

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

November 24, 2014

Flight Data Recorder

Specialist's Factual Report
By Greg Smith

1. EVENT SUMMARY

Location: Charleston, South Carolina
Date: July 28, 2012
Aircraft: Boeing 787
Registration: VT-ANJ
Operator: Boeing
NTSB Number: DCA12IA114

On July 28, 2012, at 1600 eastern daylight time, a Boeing 787-8, registration VT-ANJ, experienced an engine failure during a taxi test at Charleston AFB / International Airport (CHS), Charleston, South Carolina. The airplane was being operated by Boeing under the provisions of Title 14 *Code of Federal Regulations* (CFR) Part 91 for the purpose of conducting a taxi test with no intention for flight. There were no injuries to the 5 people on board and the airplane sustained minor damage.

2. FLIGHT DATA RECORDER GROUP

A flight data recorder (FDR) group was not convened.

3. FDR Carriage Requirements

The event aircraft, VT-ANJ, was manufactured in 2012, and was equipped dual combination recorders which provide redundant FDR functions that are intended to meet the requirements of 14CFR Part 121.344 and record a minimum of 88 parameters.

4. DETAILS OF FLIGHT DATA RECORDER INVESTIGATION

The National Transportation Safety Board's Vehicle Recorder Division received an electronic file containing the FDR data from the aircraft's aft recorder and also received the following EAFR which was installed as the forward recorder:

Recorder Manufacturer/Model: **GE EAFR-2100**
Recorder Serial Number: **16PLHY**

The recorder was in good condition and the data were extracted normally from the recorder.

Data from both recordings were evaluated and found to contain the same information for the incident time frame. Therefore, only data from the forward recorder is contained in this report.

4.1. GE EAFR-2100 Description

The EAFR-2100 is a multifunction recorder which records flight data, audio data, and communication, navigation, surveillance air traffic management (CNSATM) messages designed to meet the characteristics of *ARINC Characteristic 767, Enhanced Airborne Flight Recorder* (EAFR). Two EAFRs are installed on Boeing 787 aircraft, one forward and one aft. The forward and aft recorders are powered by the left and right 28V DC buses respectively. The forward recorder is equipped with a recorder independent power supply (RIPS) to provide backup power to the recorder for approximately 10 minutes once left DC bus power is lost. Both recorders record the same set of flight data independent of each other.

4.1.1. Recording Description

The forward EAFR recording contained approximately 35.1 hours of flight data, in ARINC 767 format. ARINC 767 data contains intrinsic timing information measured in milliseconds from the start of each recording session. The event recording session was the third session from the end of the recording. The duration of the incident recording session was approximately 2 hours 6 minutes.

4.1.2. Parameter Source and Stale Data Issues

The EAFR has an integral flight data acquisition function (FDAF). The FDAF receives data from various data sources then transmits that data to the FDR function for storage into the crash protected memory. The FDAF sends data to the FDR function according to a periodic schedule. If no new value has been received since the last time a parameter's value was sent to the FDR function, the FDAF continues to transmit the last value received from the source. This data is referred to as "stale data".

For some parameters, the FDAF has multiple prioritized data sources available from which it receives parameter values. For these parameters, a separate source index parameter is generated by the FDAF and recorded. The source index parameter indicates the source being used for a parameter¹ (or group of parameters) or if no sources are available. These source index parameters have names which end in "_SI". For parameters with a source index, stale data is indicated by the source index being set to zero indicating "no source available". During post-event processing of the FDR data, instances of stale data indicated by a "no source available" value of a parameter's source index have been omitted from the plots and tabular data.

However, parameters which have only a single source do not have a source index parameter and consequently do not have a recorded indication that the data may be stale. Such parameters have been given a "#" suffix to indicate that repeated values may actually represent stale data and that a more detailed understanding of the various aircraft systems and data path is required to fully analyze the data.

4.1.3. Engineering Units Conversions

The engineering units conversions used for the data contained in this report are based on the Flight Recorder Electronic Documentation (FRED) file which was stored on each

¹ Table A-1 in Appendix A includes a column with the source index parameter name for each parameter if applicable.

EAFR. The FRED files are based on *ARINC Specification 647A-1, Flight Recorder Electronic Documentation (FRED)*. In some cases, parameter conversions were augmented based on additional documentation from the aircraft manufacturer. Where applicable, the conversions have been changed to ensure that the parameters conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).²

The EAFR's FRED file indicates that more than 2000 parameters are recorded by the EAFR. Of those, 135 were evaluated as part of the investigation. Appendix A lists the FDR parameters verified and provided in this report.

4.1.4. Engine Loop In Control Parameters

The parameters Eng1_Loop_In_Control and Eng2_Loop_In_Control are matrices indicating the state of the engine control system and include indications for both Rolls Royce and General Electric engine configurations. Additional parameters Eng1_Loop_In_Control (GE) and Eng2_Loop_In_Control (GE) were created as subsets of the original matrices to improve the readability of the plots included below. Both the complete and subset matrix parameters are included in the tabular data in Attachment 1 to this report.

4.2. Time Correlation

An elapsed time since start of recording was generated by summing the elapsed time for a recording session with the durations of the sessions preceding it. This time is referred to as the FDR elapsed time. Correlation of the FDR elapsed time to the event local time, eastern daylight time (EDT), was established from the recorded Time_UTC_Hr_NAV, Time_UTC_Min_Nav, and Time_UTC_Sec_Nav parameters and then applying an additional -4 hour offset to change UTC to EDT.

Accordingly, the time offset for the event flight data from the EAFR's FDR elapsed time to local EDT is the following: EDT = FDR Elapsed Time – 62870.848. Therefore, for the rest of this report, all times are referenced as EDT, not FDR elapsed time.

4.3. FDR Plots and Corresponding Tabular Data

The following seven figures contain FDR data recorded during the July 28, 2012, event.

Figures 1 and 2 show basic aircraft parameters including ground speed, heading, accelerations, throttle positions and engine core (N2) and fan (N1) speeds. Figure 1 shows the period for approximately 10 minutes before and after the incident run. Figure 2 shows the 2 minute period of the incident run.

Figures 3 through 6 show additional engine status discrete parameters for the same 20 minute period as Figure 1. Figures 3 and 4 show parameters for engine 1 (the left engine) and Figures 5 and 6 show parameters for engine 2 (the right engine). Parameters for

² CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Pitch Up = +, Elevator Trailing Edge Up = +, Right Rudder = +.

engine 2 that have no data plotted after 16:06:06 are related to the EEC2_SI source index parameter which recorded a “No Source” state beginning at 16:06:06.³

Figure 7 shows the source index parameters associated with the parameters included in this report.

These figures are configured such that right turns are indicated by the trace moving toward the bottom of the page, left turns towards the top of the page, and nose up attitudes towards the top of the page.

The corresponding tabular data used to create these seven plots are included in electronic (*.csv⁴) format as Attachment 1 to this report. The tabular data in Attachment 1 includes all parameters evaluated for the time period of the incident recording session (approximately 14:49:21 to 16:55:55 EDT).

³ Handling of data from parameters that are related to a source index parameter is discussed in section 4.1.2.

⁴ Comma Separated Value format.

Figure 1 - 20 Minute Overview

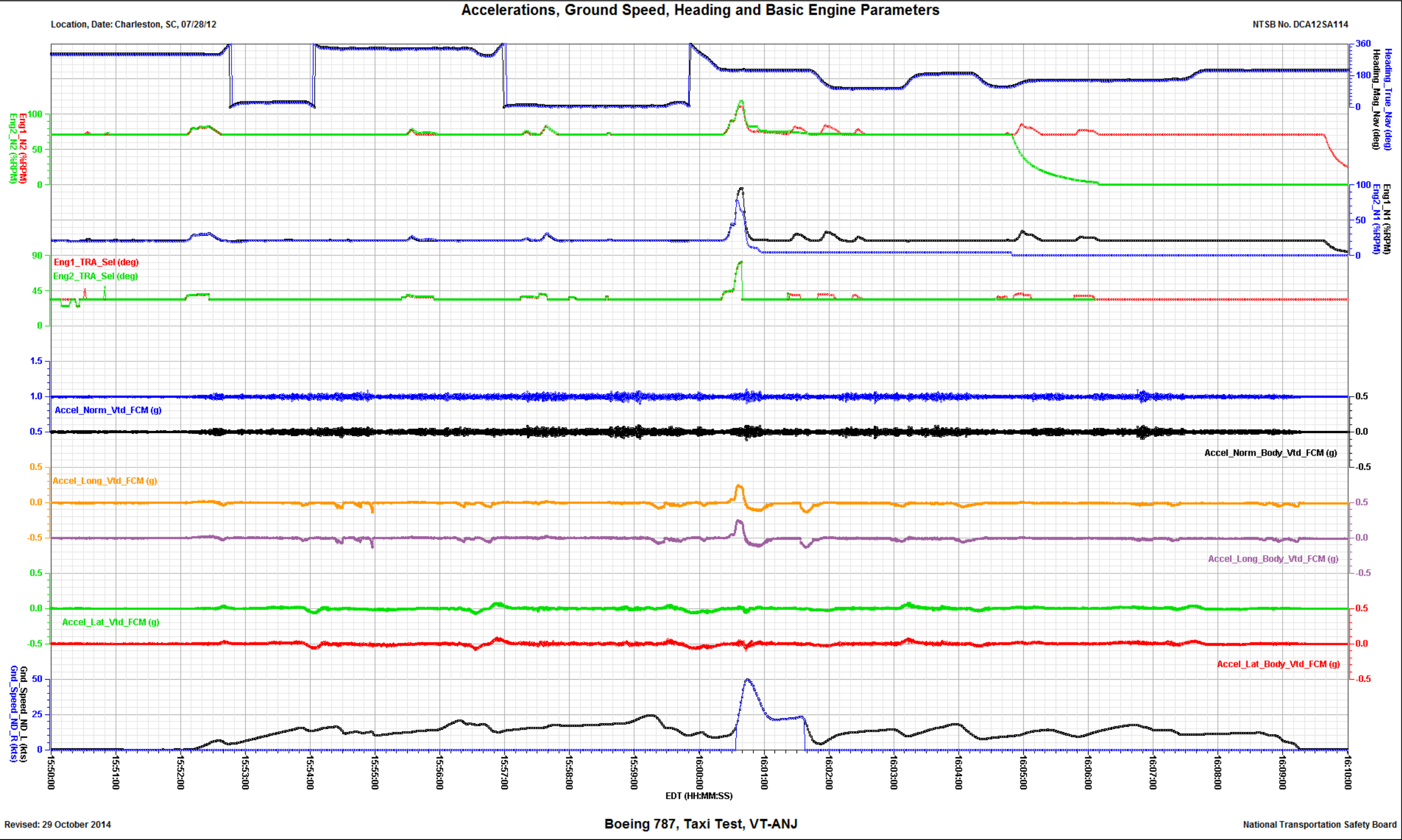


Figure 2 - Two Minute Overview

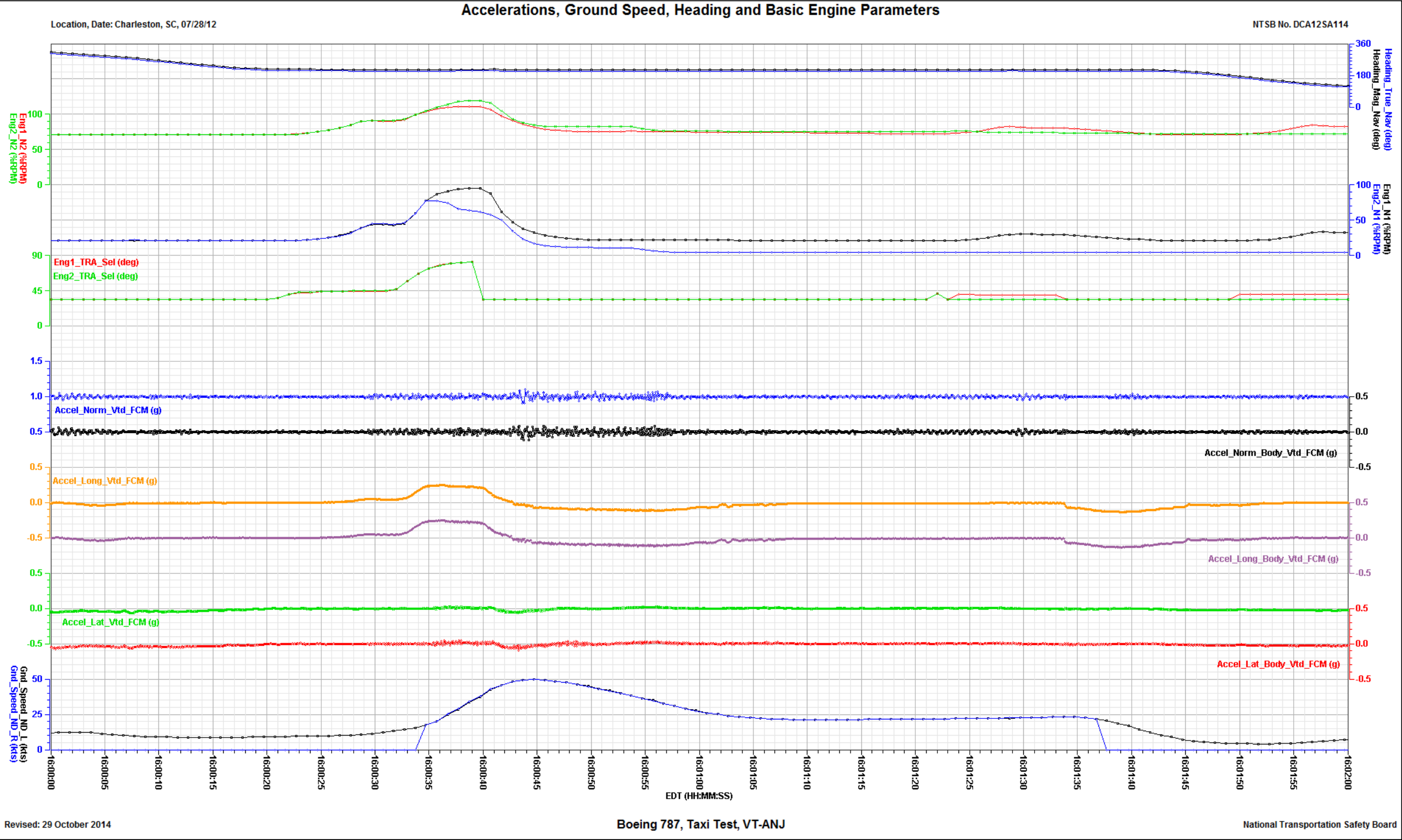


Figure 3 - Left Engine Parameters

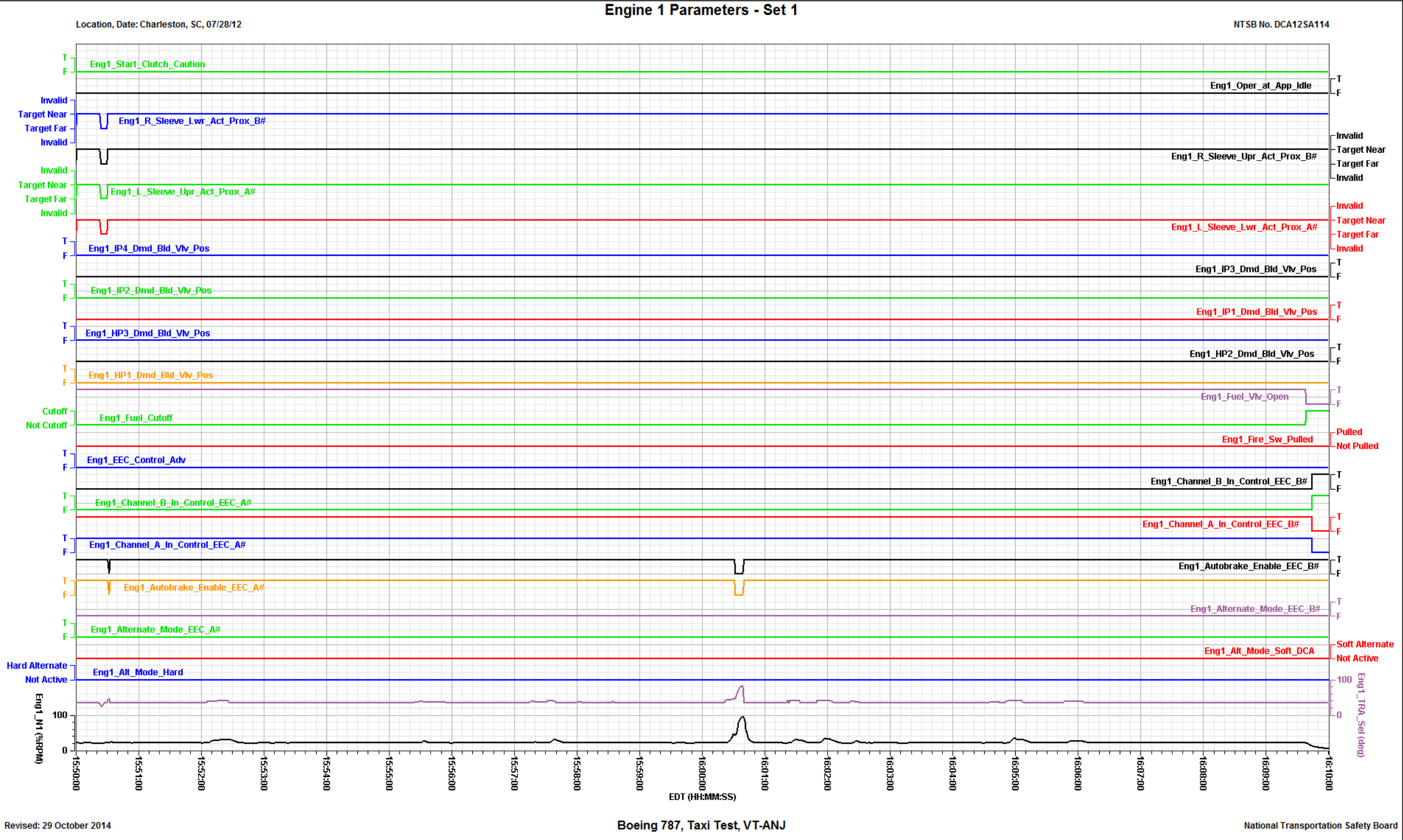


Figure 4 - Left Engine Parameters (cont.)

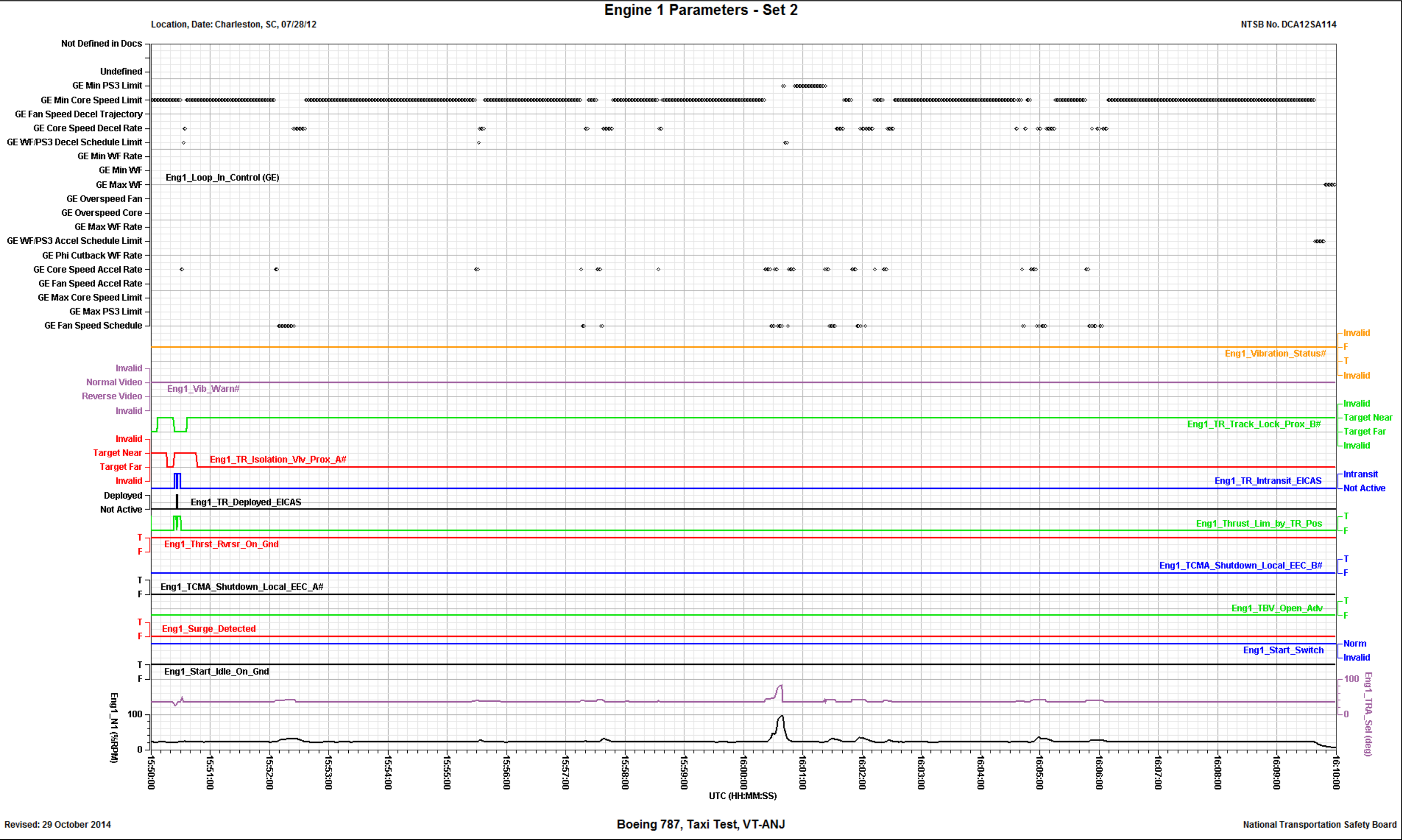


Figure 5 - Right Engine Parameters

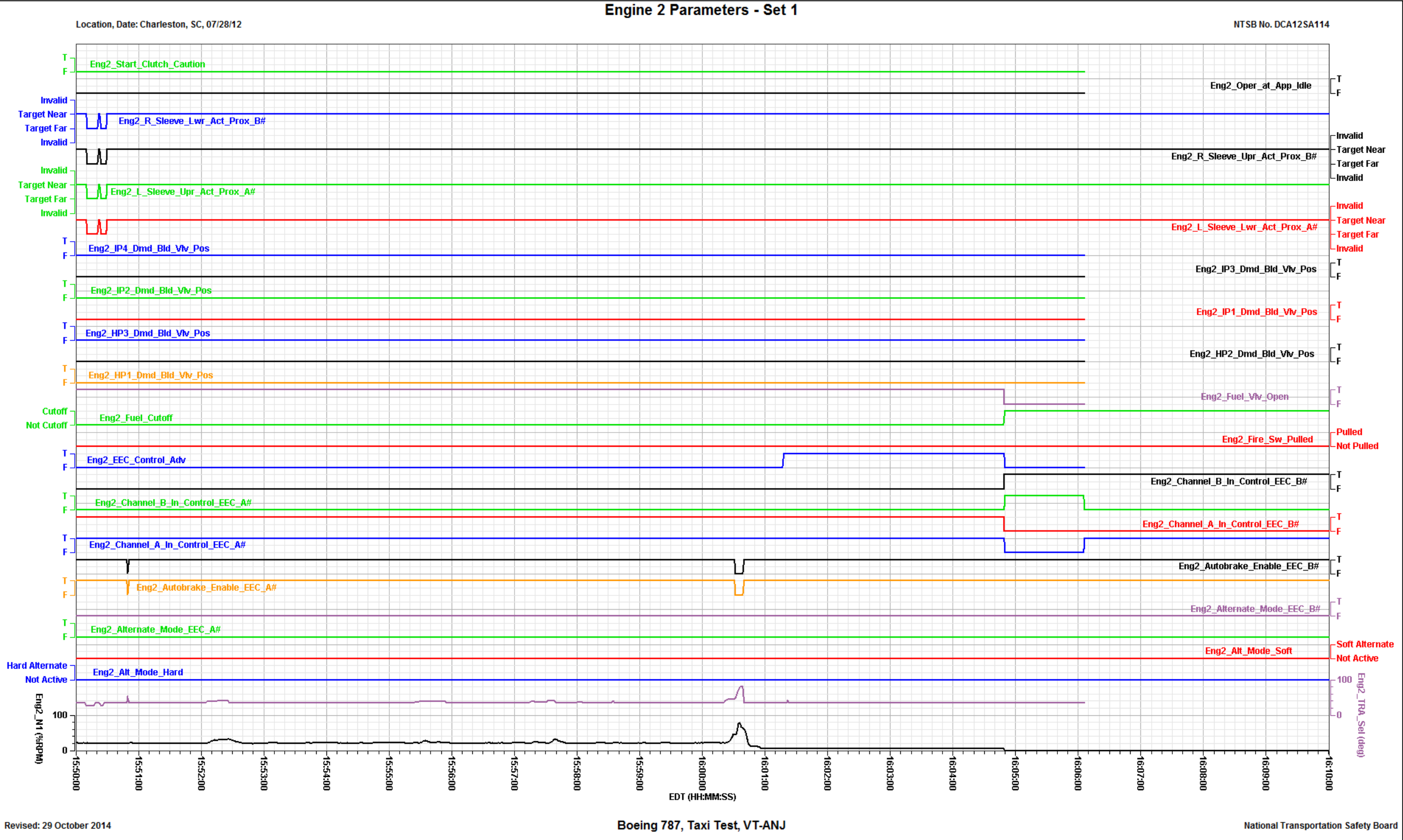
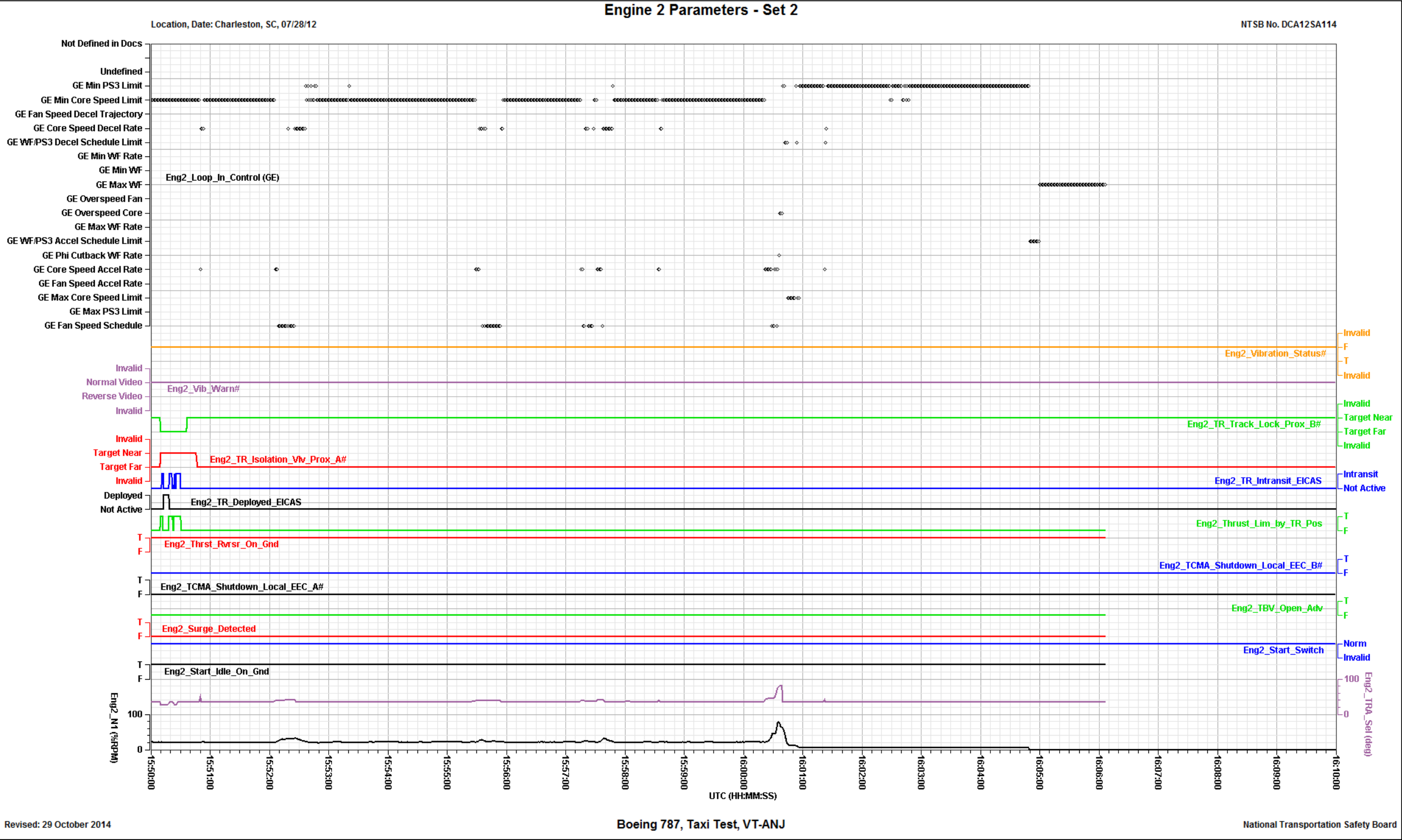
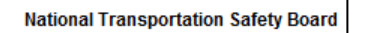


Figure 6 - Right Engine Parameters (cont.)



Source Index Parameters



APPENDIX A

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameters and table A-2 describes the unit abbreviations used in this report.

Table A-1. Verified and provided FDR parameters.

Parameter Name	Mnemonic	Units	Source Index Parameter
Accel Lat Body Vtd FCM	AccLatBody	g	ISM 1 SI
Accel Lat Vtd FCM	AccLatCG	g	ISM 2 SI
Accel Long Body Vtd FCM	AccLongBody	g	ISM 1 SI
Accel Long Vtd FCM	AccLongCG	g	ISM 2 SI
Accel Norm Body Vtd FCM	AccNormBody	g	ISM 1 SI
Accel Norm Vtd FCM	AccNormCG	g	ISM 2 SI
Date Day Nav	DateDayNav	day	NAV SI
Date Mon Nav	DateMonNav	mon	NAV SI
Date Yr Nav	DateYrNav	year	NAV SI
DCAEECL SI	DCAEECL SI		
DCAEECR SI	DCAEECR SI		
DCAEICFCL SI	DCAEICFCL SI		
DCAEICFCR SI	DCAEICFCR SI		
DCAEICFHL SI	DCAEICFHL SI		
DCAEICFHR SI	DCAEICFHR SI		
DCAEICN1L SI	DCAEICN1L SI		
DCAEICN1R SI	DCAEICN1R SI		
DCAEICN2L SI	DCAEICN2L SI		
DCAEICN2R SI	DCAEICN2R SI		
DCANDCAHS SI	DCANDCAHS SI		
DCANDFOHS SI	DCANDFOHS SI		
EEC1 SI	EEC1 SI		
EEC2 SI	EEC2 SI		
Eng1_Alt_Mode_Hard	Eng1AMHard		DCAEECL SI
Eng1_Alt_Mode_Soft_DCA	Eng1AMSoft		DCAEECL SI
Eng1_Alternate_Mode_EEC_A#	Eng1AltModeA		
Eng1_Alternate_Mode_EEC_B#	Eng1AltModeB		
Eng1_Autobrake_Enable_EEC_A#	Eng1ABEnablA		
Eng1_Autobrake_Enable_EEC_B#	Eng1ABEnablB		
Eng1_Channel_A_In_Control_EEC_A#	Eng1CHACtrlA		
Eng1_Channel_A_In_Control_EEC_B#	Eng1CHACtrlB		
Eng1_Channel_B_In_Control_EEC_A#	Eng1CHBCtrlA		
Eng1_Channel_B_In_Control_EEC_B#	Eng1CHBCtrlB		
Eng1_EEC_Control_Adv	Eng1EECAdv		EEC1 SI
Eng1_Fire_Sw_Pulled	Eng1FirePul		DCAEICFHL SI
Eng1_Fuel_Cutoff	Eng1FCOEIC		DCAEICFCL SI
Eng1_Fuel_Vlv_Open	Eng1FuVlvOp		EEC1 SI
Eng1_HP1_Dmd_Bld_Vlv_Pos	Eng1HP1Cmd		EEC1 SI
Eng1_HP2_Dmd_Bld_Vlv_Pos	Eng1HP2Cmd		EEC1 SI
Eng1_HP3_Dmd_Bld_Vlv_Pos	Eng1HP3Cmd		EEC1 SI
Eng1_IP1_Dmd_Bld_Vlv_Pos	Eng1IP1Cmd		EEC1 SI
Eng1_IP2_Dmd_Bld_Vlv_Pos	Eng1IP2Cmd		EEC1 SI
Eng1_IP3_Dmd_Bld_Vlv_Pos	Eng1IP3Cmd		EEC1 SI
Eng1_IP4_Dmd_Bld_Vlv_Pos	Eng1IP4Cmd		EEC1 SI
Eng1_L_Sleeve_Lwr_Act_Prox_A#	Eng1LSlvLwrA		
Eng1_L_Sleeve_Upr_Act_Prox_A#	Eng1LSlvUprA		
Eng1_Loop_In_Control	Eng1Loop		EEC1 SI

Parameter Name	Mnemonic	Units	Source Index Parameter
Eng1 Loop In Control (GE)	Eng1Loop		EEC1 SI
Eng1 N1	Eng1N1EIC	%RPM	DCAEICN1L SI
Eng1 N2	Eng1N2EIC	%RPM	DCAEICN2L SI
Eng1 Oper at App Idle	Eng1OpApIdl		EEC1 SI
Eng1 R Sleeve Lwr Act Prox B#	Eng1RSivLwrB		
Eng1 R Sleeve UpR Act Prox B#	Eng1RSivUpRb		
Eng1 Start Clutch Caution	Eng1SCCaut		EEC1 SI
Eng1 Start Idle On Gnd	Eng1SIOGnd		EEC1 SI
Eng1 Start Switch	Eng1Start		FD SI
Eng1 Surge Detected	Eng1SurgDet		EEC1 SI
Eng1 TBV Open Adv	Eng1TBVOpAd		EEC1 SI
Eng1 TCMA Shutdown Local EEC A#	Eng1TCMASDLA		
Eng1 TCMA Shutdown Local EEC B#	Eng1TCMASDLB		
Eng1 Thrst Rvrsr On Gnd	Eng1TRGnd		EEC1 SI
Eng1 Thrust Lim by TR Pos	Eng1ThrLim		EEC1 SI
Eng1 TR Deployed EICAS	Eng1TRDep		DCAEECL SI
Eng1 TR Intransit EICAS	Eng1TRIntr		DCAEECL SI
Eng1 TR Isolation Vlv Prox A#	Eng1TRIsoVA		
Eng1 TR Track Lock Prox B#	Eng1TRTrkLkB		
Eng1 TRA Sel	Eng1SelTRA	deg	EEC1 SI
Eng1 Vib Warn#	Eng1VibWarn		
Eng1 Vibration Status#	Eng1VibStat		
Eng2 Alt Mode Hard	Eng2AMHard		DCAEECR SI
Eng2 Alt Mode Soft	Eng2AMSoft		DCAEECR SI
Eng2 Alternate Mode EEC A#	Eng2AltModeA		
Eng2 Alternate Mode EEC B#	Eng2AltModeB		
Eng2 Autobrake Enable EEC A#	Eng2ABEanbIA		
Eng2 Autobrake Enable EEC B#	Eng2ABEanbIB		
Eng2 Channel A In Control EEC A#	Eng2CHACtrlA		
Eng2 Channel A In Control EEC B#	Eng2CHACtrlB		
Eng2 Channel B In Control EEC A#	Eng2CHBCtrlA		
Eng2 Channel B In Control EEC B#	Eng2CHBCtrlB		
Eng2 EEC Control Adv	Eng2EECAdv		EEC2 SI
Eng2 Fire Sw Pulled	Eng2FirePul		DCAEICFHR SI
Eng2 Fuel Cutoff	Eng2FCOEIC		DCAEICFCR SI
Eng2 Fuel Vlv Open	Eng2FuVlvOp		EEC2 SI
Eng2 HP1 Dmd Bld Vlv Pos	Eng2HP1Cmd		EEC2 SI
Eng2 HP2 Dmd Bld Vlv Pos	Eng2HP2Cmd		EEC2 SI
Eng2 HP3 Dmd Bld Vlv Pos	Eng2HP3Cmd		EEC2 SI
Eng2 IP1 Dmd Bld Vlv Pos	Eng2IP1Cmd		EEC2 SI
Eng2 IP2 Dmd Bld Vlv Pos	Eng2IP2Cmd		EEC2 SI
Eng2 IP3 Dmd Bld Vlv Pos	Eng2IP3Cmd		EEC2 SI
Eng2 IP4 Dmd Bld Vlv Pos	Eng2IP4Cmd		EEC2 SI
Eng2 L Sleeve Lwr Act Prox A#	Eng2LSivLwrA		
Eng2 L Sleeve UpR Act Prox A#	Eng2LSivUpRA		
Eng2 Loop In Control	Eng2Loop		EEC2 SI
Eng2 Loop In Control (GE)	Eng2Loop		EEC2 SI
Eng2 N1	Eng2N1EIC	%RPM	DCAEICN1R SI
Eng2 N2	Eng2N2EIC	%RPM	DCAEICN2R SI
Eng2 Oper at App Idle	Eng2OpApIdl		EEC2 SI
Eng2 R Sleeve Lwr Act Prox B#	Eng2RSivLwrB		
Eng2 R Sleeve UpR Act Prox B#	Eng2RSivUpRB		
Eng2 Start Clutch Caution	Eng2SCCaut		EEC2 SI
Eng2 Start Idle On Gnd	Eng2SIOGnd		EEC2 SI
Eng2 Start Switch	Eng2Start		FD SI

Parameter Name	Mnemonic	Units	Source Index Parameter
Eng2 Surge Detected	Eng2SurgDet		EEC2_SI
Eng2 TBV Open Adv	Eng2TBVOpAd		EEC2_SI
Eng2 TCMA Shutdown Local EEC A#	Eng2TCMASDLA		
Eng2 TCMA Shutdown Local EEC B#	Eng2TCMASDLB		
Eng2 Thrst Rvrsr On Gnd	Eng2TRGnd		EEC2_SI
Eng2 Thrust Lim by TR Pos	Eng2ThrLim		EEC2_SI
Eng2 TR Deployed EICAS	Eng2TRDep		DCAEECR_SI
Eng2 TR Intransit EICAS	Eng2TRIntr		DCAEECR_SI
Eng2 TR Isolation Vlv Prox A#	Eng2TRIsoVA		
Eng2 TR Track Lock Prox B#	Eng2TRTrkLkB		
Eng2 TRA Sel	Eng2SelTRA	deg	EEC2_SI
Eng2 Vib Warn#	Eng2VibWarn		
Eng2 Vibration Status#	Eng2VibStat		
FD SI	FD_SI		
Gnd Speed ND L	GndSpdNDL	kts	DCANDCAHS_SI
Gnd Speed ND R	GndSpdNDR	kts	DCANDFOHS_SI
Heading Mag Nav	HdgMagNav	deg	NAV_SI
Heading True Nav	HdgTrueNav	deg	NAV_SI
ISM 1 SI	ISM_1_SI		
ISM 2 SI	ISM_2_SI		
Key VHF C Capt#	KeyVHFCCapt		
Key VHF C FO#	KeyVHFCFO		
Key VHF C Obs#	KeyVHFCFObs		
Key VHF L Capt#	KeyVHFLCapt		
Key VHF L FO#	KeyVHFLFO		
Key VHF L Obs#	KeyVHFLObs		
Key VHF R Capt#	KeyVHFRCapt		
Key VHF R FO#	KeyVHFRFO		
Key VHF R Obs#	KeyVHFRObs		
NAV SI	NAV_SI		
Time UTC Hr Nav	UTCHrNav	hour	NAV_SI
Time UTC Min Nav	UTCMinNav	min	NAV_SI
Time UTC Sec Nav	UTCSecNav	sec	NAV_SI

NOTE: Parameters with no unit description are discrete parameters. A discrete parameter 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.

Table A-2. Unit abbreviations.

Units Abbreviation	Description
deg	degrees
kts	knots
g	g
day	day of month
mon	month
year	year
hrs	hours
min	minutes
sec	seconds
%RPM	percent revolutions per minute