power-up, the system automatically defaults to the No. 2 computer as the MASTER. The MASTER/SLAVE relationship is used for a number of software functions necessary for the two computers to work in harmony. When both computers are supplied with 28 volts dc, a serial input/output (SIO) data bus provides communication between them.

To provide aircraft stabilization, aircraft attitude information is provided to each FZ-706 Digital Flight Control Computer by independent vertical gyros. Yaw rate information is supplied to each computer by rate gyros, while pitch and roll rates are computed. Lateral, vertical and longitudinal accelerometers provide each computer with acceleration for the respective axis.

To achieve consistent handling qualities throughout the aircraft's operational airspeed and altitude envelope, pitot and static pressure are sensed for each computer by a dedicated AZ-649 Air Data Sensor.

The sensor also supplies the references used for air data flight director modes. An encoding altimeter provides barometrically corrected altitude for the altitude preselect and altitude alert functions.

The VOR receiver and optional long-range navigation systems provide required signals for typical flight director Nav tracking functions. The optional Doppler radar system interface provides lateral and longitudinal groundspeed information for the velocity hold and SAR modes.

Absolute altitude above the surface is provided to both computers by a radar altimeter. Radar altitude is used for the RADALT hold function and for gain programming of certain flight director approach modes.

For SAR operations, dual radar altimeters are required. Each computer accepts certain engine data to prevent the collective axis from exceeding programmed limits when coupled.

The two computers compare their respective engine torques, engine Temperatures (T5), and gas generator speeds (N1) via the SIO data bus. Collective limiting is based on the highest parameter perceived by either computer.

The PC-700 Autopilot Controller is used to control auto pilot engagement, Stabilization Augmentation System (SAS)/All mode selection, and active flight director selection. It also controls engagement of autopilot pre-flight test, RADALT hold and velocity hold. During flight director operation it can also control decoupling/coupling of flight director commands to the autopilot and disengagement of the collective axis.

Two MS-700 Flight Director Mode Selectors are installed. Each is used to engage or disengage modes of its respective Flight Director. Both mode selectors may be used simultaneously but only the active Flight Director will be coupled to the autopilots.

The AL-300 Air Data Command Display is used for setting altitude references and displaying airspeed or vertical speed references used by the flight director. It is also used to display diagnostic error codes from the system during self-tests or the pilot-initiated pre-flight test.

Flight control outputs from the computers are accomplished by electromechanical linear actuators. A total of six actuators are used. Each computer drives one actuator in the pitch, roll and yaw axes. Each actuator has a stroke length of +/-8.0mm (0.315 inches) and is installed in the cyclic and pedal control linkages. The stroke length gives each actuator +/-5 percent authority from its centred position. With both systems operating, a total authority of +/- 10 percent is achieved. The position of each actuator may be checked by referring to the AFCS indicator panel located in the pedestal.

Cyclic stick magnetic brake, artificial feel and auto-trim functions are performed by rotary trim actuators with full authority in the pitch and roll axes. A similar actuator is also installed in the collective axis and is driven by the active flight director when collective modes are engaged. Pilot movement of the cyclic or collective against its artificial feel spring opens a detent switch in the trim actuator. The opening of a detent switch will inhibit the actuator from running in the appropriate axis. Releasing the spring force closes the detent switch, restoring the trim motor operation.

The yaw axis uses an electro-hydraulic pedal damper/trim actuator with full authority. When both autopilots are off, the unit functions as a pedal damper only to resist sudden pedal inputs. With either autopilot engaged, the trim actuator function is active and the unit will be driven by auto-trim commands. A force switch on the unit operates similarly to the detent switch previously described. In this case, pilot movement of the pedals against fluid pressure in the actuator opens the force switch, thereby disabling the actuator. Releasing the pedals closes the switch, re-enabling the actuator.

EDZ-705 Electronic Flight Instrument System (EFIS)

The EDZ-705 EFIS consists of the following components:

- *SG-705 Symbol Generator*
- *ED-600 Electronic Displays*

- *AY403 Inclinometer*
- *DC-811 Display Controller*
- *RI-206S Instrument Remote Controller*

The EDZ-705 EFIS is a Cathode Ray Tube (CRT) display of flight information which replaces electromechanical Attitude Director Indicators (ADIs) and Horizontal Situation Indicators (HSIs).

The major advantages of this system are its extreme versatility, built-in redundancy and reliability. The pilot is afforded a higher degree of control over what information is displayed in addition to how it is displayed. The composite and reversionary modes allow continuance of a mission with a minimum of upset to normal cockpit and crew procedures. Elimination of devices such as meters, mechanical counters, and gearing provides improved reliability with fewer unscheduled removals and a much higher mean-time-between failures (MTBF).

The dual EDZ-705 EFIS consists of a pilot and co-pilot system, each of which includes a Symbol Generator (SG), a Display Controller (DC), and two Electronic Displays (EDs). Various versions of Instrument Remote Controllers (IRCS) are available which interface to the systems jointly or independently. The components of each system are identical and interchangeable.

The SG-705 Symbol Generators transform all incoming data into a video format which is then transmitted to the electronic displays. The SGs provide calculated VOR deviation and other navigation information to the flight director. The SGs also perform Nav source switching to the flight directors, eliminating the need for external Nav switching relays and associated wiring. Communication between the symbol generators is via an Avionics Standard Communications Bus (ASCB). This bus allows information to be exchanged between the SGs and provides interconnect flexibility to various sensors.

The ED-600 Electronic Displays contain a full-color, high-resolution CRT, along with the necessary electronics to convert the video format from the symbol generator into a picture. Phototransistors located left and right of the tube automatically increase brightness as required during daylight operations.

The EADI and EHSI presentations are similar to electromechanical instruments except that when various information is unnecessary it is removed from the display. This provides the pilot with a less cluttered presentation allowing faster interpretation. An AY-403 Inclinometer is fastened to the EADI to provide slip and skid information.

In addition to conventional flight information, the system can also display weather radar and lightning sensor presentations over a variety of map formats, including search patterns. A hover display of lateral and longitudinal velocity is also provided if equipped with optional Doppler Radar.

The DC-81 1 Display Controller is used to select modes of operation, sources, and data to be displayed from the symbol generators to the electronic displays.

The RI-206S Instrument Remote Controller (IRC) is used to select course and heading on the EHSI.

Attitude and Heading Reference System (AHRS)

The attitude and heading reference system (AHRS) provides accurate attitude and heading information to the electronic flight instrument system (EFIS). The AHRS provides attitude information to the electronic attitude direction indicators (EADIs) from the three rate gyros contained within each attitude and heading reference unit (AHRU). Heading information is provided to the electronic horizontal situation indicators (EHSIs) either by being slaved to the earth's magnetic field when operating in the SLAVED mode, or referenced to a stabilized magnetic gyro compass heading when operating in the FREE mode. The AHRS consists of: No. 1 and No. 2 AHRU, located in the nose *compartment; a MSU CalProm, located on each AHRU; a compass control panel, located in the lower console; and a magnetic sensor unit (flux valve), located in tail section. The AHRS interfaces with the EFIS, and the dual digital automatic flight control system (DDAFCS).*

Helicopters pitch and roll attitudes are visually displayed on the pilot's and co-pilot's EADI. The indicator display contains a fixed bar representing the helicopter, a moving sphere with a distinct white horizon line dividing the two colors, blue above and brown below, a fixed roll scale with white movable index on the top of the moving sphere, and a pitch reference scale. The relative position of the fixed bar (helicopter) and the horizon line indicates the helicopter's attitude referenced to the earth's horizon. Pitch and roll displacement signals from the level sensors causes the indicator sphere to move. The amount of pitch is shown on the indicator by the position of the fixed bar relative to the pitch reference scale on the sphere. The position of the fixed bar, relative to the sphere horizon line, indicates the direction of pitch. The bar above the horizon line indicates climb, and the bar below the horizon line indicates dive. The amount of roll is shown by the position of the roll index on the sphere relative to the roll angle scale. The right or left movement of the roll index indicates the direction of roll.

If an attitude source failure occurs in one AHRU, an attitude warning discrete signal is applied through the EFIS symbol generator to the EADI. This signal causes the pitch scale and roll index to be removed, the sphere to change entirely blue, and a red ATT annunciator (warning flag) to be displayed in the middle of the sphere.

With the compass control panel SLAVE-FREE switches set to SLAVE, the gyro is slaved to the earth's magnetic field to provide accurate heading information to the pilot's and co-pilot's EHSI indicators. The compass synchronization (SYNC) indicator on the EHSI, provides a visual indication when the AHRS is synchronized (electrically and mechanically aligned). If the SYNC indicator initially reads off-centre, setting the

MAN/SYN +/v switches on the compass control panel in the direction indicated will centre the SYNC indicator, indicating AHRS synchronization.

The magnetic sensor unit senses the direction of the earth's magnetic field and produces a heading signal that is applied to the stabilized magnetic compass gyro inside each AHRU. This gyro is linked to a heading synchro, and the resultant rotation with respect to the gyro case creates a heading and slaving differential (reference heading) signal. This signal is applied to the pilot's and co-pilot's EFIS symbol generators. The generators apply the heading and slaving differential signals to the pilot's and co-pilot's EHSIs to reposition the compass cards to the correct magnetic heading. Deviation that may be caused by unwanted magnetic fields is compensated for by the MSU CalProm. When the position of the EHSI compass card is in disagreement with the helicopter's magnetic heading, the slew synchro applies a slaving error signal to each AHRU. Each AHRU then provides a new slaving signal in response to the compass card displacement. This output signal is then applied to the EHSI +/- indicator to indicate the amount of AHRS misalignment (non-synchronization).

With the control panel SLAVE-FREE switches placed to FREE, the AHRS slaving circuits are deenergized. Free drift of the stabilized magnetic compass gyro outer gimbal, as a result of changes in helicopter heading, creates a heading synchro signal as in the SLAVE mode. The heading synchro signal is then applied to the EFIS symbol generators. This signal is then sent to the pilot's and co-pilot's EHSI to reposition the compass cards to the new heading. Since rotation of the earth creates an apparent drift in the differential signal from the heading synchro, drift cancellation is done manually by setting the MAN/SYN +/v switch in the direction required to bring compass card back to the correct magnetic heading.

If a heading source failure occurs, the heading warning discrete signal is applied through the EFIS symbol generator to the EHSI. This causes the HDG warning flag to *be illuminated, the bearing warning flag, bearing pointers, course select pointer, course deviation pointer, and course scales to be removed.*

1.6.8 Weight and balance

The load sheet provided for departure from Erha showed that there were 10 Passengers (PAX) with total body weight of 1,908 lb and cargo of 109 lb. The aircraft had a total payload of 2,289 lb. The actual weight of the aircraft on take-off was 2,026 lb with 9 passengers of total body weight of 1,717 lb, luggage of 259 lb and cargo of 50 lb.

The aircraft has a Maximum allowable Take-off Weight (MTOW) of 11,500 lb.

1.7 Meteorological Information

The weather information for this flight was obtained from Automatic Telecommunications Information Service (ATIS).

ACTUAL	**LOS**
Time:	0900 UTC
Wind:	VRB 02 kt
Visibility:	1400 m
Weather:	HAZE
Cloud:	Few @ 1100 FT
Temp/Dew Point:	28/25 ^{o}C
QNH:	1015
TREND:	Tempo 1500 M

1.8 Aids to Navigation

The aircraft is fitted with an attitude and direction system comprising of the Compass, the attitude indicating system, the standby Magnetic Compass, the Turn and Slip Indicator, the Attitude and Heading Reference System (AHRS) and the Standby Attitude Indicator (STBY ATT).

1.9 Communications

The helicopter is equipped with an intercommunication system (ICS), a single or a dual VHF communication system is available for helicopter to ground or helicopter to other airborne aircraft communication and a passenger audio advisory system.

There was good communication between the aircraft and ATC. The crew briefed the passengers of the intention to ditch the aircraft and advised that they be prepared.

1.10 Aerodrome Information

The destination aerodrome for this aircraft was Murtala Muhammed Airport, Ikeja, Lagos (DNMM). It has two parallel runways designated 18R/36L and 18L/36R. Runway 18R/36L has a dimension of 3,900 m by 60 m while the

18L/36R have a dimension of 2,742 m by 45 m. The DNMM has an elevation of 65 ft AMSL.

1.11 Flight Recorders

This aircraft is equipped with a Multi-purpose Flight Recorder (MPFR) and a Flight Anomalous Event Recorder (FAERITO). The FAERITO is not an NCAA requirement.

1.11.1 Multi-purpose Flight Recorder (MPFR)

Part Number:	D51615-102
S/N:	001664-003
Manufacturer:	Penny and Giles
Data Storage:	Solid State Memory

1.11.2 Flight Anomalous Event Recorder Information Technology Open (FAERITO) Image Recorder-3 Camera

Part Number:	4308-05000-20-101
S/N:	4308-000032
Manufacturer:	Physical Optics Corporation
Data Storage:	Solid State Memory

The FAERITO is a multi-functional unit that supports audio, video and flight data recording. This unit is not a standard requirement on this aircraft by the Nigerian Civil Aviation Authority (NCAA).

The recorders were recovered from the submerged aircraft the next day and then shipped in a box filled with fresh water to the UK AAIB on 8th of February, 2016. This was to prevent salt water corrosion as a result of the aircraft submerging in salt water. The MPFR is a combined Cockpit Voice Recorder (CVR) and Flight Data Recorder. The UK AAIB has a Crash Damaged Recovery Equipment (CDRE) to support recovery of data from accident damaged units. It ensures that the memory board and its contents cannot be altered in anyway. Once the raw digital data FIS is downloaded from the memory board, a combination of software developed by Penny and Giles and the UK AAIB converts the data to audio and flight data in engineering units.

The MPFR was downloaded and analysed but only four parameters (Pressure Altitude, Indicated Airspeed, Master Caution and Autopilot Engaged 1 & 2) were obtained. The CVR audio was transcribed at the Bureau's laboratory in Abuja.

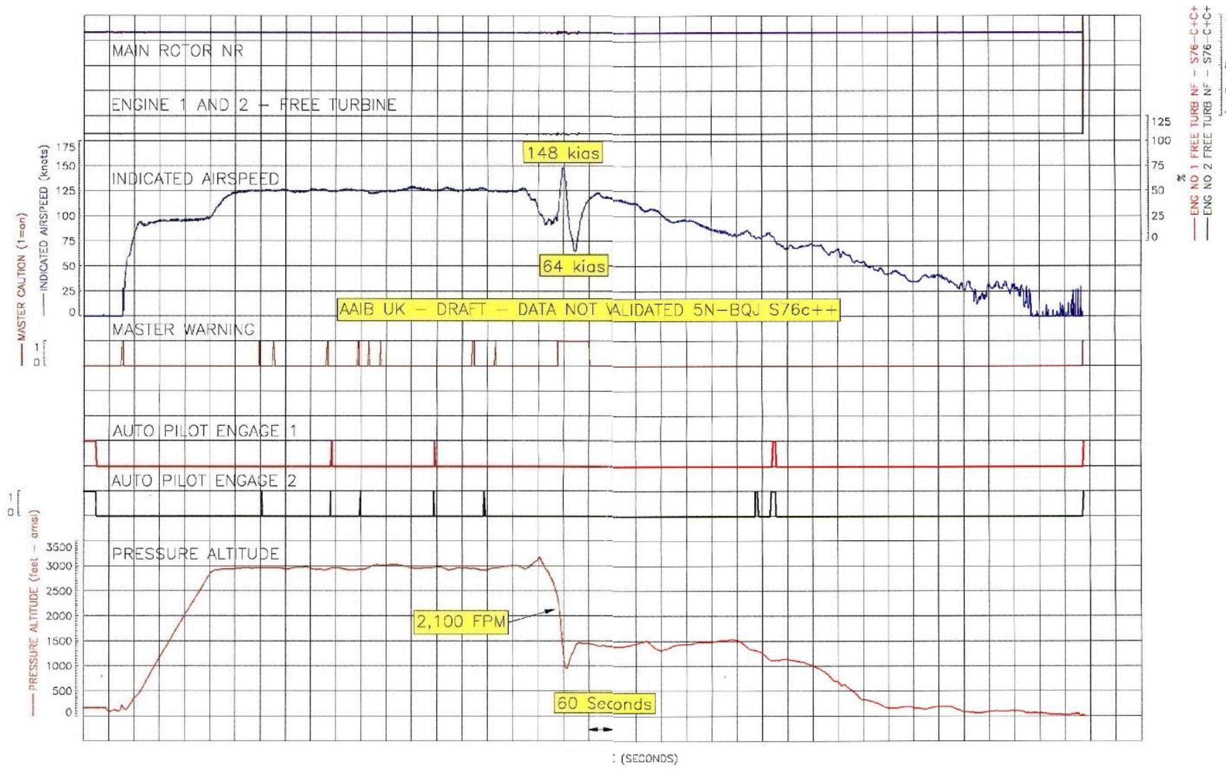

Figure 1: FDR Plot showing obtained parameters

1.12 Wreckage and Impact Information

The aircraft was fairly intact although damaged as a result of being submerged in salt water. The life rafts were deployed, and the doors were detached from the aircraft.

Figure 2: The aircraft being transported after recovery from the ocean

Figure 3: The aircraft being transported after recovery

1.13 Medical and Pathological Information

The crew and passengers were taken to a hospital in Lagos where toxicology tests were performed on the crew only. The tests were negative for any substance of abuse.

1.14 Fire

There was no fire outbreak.

1.15 Survival Aspect

The aircraft flight compartment equipment consists primarily of those items necessary for the comfort and safety of the Captain and First Officer. The Flight equipment includes the Captain and First Officer seats, safety belts, shoulder harnesses, inertia reels, ash receivers and receptacles, certificate holder, data pouch, nameplate, and first aid kit.

The Passenger compartment equipment also consists primarily of those items necessary for the comfort and safety of the passengers. Passenger compartment equipment include: passenger seats with safety belts, ash receivers, soundproofing, and floor covering.

The accident was survivable as there was liveable volume available for the crew and passengers. The aircraft speed on impact with the water was about 20 kt; hence the aircraft did not disintegrate on contact with the water surface. If the aircraft speed on contact with the water surface was high, the aircraft would have possibly flipped over, disintegrated and there could possibly not have been any survivor. The crew successfully carried out a controlled landing on water and the aircraft floats were deployed. All the nine passengers and crew exited the aircraft without any injury. The occupants were then rescued by a boat in the vicinity of the accident. There were other aircraft in the vicinity of the crash that helped to raise 5N-BQJ; Caverton Helicopters and Azman Aircraft. The rescue operations were initiated by the National Emergency Management Agency. A speed boat was dispatched from the Sea Trucks Group (STG) Jascon 25 ship, to rescue crew and passengers. Several other boats from CHEVRON, AGIP and SHELL were involved in the rescue effort. Passengers and crew were all taken to the ship which subsequently berthed at the Eko Support Quay. They were later taken to a hospital in Lagos where toxicology tests were performed on the crew only.

1.16 Test and Research

The two Engine Control Units (ECU) were sent to Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile (BEA) in France for examination.

Work performed:

Both computers were immersed following the accident. They were received in water and in good condition. They were opened and the main electronic boards from the module A and B of the two ECUs were extracted.

The following process was applied on the four boards:

- Board drying at a temperature of 90°C for more than 48 hours,
- Memory component unsoldering under temperature monitoring,
- Memory component cleaning,
- Memory component electrical characterization and read-out using the BEA memory reader.

The following binary files were generated:

- *5N-BQJ_ECU_5076_moduleA.bin*

- *5N-BQJ_ECU_5076_moduleB.bin*
- *5N-BQJ_ECU_6361_moduleA.bin*
- *5N-BQJ_ECU_6361_moduleB.bin*

The decoding process was carried out using the BEA dedicated software and the manufacturer's proprietary documentation referenced *AA015378 issue B and AA001412 issue B*. The data were shared with Turbomeca for analysis. The parameters recorded in the failure contexts were recorded during the sequence of impact with the water and were analysed carefully in regards with FDR data.

The FDR plot also indicated that the engine was functional up to the point of impact.

The complete examination result is attached as **Appendix 1.**

Some components were sent to the National Transportation Safety Board (NTSB) for various tests. These were the:

1) Air Data Display (ADD) Download.
2) Enhanced Ground Proximity Warning System (EGPWS) Download.
3) Flight Control Computers (1 and 2) Downloads.
4) Health and Usage Management System (HUMS) Download.
5) Functional Test/Examination of the Main Rotor Servos (Forward, Aft and Lateral).
6) Functional Test/Examination of the Tail Rotor Servo Actuator.
7) Functional Test/Examination of the Transducers (Collective/Roll/Yaw/Pitch).

These tests/examinations were carried out under the supervision of the NTSB. All the examinations were inconclusive as a result of salt water corrosion of these components. It is noteworthy that the aircraft had been submerged in salt water for more than 24 hours before recovery.

Reports of the examinations are attached in **Appendix 2.**

1.17 Organizational and Management Information

1.17.1 Bristow Helicopters (Nigeria) Limited (BHNL)

Bristow Helicopters (Nigeria) Ltd., an affiliate of Bristow Group, is a provider of industrial aviation services offering air transportation to the Nigerian oil and gas industry and has been in operation for more than 40 years. During the last eight years, Bristow Helicopters (Nigeria) Ltd. ventured into deep water helicopter services. Bristow Helicopters operations include both the fixed wing and helicopter; the company conducts all its operations in accordance with the approved NCAA Air Operators Certificate (AOC). The Operations Manual is developed primarily to guide operations taking place over and within the territory of Nigeria.

1.17.1.1 Technical Directive (TD)

Bristow Helicopters (Nigeria) Ltd. issued a Technical Directive number S76-05-132 which is for S76 aircraft types. The purpose of the TD is to carry out a one-time Safety Assurance Inspection for the Return to Service of all S76 fleet in

Nigeria. The effectivity is for all Nigerian Registered S76 Aircrafts. The TD was issued after the accident.

Technical Directive

ALERT

Type:	S76C Series	Number:	S76	- 05 -	132

Subject:	**One Time Safety Assurance Inspection – Return to Service of 5N Registered Aircraft.**
Effectivity:	All 5N (Nigerian) registered S76 aircraft.

Description:
The purpose of this TD is to carry out a one-time safety assurance inspection for the return to service of the S76 fleet in Nigeria, pending further information from the investigation of the water landing incident.

Compliance: **Before next flight (One off technical positioning flight for movement to a maintenance facility, allowable with prior approval only).**

Action:

Carry out the following inspections/checks:

1. Review airworthiness documentation to ensure compliance with all relevant Bristow Technical Directives, Airworthiness Directives and manufacturer issued ASBs.
2. Carry out a compliance review of the scheduled maintenance inspections for the airframe and all components, including engines and emergency equipment.
3. Carry out a detailed integrity inspection on the flying control system to include control rods, bellcranks, cables, pulleys, AFCS flight controls including pitch, roll and yaw AFCS actuators, trim servos (Coll/Pitch/Roll) and the pedal damper. Inspect all hydraulic servos for condition, wear and leakage. On completion of the detailed inspection a full and free movement check must be carried out with each hydraulic system in turn (ref AMM 67-00-00 flight control motion and clearance checks) and a re-certification of duplicate inspections of all critical parts.
4. Carry out a detailed integrity inspection of the drivetrain to include engines, all gearboxes and drive shafts. (ref AMM 66-10-00, 66-20-00, 66-30-00, 66-40-00.
5. Perform a detailed review of the HUMS system data (minimum of a 60 days / 200 hour period, whichever is greater) to verify all data captured; identify any exceedances and trends including a check of corrective actions taken, to assure the appropriate level of monitoring.

Compiled by:		Vetted by:			
Date:	10 February 2016	TD No.:	S76	- 05 -	132

Page 1 of 3 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76C Series	Number:	S76	- 05 -	132

Subject:	**One Time Safety Assurance Inspection – Return to Service of 5N Registered Aircraft.**
Effectivity:	All 5N (Nigerian) registered S76 aircraft.

6. Carry out a 100 hour check. During inspection pay particular attention to fluid leaks, condition and security of all parts / panels.

7. Carry out a wiring loom inspection in the cockpit area for signs of chaffing / arcing / burning Confirm wiring harnesses conform to electrical standard practices 20-32-00 para 2.

8. Final check – Check cleanliness of all engine, transmission, drivetrain and control decks (FOD, liquid etc) before closing up panels. Refit all removed panels and check for security of attachment and correct installation of all fasteners.

9. Carry out ground run for correct operation of all systems.

List of Attachments:	Appendix 1 inspection worksheet (Rev 1).

Recurring	☐Yes ☒No	**IFS Mod**	☒Yes ☐No	**E.L.A. Affected**	☐Yes ☒No
Weight and Balance	☐Yes ☒No	**WEIGHT**		**MOMENT**	

Additional Information:

ALERT

Compiled by:		Vetted by:			
Date:	10 February 2016	TD No.:	S76	- 05 -	132

Page 2 of 3 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76C Series	Number:	S76	- 05 -	132

Subject:	**One Time Safety Assurance Inspection – Return to Service of 5N Registered Aircraft.**
Effectivity:	All 5N (Nigerian) registered S76 aircraft.

Technical Directive Acknowledgement – Americas & Bristow Academy ONLY

Base:	**A/C Reg.No.:**
Ser.No.:	**A/C TT:**
Date:	**Name:**
A and P:	(PRINT)
Technical Signature:	

To GOM personnel:	**On completion please return this sheet to ARA Tech Records department.**
To BRISTOW ACADEMY personnel:	**On completion please return this sheet to (Titusville).**

ANY ADDITIONAL INFORMATION REQUIRED:

ALERT

Compiled by:		Vetted by:			
Date:	10 February 2016	TD No.:	S76	- 05 -	132

Page 3 of 3 (TD Acknowledgment page - for Americas ONLY)

1.17.1.2 Emergency Operations Procedure (EOP)

Bristow Helicopters (Nigeria) Ltd. has an Approved Emergency Operations Procedure Manual which the crew are expected to consult in the event of an emergency.

S76 C++ EMERGENCY PROCEDURES — Bristow

AUTOPILOT & FD MALFUNCTION INDEX

Indication	Malfunction	Ref
DAFCS + AP1 AP2	DUAL AP FAILURE	5/1
DAFCS + AP1 or AP2	SINGLE AP FAILURE	5/2
DAFCS + CLTV	COLLECTIVE CAUTION	5/3
DAFCS DCPL	DECOUPLE CAUTION	5/4
TRIM FAIL	TRIM FAIL CAUTION	5/5
	SUDDEN DISTURBANCE	5/6
	OSCILLATIONS	5/7
	FD FAILURE	5/8
	FD COUPLER FAILURE	5/9

P. 51 January 2009 **5/0**

Bristow — S76 C++ EMERGENCY PROCEDURES

5/1 – DUAL AP FAILURE

INDICATIONS DAFCS + AP1 AP2

IMMEDIATE ACTIONS

1. CONTROLS — RESTORE aircraft attitude
2. AIRSPEED — REDUCE to below 120 knots

SUBSEQUENT ACTIONS

1. AP RESET SWITCHES — RESET in sequence
2. AP SELECTORS — RE-ENGAGE

If fail lights remain on:

3. CONDITIONS — Attempt to become VMC
4. LAND — As soon as practicable

5/2 – SINGLE AP FAILURE

INDICATIONS DAFCS + AP1 or AP2

IMMEDIATE ACTIONS

1. CONTROLS — RESTORE aircraft attitude

SUBSEQUENT ACTIONS

1. AP RESET SWITCH — RESET affected AP
2. AP SELECTOR — RE-ENGAGE

CONSIDERATIONS

If reset is unsuccessful, continue the flight on remaining system. FD modes may be re-engaged but coupling to a single AP is inhibited.

Resetting #2 AP/FD may cause #1 AP/FD to automatically disengage.

5/1 - 2 January 2009 P. 52

S76 C++ EMERGENCY PROCEDURES — Bristow

5/3 – COLLECTIVE CAUTION

INDICATIONS DAFCS + CLTV

IMMEDIATE ACTIONS

1. CONTROLS — RESTORE aircraft attitude

SUBSEQUENT ACTIONS

1. COLLECTIVE TRIM — Check ON

If N1, Torque or T5 limits are exceeded:

2. COLLECTIVE — DECREASE as required
3. IAS / VS DATUM — REDUCE if coupled

If caption remains when N1, Torque and T5 are below limits:

4. APs — Switch OFF in turn, then ON
5. COLLECTIVE — CONTROL manually

CONSIDERATIONS

The CLTV caption will always illuminate when Torque exceeds 100 ±4% or when N1 exceeds 100% for 5 seconds or 101.0% for any period of time. When operating OEI in aircraft not equipped with the Collective Limit Inhibit System, this caption will illuminate every time these parameters are exceeded.

5/4 – DECOUPLE CAUTION

INDICATIONS DAFCS + DCPL

IMMEDIATE ACTIONS

1. CONTROLS — RESTORE aircraft attitude

SUBSEQUENT ACTIONS

1. FLIGHT DIRECTOR — RESELECT or TRANSFER to another mode

P. 53 February 2012 **5/3 - 4**

Bristow — S76 C++ EMERGENCY PROCEDURES

5/5 – TRIM FAIL CAUTION

INDICATIONS TRIM FAIL

IMMEDIATE ACTIONS

NIL

SUBSEQUENT ACTIONS

1. APs — Switch OFF in turn, then ON

If caution extinguished:

2. CONTINUE THE FLIGHT

If caution not extinguished:

2. CONTROLS — Fly with HANDS AND FEET ON the controls

CONSIDERATIONS

If the flight is to be continued with the caution remaining, consideration should be given to the restrictions imposed by the MEL – Flight with DAFCS SPZ-7600 Inoperative.

5/6 – SUDDEN DISTURBANCE

INDICATIONS Hardover

IMMEDIATE ACTIONS

1. CONTROLS — RESTORE aircraft attitude

5/5 - 6 January 2009 P. 54

1.17.1.3 Operations Manual (Part B)

The crew are expected to follow procedures as contained in the Approved Operations Manual Part B (S76C++ Checklist) during flight operations.

Bristow (October 2014)

CHECKLIST S76 C++

Ground Checks – Appendix C3 to Section 4 of the Operations Manual Part B (S76 C+/++)

———— Action by Both Crew
------------ Action by Pilot Flying
1st Flight of the Day Check
.... Action by Pilot Monitoring

PRE START

1. Brakes ------------------------- RECYCLE ON
2. Gear/Liferaft Pins/**Tech Log** ------- STOWED
3. Servo Switches -------------------BOTH ON
4. Standby Battery ------------------TEST / ON
5. Battery/External Power----------------ON
6. IIDS ------------------------------- PASS
7. Overhead Switches -------------------- A/R
8. Heater/Blower --------------------------OFF
9. Engine Fire Detection------------------ TEST
10. Prime Switches------------------------OFF
11. Engine Control Switch ---------------AUTO
12. 26V AC Circuit Breakers------------------IN
13. Rotor Brake ------------------ CHECK – A/R
14. Flood/Wander Lights----------------- CHECK
15. Upper/Lower Circuit Breakers-------------IN
16. Compasses ------------------------ SLAVED
17. Trim Switches ---------------------------ON
18. CVFDR / PA /AFDS ------------------ TEST
19. ADELT ------------------------------- TEST
20. Engine Out Warning ------------------ TEST
21. Essential Bus Recovery Switch----------- OFF
22. Chip Detector ------------------------- TEST
23. Centre Console Switches ---------------- A/R
24. Electrical Test Panel ---------------------OFF
25. Floats Test ---------------------------- NORM
26. IIDS/DECU ------------------ TEST / CHECK
27. Co-Pilot's Panel ---------------------- CHECK
28. Pilot's Panel ------------------------- CHECK
29. Landing Gear Panel ----------- CHECK / TEST
30. OAT ---------------------------------- CHECK
31. Standby Compass ------------------- CHECK
32. Fuel Levers ---------------------CROSSFEED
33. Engine Control Levers ----------------- STOP
34. Electrical Parameters ----------------- CHECK

FIRST ENGINE START (BRAKE OFF)

1. Lights--------------------- ANTI COLL/POSN
2. Engine -------------------------------- START
3. Nr-------------------------------- SET 65%
4. Flight Controls/Servo Switches ------ CHECK
5. HEEL/Emergency Lights -------- TEST / ARM
6. Radio Master ----------------------------ON
7. External Power-------------- OFF / REMOVE

FIRST ENGINE START (BRAKE ON)

1. Lights------------------------------------ A/R
2. Engine-------------------------------- START
3. HEEL/Emergency Lights --------- TEST / ARM
4. Radio Master ------------------------------ON
5. External Power--------------- OFF / REMOVE

-----Rotor Engagement-----

1. Rotor Brake ----------------------RELEASE
2. Nr --- --------------------------- SET 65%
3. Flight Controls/Servo Switches--------CHECK

SECOND ENGINE START

1. Engine -------------------------------- START
2. Inverters ---------------------------------ON
3. EFIS ---------------------------- BOTH ON
4. Anti-Icing/Blower ---------------- TEST / A/R
5. Engine Levers ------------------------- FLY
6. Fuel Levers ------------------------ DIRECT
7. Nr.. 107%
8. OEI Stops ---------------------------CHECK
9. Baggage Smoke Detector --------------TEST
10. Inverters -------------------------------TEST
11. Avionics/WXR ---------------- ON / STANDBY
12. Barrier Filter ------------------ CHECK / TEST
13. APs ------------------------------ TEST / OFF
14. AHRS/EGPWS/IIDS Reversion ----------TEST
15. Instruments/Radios/Navaids__ CHECK/TEST
16. N1 Values____________________ CHECK

SHUTDOWN

1. After Landing Checks--------------COMPLETE
2. EFIS/Radio Master ----------------------- OFF
3. Landing/Search Light ------------------- OFF
4. HEEL/Emergency Lights ----------------- OFF
5. Anti-Ice/Blower ------------------------- OFF
6. Circuit Breakers ------------------------ PULL
7. Centre Console Switches ---------------- OFF
8. GPS/WXR/Stby Horizon ----------------- OFF
9. Engines (after 30 secs)------IDLE then STOP
10. Rotor Brake ----------- APPLY below 65% Nr
11. Fuel Levers -------------------OFF (N1 Zero)
12. Overhead Switches --------------------- OFF
13. IIDS/DECU/ZING ---------------CHECK/OFF
14. Battery ------------------------------- OFF

Bristow (October 2015) **CHECKLIST S76 C++**

Flight Checks – Appendix C3 to Section 4 of the Operations Manual Part B (S76 C+/++)

———— Action by Both Crew

Offshore/Swamp Items

.... Action by PM

▶ Shuttle Checks

PRE - TAXI

1. Brief ____________CREW / PASSENGERS
2. Doors/Pins ____________LOCKED/STOWED
3. Cabin Notices ____________ON
4. Lights ____________A/R
5. Cyclic Stick Guard ____________ DISENGAGED
6. Brakes/Chocks ____________ OFF / REMOVED

BEFORE TAKE-OFF

1. Blower ____________ A/R
2. Fuel/Engine Levers ____________DIRECT / FLY
3. Altimeters/AAI ____________ SET / X CHECK
4. RadAlt Bugs/Next Course ____________ SET
5. Speed Bugs ____________ SET
6. Radios/Navaids ____________ SET
7. Displays/DECU ____________CHECK
8. Fuel ____________CHECK

At Take-Off Point

9. Brakes ____________ A/R
10. APs ____________ ENGAGE BOTH
11. Floats ____________ARM
12. Transponder/ADELT/TCAS ___ ALT/ARM/SET
13. Tracking System ____________ CONFIRM ACTIVE
14. Lights ____________ON

HOVER

1. CWP / Ts & Ps / Nr.......................... CHECK
2. Power Margin .... CHECK

AFTER TAKE-OFF / GO AROUND

▶ 1. Floats ———————OFF
2. Gear ———————UP
3. Altimeters/MESA/AAI———SET / X CHECK
4. Radios/Navaids/WXR——— CHECK
5. Brakes ——————— A/R
6. Compasses——— CHECK / SLAVED

CLIMB / CRUISE / DESCENT

1. OAT/DECU ———————CHECK
2. Altimeters/MESA/AAI——— SET / X CHECK
3. RadAlt Bugs ——————— SET
4. Fuel ———————CHECK
5. Radios/Navaids ———————CHECK
6. Searchlight——————— A/R

APPROACH

1. Search Light——————— ON
2. Radios/Navaids/WXR——— CHECK
3. Altimeters/MESA/AAI—— SET / X CHECK
4. RadAlt Bugs ——————— SET
5. EGPWS ———————A/R
▶ 6. DECU/Barrier Filter ——— CHECK
▶ 7. Brakes ——— A/R CHECK PRESSURE
8. Gear———DOWN or WARNING SET
9. Brief——— APPROACH/CREW/PAX

FINAL

1. RadAlt Bugs ——————— SET
▶ 2. Gear ——————— DOWN
▶ 3. WXR———————STANDBY
4. Compasses——————— A/R
5. Lights ——————— A/R
▶ 6. Floats ———ARM BELOW 75KTS
▶ **7.** Destination ———**IDENTIFY NAME**

CONFIRM LANDING CLEARANCE

AFTER LANDING

1. APs——————— OFF
2. Transponder/ADELT——— OFF
3. Lights ———————A/R

------At Parking Spot------

4. Parking Brake/Chocks ——— ON / IN
5. Cyclic Stick Guard ——— ENGAGED
6. Cabin Notices ———————A/R

OFFSHORE/SWAMP ROTORS RUNNING TURNROUND

AFTER LANDING

1. Cyclic Stick Guard ———ENGAGED/STOWED
2. APs———OFF/ENGAGE BOTH
3. Displays/DECU ____________ CHECK
4. Engine levers ——— A/R/107Nr-FLY
5. Floats/ADELT ——— OFF/ARM
6. Lights ——— ALL OFF A/R
7. Cabin Notices———A/R
8. HLO ——— CLEARANCE/CHOCKS
9. DOORS——— A/R / SECURED

REVERSE FOR OFFSHORE/SWAMP BEFORE TAKE-OFF

1.17.1.4 Extracts from the Sikorsky S76C++ Rotorcraft Manual

SA 4047-76C-14 | SIKORSKY 76® FLIGHT MANUAL | Part 2, Section I Systems Descriptions

STICK TRIM Switches

Stick trim switches are provided for cyclic, collective and yaw force trim. These switches are normally located in the center console, and should be ON for normal system operation. Autopilot operation in the ATT mode will automatically revert to (or engage in) SAS if the cyclic stick trim switch is off.

Remote Standby Switch

A remote standby switch is located on the cyclic grip, Figure 1-46. It is equivalent in all functions to the SBY switch on the flight director mode selector, respective of copilot vs. pilot side. That is, the copilot's cyclic remote standby switch is dedicated to the No. 1 flight director, the pilot's is dedicated to the No. 2 flight director. During preflight test performance, either side may be used to bypass the lamp test or sequence through error codes.

Remote Go-Around Switch

A remote go-around switch is located on each collective grip, Figure 1-46. Pressing the switch will only engage go-around on its respective flight director. Go-around cannot be disengaged by the remote switch. This prevents accidental disengagements during missed approach procedures.

NOTE

The remote standby and go-around switches noted above control their respective flight directors only. That is, the switches located on the copilot's controls only affect FD1 while those on the pilot's controls only affect FD2.

FD DCPL

The purpose of the optional Flight Director De-couple Annunciator is to advise the flight crew that the controlling flight director has been de-coupled. The annunciator will illuminate when the active flight director is de-coupled purposefully by any of the following actions:

1. The couple (CPL) button is pressed on the autopilot control panel.
2. The active flight director is set to Standby (SBY) on its mode selector.
3. The active flight director is set to Standby with the corresponding cyclic DECOUPLE switch.

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Although the primary function of the system is to alert the flight crew that the controlling flight director has been manually de-coupled, the FD DCPL annunciator will also illuminate if the active flight director is de-coupled by the following equipment shutdowns:

1. Failure of AP1 or AP2
2. De-selection of AP1 or AP2
3. AHRS failure
4. Air data computer failure if the same side active flight director is coupled in a single cue air data mode.
5. Air data computer failure if the same side active flight director is coupled in a two cue air data mode, if both cues are air data modes (example: IAS and ALT).

The FD DCPL annunciator will activate in response to the previously described de-couple events in a flashing mode, accompanied by a non-repeating aural tone. The aural tone or voice alert is an additional option. When the annunciator is pressed, the flashing stops, and the annunciator remains illuminated until the active flight director is again placed in a coupled mode.

The annunciator will also activate if RAD ALT HOLD is selected when BAR ALT HOLD is coupled. In this case the flight director is still coupled but a de-couple action (BAR ALT HOLD off) in reference to the mode selector has occurred. Note that RAD ALT HOLD (Figure 1-19) is not a selectable feature of the mode selector.

WARNING

The FD DCPL annunciator is not intended to detect system failures and the flight crew should monitor the cockpit for all standard failure annunciations.

STBY CDI The STBY CDI switch, Figure 1-19, is used to turn on the optional standby Course Deviation Indicator, which is used for back-up navigation during single pilot operations.

To utilize the standby CDI, the switch is pressed to illuminate ON, on the pushbutton switch front.

COMMAND DISPLAY

AL-300 Display The primary function of the AL-300, Figure 1-21, is to display the command, or reference, numbers that are used with the ALT PRE, IAS, VS, RAD ALT, VEL HLD, or altitude alert mode(s). Refer to appropriate mode descriptions for more information.

Whenever the IAS, VS, RAD ALT, or VEL HLD (Doppler valid) modes are selected the display will show the reference number for that mode for a period of 5 seconds. Any time the appropriate four-way switch is actuated to beep to a new reference, the display will show the appropriate mode value being changed. When FTR is pressed with a mode engaged, the AL-300 will display the current reference value for that mode. When FTR is released, the displayed value will become the new reference for that mode. For example, when engaging IAS while flying at 100 KIAS, the display will show 100 knots for a period of 5 seconds. The pilot may then use the four-way switch on the cyclic to increase or decrease the airspeed reference as desired.

When SBY is pressed, the AL-300 will display all eights (88888) and face legends as a lamp test. At power up, the display will show all dashes (-----). During preflight test, the pilot (or copilot) may cycle the display to show error codes by pressing the SBY switch.

ANNUNCIATORS

DAFCS Caution Panels Failures of autopilot No. 1 or No. 2 are annunciated in amber on the DAFCS caution panels, Figure 1-22. Emergency procedures pertaining to autopilot failures are presented in Part I, Section III, Emergency Procedures.

The AP1 or AP2 annunciator will illuminate whenever the respective autopilot disengages during normal operation. The disengagement may be caused by a number of different malfunctions such as ac or dc electrical power interrupts, invalid vertical gyro and AP computer failure, to name a few. Refer to the Tests and Continuous Monitoring section.

The amber CLTV annunciator will illuminate under the following circumstances:

Engagement of a collective mode while the STICK TRIM - CLTV switch is OFF.

Table 1-8. Error Codes

PWR UP	PRE FLT	CONT TEST			
	X		E	248	SECONDARY RADAR ALTIMETER NOT VALID

Table 1-9. Failure Monitoring, Display and Warning Logic

AUTOPILOT/ FLIGHT DIRECTOR MODE	FAILURE	WARNING DISPLAY	FLIGHT DIRECTOR COMMAND RESPONSE	AUTOPILOT RESPONSE
Any	Vertical Gyro	ATT Flag on EADI	Bars or Cue BOV*	Autopilot Disengages
	Flight Director Computer	FD Flag on EADI	Modes Reset	Autopilot Disengages
Heading Hold Pitch Hold (No FD Mode selected)	Vertical Gyro	ATT Flag on EADI		Autopilot Disengages
	Directional Gyro	HDG Flag on EHSI		Roll Attitude Level, Autopilot Remains Engaged
HDG	Directional Gyro	HDG Flag on EHSI	Roll Bar BOV	Autopilot Remains Engaged
	EHSI	HDG Flag on EHSI	Roll Bar BOV	Autopilot Remains Engaged
NAV/BC/VOR APR	Directional Gyro	HDG Flag on EHSI	Roll Bar BOV	Autopilot Remains Engaged
	EHSI	HDG Flag on EHSI	Roll Bar BOV	Autopilot Remains Engaged

Compass Splits

Local magnetic interference can affect the flux valves providing different information to one AHRS than to the other. Thus, the two AHRSs can provide different heading information, causing differences in the pilot's and co-pilot's cockpit displays and may trigger the comparator monitor.

Possible causes for heading splits can be vehicles parked by the aircraft, or ferromagnetic material or electrical installations on the ground (e.g., taxiway or runway heating).

After takeoff the magnetic distortion leading to compass splits normally disappears. It will then take several minutes for the heading difference to "slow slave" out. The system may be instantly realigned by switching from Slaved mode to DG mode and back again to Slaved mode through use of the compass control switches.

Latitude Limits for Magnetic Heading

Magnetic heading sensing is unreliable in the vicinity of the magnetic poles. This is due to the steep inclination of the magnetic field, reducing drastically the usable horizontal component of the magnetic field. In addition, other effects, like the convergence of the magnetic field and magnetic variations of up to 180° prevent the use of magnetic stabilized heading in these areas. Therefore, the DG mode should be selected by the pilot.

OPERATING INSTRUCTIONS

Alignment on Ground

Alignment is automatic on application of power. No pilot action is required.

After a temporary aircraft power loss (voltage drop due to engine start etc.) a realignment is initiated automatically upon restoring of power. No pilot action is required.

NOTE

- The DG/Slaved switch has to be set to the "Slaved" position in order to achieve a correct heading alignment.
- Do not move the aircraft until all of the three warning flags from the AHRS, (ATT, HDG, and TR) have disappeared.

To achieve full performance (lowest drift) of the system, an alignment time of 2 minutes should be used. This is done by keeping the aircraft stationary for 90 seconds. after the flags have disappeared.

Alignment in Air

Alignment in the air is automatic on application/restoring of power to the AHRS. No pilot action is required to initialize an in-flight alignment. However, to allow the AHRS to successfully finish the alignment, the aircraft has to be flown straight and level, until all of the warning flags have disappeared (ATT, HDG, TR).

NOTE

- The DG/Slaved switch has to be set to the "Slaved" position in order to achieve a correct heading alignment.
- If a realignment is required due to invalid AHRS output a power interrupt of more than 0.5 seconds can be generated by cycling the AHRS circuit breakers.

Compass Controller Operation

DG/Slaved Switch

The "DG/Slaved" switch allows the pilot to manually select either the Slaved mode or the DG mode. In "Slaved" position, heading from the flux valve is used as long term heading reference, whereas in "DG" position no long term reference for heading is used, and the AHRS operates as a conventional free directional gyro.

The DG mode may be used on the ground prior to flight in an area where the magnetic field is disturbed and the resulting slaved heading is unreadable. If this condition exists when the aircraft is aligned for take-off, the AHRS systems should be switched into the DG mode and an accurate heading for the takeoff should be set on the display. Once the aircraft is airborne the systems should be switched to the Slaved mode.

Systems may be cycled from Slaved to DG and back to Slaved mode in the air to relieve minor heading splits.

Manual SYN Switch

The function of the manual SYN switch is to manually slew the AHRS heading output to a desired value.

When set to the left or right +/- marker, the indicated heading is slewed left or right respectively, at 2°/sec, for the first 3 seconds. Thereafter, at 8°/sec.

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and level flight. The pilot's feet should be positioned on the pedal switches to avoid sudden aircraft heading changes as a result of heading realignment.

3. Immediate heading realignment is provided in the SLAVE mode by momentarily selecting the slew function right or left while in unaccelerated, wings level flight or level on the ground. If realignment is inadvertently commanded in other than wings level flight, slaving will be immediate and convergence will proceed at one degree per second or less once wings level.

4. Prior to takeoff with AHRS selected normally in the SLAVE mode, significant heading error can occur when operating from areas with known or suspected adverse magnetic influence (metal structures such as oil rigs, steel reinforced subsurface construction, metal fencing, etc.). In such situations, consider using the slew function to realign indicated heading to a known visual reference (e.g. runway heading or equivalent) in the FREE mode. Then, after takeoff, when established in straight and level flight, switch to the SLAVE mode with pilot's feet on pedal switches.

5. An AHRS test mode can be commanded by either the pilot's or copilot's AHRS TEST switch. When selected, the AHRS will present 015 degrees heading, 5 degrees pitch up, 45 degrees roll right and right turn rate data. The test data will remain displayed for 1 second after the switch is released. The test mode is inhibited in flight.

WARNING

The AHRS test should be conducted with both autopilots OFF. Conducting the test with one or both autopilots ON may cause sudden flight control movement in the pitch, roll, and yaw axes.

PULSELITE SYSTEM

OPERATION

To pulse the landing/recognition lights, move the corresponding switch to the PULSE position.

RECOGNITION LIGHTS

OPERATION

The RCGN LTS control switch is located on one of the overhead switch panels or on the master switch panel. It has two positions labeled ON and OFF.

The RCGN LTS control system will have a third position labeled PULSE. When the switch is moved to this position, the recognition lights will pulse on and off.

FAA APPROVED DECEMBER 20, 1999
Revised October 25, 2010

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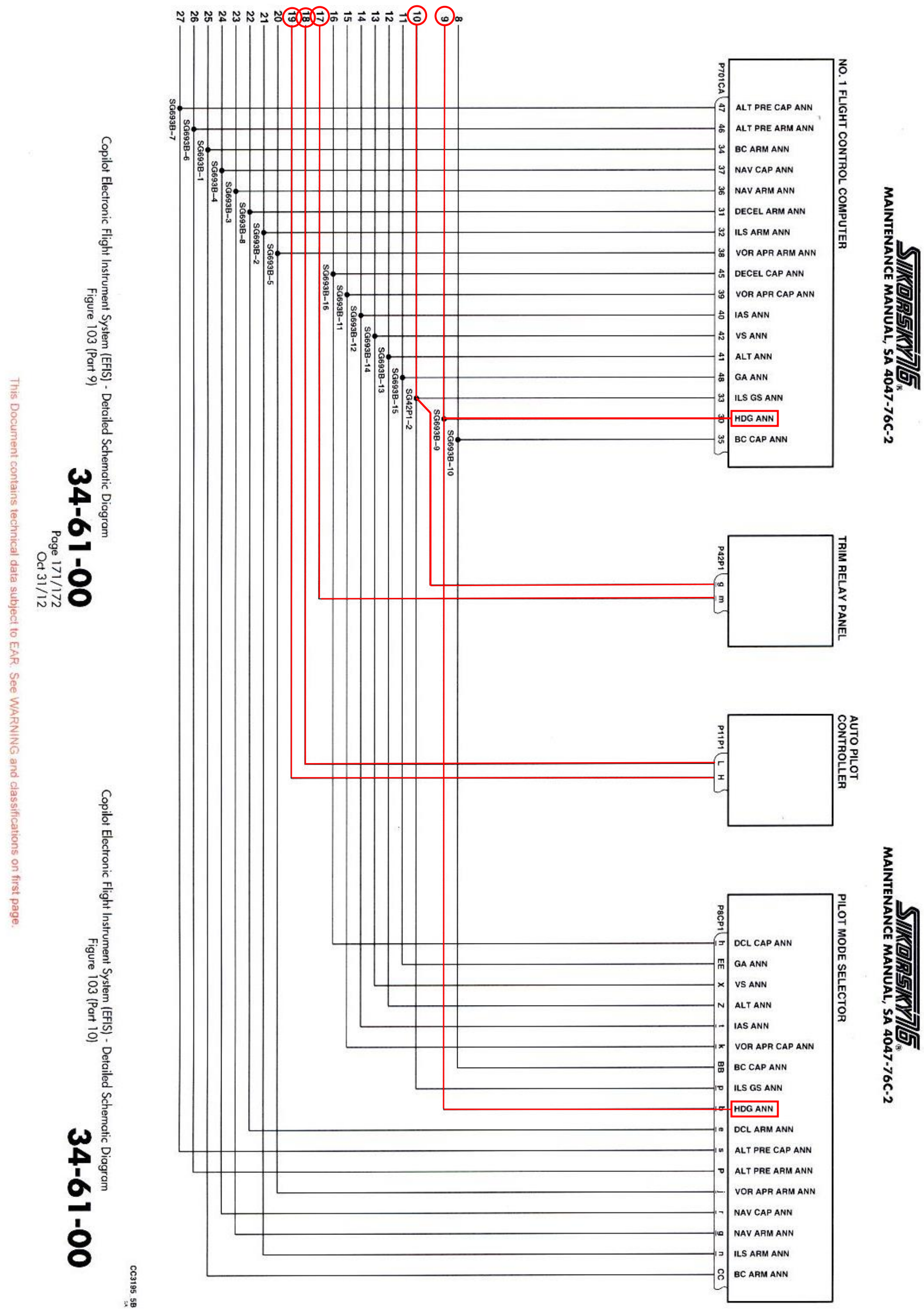
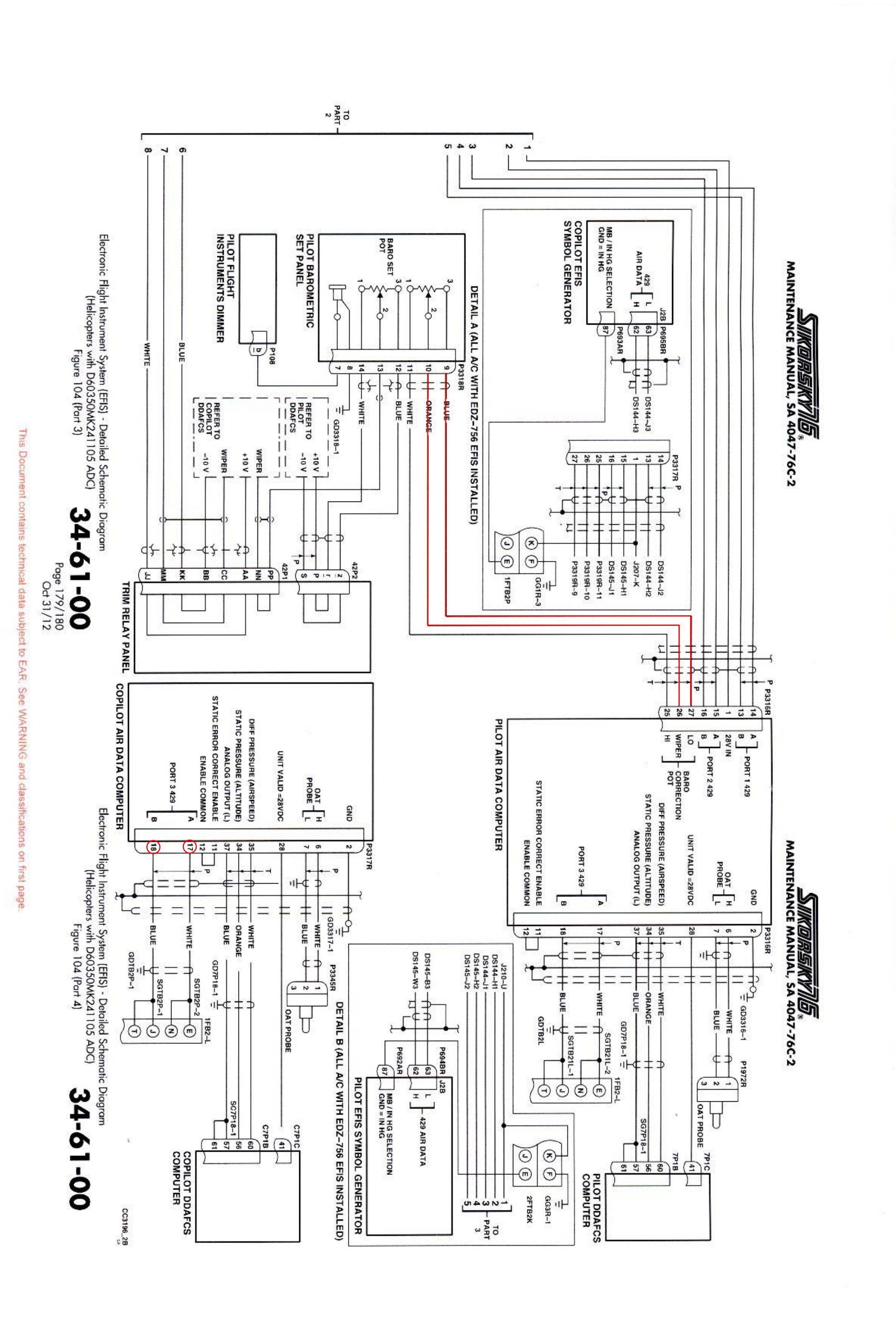
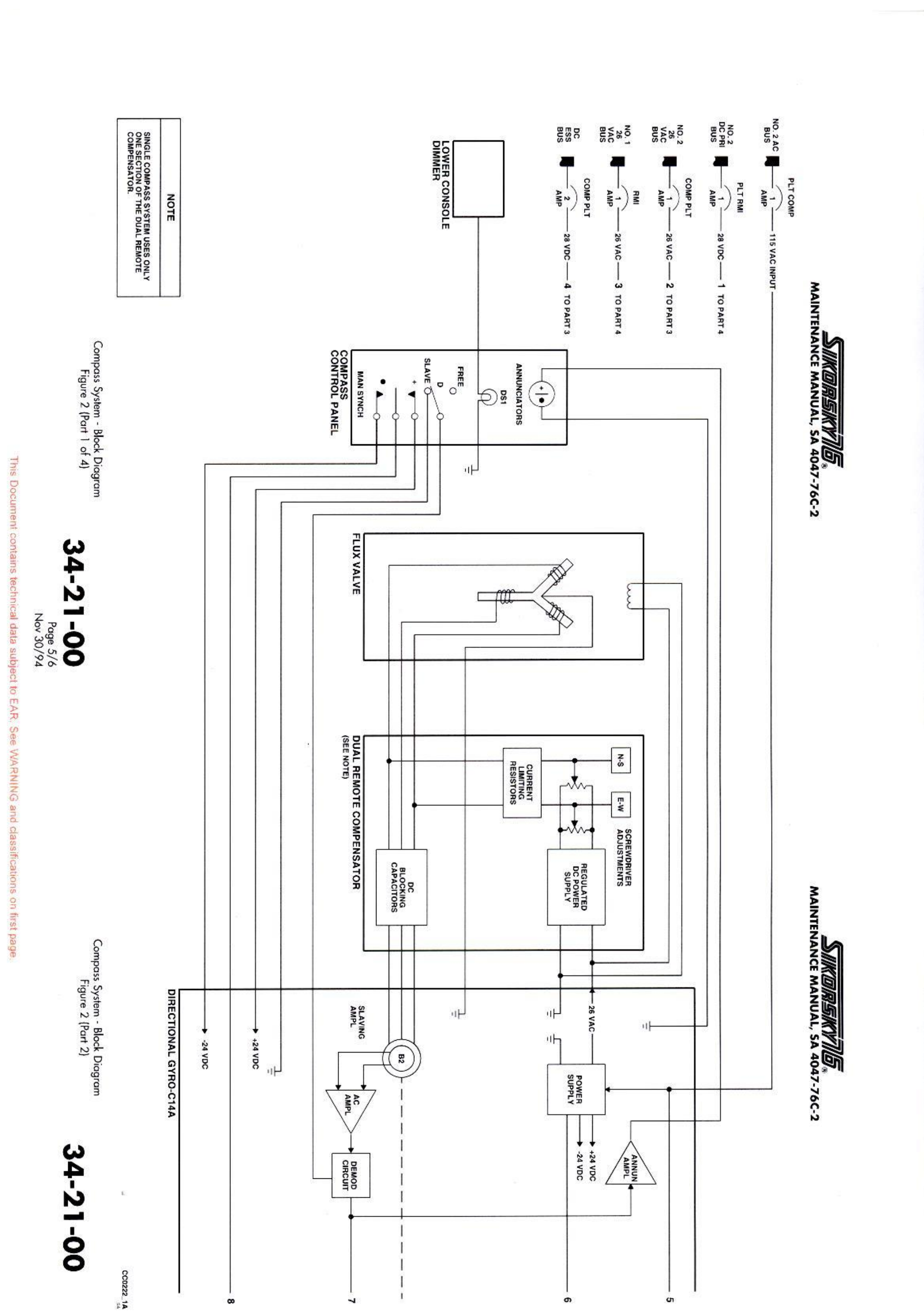
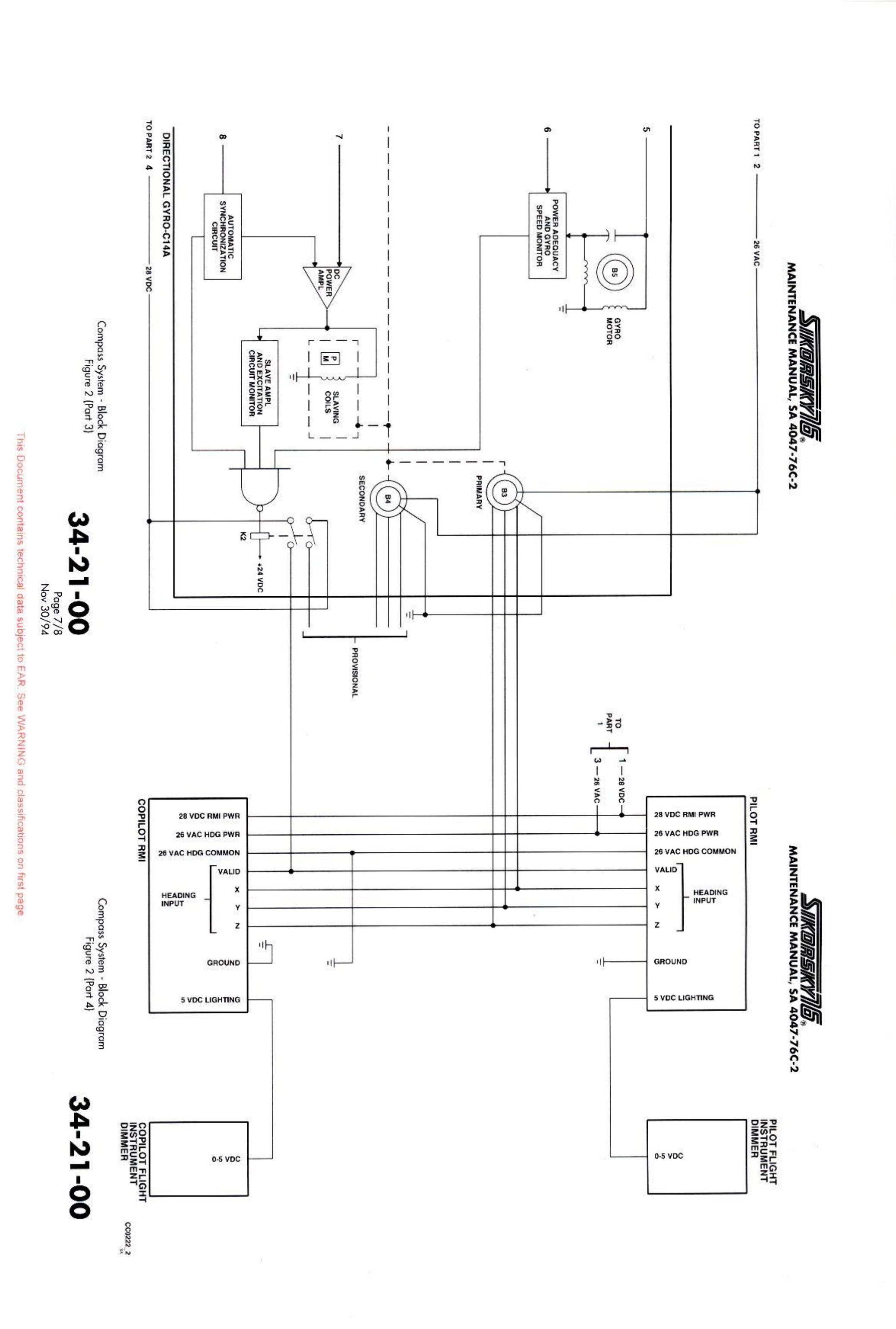
1.17.1.5 Extracts from the Sikorsky S76C++ Aircraft Maintenance Manual (AMM)




MAINTENANCE MANUAL, SA 4047-76C-2
DETAIL A (ALL A/C WITH EDZ-756 EFIS INSTALLED)
COPILOT EFIS SYMBOL GENERATOR
PILOT BAROMETRIC SET PANEL
PILOT FLIGHT INSTRUMENTS DIMMER
TRIM RELAY PANEL
PILOT AIR DATA COMPUTER
COPILOT AIR DATA COMPUTER
DETAIL B (ALL A/C WITH EDZ-756 EFIS INSTALLED)
PILOT EFIS SYMBOL GENERATOR
PILOT DDAFCS COMPUTER
COPILOT DDAFCS COMPUTER
OAT PROBE
Electronic Flight Instrument System (EFIS) - Detailed Schematic Diagram
(Helicopters with D60350MK241105 ADC)
Figure 104 (Part 3)
Figure 104 (Part 4)
34-61-00
Page 179/180
Oct 31/12
This Document contains technical data subject to EAR. See WARNING and classifications on first page.


SIKORSKY S-76 MAINTENANCE MANUAL, SA 4047-76C-2
NO. 2 AC BUS
NO. 2 DC PRI BUS
NO. 2 26 VAC BUS
NO. 1 26 VAC BUS
DC ESS BUS
PLT COMP
PLT RMI
COMP PLT
RMI
115 VAC INPUT
28 VDC
26 VAC
TO PART 3
TO PART 4
LOWER CONSOLE DIMMER
NOTE
SINGLE COMPASS SYSTEM USES ONLY ONE SECTION OF THE DUAL REMOTE COMPENSATOR.
ANNUNCIATORS
DS1
FREE
SLAVE
MAN SYNCH
COMPASS CONTROL PANEL
FLUX VALVE
N-S
E-W
CURRENT LIMITING RESISTORS
SCREWDRIVER ADJUSTMENTS
REGULATED DC POWER SUPPLY
DC BLOCKING CAPACITORS
DUAL REMOTE COMPENSATOR (SEE NOTE)
POWER SUPPLY
ANNUN AMPL
SLAVING AMPL
AC AMPL
DEMOD CIRCUIT
+24 VDC
-24 VDC
DIRECTIONAL GYRO-C14A
Compass System - Block Diagram
Figure 2 (Part 1 of 4)
Compass System - Block Diagram
Figure 2 (Part 2)
34-21-00
Page 5/6
Nov 30/94
This Document contains technical data subject to EAR. See WARNING and classifications on first page.


SIKORSKY S76
MAINTENANCE MANUAL, SA 4047-76C-2
TO PART 1 2
26 VAC
5
6
POWER ADEQUACY AND GYRO SPEED MONITOR
B5
GYRO MOTOR
7
8
AUTOMATIC SYNCHRONIZATION CIRCUIT
DC POWER AMPL
SLAVE AMPL AND EXCITATION CIRCUIT MONITOR
SLAVING COILS
PRIMARY
B3
SECONDARY
B4
K2
+24 VDC
PROVISIONAL
DIRECTIONAL GYRO-C14A
TO PART 2 4
28 VDC
Compass System - Block Diagram
Figure 2 (Part 3)
34-21-00
Page 7/8
Nov 30/94
TO PART 1
1 — 28 VDC
3 — 26 VAC
PILOT RMI
28 VDC RMI PWR
26 VAC HDG PWR
26 VAC HDG COMMON
VALID
X
Y
Z
HEADING INPUT
GROUND
5 VDC LIGHTING
COPILOT RMI
PILOT FLIGHT INSTRUMENT DIMMER
0-5 VDC
COPILOT FLIGHT INSTRUMENT DIMMER
Compass System - Block Diagram
Figure 2 (Part 4)
34-21-00
C0222
This Document contains technical data subject to EAR. See WARNING and classifications on first page

1.17.2 Nigerian Civil Aviation Authority (NCAA)

The Nigerian Civil Aviation Authority (NCAA) is the regulatory authority for the Aviation Industry.

The NCAA issued an emergency All Operators Letter (AOL) 058 in respect to all 5N registered Sikorsky S76 C Helicopters type. This letter was issued after the accident.

NIGERIAN CIVIL AVIATION AUTHORITY

NCAA

P.M.B. 21029, 21038, IKEJA-LAGOS.

ALL OPERATORS LETTER (AOL 058)

Circular Ref: NCAA/DAWS/AD.1104/AOL 058/Vol.I

Date: 12th February, 2016

To: All Sikorsky S76C Operators

From: Directorate of Airworthiness Standards

Attn: Accountable Manager / Quality Assurance Manager

SUBJECT: SAFETY INSPECTIONS ON ALL SIKORSKY S76C HELICOPTERS

PREAMBLE

One of the Nigerian registered S76C++ helicopter was involved in a controlled ditching incident and prior to the occurrence the flight crews reported that a passenger reported an unusual burning smell emanating from the cabin during the previous flight. During the flight that led to the incident, the flight crew reported the 'TRIM-FAIL' and 'DAFCS caution lights illuminated repeatedly for some time, the collective became heavy and a power drop anytime it is pulled. There was a slight turn to the right with a high rate of descent and fast spinning of the EHSI and compass with instruments readings inaccurate. The Authority discovered that the incident as reported by the flight crew is similar to the Humberside Airport incident involving a UK registered Sikorsky S76C in September 2012.

As an interim safety measure, the Authority has determined that the underlisted safety inspections be carried out on all Sikorsky S76C series helicopter operating in Nigeria.

ACTION REQUIRED

All operators of Sikorsky S76C helicopters in Nigeria are hereby required to carry out the underlisted inspections:

1. Visual Inspection of left hand overhead and cockpit area wiring loom for signs of chaffing/arcing/burning in accordance with relevant S76C AMM 20-32-00
2. Detailed inspection of the flight control system which includes control rods, bellcranks, cables, pulleys AFCS flight controls including pitch, roll and yaw AFCS actuators, trim servos (Coll/Pitch/Roll) and pedals damper. Inspect all hydraulic servos for condition, wear and leakage in accordance with relevant S76C AMM 67-00-00.
3. Detailed inspection of the drivetrain to include engines, all gearboxes and drive shafts in accordance with the relevant S76C AMM 66-10-00, 66-20-00, 66-30-00, 66-40-00.

Corporate Headquarters: Nnamdi Azikwe Int'l Airport, Domestic Wing, Abuja.
Tel: +234 (1) 7610041, +234 (1) 7610042, +234 (1) 7610043, +234 (1) 7610044, Tel/Fax: +234 807 729 1113,
Lagos Office: AVIATION HOUSE, Murtala Mohammed International Airport (MMIA) Domestic Wing, Ikeja.
Tel: +234 (1) 4721521 Fax: +234 (1) 2790421 Consumer Protection: +234 (1) 7607286(24hrs); Airworthiness: +234 (1) 4734482;
Licencing: +234 (1) 7739972; Operations: +234 (1) 4714339; Switch Board: +234 (1) 7610036, +234 (1) 7610037.
Email: info@ncaa.gov.ng Website: www.ncaa.gov.ng

Action is required to be complied within 72 hours with effect from today, 12th February, 2016 and repeated every 300 flight hours until further notice. Evidence of the initial accomplishment of this AOL should be forwarded to the Authority immediately.

[illegible]
For: Director General

1.18 Additional Information

The FDR download confirmed the crew assertion of an un-command rapid rate of descent and speed reduction. The aircraft descended within 60 seconds from 3,000 ft to 1,000 ft approximately at the rate of 2,100 Feet Per Minute (FPM), loosing speed from 148 KIAS to 64 KIAS over the same period (60 seconds) before stabilizing at 1,500 ft.

Annual flight recording readout for the aircraft was not available since it came into service in Nigeria in 2013. This is a requirement in accordance with NCAA (Order 001) 2014 paragraph 4 which stipulates requirement for continued serviceability and inspection of flight recorder systems.

ICAO Annex 6 Part III also refers to the same requirement.

1.19 Useful or Effective Investigation Techniques

Nil.

2.0 ANALYSIS

2.1 Flight Operations

2.1.1 Crew Qualifications and Training

The crew were properly certificated and qualified to conduct the flight in line with the requirements of the Nigerian Civil Aviation Regulations (Nig.CARs).

During the course of this investigation, it was discovered from the crew training records that the Captain had undergone operator proficiency check (Autopilot/Flight Director malfunction procedure) once in 2013, twice in 2014 and once in 2015. After the accident, operator proficiency check (Autopilot/Flight Director malfunction procedure) was done twice in 2016 and 2017 respectively.

The company records also show that the First Officer had undergone operator proficiency check (Autopilot/Flight Director malfunction procedure) twice in 2014 and 2015 and once in 2016.

There is a company requirement that the Autopilot/Flight Director malfunction procedural recurrent training must be covered over a rolling 36-month period, although the operator carries out the exercise more frequently than is stipulated in the training document.

On the first approach to Erha, the Captain did a go-around and came back for a second approach and landed. At this point the Captain exclaimed about 'needing OPC'[3], indicating that she did not feel totally confident about her proficiency on

[3]OPC - Operator Proficiency Check

the aircraft. The Captain on this flight had returned from leave off-work shortly before the day of the occurrence, and this was her first flight afterwards. The investigation revealed that on resumption of duty, the Captain had not undergone any refresher programme to 'bring her up to speed', as it was not required by company procedure.

2.1.2 Conduct of the Flight

On the 3rd of February, 2016, 5N-BQJ, a domestic chartered flight departed Murtala Mohammed Airport Lagos (DNMM) for Erha Floating Production Storage Off loading (FPSO) platform. On this first leg of the flight, the Captain was the pilot flying (PF) while the First Officer was pilot monitoring (PM). On this leg of the flight to Erha, the Captain noticed there was a vibration of the aircraft, and the crew reported that Digital Auto Flight Control System (DAFCS) and TRIM FAIL lights illuminated twice and were reset, as required by the Emergency Operating Procedure.

According to the PM, a passenger seated in the middle row complained of smelling an unusual burning smell which the Captain could not ascertain on ground Erha.

The Bureau carried out a continuity test on the aircraft electrical system; the system was confirmed functional at the time of the accident.

5N-BQJ departed Erha FPSO for Lagos at 09:50 h with 9 passengers and 2 crew estimating Lagos at 10:40 h, maintaining altitude of 3,000 ft AMSL and an endurance of 1h 35 mins. The First Officer was the PF while the Captain was the PM on this leg of the flight.

According to the Captain, 15 minutes into the flight, there were repeated TRIM FAIL DAFCS system indications. From the CVR analysis, there were repeated "DE-COUPLE" failure annunciations. This should have been a source of concern to the crew, instead they reset the system as many times as the warning came on.

The Bristow S76C++ Emergency Procedure indicates that these warnings are indications of auto-pilot and Flight Director malfunctions. This aircraft is equipped with a dual DFZ-760 DAFCS systems that combines autopilot and flight director functions and requires synchronized heading input from the compass control among other inputs. Where inputs from the compass control are not synchronized, a flight director malfunction may occur as was the case in this accident. See section 1.17.1.4.

Shortly afterwards, the collective and cyclic controls became 'heavy' and unresponsive to inputs, as reported by the crew. This could also be adduced to the Flight Director malfunction.

At this point, the Emergency Operations Procedure (EOP) manual was consulted; the autopilot system disconnected, and the Aircraft flown "Hands and Feet" on the controls.

The Captain said, "We are flying hands and feet on the controls now. Let us see if it will come back or not. The First Officer said "COMPASS" and the Captain responded, "YOURS TO CHECK". The First Officer went further to say "OK COMPASS, I GUESS WE LEAVE ON FOR NOW".

This indicates that the crew were not aware of the severity of the situation they were in, hence the Captain also said, "OK, reset it and we'll try it again."

The company Operations Manual (Part B) checklist requires that the compasses be selected to SLAVE mode after take-off. Evidence available to the Bureau indicated that the No. 1 & 2 COMPASSES were in FREE DG mode. (See Figure 4).

Figure 4: Compass control panel

According to the CVR transcript, the First Officer said "Setting…., Setting…. Setting. Set the Compass. OK because the Compass seems to be turning by itself."

The Captain responded, "Turn to your Side. The Compass is Confusing."

The First Officer also remarked "yeah, what is going on, because I'm turning."

The Captain said, "Are you turning...I have control…"

The comments of the Captain and the First Officer indicated that they were alarmed. The crew should have confirmed the position of the Compass control switch and returned same to the SLAVE mode and the heading synchronized appropriately. This should have resolved the Flight Director malfunction and the flight would have continued normally.

The First Officer told the Captain that the Altitude Holding was "Fine but the Heading is not accurate". The First Officer went further to say "Yeah, the problem is that we don't know the Heading in which we are right now. Which direction?"

The aircraft deviated from the intended flight path. Due to either an uncommanded control input by a degraded auto pilot or an inadvertent control input from PF, the aircraft went into a high rate of descent (2,100 ft/min) as shown in the FDR plot. The crew became very agitated, but later regained control of the flight path at 1,000 ft AMSL. Thereafter, the crew stabilized the aircraft at 1,500 ft. According to the CVR transcript the Captain said, "we are maintaining 1,500 ft this time, we lost all our instruments." The PF went further to say "Yeah, the problem is that we don't know the heading in which we are right now. Which direction?" At this point the crew decided to ditch the aircraft.

2.2 The Aircraft

2.2.1 Aircraft Maintenance

The aircraft had a valid certificate of airworthiness. Investigation revealed that the aircraft was maintained in accordance with the NCAA approved maintenance programme. There were no record of outstanding Technical Directives (TDs), Service Bulletins (SBs) or Airworthiness Directives (ADs) to be complied with as at the time of the accident.

There was no deferred defect or any snag that could have precluded the aircraft operating safely, although the crew expressed their dissatisfaction with aspects of the aircraft's performance on both flights.

There was no evidence to show that the operator carried out the annual recording readouts of Flight Recorders. This was evident during the course of the FDR download and analysis as certain parameters pertinent to this accident such as Heading, Bank/Roll/Pitch attitudes etc could not be obtained.

Aircraft Operators are required to perform periodic maintenance readouts on flight recorder systems, usually once a year. This applies to both FDR's (Flight Data Recorder) and CVR's (Cockpit Voice Recorders).

Readout Analysis examines all recorded parameters for their validity and serviceability and creates recognised readout reports which state the serviceability of the aircraft's flight recorder system. This is a requirement by ICAO Annex 6 part III and Nigerian Civil Aviation Authority (NCAA) Order 001 item 4 of 2014.

2.2.2 Mass and Balance

5N-BQJ departed Erha FPSO with 9 passengers with total body weight of 1,717 lb, luggage of 259 lb and cargo of 50 lb, giving a total payload of 2,026 lb, which is within the allowable Maximum Take Off Weight (MTOW) of 11,500 lb.

Therefore, weight was not a factor in the accident.

2.2.3 Aircraft Avionics Systems

The aircraft is fitted with SPZ-7600 Integrated Flight Control System. This system also has the following subsystems: the DFZ-7600 Digital Automatic Flight Control System (DFACS), EDZ-705 Electronic Flight Instrument System (EFIS) and an Attitude and Heading Reference System (AHRS).

The AHRS consists of No. 1 and No. 2 AHRU, located in the nose compartment; an MSU CalProm, located on each AHRU; a compass control panel, located in the lower console; and a magnetic sensor unit (flux valve), located in the tail section. The AHRS interfaces with the EFIS, and the Dual Digital Automatic Flight Control System (DDAFCS).

During the field examination of the Compass Control Panel, it was discovered that the Compass switches on both sides; the Captain and First Officer, were on the Free DG Mode. The Aircraft Operations Manual (Part B) checklist requires that for normal operations, the switch should be in the SLAVE mode.

This aircraft was operated in the free DG Mode and as a result, the heading information being fed into the Flight Director were not synchronised, hence the crew were getting unreliable heading information.

2.2.4 Crew Resource Management

Crew resource management or cockpit resource management (CRM) is a set of training procedures for use in environments where human error can have devastating effects. Used primarily for improving air safety, CRM focuses on interpersonal communication, leadership, and decision making in the cockpit.

During the flight from Erha to Lagos, the CVR transcript confirmed that the crew executed the items in the Bristow S76C++ Pre-Taxi, Before Take-off and After Take-off checklists, but omitted the crucial 6th item on the After Take-off/Go-Around Checklist-**Compasses…Check/Slaved**.

The emergency started 15 minutes into the flight from Erha FPSO to Lagos. From the CVR transcript, control of the aircraft during this emergency switched between the Captain and the First Officer on several occasions. It was not clear who was in control of the aircraft over a period of time until shortly before the aircraft was ditched, at which point the First Officer was identified to be in control.

The Captain's responses both before and during the emergency did not show the expected level of confidence with the operations of the aircraft, in her role as commander of the flight. She had earlier iterated this on the outbound leg to Erha FPSO, with the comment, "After a month 'Oomo', I need OPC." This flight from Lagos to Erha FPSO was her first flight after resumption from a month's vacation. The investigation showed that at the time of the occurrence, BH(N)L policy for returning pilots to flight duty after a period of absence, only requires that the pilot's simulator checks be valid on resumption but does not include base or line checks to prepare returning crew for flight operation duties.

The Captain maintained communication with ATC and gave the command for a ditching when the crew decided that the aircraft could not be flown safely to land at the target airfield.

3.0 CONCLUSIONS

3.1 Findings

1) The flight crew were certificated and qualified to conduct the flight in accordance with applicable Nigerian Civil Aviation Regulations (Nig.CARs).
2) The helicopter was maintained in accordance with the approved maintenance programme.
3) The Helicopter was manufactured in 2007 with total Airframe Hours of 6,867 h (As at 02/02/2016).
4) On the outbound flight to Erha FPSO, a passenger reported smelling a burning smell in the cabin which was not established by the crew on landing.
5) On the inbound flight to Lagos, the crew reported instrument and flight control problems with repeated TRIM FAIL and DAFCS illuminations.
6) The crew declared the first May Day call at 66 NM to Lagos and later updated it.
7) Lagos Approach Control could not raise 5N-BQJ and had to rely on other aircraft in the vicinity to relay information.
8) There were eleven persons on onboard including two crew at the time of ditching.
9) The aircraft ditched in the Atlantic Ocean at 77 NM and radial 139^0 from LAG.

10) The life rafts on the helicopter were deployed with the left life raft slightly damaged.
11) The Search and Rescue including evacuation of crew and passengers were promptly carried out.
12) The Helicopter capsized and was later submerged in the salty waters of the ocean while the emergency flotation devices prevented the helicopter from sinking immediately.
13) One of the two flotation bottles under the crew seats was discharged.
14) There was no evidence of fire outbreak before and after ditching.
15) Defects were discovered in the Flight Data Recording Systems.
16) Annual Flight Recording Readouts for the aircraft were not carried out.

3.2 Causal Factor

The crew switched the Compass to “FREE” DG mode for Landing on the helideck at Erha FPSO, and did not return to the “SLAVE” mode after take-off which caused the trim fail to cut off consistently which in turn disengaged the autopilot as a result of the unsynchronised heading inputs.

3.3 Contributory Factors

1) Non-adherence to Company Operations Manual (Part B checklist) as it relates to after take-off checks.

2) The crew did not disengage the autopilot to fly the aircraft manually.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendation 2019-020

Bristow Helicopters (Nigeria) Ltd. should ensure that annual flight recorder readout is carried out for every aircraft in their fleet in accordance with NCAA Order 001 2014 and ICAO Annex 6 Part III.

4.2 Safety Recommendation 2019-021

Bristow Helicopters (Nigeria) Ltd. should ensure that the annual flight recorder readouts records obtained should be preserved with appropriate current data frame layout.

4.3 Safety Recommendation 2019-022

Bristow Helicopters (Nigeria) Ltd. should ensure that Flight Crew follow approved checklist items, and procedures at all times.

4.4 Safety Recommendation 2019-023

Bristow Helicopters (Nigeria) Ltd. should consider reviewing their procedure for returning crew back to flight duties after staying out of flight duty for any period up to thirty days.

SAFETY ACTIONS

After the accident, the Nigerian Civil Aviation Authority (NCAA) issued an All Operators Letter (AOL 058- Circular Reference: NCAA/DAWS/AD.1104/AOL058/Vol.1) involving all Nigerian Registered Sikorsky S76C aircraft.

After the accident, Bristow Helicopters (Nigeria) Ltd., the Operator, issued a Technical Directive (TD- S76-05-132) involving all Nigerian Registered S76C aircraft in their fleet.

APPENDICES

Appendix 1: AAIB Laboratory Report

AAIB
Laboratory Report

FAERITO Image recorder
Penny and Giles MPFR

Sikorsky S76C++
Registration 5N-BQJ serial number 760656
Bristow Helicopters (Nigeria) Limited

Ditched 78 nautical miles from Lagos – destination Murtala Muhammed Airport
03 February 2016, 1120 UTC

Compiled by:

Department for

Introduction

The AAIB was requested by the Nigerian Accident Investigation Bureau (NAIB) on 08 February 2016 to assist with the readout of two flight recorders recovered from a Sikorsky S76C++ helicopter, registration 5N-BQJ, that ditched 78 nautical miles from Lagos whilst enroute to Murtala Muhammed Airport. The flight crew reported flight control difficulties and carried out a ditching. There were no fatalities. The following report provides details of the readout procedure:

Recorders

1.	Manufacturer:	Penny & Giles
	Type:	Multi-Purpose Flight Recorder (MPFR) Voice and Flight data.
	Part number:	D51615-102
	Serial Number:	001664-003
	Data storage:	Solid state memory

2.	Manufacturer:	Physical Optics Corporation
	Type:	Flight Anomalous Event Recorder Information Technology Open (FAERITO) Image Recorder – 3 camera system
	Part number:	4308-05000-20-101
	Serial Number:	4308-000032
	Data storage:	Solid state memory

Recorder overview

MPFR

The MPFR is a combined Cockpit Voice Recorder (CVR) and Flight Data Recorder designed and manufactured by Penny and Giles.

The UK AAIB has Crash Damaged Recovery Equipment (CDRE) to support the recovery of data from accident damaged units. This is equipment manufactured by Penny and Giles. It ensures that the memory board and its contents cannot be altered in anyway. Once the raw digital data fis downloaded from the memory board, a combination of software developed by Penny and Giles and the AAIB converts the data to audio and flight data in engineering units.

The MPFR recorded

- 120 minutes of audio. This consists of:
  - 30 minutes of high quality audio for the P1 and P2 positions.
    - File name CV2 stripped.wav
    - File name CV3 stripped.wav
  - 30 minutes of high quality audio for the Cockpit Area Microphone (CAM)
    - File name HQC stripped.wav
  - 120 minutes of low quality audio containing the P1 and P2 positions combined.
    - File name CVC stripped.wav
  - 120 minutes of low quality audio containing the CAM
    - File name LQC stripped.wav
- ~80 hours of Flight Data at 64 wps.
    - File name fd1.fdr
    - File name fd2.fdr

    Note: these are the raw data files downloaded from the MPFR.

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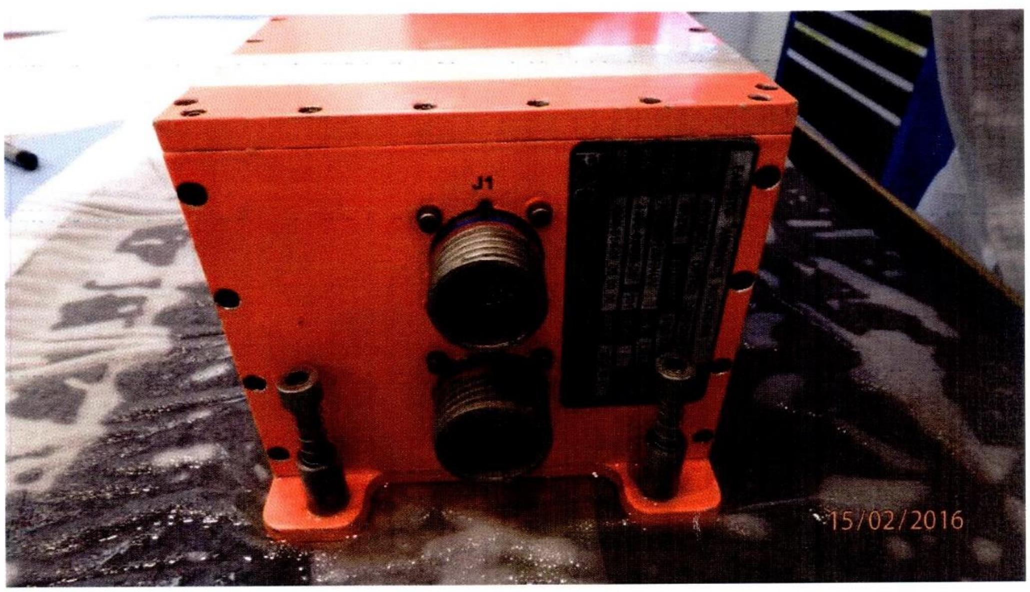
FAERITO Image recorder

The FAERITO image recorder records images at up to five frames per second from three cameras, left, centre and right. The left and right cameras are directed to record the P1 and P2 PFD and NMD displays and the centre camera the engine instrument and standby artificial horizon. The cameras do not record an outside view of the cockpit, nor the flight crew or passengers. On the S76C++, the image recording system was installed due to the requirement to record additional parameters on the FDR. This could not be easily achieved and the solution was to install the image recording system to capture the information.

The recorder removed from 5N-BQJ is understood to be the first accident damaged recorder of this type. The download of data and display of images was made using replay software provided by the manufacturer, who is Physical Optics Corporation (POC).



Transportation to AAIB UK

1. The two recorders were delivered to the UK AAIB by the NAIB on Monday 15 February 2016. The units were packaged in a single container and kept submerged in water during the transfer to the UK

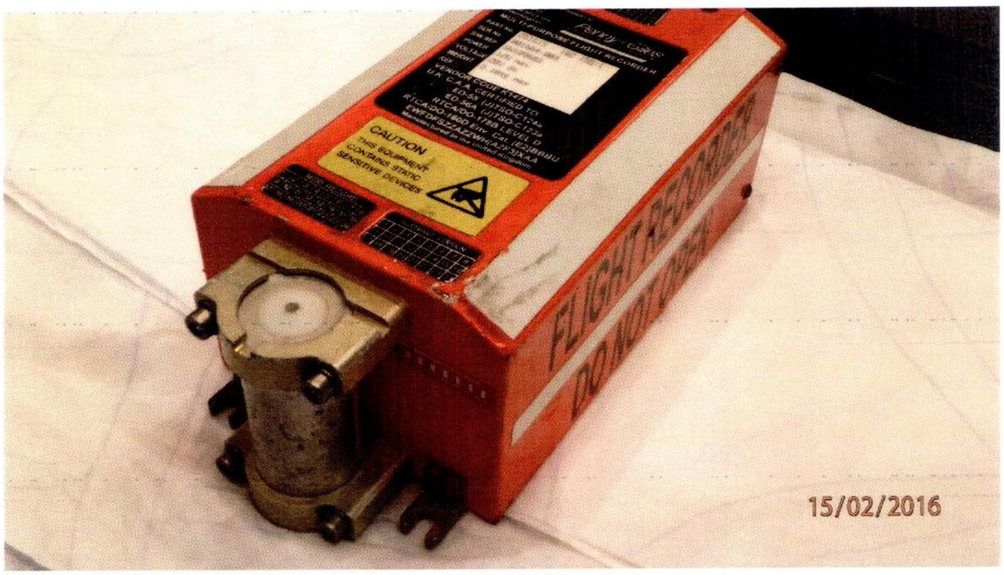
Photograph taken at AAIB laboratory

2. The units were removed from the shipping container at the AAIB and remained in fresh water until the individual disassembly process commenced.

Disassembly[1] and readout

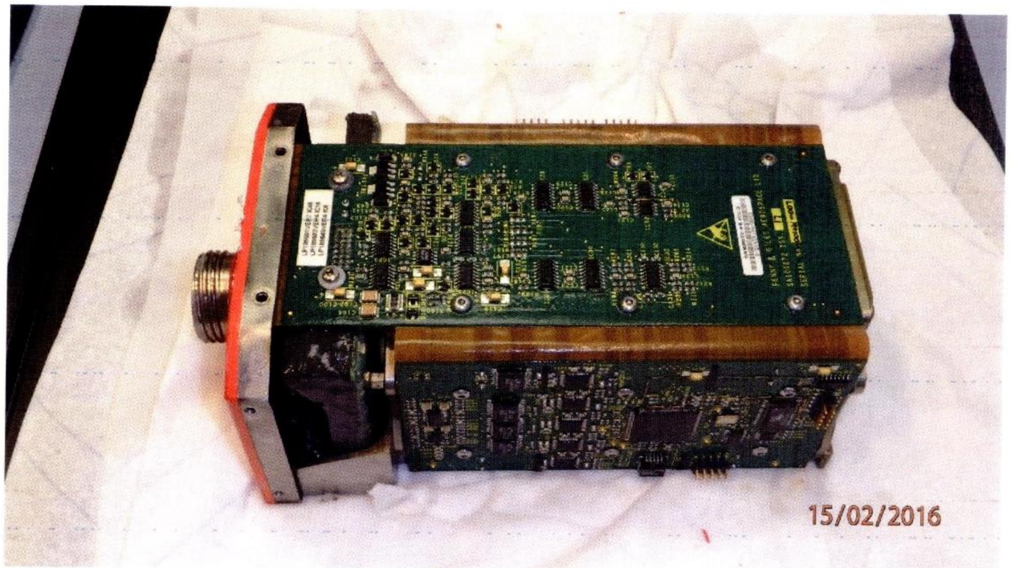
MPFR

1. The top cover of the unit was removed to provide access to the crash protected memory module. It was noted that there was no evidence of impact penetration to the case.

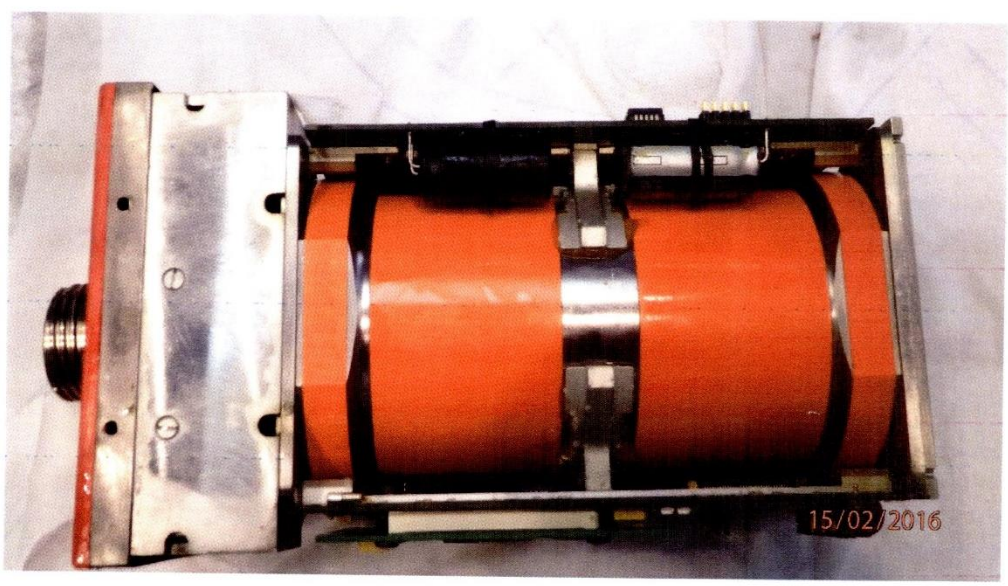


[11]ESD precautions were observed at all times.

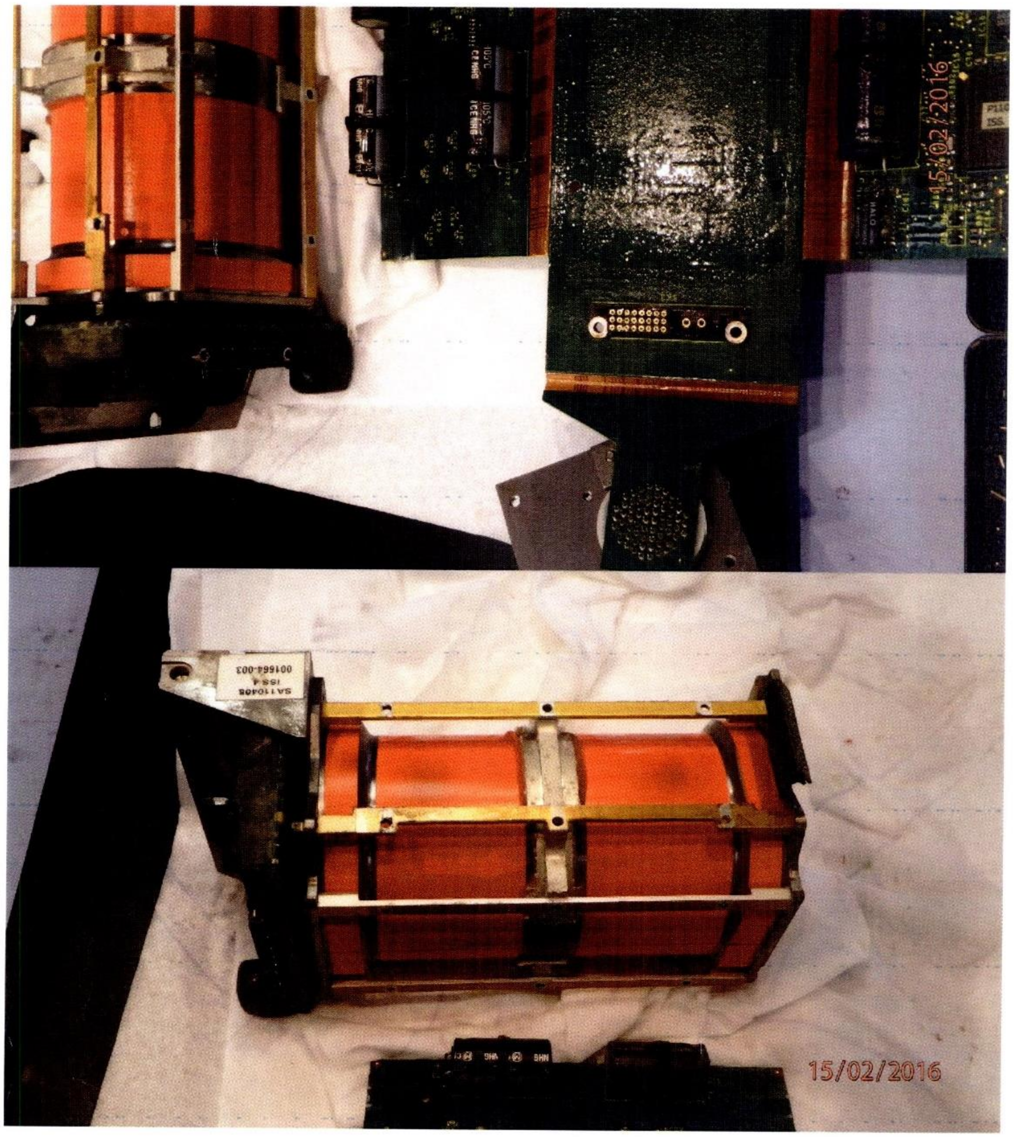
2. The circuit boards were removed to provide access to the memory module.



3. The chassis was dismantled to enable the crash protected memory module to be removed



Department for



Crash protected memory module

4. The memory module was opened to enable the memory board to be accessed.

5. The memory board is encapsulated within two cylinders. The first cylinder was cut open to enable the inner cylinder to be removed.

6. Small cuts in the top and bottom of the inner cylinder were made to enable the memory board to be extracted.

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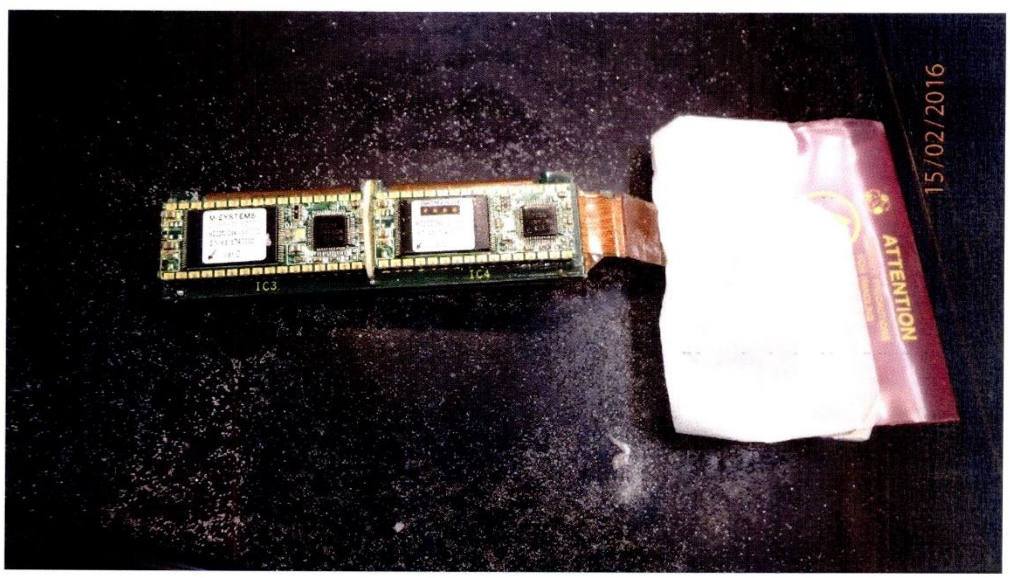

7. Water had entered the inner cylinder. The memory board was cleaned, inspected and placed in a humidity controlled drying cabinet for 48 hours at 50℃. No defects were identified during inspection of the board.

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8. The memory board was connected to the Penny and Giles CDRE download equipment. The download was successful.

9. The FDR raw data files were decoded using two readout systems; AAIB and Penny and Giles PGS.

A significant number of parameters were not functioning correctly. Altitude, airspeed, engine turbine and main rotor speed appeared to have been recorded with valid data though.

The engineering unit conversion document (Data Frame Layout), was checked against the AAIB decoding software and no anomaly was found. Review of the status parameters of the Flight Data Acquisition Unit (FDAU) recorded within the FDR data, indicate an internal fault within the FDAU. This would reasonably explain why some parameters are functional and others are not.

The same erroneous results with parameters was found when replayed using the Penny and Giles PGS replay system. This provided an independent check of the AAIB replay system results.

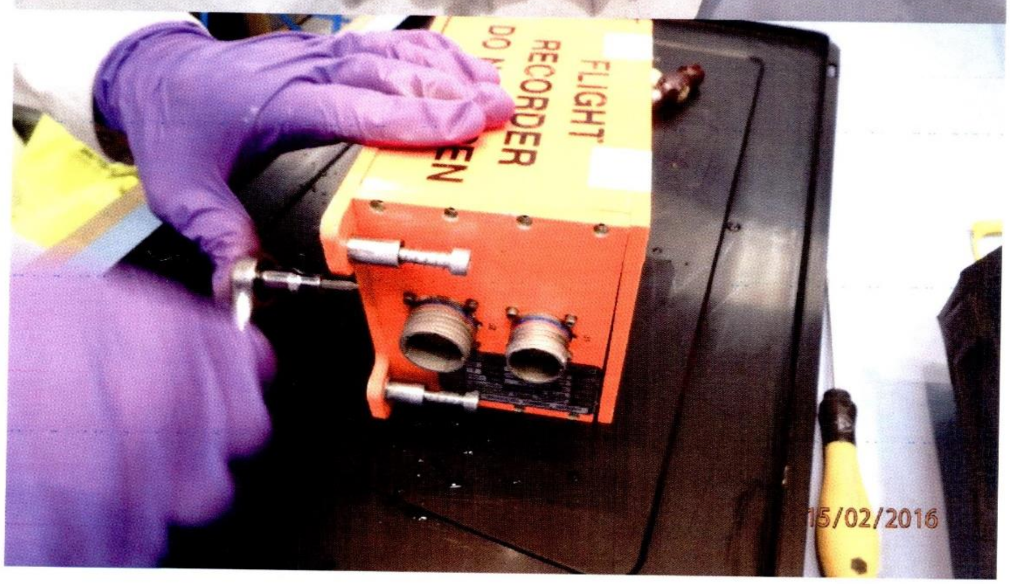
A preliminary review confirmed the accident flight was recorded and a plot of several parameters provided.

10. CVR: the accident flight was recorded and the quality of the recording was good. The preceding flight was also recorded.

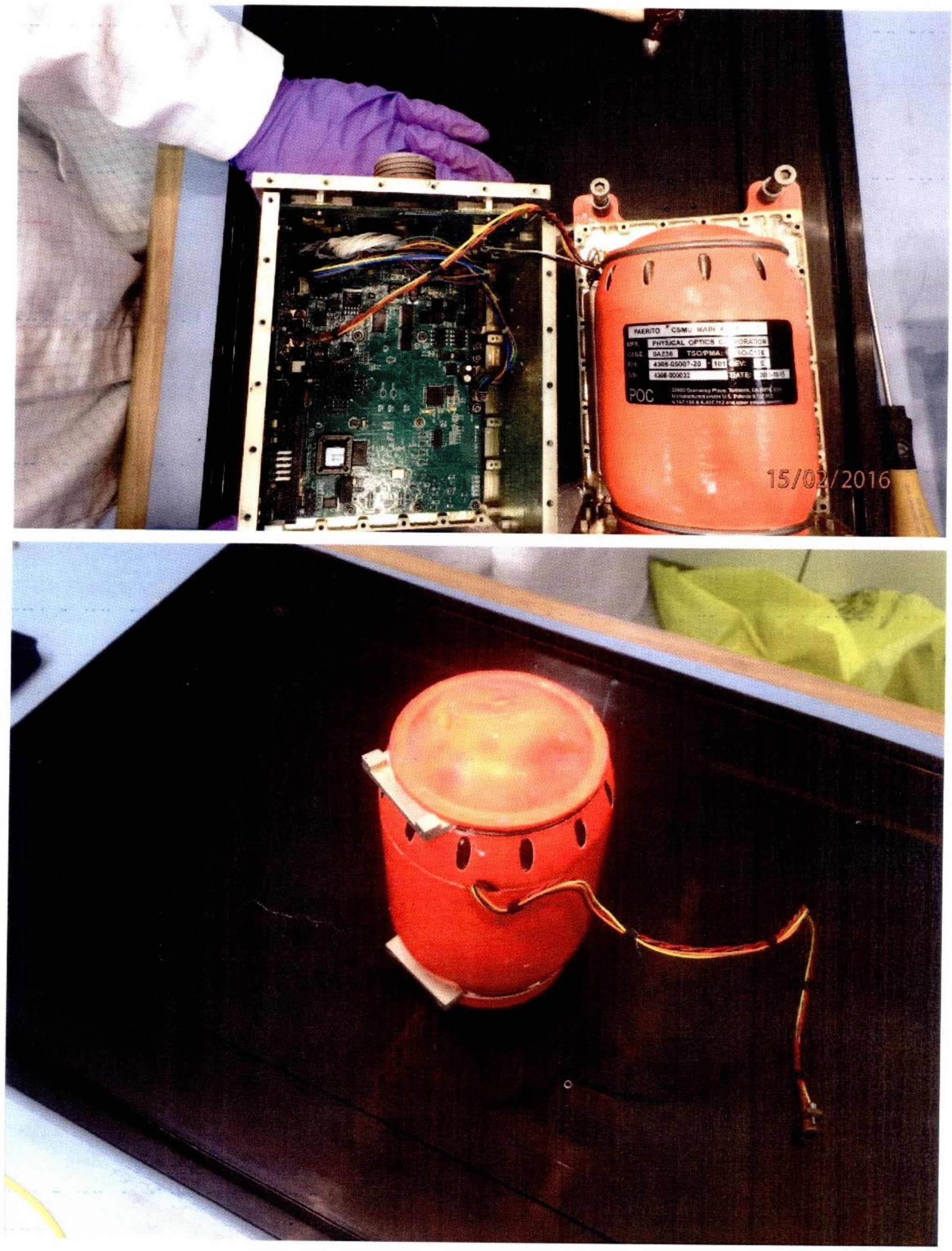
11. The failed parameters had similar characteristics of alternating patterns. The manufacturer of the FDAU, Teledyne, was contacted for information relating to the recording of parameters when a fault was present within the FDAU.

FAERITO image recorder

1. The crash protected memory module was removed from the chassis. It was noted that there was no evidence of impact penetration to the case.



Department for



Crash protected memory module

Department for

2. The memory module was opened to determine if water had entered the protective cylinder that contains the memory board. Water was found to have entered the outer insulating material, but the inner cylinder appeared dry. As a precaution, the memory module was placed in a humidity controlled drying cabinet for 10 hours at 50℃.

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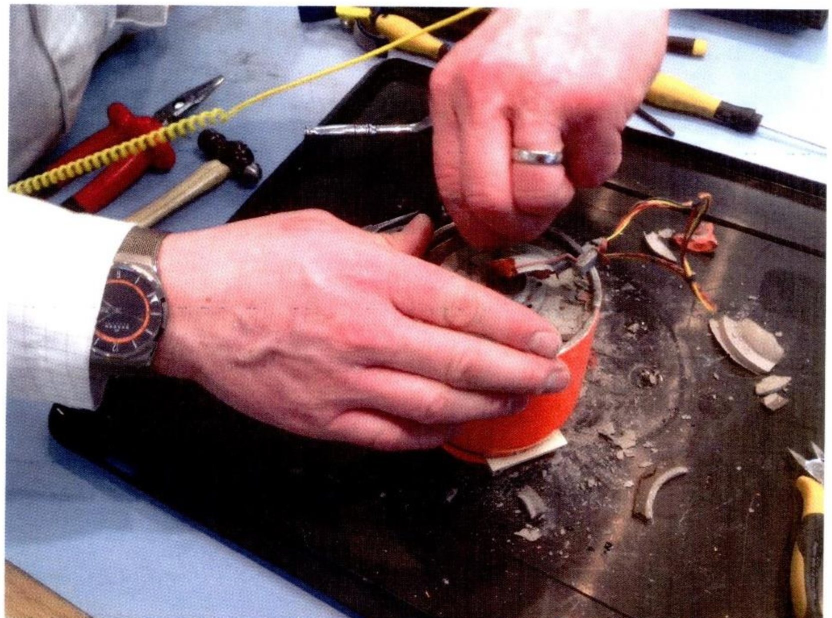
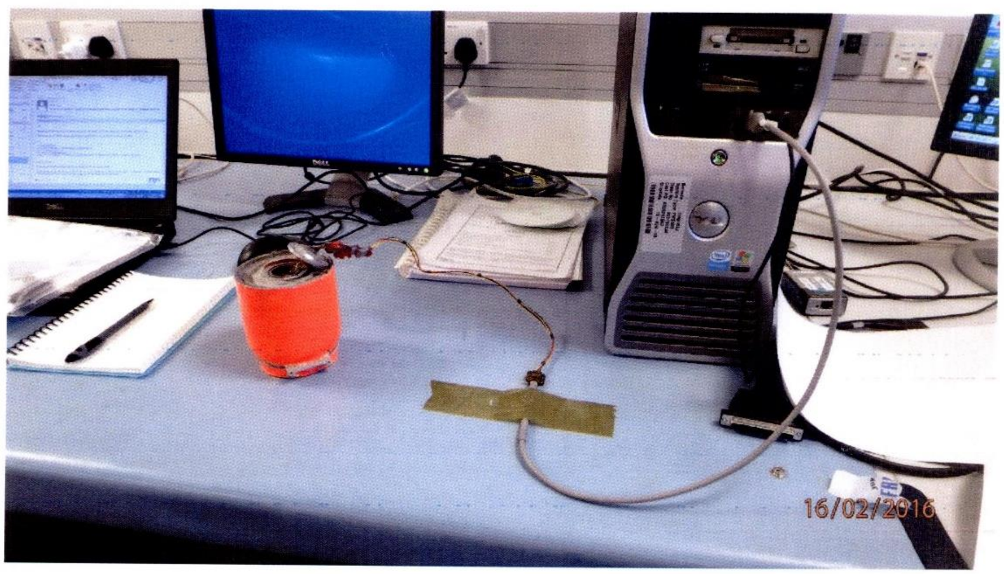


Department for

Department for

3. The memory board was connected to the download P.C installed with the DVRS download and replay software. A cable assembly manufactured by POC for recovering data from accident damaged units was used.

   It was noted that one wire attached to the memory board was loose. A small movement of the wire restored the connection and a successful download was achieved with no errors displayed. A further four downloads were made and the data files compared. No discrepancies in the size of the data files were noted, indicating that all of the available data had been extracted succesfully.



4. When replayed using the DVRS software, the images from the left and right camera were found to contain only a few images. The majority of the time, a "blue" screen was presented. Discussions with POC indicate that this normally occurs when no input signal is received to the recorder.

   The centre camera images appeared to be available throughout the duration of the recording.

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5. A Built-In-Test (BIT) file was provided to POC for analysis. POC confirmed that this indicated a defect with the data from the left and right camera.

6. With the permission of the NAIB, the download files were provided to POC to determine if images from the left and right camera could be recovered.

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Appendix 2: NTSB component examination report

Flight Control Computer Examination

7015480-903

Honeywell Factual Report

May 27, 2016

1

This report is the documentation of the history event/error code download from two flight control computers (FCC) that occurred on May 12, 2016. This was done at the Honeywell Deer Valley facility. Oversight was provided by the FAA.

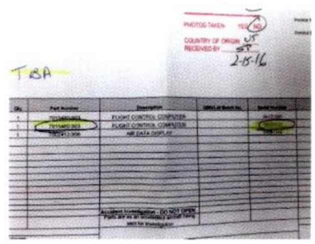
There were two flight control computer units (7015480-903) that were recovered from the incident and brought into the Honeywell facility. See below for unit information.

Unit 1 (Marked with "CP" on top)
7015480-903, SN 06121889

The units appear to have spent some time submerged in water and signs of salt and corrosion can been seen on the connectors.

2

Unit 2 (marked with "P" on top)
7015480-903, SN 08032162

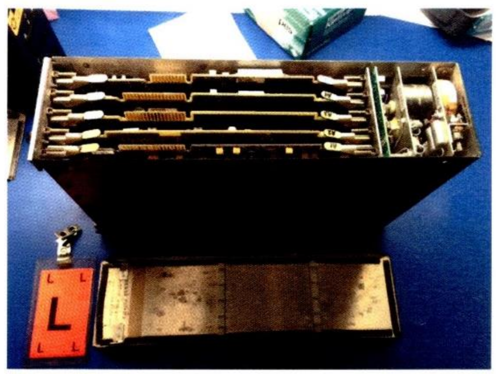


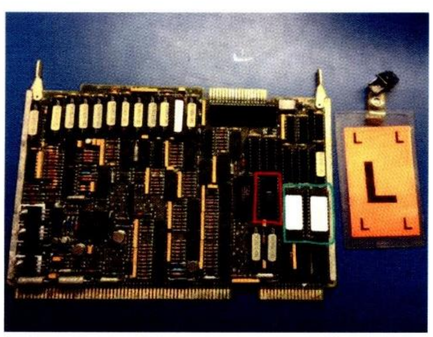
Again, unit 2 showed signs of salt and corrosion on the connectors.

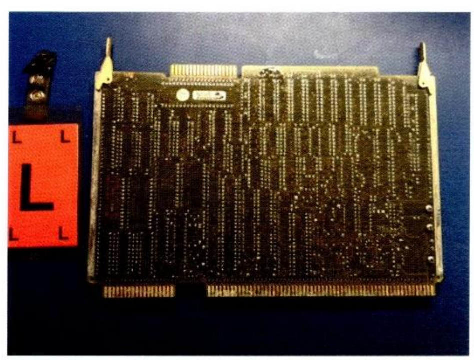
3

Unit 1 and 2 were opened to locate the processor Circuit Card Assembly (CCA) aka board that contains the EEPROM (Electrically Erasable Programmable Read-Only Memory), where the error codes are stored. The processor board part number is 7013868-903.

The red "L" tag designates unit 1 ("Co-Pilot").

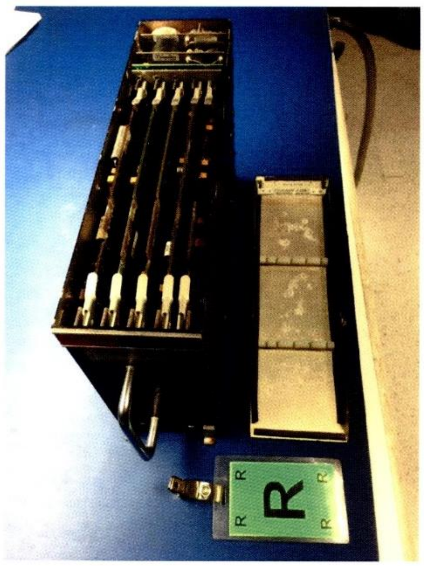


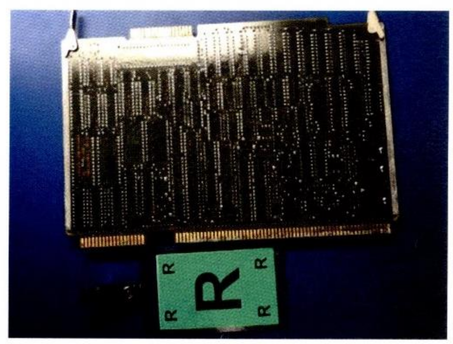




The EEPROM containing the error codes is highlighted in a red box above. Also, the flight software memory devices are highlighted by the green box.

The green "R" tag designates unit 2 ("Pilot").





The EEPROM containing the error codes is highlighted in a red box above. Also, the flight software memory devices is highlighted by the green box.

Both units had corrosion on the board connectors. The corrosion on the connector was able to be cleaned off with a toluene solution.

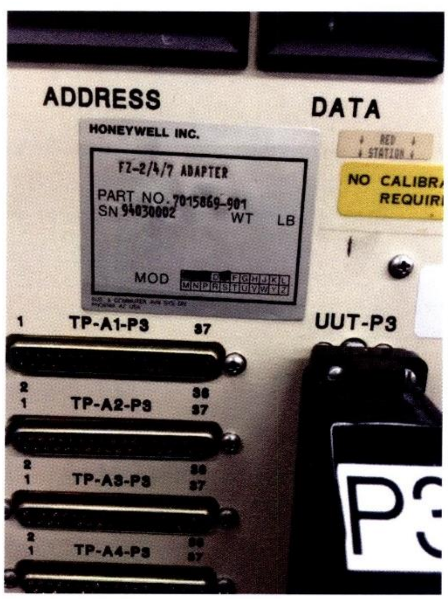
All of the boards appeared to exhibit signs of corrosion as well as the backplane, which these processor units were plugged into. In an effort to mitigate the risk of introducing additional error codes into the EEPROM due to the corrosion on the hardware, it was decided that each processor board would be installed in a slave test unit.

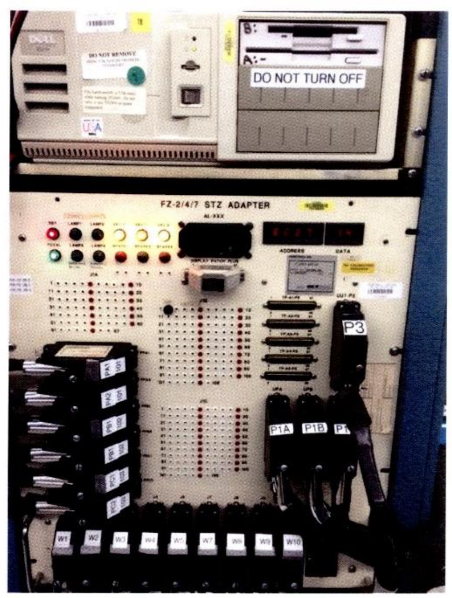
The processor board from unit 2 (pilot) was removed and installed in a slave test unit (pictured) below.

The accident flight software memory devices (highlighted in green box on processor CCA) were removed from the unit 2 processor CCA and replaced with the devices from the slave test unit's processor CCA. The accident flight software memory devices were set aside for now.

The test box containing the unit 2 processor CCA was then taken to the production area for testing. It was hooked up to the test setup. Below is the test fixture and adapter information.

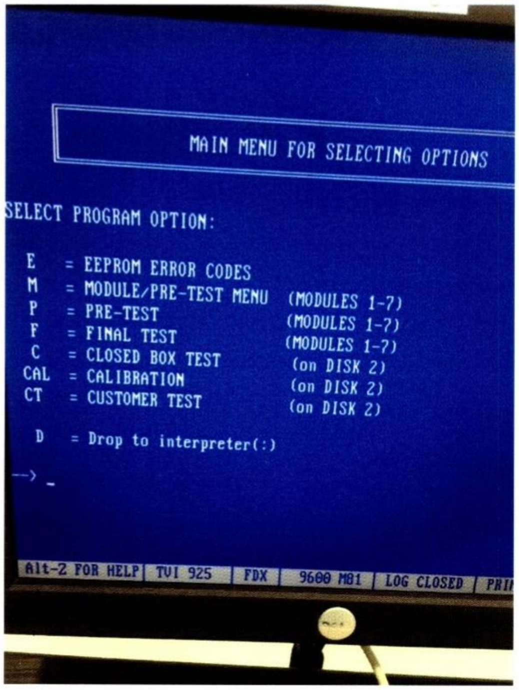

AV. DIV.
55087
Honeywell STZ-110
TEST SYSTEM
PART NO. 7006326-902
DMM
J7
J8
J9
J10


ADDRESS
DATA
HONEYWELL INC.
FZ-2/4/7 ADAPTER
PART NO. 7015869-901
SN 94030002 WT LB
MOD
TP-A1-P3
UUT-P3
TP-A2-P3
TP-A3-P3
TP-A4-P3
P3


DO NOT TURN OFF
FZ-2/4/7 STZ ADAPTER
P3
P1A
P1B

7

The test setup has a monitor hooked up displaying what kind of test options can be performed. Option E was selected to get the EEPROM error codes.



The first attempted download was unsuccessful. The test setup with the slave test unit did not result in the appropriate pre-test annunciations (no FDVAL). The unit 2 processor CCA was removed from the test unit and additional cleaning with Scotch-Brite was performed on the connector. It was then reseated into the test unit. The option E test attempt was successfully executed. The downloaded EEPROM error codes were printed out. The filename of this report is **Pilot 1st Run FCC.pdf**.

The accident flight software memory devices (highlighted in green box on the CCA pictorial) were then reinstalled back onto the unit 2 processor CCA. The test set-up was attempted again, but did not result in the appropriate pre-test annunciations (no FDVAL). No download was attempted.

To verify the setup, the accident flight software memory devices were removed again and the slave test unit flight software memory devices were reinstalled on the accident CCA. A second option E test attempt was successfully executed. The downloaded EEPROM error codes were printed out. The filename of this report is **Pilot 2nd Run FCC.pdf**.

No additional troubleshooting was performed on the accident flight software memory devices at this time.

8

Next, the unit 1 (Co-pilot) processor CCA underwent the same test procedure as did the unit 2 (pilot) processor CCA. The connectors were cleaned with a toluene solution and Scotch-Brite. The accident flight software memory devices were left on the accident CCA. The unit 1 processor CCA was installed in the slave test unit and mounted in the test fixture. Due to a setup error on the test bench, an error 7 was introduced into the EEPROM.

The option E test attempt was successfully executed. The downloaded EEPROM error codes were printed out. The filename of this report is **CO-Pilot 1st Run FCC.pdf.**

A second option E test attempt was successfully executed. The downloaded EEPROM error codes were printed out. The filename of this report is **Co-Pilot 2nd Run FCC.pdf.** Again due to a setup error on the test bench, a second error 7 was introduced into the EEPROM.

--END--

SUMMARY OF COMMENTS TO DRAFT FINAL REPORT

The draft final report was submitted for comments to the Nigerian Civil Aviation Authority, Bristow Helicopters (Nig.) Limited, National Transportation Safety Board, and the Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile, in compliance with sub-section 6.3 of Annex 13 to the ICAO Convention.

Nigerian Civil Aviation Authority remarked that no Safety Recommendation was made to address the Crew Resource Management (CRM) issues highlighted in the report. Several other editorial remarks were made.

Bristow Helicopters (Nig.) Limited proposed several amendments to the draft final report, presenting its views on the Causal and Contributory factors, Safety recommendation, Factual and technical contents, rationale in analysis and notable omissions. Pertinent comments were adopted and necessary amendments made to the draft final report.

National Transportation Safety Board had no comments on the draft final report.

Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile commented that the facts, analysis and conclusion are in accordance with its understanding of the event.