

**FMS DATA EXTRACTION
FOR
NTSB IDENTIFICATION: DCA20MA059**

RELEASED

<u>Status</u>	<u>Date</u>
Revision 2	December 2, 2020

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REVISION HISTORY

<u>Revision</u>	<u>Date</u>	<u>Name-Description</u>
Revision 2	12/02/2020	Added additional information about power fail position. Updated copyright notice.
Revision 1	11/04/2020	Added notes for power fail position and VOR bearing. Updated copyright notice.
Released	10/16/2020	Original.

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1 INTRODUCTION

This document contains a list of parameters downloaded from a Flight Management System (FMS) and converted to human-readable form. These were done at the request of the National Transportation Safety Board (NTSB) for its investigation of an incident identified as DCA20MA059. The download procedure was performed at UA's Duluth, Georgia, facility on Tuesday, March 3, 2020 and was witnessed by Sikorsky and NTSB personnel.

The UNS-1K system consists of a Control Display Unit (CDU) mounted in the cockpit and a Navigation Computer Unit (NCU) mounted in the avionics bay. An NCU was recovered from the accident site. The NCU contains several computer boards. Its CPU board runs the FMS application software. The information requested by the NTSB resides on this board.

All RAM on the CPU board is battery-backed, which allows the FMS to hibernate during power interruptions. The entire state of CPU board memory is frozen at the instant that external power to the FMS is removed. The battery will last several years before it is exhausted. Unless there was physical or electrical damage to the CPU board, all FMS parameters are recoverable. The other boards inside the CDU and NCU do not retain any information after power is removed.

In this case, the NCU and its CPU board sustained significant damage. A special procedure was used to remove the memory devices from the damaged unit and install them in a healthy surrogate CPU board for download. This procedure was successful. The memory image was downloaded and was completely uncorrupted.

The downloaded memory image was used to generate this report. This involved using the memory map of the software (SCN 604.3) to identify the addresses of parameters of interest and then decoding their binary values to human-readable form.

2 REFERENCES

Table 2-1 Acronyms and Abbreviations

Acronym/Abbreviation	Description
ADC	air data computer
ARINC	Aeronautical Radio, Incorporated
ASCB	avionics standard communication bus
AUX	auxiliary
CDU	control display unit
CPU	central processing unit
DME	distance measuring equipment
DR	dead reckoning
FMS	Flight Management System (UASC)
FPL	flight plan
ft	feet
GMT	Greenwich Mean Time
GPS	global positioning system
IAS	indicated air speed
kts	knots
min	minutes
MSG	message
NA	not applicable
NCU	navigation computer unit
NM	nautical miles
NTSB	National Transportation Safety Board
PC	personal computer
PN	part number
pph	Pounds per Hour
PVOR	Pseudo-VOR
RAM	random access memory
SCN	software control number
SN	serial number
TAS	true air speed
UA	Universal Avionics
UNS	Universal Navigation System
UTC	coordinated universal time

Acronym/Abbreviation	Description
VNAV	vertical navigation
VOR	VHF omnidirectional range

3 HARDWARE AND SOFTWARE VERSIONS

Table 3-1 NCU Identification

Model	UNS-1K
Part Number	1116-40-1110
Serial Number	529
Mod Levels	1, 5, 19
FMS Software	604.3
GPS Software	10.3
Auxiliary Software	1.6
Analog Software	NA
Bootstrap Software	2.3
ARINC Software	2.1
ASCB Software	NA
Advanced Performance Database	Not installed
Condition	Significant damage to the enclosure. Missing top. CPU board not missing any components. Battery voltage measured at the battery is nominal. Battery voltage measured at the eight RAM devices is nominal.

4 DECODED FMS DATA

4.1 Configuration Settings

Aircraft-specific FMS configuration settings are stored in a non-volatile Configuration Module attached to the NCU mounting tray. This is so the NCU can be replaced without the need to reconfigure its replacement. At power up, the FMS reads the Configuration Module and stores a copy of its image in RAM. The configuration parameters in Table 4-1 were obtained from this copy.

The configuration settings determined which FMS options were selected and which interfaces were active. These were used to select which parameters to decode for this report.

Table 4-1 Configuration Settings

CDU Page	Field Name	Setting
A561 XMIT 1/1	561 BUS	LRN DATA

CDU Page	Field Name	Setting
A561 XMIT 1/1	DTG FORMAT	ARINC 561
AIR DATA 1/1	A/S DISPLAY	TAS AND IAS
AIR DATA 1/1	A/S FORMAT	DIGITAL
AIR DATA 1/1	ALT DISPLAY	BOTH
AIR DATA 1/1	BARO ALT FMT	DIGITAL
AIR DATA 1/1	MACH FORMAT	NONE
AIR DATA 1/1	MINIMUM TAS	5 kts
AIR DATA 1/1	PRESS ALT FMT	DIGITAL
AIR DATA 1/1	SAT FORMAT	NONE
ANALOG OPT 1/1	(DESIRED TRK)RELATIVE TO	NOSE
ANALOG OPT 1/1	(WPT BRG)RELATIVE TO	NOSE
ANALOG OPT 1/1	ANALOG ATT	NONE
ANALOG OPT 1/1	DESIRED TRK	SYNCHRO
ANALOG OPT 1/1	PITCH CMD	NONE
ANALOG OPT 1/1	WPT BRG FMT	SYNCHRO
ANALOG OPT 1/1	WPT BRG OFFSET	0 DEGREES
ANALOG OPT 1/1	WPT BRG SIG	WAYPOINT BEARING
APPR OPT 1/1	APPR MODE	ENABLED
APPR OPT 1/1	FPA LIMIT	7.5°
APPR OPT 1/1	REMOTE ARM	DISABLED
APPR OPT 1/1	REMOTE TUNE	ENABLED
APPR OPT 1/1	ROLL GAINS	3X
APPR TYPES 1/1	BC	ADVISORY
APPR TYPES 1/1	GPS	ENABLED
APPR TYPES 1/1	ILS	ADVISORY
APPR TYPES 1/1	LOC	ADVISORY
APPR TYPES 1/1	NDB	ENABLED
APPR TYPES 1/1	RNV	ENABLED
APPR TYPES 1/1	VFR	ENABLED
APPR TYPES 1/1	VOR	ENABLED
APU OPT 1/1	APU SOURCE	NONE
APU OPT 1/1	FUEL FLOW1	0
APU OPT 1/1	FUEL FLOW2	0

CDU Page	Field Name	Setting
APU OPT 1/1	FUEL FLOW3	0
APU OPT 1/1	FUEL FLOW4	0
ARINC RCV 1/2	PORT 0	LS GPS 1 B1
ARINC RCV 1/2	PORT 1	NO SENSOR
ARINC RCV 1/2	PORT 2	NO SENSOR
ARINC RCV 1/2	PORT 3	LS 429 ADC
ARINC RCV 1/2	PORT 4	571 RADAR
ARINC RCV 1/2	PORT 5	LORAN
ARINC RCV 1/2	PORT 6	NO SENSOR
ARINC RCV 1/2	PORT 7	NO SENSOR
ARINC XMIT 1/1	PORT 0	429 HS
ARINC XMIT 1/1	PORT 1	571 LRN
ARINC XMIT 1/1	PORT 2	429 LS
ARINC XMIT 1/1	PORT 3	429 XFILL
CABIN DISP 1/1	CABIN DISP	DISABLED
CONFIG 2/2	AIRCRAFT IDENTIFICATION	Not defined
CONFIG 2/2	CONFIG MODULE UPDATES DATE #1	2/8/2001 15:46:35
CONFIG 2/2	CONFIG MODULE UPDATES DATE #2	2/8/2001 15:10:16
CONFIG 2/2	CONFIG MODULE UPDATES DATE #3	2/8/2001 14:51:54
CONFIG 2/2	CONFIG MODULE UPDATES DATE #4	2/6/2001 19:41:42
CONFIG 2/2	SCN	604.3
CSDB OPT 1/1	RCVR 0	VOR
CSDB OPT 1/1	RCVR 1	NONE
CSDB OPT 1/1	RCVR 2	SINGLE DME
CSDB OPT 1/1	RCVR 3	NONE
CSDB OPT 1/1	XMITTER 0	TUNE
CSDB OPT 1/1	XMITTER 1	NONE
DISC IN 1/2	DISC IN 1	NONE
DISC IN 1/2	DISC IN 2	NONE
DISC IN 1/2	DISC IN 3	NONE
DISC IN 1/2	DISC IN 4	NONE

CDU Page	Field Name	Setting
DISC IN 1/2	DISC IN 5	NONE
DISC IN 1/2	DISC IN 6	STRUT
DISC IN 1/2	DISC IN 7	NONE
DISC IN 1/2	DISC IN 8	NONE
DISC IN 2/2	DISC IN 10 28V	NONE
DISC IN 2/2	DISC IN 11	NONE
DISC IN 2/2	DISC IN 9	NONE
DISC OUT 1/2	DISC OUT 1	WPT ANN
DISC OUT 1/2	DISC OUT 2	SXTK ANN
DISC OUT 1/2	DISC OUT 3	APPR ANN
DISC OUT 1/2	DISC OUT 4	HDG ANN
DISC OUT 1/2	DISC OUT 5	GPS INTEG
DISC OUT 1/2	DISC OUT 6	NONE
DISC OUT 1/2	DISC OUT 7	NONE
DISC OUT 1/2	DISC OUT 8	FMS VALID
DISC OUT 2/2	DISC OUT 9 28V	NONE
DISPLAY CONFIG	COLORS	STANDARD
EFIS OPT 1/1	TYPE	429 GAMA
FMS CONFIG 1/3	FMS OPTIONS	ALL DIGITAL
FMS CONFIG 3/3	FLIGHT LOG	ENABLED
FMS CONFIG 3/3	MAX STBY TIME	2 HOURS
FMS CONFIG 3/3	PLT DB @ PWRUP	RETAINED
FMS CONFIG 3/3	POS EST DISP	Q
FMS CONFIG 3/3	STRUT SW	ANALOG
FUEL OPT 1/1	# OF ENGINES	2
FUEL OPT 1/1	EMPTY WEIGHT	-----
FUEL OPT 1/1	DISPLAY UNITS	LBS
FUEL OPT 1/1	FUEL FLOW TYPE	DC LINEAR
FUEL OPT 1/1	FUEL MODE	ENABLED
INTERNAL	CONFIG DATA CHECKSUM	60BA
INTERNAL	CONFIG DATA REVISION	2
INTERNAL	CONFIG DATA VERSION	106
NAV OPT 1/1	A/C ROLL STR	ENABLED

CDU Page	Field Name	Setting
NAV OPT 1/1	A/C TYPE	HELICOPTER
NAV OPT 1/1	AT OR ABOVE ALT	16501 FT
NAV OPT 1/1	AT OR ABOVE BANK LIMIT	22°
NAV OPT 1/1	AT OR BELOW ALT	16500 FT
NAV OPT 1/1	AT OR BELOW BANK LIMIT	22°
NAV OPT 1/1	HDG SEL	ENRT+APPR
PERF DISP OPTS	PERF EFIS DISP	DISABLED
PERF OPT 1/1	ADVANCED	DISABLED
PERF OPT 1/1	ASCB	DISABLED
PERF OPT 1/1	BASIC	ENABLED
PERF OPT 1/1	CLIMB GRAD	500
PERF OPT 1/1	EFIS	DISABLED
PERF OPT 1/1	MANUAL	DISABLED
PL4-OPT 1/1	ADF DIAG	N/A
PL4-OPT 1/1	CHP	N/A
PL4-OPT 1/1	FUEL MAX	N/A
PL4-OPT 1/1	MLS	N/A
PL4-OPT 1/1	PL-4 REF	N/A
PL4-OPT 1/1	RAD ALT	N/A
PL4-OPT 1/1	RADAR TYPE	N/A
PL4-OPT 1/1	TCAS	N/A
TAWS CONFIG 1/1	MODE/RANGE SEL	N/A
TAWS CONFIG 1/1	PAGE DISPLAY	N/A
TUNE OPT 1/1	# ADFS	1
TUNE OPT 1/1	# ATC	1
TUNE OPT 1/1	# COMS	2
TUNE OPT 1/1	# NAVS	2
TUNE OPT 1/1	COMM RADIO	25 KHz
VNAV OPT 1/2	FPA LIMIT	7.5°
VNAV OPT 1/2	TEMP COMP	ENABLED
VNAV OPT 1/2	VDEV SCALE	NORMAL
VNAV OPT 1/2	VDEV STOW	ENABLED
VNAV OPT 1/2	VNAV MODE	ENABLED
VNAV OPT 2/2	429/571/ASCB PITCH	ENRT+APPR

CDU Page	Field Name	Setting
VNAV OPT 2/2	429/571/ASCB VDEV	ENRT+APPR
VNAV OPT 2/2	429/571/ASCB VERT SPD	ENRT+APPR
VNAV OPT 2/2	ANALOG PITCH	ENRT+APPR
VNAV OPT 2/2	ANALOG VDEV	ENRT+APPR
XFILL OPT 1/1	FPL	ENABLED
XFILL OPT 1/1	FUEL	ENABLED
XFILL OPT 1/1	INITIAL	ENABLED
XFILL OPT 1/1	MASTER	ENABLED
XFILL OPT 1/1	TUNE PRESETS	ENABLED
XFILL OPT 1/1	XFILL MODE	PULL

4.2 System Status

The system status includes parameters obtained from external sources and parameters that are computed by the FMS. The parameters are frozen at the instant power was removed. The time since last update depends on how often the input is emitted by its source, how often the input is sampled by the FMS, and how often the FMS updates its internal variables and outputs. The basic processing cycle for the FMS is 1 Hz, so the age of the following parameters is between 0 and 1 seconds for FMS outputs and 0 to 2 seconds for inputs.

Table 4-2 System Status

Parameter	Value
Date	26 January 2020
GMT	17:45:36
Navigation Mode	Dead Reckoning (using magnetic heading and true air speed)
System Position (GPS position propagated by heading and true air speed)	N 34:08.17861 W118:41.55108 (34.1363101n 118.692518w)
Reference Position (Blended GPS/DME position propagated with GPS velocities)	N 34:08.17861 W118:50.54967 (34.1363101n 118.8424945w)
DME Position (Position computed from DME range measurements)	N 34:23.21876 W119:13.96316 (34.38697938n 119.2327194w)

Parameter	Value
Displayed DME Data	Most recent four DMEs that have been interrogated. No DMEs had been received for at least 128 seconds.
Altitude	1119 ft
Altitude 1 second ago	1262 ft
Derived Vertical Speed (computed by FMS based on altitude change)	-7718 ft/min
Filtered Derived Vertical Speed (Derived Vertical Speed with 4 second lag filter)	-5254 ft/min
True Air Speed	85.53125 m/s (166.26 kts)
Indicated Air Speed	162.80 kts
Ground Speed	83.46875 m/s (162.25 kts)
System Velocity	N 27.208 m/s E 78.926 m/s
True Track Angle	71.00°
Magnetic Heading	57.5°
Magnetic Variation	E 12.15°
Wind	2.1875 m/s 91.63°
Active From Waypoint	(PPOS) N 34:15.04816 W118:45.62296 (34.25080271n 118.7603827w)
Active To Waypoint	Direct to KCMA N 34:12.82459 W119:05.66231 (34.2137432n 119.09437w)
Desired Track (true)	261.7°
Cross Track Distance (from Reference Position)	-11905 m (Left 6.428 NM)
Along Track Distance (from Reference Position)	21697 m (11.715 NM)

Parameter	Value
Bearing to Terminator (true) (from Reference Position)	290.5°
Distance to Terminator	24761 m (13.370 NM)
System Status	Initial GMT, Date, and Position VERIFIED Airborne Magnetic Variation VALID Mag/True Mode MAGNETIC Test mode OFF PVOR mode OFF VNAV mode OFF Go-Around mode OFF Selected Cross Track OFF Approach mode OFF
Fuel and Weight Data	Not Used
Estimate of position uncertainty (95%)	7.5 NM
Power Interruption Data	January 26 16:25:17 Duration 4 seconds Reference Position was N 33:20.18317 W118:18.70394 (33.336386n 118.311732w) Note: When the FMS is initialized, it will default to the position stored when power was previously removed or the GPS position, if it is available. This position is presented to the crew on the FMS initialization page, where the crew can accept it, or manually change it before accepting it. Should the crew accept a Reference Position that is significantly different from the actual aircraft position, the FMS will annunciate position uncertain and post difference warning messages after GPS position becomes available. Over time, the Reference Position would converge to true position by using DME and GPS.

Parameter	Value
NAV Leg Editing Buffer	Pilot performed a Direct-TO (DTO) KCMA at 17:37:43 when Reference Position was N 34:15.048 W 118:45.623 (34.25080n 118.76038w) Result was the following navigation legs: FROM (PPOS) TO KCMA NEXT ----- NEXT+1 ----- NEXT+2 ----- NEXT+3 -----

4.3 Lateral Flight Plan

The lateral flight plan contained one Direct-TO leg to KCMA.

Table 4-3 Lateral Flight Plan

Leg No.	Path	Terminator	Comment
1	Initial Fix	KCMA	Camarillo Airport

4.4 Vertical Flight Plan

Vertical navigation mode was inactive. No vertical plan was defined.

4.5 Discrete Outputs and Inputs

Table 4-4 Discrete Outputs and Inputs

Parameter	Value
Discrete Outputs	Waypoint Alert OFF Selected Cross Track Mode OFF Approach Mode OFF Heading Mode OFF GPS Integrity OFF FMS Valid ON Vertical Track Alert OFF MSG Annunciator ON Steering Valid ON
Discrete Inputs	Strut switch IN AIR

4.6 Digital Outputs

The digital outputs are shown in the following table. The references in parentheses are the ARINC labels that correspond to the decoded parameter.

Table 4-5 ARINC 429 Digital Outputs

Parameter	Value
Selected Heading (L101)	No Computed Data
ILS Course (L105)	No Computed Data
Pseudo ILS Course (L110)	No Computed Data
True Desired Track (L114)	261.7°
True Waypoint Bearing (L115)	290.4°
Cross Track Distance (L116)	L 6.421 NM
Vertical Deviation (L117)	No Computed Data
Horizontal Command (L121)	Right 21.0°
Vertical Command (L122)	No Computed Data
UTC resolution 1/10 minute (L125)	17:45.6
Magnetic Variation (L147)	E 12.3°
UTC (L150)	17:45:36
Wind on Nose (L163)	4 kts
Pseudo Localizer Deviation (L173)	No Computed Data
Pseudo Glideslope Deviation (L174)	No Computed Data
Baro-Corrected Altitude (L204)	1118 ft
True Air Speed (L210)	166.25 kts
Distance to Go (L251)	13.375 NM
Time to Go (L252)	4.9375 minutes
Date (L260)	1/26/20
GPS Discrete Word (L261)	Approach not active Terminal Mode GPS Integrity FAIL
FMS Navigation Mode (L266)	Dead Reckoning Position Uncertain

Parameter	Value
Status (L270)	NAV Valid MSG Present Selected Crosstrack OFF Waypoint Alert OFF Vertical Waypoint Alert OFF Mag/True Mode MAGNETIC TO/FROM = TO Approach OFF Dead Reckoning Position Uncertain Estimated Position Uncertainty = 7.5 NM
Status (L275)	HSI Valid Magnetic Mode MAGNETIC MSG Alert ON Selected Cross Track OFF TO/FROM = TO Heading Mode OFF Approach Mode OFF Dead Reckoning ON Waypoint Alert OFF
Present Position Latitude 24-bit resolution (L310)	N 34:08.19489 (34.13658142n)
Present Position Longitude 24-bit resolution (L311)	W118:50.48058 (118.8413429w)
Ground Speed (L312)	156.625 kts
True Track Angle (L313)	51.9°
True Heading (L314)	57.5°
Filtered Wind Speed (L315)	4.5 kts
Filtered Wind Angle (L316)	91.8°
Drift Angle (L321)	0.4°
Lateral Full Scale Display Deviation (L326)	1.0 NM
Vertical Full Scale Display Deviation (L327)	500 ft
N/S Velocity (L366)	N 52.875 kts
E/W Velocity (L367)	E 153.375 kts
Distance to Destination (L351)	No Computed Data
Estimated Time to Destination (L352)	5 minutes
Local Time Offset (L353)	No Computed Data
Equipment Ident (L371)	UASC

4.7 Sensor Data

The FMS receives data from its internal GPS and from external aircraft systems. The external systems include one Air Data Computer, one LORAN, one VOR, one DME one heading source and two fuel flow sensors. LORAN inputs are not listed because that system is obsolete.

4.7.1 GPS Inputs

The internal GPS was operating and in NAV mode when power was lost, however its position was invalid, indicating it was in the process of exiting NAV mode.

Table 4-6 ARINC 743A GPS Inputs

Parameter	Value
Last Known GPS Position	N 34:08.130522 W 118:41.58977 (34.13551n 118.693162w)
Coarse Latitude (L110)	No Computed Data
Fine Latitude (L120)	No Computed Data
Coarse Longitude (L111)	No Computed Data
Fine Longitude (L121)	No Computed Data
HDOP (L101)	6.375
VDOP (L102)	3.6875
Ground Speed (L112)	137.75 kts
Satellite Deselection (L126 and L127)	Not Received
HIL (L130)	No Computed Data
UTC (L150)	17:45:36
Date (L261)	26 January 2020
GPS Status (L273)	Mode NAV 4 Satellites Used 10 Satellites Visible
GPS Diagnostic (L277)	No faults.

<p>Satellite Data Note: There are 12 entries in this table, and each is updated once per second. The ages of the measurements are between 1 and 12 seconds.</p>	<p>Vehicle 22 Tracking Status = Fast Sequencing SNR = 47 dB Elevation = 85° Azimuth = 196°</p> <p>Vehicle 3 Tracking Status = Fast Sequencing SNR = 0 dB Elevation = 67° Azimuth = 318°</p> <p>Vehicle 4 Tracking Status = Fast Sequencing SNR = 0 dB Elevation = 42° Azimuth = 298°</p> <p>Vehicle 26 Tracking Status = Fast Sequencing SNR = 31 dB Elevation = 27° Azimuth = 108°</p> <p>Vehicle 23 Tracking Status = Fast Sequencing SNR = 0 dB Elevation = 38° Azimuth = 296°</p> <p>Vehicle 31 Tracking Status = Fast Sequencing SNR = 0 dB Elevation = 37° Azimuth = 42°</p> <p>Vehicle 1 Tracking Status = Fast Sequencing SNR = 0 dB</p>
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Parameter	Value
	Elevation = 32° Azimuth = 218°
	Vehicle 16 Tracking Status = Fast Sequencing SNR = 0 dB Elevation = 27° Azimuth = 138°
	Vehicle 14 Tracking Status = Fast Sequencing SNR = 0 dB Elevation = 23° Azimuth = 70°
	Vehicle 9 Tracking Status = not assigned to channel SNR = 0 dB Elevation = 14° Azimuth = 282°

4.7.2 Air Data Inputs

The references in parentheses are the ARINC labels that correspond to the decoded parameter.

Table 4-7 Air Data Inputs

Parameter	Value
Pressure Altitude (L203)	827 ft
Baro Corrected Altitude (L204)	965 ft
Indicated Air Speed (L206)	162.8125 kts
True Air Speed (L210)	158.875 kts

4.7.3 Fuel Flow Inputs

Fuel flow was sensed by analog DC inputs. Two engines were configured. The FMS integrates the fuel flow by each engine to estimate the fuel used by each engine.

Table 4-8 Fuel Flow Inputs

Parameter	Value
Engine 1 fuel flow	231 pph
Engine 2 fuel flow	224 pph
Engine 1 fuel used	228.1 lbs
Engine 2 fuel used	220.8 lbs

4.7.4 Analog Heading Inputs

The FMS was configured to receive heading from an analog heading source.

Table 4-9 Analog Heading Inputs

Parameter	Value
Heading Status	Valid Magnetic Referenced
Magnetic Heading (100 msec latency)	45.4°

4.7.5 DME and VOR Inputs

One Collins Serial Data Bus (CSDB) DME and one CSDB VOR were configured.

Table 4-10 DME and VOR Inputs

Parameter	Value
VOR Station Identifier	CMA
VOR Station Position from Navigation Database	N 34:12.751 W 119:05.661 (34.21252n 119.09435w)
VOR Radial Note: VOR radial was not being received. This value is the last valid radial from the receiver; the age of this parameter is unknown.	86.2°
VOR Status	Station Tuned but radial is not received
Computed distance to VOR station	38001 m (20.51 NM)
VOR Frequency	115.80
VOR Station Declination	E 14.9°

Parameter	Value
DME Status	REFLAT VALID DME ON POS UNCERTAIN Less than 2 DME Propagating DME List Not Empty Co-located DME on list VOR-NAV DME Uncertainty > 10 NM
DME Stations for short-range navigation	No DMEs Received
Scanned DME Stations	Fifteen DMEs being scanned. None responded.

4.8 Timeline

There are a limited number of events the FMS records with a timestamp. The following table shows the timeline leading up to the moment power was removed. The times are expressed in UTC on January 26, 2019.

Table 4-11 Timeline

Time (UTC)	Event
16:25:17	Short-term power interruption
16:25:21	Power restored
17:07:14	Takeoff time
17:37:43	DTO KCMA
17:45:36	Power Loss
No Data	Landing time

4.9 Faults and Messages

The results of power-on-self-test and contents of the MSG page are shown in Table 4-12.

Three messages were posted for viewing on the MSG page. None had been read. All are the category which is posted when the condition occurs and removed when the condition clears.

The oldest message was POSITION UNCERTAIN which was posted when the uncertainty in the system position was greater than 1.0 nautical mile.

The next newer message is DEAD RECKONING MODE which was posted when the DME measurements had been missing for more than 128 seconds and the GPS position was invalid.

The newest message was GPS 1 DIFFERENCE 6 NM which was posted when the GPS position was valid. This is the difference between the GPS position and the average GPS/DME position.

Table 4-12 Faults and Messages

Parameter	Value
Self-Test Pass/Fail Status	Program Checksum Pass Non-volatile RAM Pass Clock/Calendar Pass Battery Pass Power Supply Pass Configuration Module Pass AUX Board Pass Analog Board Pass ARINC Board Pass Database RAM Pass Navigation Database Pass User-defined Database Pass
Message Page	<p>The following messages were posted by the FMS, but they had not been read by the pilot. They are listed from newest to oldest.</p> <p>GPS 1 DIFFERENCE 6 NM Tested every 1 second Posts when GPS position is valid and difference between REFPOS and GPSPOS > 6.0 NM.</p> <p>DEAD RECKONING MODE Tested every 4 seconds Posts when current navigation mode changes to DR.</p> <p>POSITION UNCERTAIN Tested every 4 seconds Posts when difference between REFPOS and SYSPOS > 1.0 NM</p>

4.10 Navigation Database

The FMS can store two complete Navigation Databases which are valid for 28 days. Only one of the databases can be selected at a time. There were two different Navigation Databases installed. The database in Bank 2 was current and active. The database in Bank 1 was expired and deselected.

Table 4-13 Navigation Database

Parameter	Value
Bank 1 Status	Deselected, not failed, expires on January 2, 2020.
Bank 1 Contents	Helicopter Database covering USA, Canada, Latin America and South Pacific.
Bank 2 Status	Active, not failed, expires on January 30, 2020.
Bank 2 Contents	Helicopter Database covering USA, Canada, Latin America and South Pacific.

4.11 User-Defined Databases

The FMS allows the pilot to create user-defined waypoints, procedures and routes. The memory devices that contain the user-defined databases was not downloaded because there is no evidence that these were accessed prior to the incident.

4.12 Advanced Performance Database

The FMS did not have an Advanced Performance Database installed.

4.13 CDU Page

The CDU was displaying the NAV 1/2 page. The information displayed on the CDU is shown in Figure 4-1.

```

-----
P O S           N A V           1 / 2           m M S G
FR ( P P O S )           1 7 : 3 7 |   H D G >
 2 5 0 °   1 3 . 4 N M   0 + 0 4 |
T O K C M A           1 7 : 5 0 | M N V R >
NX - - - - -
-----
X T K ( T ) L   6 . 4   g s           1 5 7
h e a d w i n d   4   b r g           2 7 8 °
w i n d   0 9 2 t /   4   t k e   R 1 6 9 °
-----
  
```

Figure 4-1 NAV 1/2 Page

4.14 Key Press History

The FMS keeps a running history of up to 100 of the most recent key presses the crew entered on the CDU. The key presses are not time-stamped. Only the sequence of key presses is recorded.

Knowing the layout of the CDU pages and the sequence of key presses, it is possible to reconstruct the crew's actions. The key presses are listed from oldest to newest

Table 4-14 Key Press History

Mode	Field	Page	Key	Crew Action	Result
INIT	6	0	L5	On the INIT page, pressed the ACCEPT key.	System position, UTC and date initialized from GPS if it was in NAV or from memory and real-time clock if not.
INIT	255	0	DTO	On the INIT page, pressed the DTO key.	Go to the DTO 1/1 page.
DTO	3	0	K	On the DTO page waypoint field, pressed the K key.	
DTO	3	0	C	On the DTO page waypoint field, pressed the C key.	
DTO	3	0	M	On the DTO page waypoint field, pressed the M key.	
DTO	3	0	A	On the DTO page waypoint field, pressed the A key.	
DTO	3	0	ENTER		Entered KCMA, causing automatic page change to KCMA info page.
WPT	16	0	ENTER	Highlight ACCEPT key.	

Mode	Field	Page	Key	Crew Action	Result
WPT	16	0	ENTER	ACCEPT KCMA.	FMS performs a Direct TO from present position to KCMA.
NAV	255	4	ENTER	On the NAV 1/2 page, accept the default for the NEXT leg after KCMA.	This completed the Direct TO KCMA, with no leg after.
NAV	255	4	DTO	On the NAV 1/2 page, pressed the DTO key.	
DTO	3	0	ENTER	Accepted the default (DTO KCMA).	
NAV	255	4	ENTER	On the NAV 1/2 page, accept the default for the NEXT leg after KCMA.	This refreshed the Direct TO KCMA from the present position.
NAV	255	4	DTO	On the NAV 1/2 page, pressed the DTO key.	
DTO	3	0	ENTER	Accepted the default (DTO KCMA).	
NAV	255	4	ENTER	On the NAV 1/2 page, accept the default for the NEXT leg after KCMA.	This refreshed the Direct TO KCMA from the present position.