NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

May 22, 2012

Non-Volatile Memory Devices

Specialist's Factual Report
By Michael Bauer

1. EVENT SUMMARY

Location: Baltimore, Washington
Date: January 30, 2012
Aircraft: Gulfstream G150
Registration: N272CB
NTSB Number: ERA12IA166

On January 30, 2012, at 1844 Eastern Standard Time, an Israel Aerospace Industries Gulfstream G150, N272CB, operated by Chattem Inc., sustained minor damage during a landing overrun at Baltimore Washington International Airport (BWI), Baltimore, Maryland. The two certificated airline transport pilots were not injured. The corporate repositioning flight was conducted under the provisions of 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed and an instrument flight rules flight plan was filed for the flight that departed from Pocono Mountains Municipal Airport (MPO) Mount Pocono, Pennsylvania, at 1808.

2. DATA GROUP

A recorded data group was not convened.

3. DETAILS OF FLIGHT DATA INVESTIGATION

The Safety Board's Vehicle Recorder Division received the following devices:

Device Manufacturer/Model: **Rockwell Collins MDC-3110**
Device Serial Number: **2HT6H**

Device Manufacturer/Model: **Honeywell MK V EGPWS**
Device Serial Number: **EMK5-27996**

Device Manufacturer/Model: **Honeywell Digital Electronic Engine Control**
Device Serial Number: **18-BC0131**

Device Manufacturer/Model: **Honeywell Digital Electronic Engine Control**
Device Serial Number: **107-BC0116**

3.1. Rockwell Collins Maintenance Computer Card

The Rockwell Collins Maintenance Diagnostic Computer (MDC) aids an aircraft operator in detecting and troubleshooting aircraft component problems. The MDC monitors aircraft system line replaceable units (LRUs) to determine failures and to identify LRUs that may require replacement. It logs this information to help permit the diagnosis of LRU faults. Other MDC functions include real-time display of aircraft system parameter information.

The MDC sub-system is composed of two parts, the MDC application hardware/software and the MDT (Maintenance Data Tables.) The MDC provides the operating system, application software and hardware platform. The MDT provides aircraft specific configuration (i.e. Gulfstream G-150) and equipment information for the MDC application software. The MDC also utilizes a cockpit MFD as the display media for presenting its information to the operator and uses a variety of formats, including English-readable text and binary readouts, to depict diagnostic information.

The MDC includes the ability to download stored data through a download device. The MDC contains Non-Volatile Memory (NVM) used for storage of flight leg information and Fault and Service message events. Included with the Fault and Service message data is additional data pertaining to the stored messages.

3.1.1. Recorder Condition

The MDC was in good condition. The unit was downloaded at the manufacturer's facility in Cedar Rapids, IA by Rockwell Collins personnel. The data recovered from the unit was then supplied to the Safety Board's Vehicle Recorder Division.

3.1.2. Recording Description

Multiple reports were downloaded from the device. Data from the flight leg summary, fault message history and service message history was extracted from the device. The MDC flight leg summary contained 89 flight legs. Based on date and time information within the fault and service messages, flight leg 89 was identified as the event flight. The MDC typically will increment the flight leg when the aircraft weight on wheels indication transitions from "On Ground" to an "In Air" configuration[1]. Fault messages and service messages for flight leg 89 are summarized in Appendix A.

3.2. Honeywell MK V EGPWS

The EGPWS NVM does not continuously record, but rather stores data only when certain criteria are met. The readout process at the manufacturer's facility produces several files of flight history data which encompass operational, documentary, fault and warning information.

The documentary data file outputs position information with respect to take-off, landing and terrain inhibit selections. The device will record a take-off record when the EGPWS "In Air" transitions from "False" to "True". The device will record a landing record when the EGPWS terrain clearance is less than 50 feet and the aircraft is in a landing configuration

[1] The MDC can also increment the flight leg based on other parameters such as airspeed, engine N2, or door position.

(i.e gear or flaps in correct position). The position records include latitude and longitude position and altitude and system time.

The flight history data warning file outputs performance data as related to the operation of the aircraft. These data do not continuously record but, rather, if an alert or warning related to the EGPWS function activates, the unit retains data points for 20 seconds prior to the activation of the warning and 10 seconds afterwards. The EGPWS parameters are only sampled 1 time per second but the actual time of occurrence can be anywhere within the second.

3.2.1. Recorder Condition

The EGPWS was in good condition and the data were extracted normally from the device using the manufacturer's recommended procedure.

3.2.2. Recording Description

The data extracted from the device was provided to the EGPWS manufacturer for decoding. The decoded files were then provided to the NTSB. The EGPWS recorded 326 flight legs, with the last leg being the flight from to MPO to BWI.

The unit recorded a landing record at BWI at a system time[2] of 1143:03:17. Table 1 contains the information from the position record.

Table 1 - Landing record from EGPWS

Parameter	Value
Latitude (deg)	39.17663
Longitude (deg)	-76.65363
Geometric Altitude (ft)	158.00
GPS Altitude (ft)	168.00
True Heading (deg)	327.66 (-32.34 recorded)
VFOM[3]	18.00
Position Uncertainty	0.0015
Position Source	GPS1

A warning/alert record was recorded at 1143:36:33, approximately 33 minutes after the landing record. All of the position data in the record was invalid and unusable.

3.3. Honeywell Digital Electronic Engine Control (DEEC)

The TFE731 N1 DEEC's include an incident recorder which collects engine and aircraft operational data and records it into NVM for post accident/incident download and analysis. The incident recorder provides a record of engine speeds and inter-turbine temperatures, along with aircraft parameters relating to the engine, and control modes during operation. It should be noted that the DEEC casing is not designed to be crash worthy, and memory

[2] System time is in hours, minutes, and seconds (HH:MM:SS), with hours being cumulative time.
[3] Vertical Figure of Merit (VFOM)

data could be lost for a variety of reasons including, but not limited to, impact and fire damage.

The incident recorder collects data into ten memory buffers for the last 85 minutes, 20 seconds of engine ground and/or flight time. The recorder will automatically power off approximately five minutes after weight-on-wheels (WOW) is established. This feature prevents the DEEC from accidentally overwriting the data in memory if aircraft power remains on after the engines have been shut down. Appendix B contains a list of parameters the incident recorder stores in NVM.

The data set stored in the first memory buffer is recorded once per second for the last 512 seconds (8 minutes, 32 seconds) prior to power down or 5 minutes after weight on wheels. For data sets recorded beyond 512 seconds, individual scans are stored in nine additional buffers with decreasing frequency. As data points roll into the downstream buffers, certain data points are dropped. For example, the data points in the second buffer are two seconds apart and the data points in the third buffer are 4 seconds apart, and so on.

The data is recorded in data "buckets" to minimize the space required for data storage. With this recording methodology, the exact data parameter is not physically recorded to memory. A digital bit value that corresponds to a data parameter range is recorded to memory whenever a parameter is within a given range. For example a N1 speed of 37% will be recorded as one data point in the "30-40" bucket for that given moment in time. This results in transient data being displayed in a "stair-step" fashion, and not the smooth transient change that actually occurs during operation. In addition, the same parameters from each engine, even though close in actual value, may appear as having a larger difference when plotted. For example, N1 speeds of 39 and 40% will be plotted as "30-40" and "40-50", respectively. Some of the parameters have finer bucket ranges than others, giving some parameters greater resolution than other parameters.

3.3.1. Recorder Condition

Both DEEC's were in good condition. The units were downloaded at the manufacturer's facility in Tucson, AZ by Honeywell personnel. The data recovered from the unit was then supplied to the Safety Board's Vehicle Recorder Division.

3.3.2. Recording Description

As described in section 3.3, 85 minutes and 25 seconds of data (5,120 seconds) was recovered from both the left and right engine DEEC's. The event flight was captured by both DEEC's.

3.3.3. Engineering Units Conversions

The data extracted from the DEECs were provided in engineering units.

As described in section 3.3, the digital value of the parameter is recorded in memory with respect to a data parameter range. For the parameter Eng1 PLA[4], the parameter range refers to both enumerations and position values. "Idle-40" refers to a PLA position range of idle to 40 degrees. Honeywell provided information stating that "Idle" refers to a PLA

[4] Power Lever Angle (PLA)

position of greater than or equal to 7 degrees and less than or equal to 26 degrees. Therefore the discrete position setting in the plotted data of “Idle-40” refers to a PLA position of 7 degrees to 40 degrees and the setting of “<Idle” refers to a PLA position less than 7 degrees.

Appendix B lists the parameters provided in this report.

3.4. Time Correlation

Each device stores the last 5,120 seconds. The data is plotted in reference to seconds and is not correlated to local time. Each DEEC’s time is independent from the other.

3.5. Plots and Corresponding Tabular Data

The following two figures contain data recorded from the DEECs during the January 30, 2012 event.

Figure 1 contains a plot of data from both the left and right engine DEECs for the entire event flight. To illustrate the different data rates as recorded by each DEEC, lines are positioned on the plot at each data rate transition. The event flight was approximately 36 minutes long.

Figure 2 contains a plot of two minutes of data during the landing portion of the event flight.

The Eng1 Gear WOW and Eng2 Gear WOW transition from “Air” to “Ground” at 4,889 sec. Approximately 11 seconds from the WOW transition, the Eng1 TR and Eng2 TR transitioned from “Stowed” to “Deploy”. Approximately 25 seconds from the WOW transition the Eng1 TR and Eng 2 TR returned to the “Stowed” state and remained in that condition for the remainder of the recording.

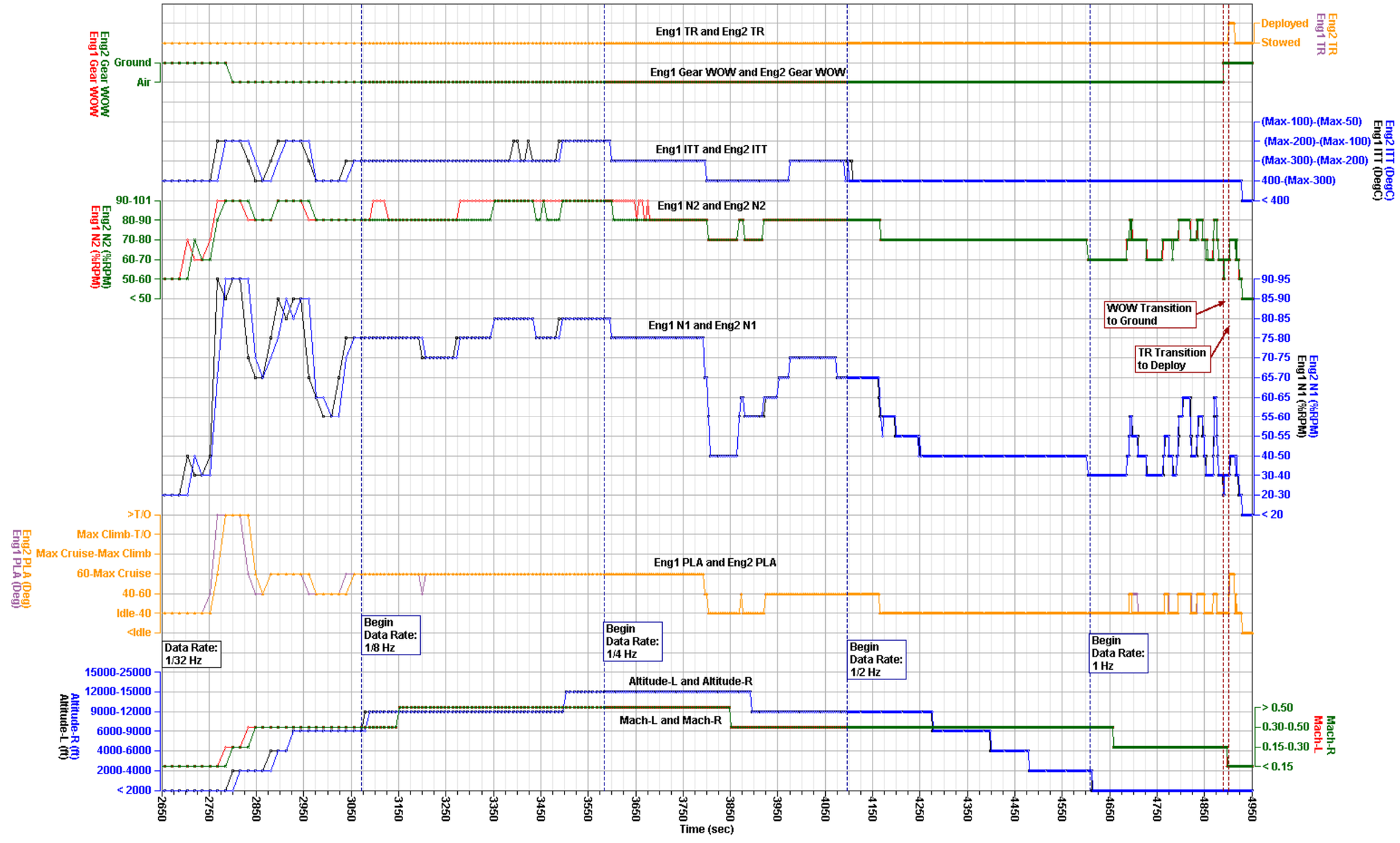
The corresponding tabular data used to create these three figures are provided in electronic (*.csv[5]) format as Attachment 1 to this report.

[5] Comma Separated Value format.

Gulfstream G150, N272CB

Location, Date: Baltimore, Maryland, 01/30/12

NTSB No. ERA12IA166



Revised: 11 May 2012

National Transportation Safety Board

Figure 1 – Left and Right DEEC data for the entire event flight

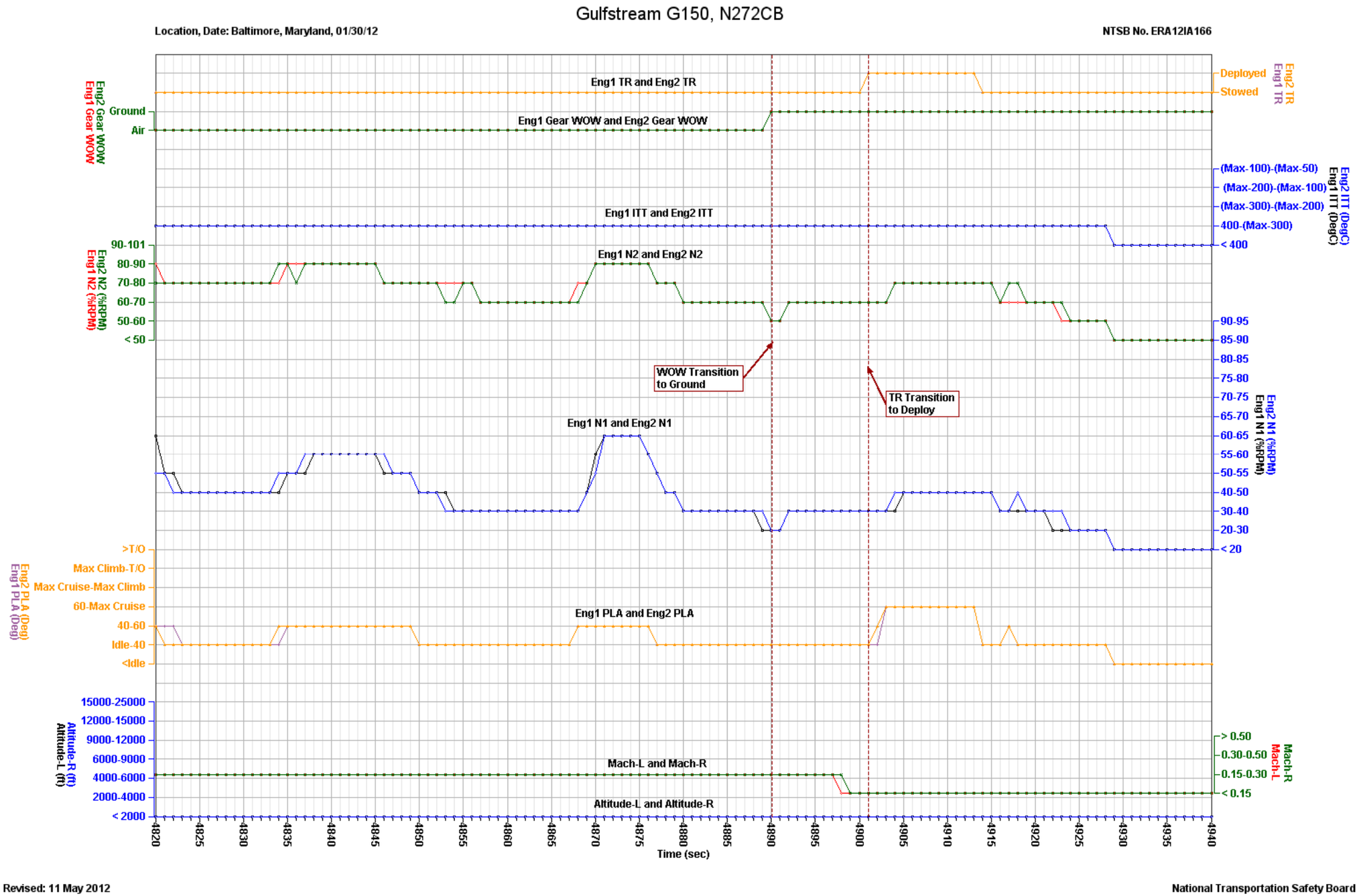


Figure 2 -Left and Right DEEC data for the landing sequence of the event flight

APPENDIX A

This appendix contains the MDC fault and service messages for the event flight. The recorded time is provided to the MDC from the GPS system. The estimated actual time is based on information from the aircraft maintenance data table (MDT) which includes two delays within the system architecture. The delays are variable within each message to avoid any erroneous maintenance fault indications.

Table A-1 - MDC fault and service messages from the event flight.

Fault/ Service Message	ATA		LRU	DATE	STATUS	FLIGHT LEG	FAULT MESSAGE	INTERMITTENT COUNT	GROUND/ AIR/TAXI	TIME (EST)	EST ACTUAL TIME (EST)
Fault	ATA34-44	RADIO ALTIMETER	RAD ALT	30-JAN-12	FAILED/WIRING	89	NO L-RALT-3 BUS OUTPUT	INTERMITNT: 0	TAXI	18:43:29	18:43:16
Fault	ATA34-15	STALL WARNING SYSTEM	SWT	30-JAN-12	FAILED	89	STALL WARN DISC OUT	INTERMITNT: 0	GROUND	18:43:47	18:43:39

APPENDIX B

This appendix describes the parameters recorded by the HI DEEC. Table B-1 lists the parameters and table B-2 describes the unit abbreviations used in this report.

Table B-1. Verified and provided parameters.

Parameter Name	Parameter Description
1. Altitude-L (ft)	Left DEEC Pressure Altitude
2. Altitude-R (ft)	Right DEEC Pressure Altitude
3. Eng1 Gear WOW (discrete)	Left DEEC Weight On Wheels Indication
4. Eng1 ITT (degC)	Left Engine Inter Turbine Temperature
5. Eng1 N1 (%RPM)	Left Engine N1, Low Pressure Spool Percent Speed
6. Eng1 N2 (%RPM)	Left Engine N2, High Pressure Spool Percent Speed
7. Eng1 PLA (Deg)	Left Engine Power Lever Angle
8. Eng1 TR (discrete)	Left Engine Thrust Reverser Position
9. Eng2 Gear WOW (discrete)	Right DEEC Weight On Wheels Indication
10. Eng2 ITT (deg C)	Right Engine Inter Turbine Temperature
11. Eng2 N1 (%RPM)	Right Engine N1, Low Pressure Spool Percent Speed
12. Eng2 N2 (%RPM)	Right Engine N2, High Pressure Spool Percent Speed
13. Eng2 PLA (Deg)	Right Engine Power Lever Angle
14. Eng2 TR (discrete)	Right Engine Thrust Reverser Position
15. Mach-L	Left DEEC Mach Number
16. Mach-R	Right DEEC Mach Number

Table B-2. Unit abbreviations.

Units Abbreviation	Description
%rpm	percent revolutions per minute
deg	degrees
degC	degrees Celsius
discrete	discrete
ft	feet

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.