NATIONAL TRANSPORTATION SAFETY BOARD

November 6, 2002

Performance Study

A. ACCIDENT: DCA02MA054

Location: Tallahassee, FL
Date: July 26, 2002
Time: Approximately 05:37 Local (9:37 UTC)
Airplane: FedEx, N497FE

B. GROUP IDENTIFICATION:

The Vehicle Performance group members were:

Chairman: Dennis Crider
National Transportation Safety Board
Washington, DC

Member: Kevin Renze
National Transportation Safety Board
Washington, DC

Member: Captain Grover Trask
Federal Express
Memphis, TN

Member: Corey Stephens[1]
Air Line Pilots Association
Herndon, VA

C. SUMMARY

On July 26, 2002, at approximately 0537 EDT, a Boeing B-727-232, N497FE, operating as FedEx flight 1478, crashed into trees on short final approach to runway 9 at the Tallahassee Regional Airport (TLH), Tallahassee, Florida. The flight was operating under provisions of Title 14 Code of Federal Regulations Part 121, as a scheduled cargo flight from Memphis, Tennessee (MEM) to TLH. Night visual meteorological conditions prevailed at the time of the accident. The three flight crewmembers were injured, two seriously, and the aircraft was destroyed by impact and resulting fire.

[1] Mike Huhn substituted for Corey Stephens for fieldwork conducted July 28th 2002. Corey is the performance group member signing for Air Line Pilots Association (ALPA).

D. DETAILS OF INVESTIGATION

Ground Evidence

A swath of broken trees was found aligned with runway 9, the intended landing runway. A ground scar began near the edge of the forest and bent to the southeast towards the main wreckage location (figure 1).

Figure 1: Accident site looking east

Figure 2 shows the view looking west (away from the runway and toward the foreground forest in figure 1) at the broken tree swath. As can be seen, height of the tree breaks on the trees on the south side of the swath are lower than the tree breaks on the north side of the swath on the east end (towards the runway) of the path. This also can be seen in figure 3 which shows an aerial view of the tree swath looking west, away from the runway.

Figure 2: tree swath looking west

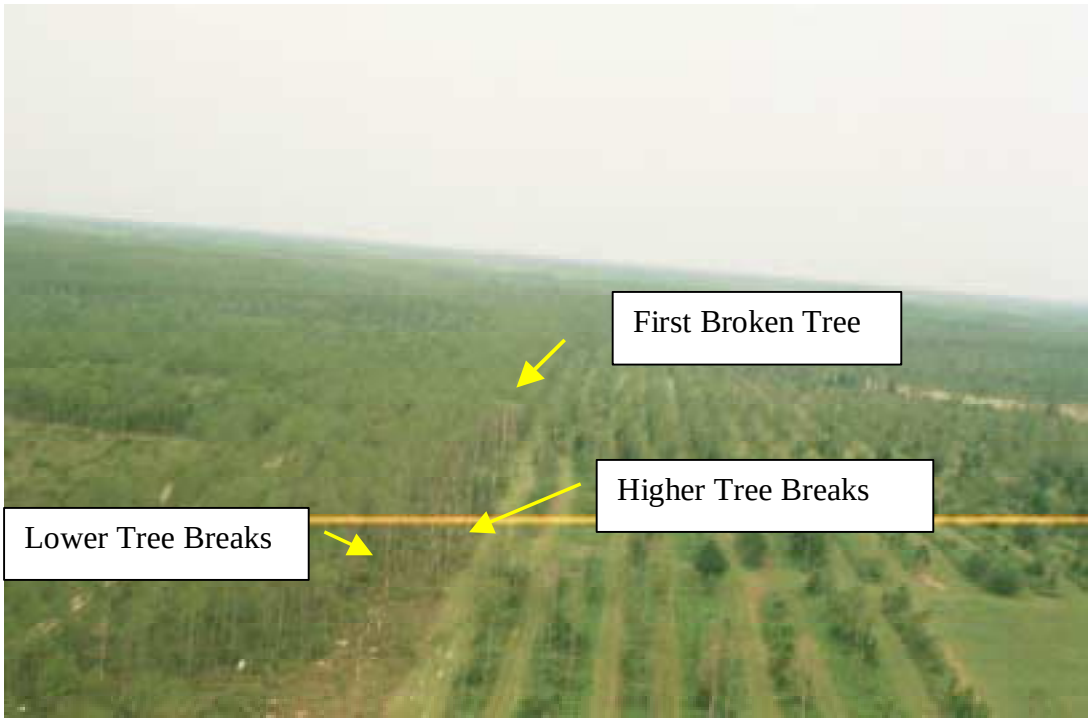


Figure 3: aerial view of tree swath

The Federal Bureau of Investigation (FBI) produced a high precision survey of the accident site for the National Transportation Safety Board's structures group[2]. The performance group also performed a site survey. Positions from both of these surveys are superimposed on an aerial picture of the airport in figure 4. Note that the photo does not include recent changes to the airport such as the construction off the East end of runway 9.

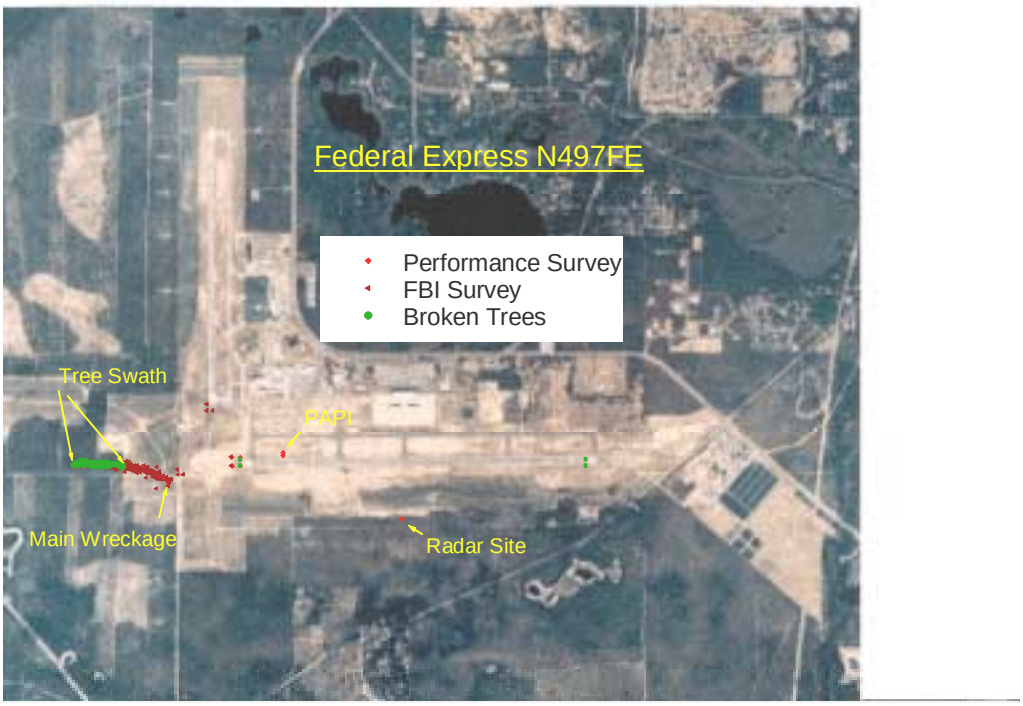


Figure 4: Survey Positions

[2] See Structures Group Chairman's factual report for more information

Radar Data

Radar range and azimuth data for the accident flight were obtained from the Federal Aviation Administration. These data were converted to rectangular coordinates using the RadarBox program. The following radar antenna information was used in this conversion.

Radar Antenna Location: 30:23:15.68 N, 84:20:41.15 W
Magnetic Variation: 3 deg West
Antenna height: 72 ft base + 67 ft tower = 139 ft MSL

The uncorrected radar data are used to show the aircraft's approach to runway 9 in figure 5. This figure also shows the runway position from the airport layout plan and points from the wreckage site surveys.

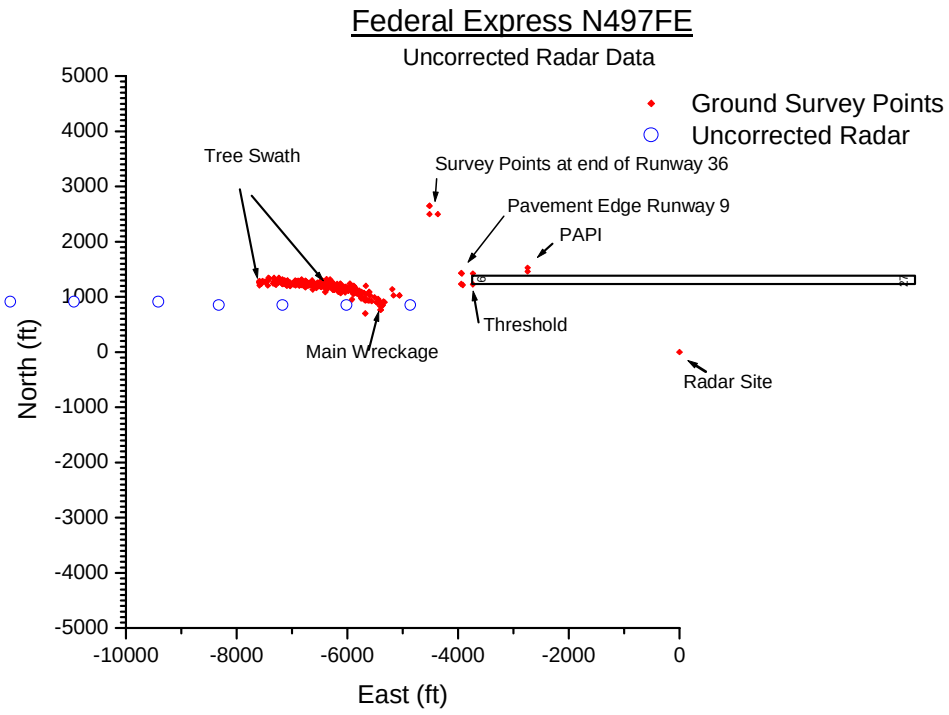


Figure 5: Uncorrected Radar

As can be seen in Figure 5, the uncorrected radar data places the last radar point past the main wreckage location. Further, the uncorrected radar path is south of the actual path as recorded by the broken tree swath. These inconsistencies require that the radar data be corrected to account for those differences. Since the radar path was aligned with the runway, the azimuth data did not require correction. It was concluded that the radar

range data were incorrect[3]. A range offset of 2400 ft was required to bring the radar path to the actual path. The corrected radar data, which provides a consistent match between radar data and ground survey data, are plotted in Figure 6.

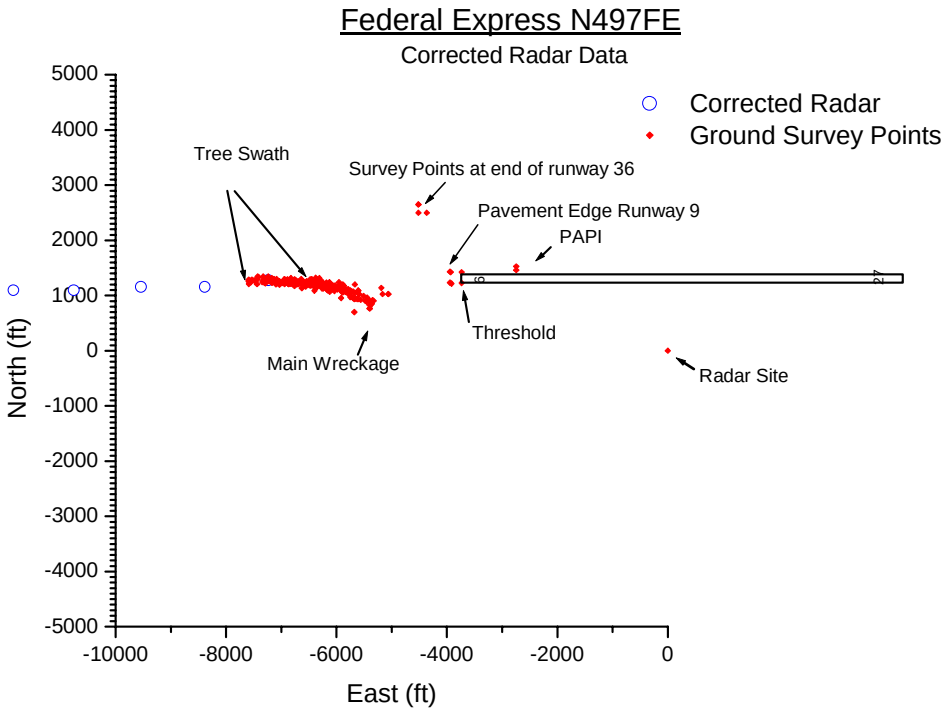


Figure 6: Corrected Radar Data

An expanded view of the radar data showing the turn to final is shown in Figure 7.

[3] See Appendix A for additional information on radar test to investigate the radar range offset.

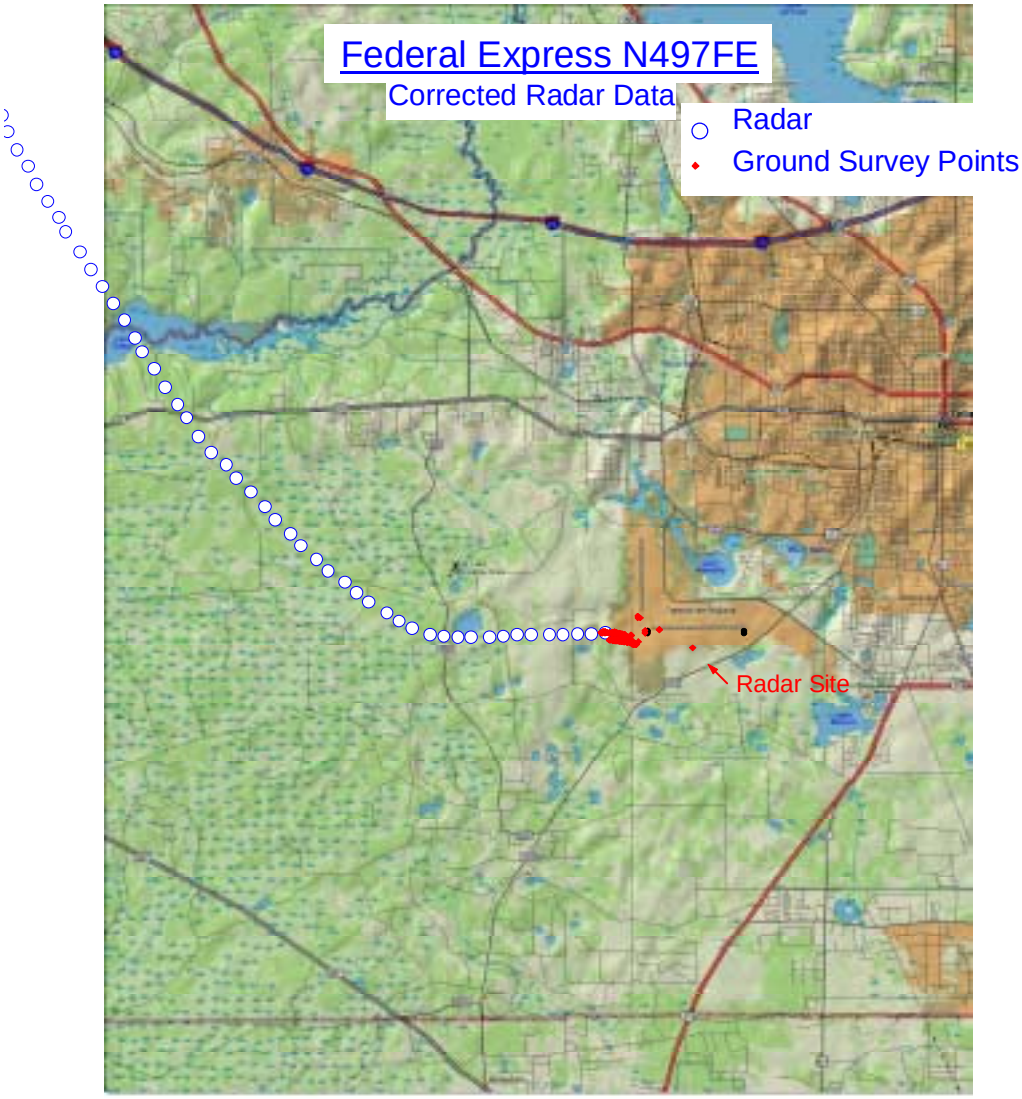


Figure 7: Expanded Scale Corrected Radar

Radar data were synchronized with the flight data recorder (FDR) data by aligning the pressure altitude. This resulted in the following time correction:

FDR elapsed time = Radar time - (34516.04 - 7072), in seconds

where radar time is UTC time recorded by the radar converted to seconds past midnight. In addition, by examining periods of level flight, it was found that the radar pressure altitude was 100 ft higher than the altitude recorded by the flight data recorder. Accordingly, 100 ft was subtracted from the radar pressure altitude to match the FDR[4]. The synchronized and corrected radar pressure altitude time history is shown in figure 8.

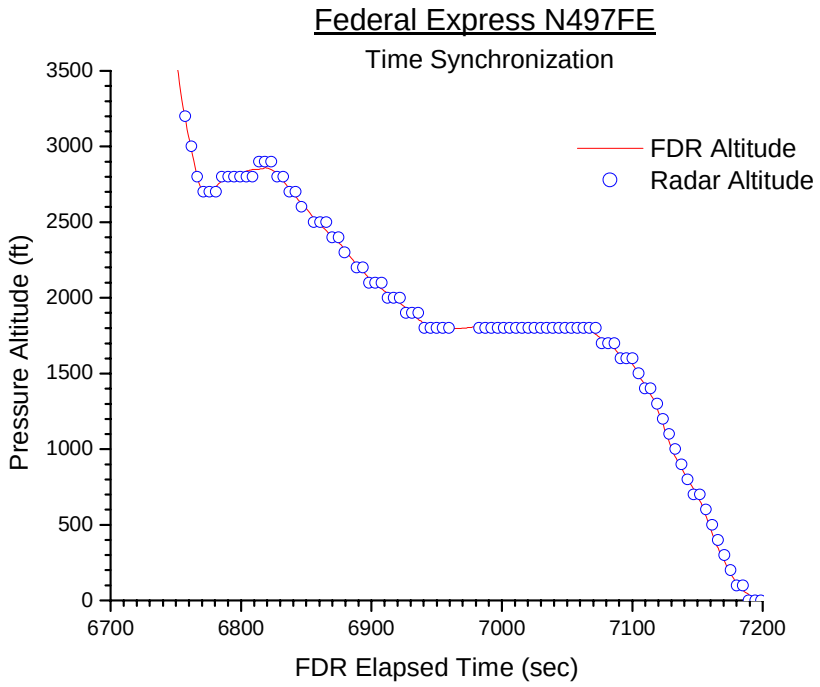


Figure 8: Pressure Altitude Time synchronization

Pressure altitude is based on a standard altimeter setting of 29.92 (in. Hg.) Mean sea level altitude can be derived from pressure altitude by adjusting the altitude to the accident altimeter setting of 30.10 (in. Hg.) Mean sea level (MSL) altitude is plotted together with radio altitude in figure 9.

[4] Radar altitude (which is only recorded to the nearest 100 ft) has shown this offset on other accident/incidents. Further, the MSL altitude derived from FDR altitude matches the crash site.

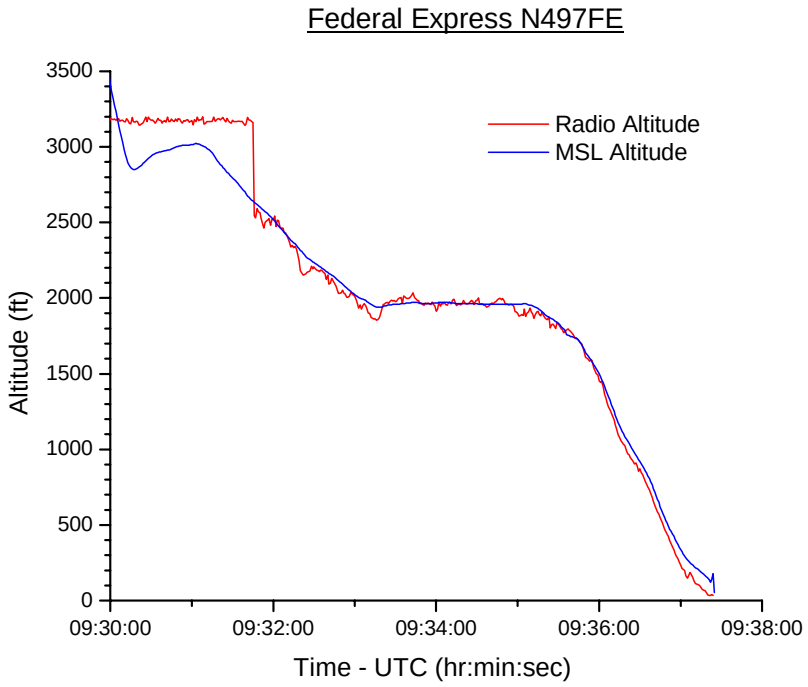


Figure 9: MSL and Radio altitude

Flight Path Integration

With the radar and FDR synchronized, data from the FDR was integrated with Kinsurf to determine the flight path to a higher resolution than from the radar data alone. The integration started from the last radar point at 1800 ft before the final descent. This point occurred at FDR elapsed time 7072 seconds when the corrected radar data shows the airplane at -38644 ft East, 15190 ft North (relative to the radar antenna).

A flight path integration is dependent on angle of attack and sideslip. These quantities are typically (when not recorded) derived from an aerodynamic model. The aerodynamics for a 727-200 was approximated with a 737-200 using scaled input[5]. Initially, the input aircraft weight was factored down by multiplying by the ratio of the wing area of a 737-200 to the wing area of a 727-200. However, a further reduction in input weight to 50000 lb was necessary to match the radar integrating the flight path using the 737-200 aerodynamic model. Radar was matched with an East position vs. time plot and a North position vs. time plot. These plots are shown in figures 10 and 11. An offset of 6.0 degrees was subtracted from FDR magnetic heading to obtain true heading for the integration (3 degree magnetic variation and an instrument offset (see figure 15)). Further it was found that the integrated data with the original wind estimate showed a slower ground speed than the radar. Accordingly, a tail wind component was

[5] At this writing the National Transportation Safety Board does not have an aerodynamic model 727.

added to get the integrated path through the radar data at the correct times. The winds required for the match are summarized in the following table.

Winds for Integration

Time (UTC)	WIND DIRECTION (DEG)	WIND VELOCITY (KTS)
9:35:16	270	10
9:35:34	270	10
9:35:44	270	15
9:36:34	240	12
9:36:59	260	15
9:37:19	270	17
9:37:24	160	6

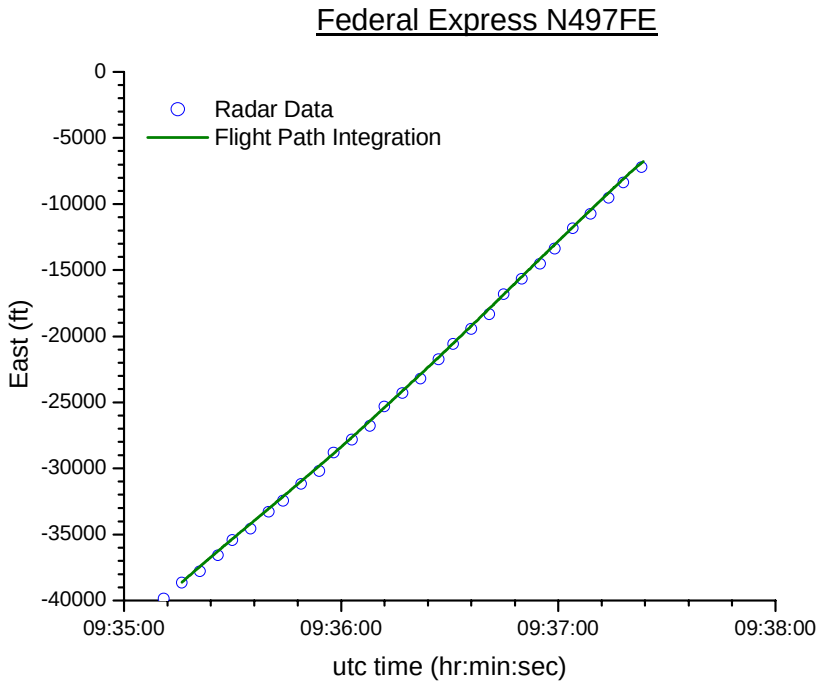


Figure 10: East position match

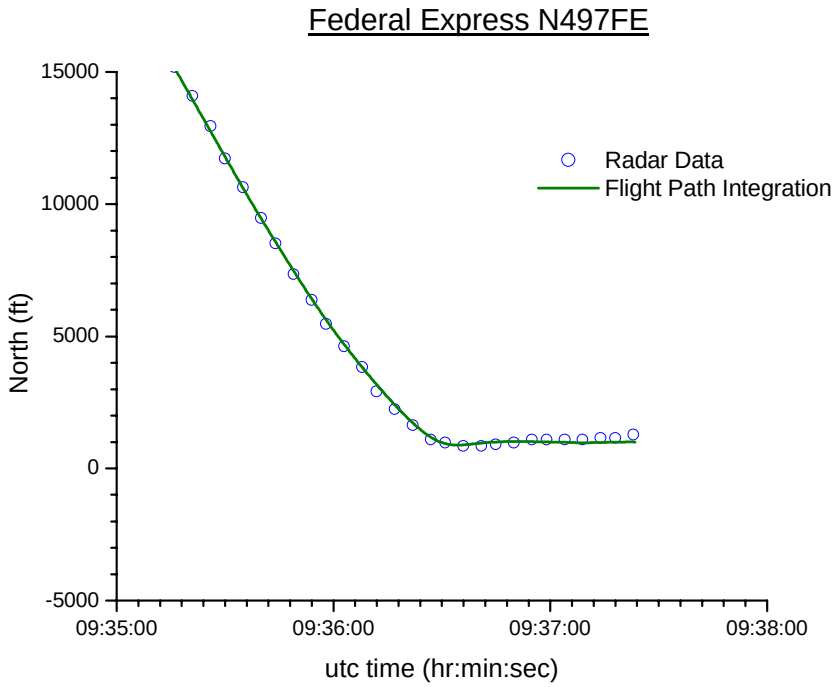


Figure 11: North position match

The integrated flight path is compared with corrected radar with MSL altitude in figure 12.

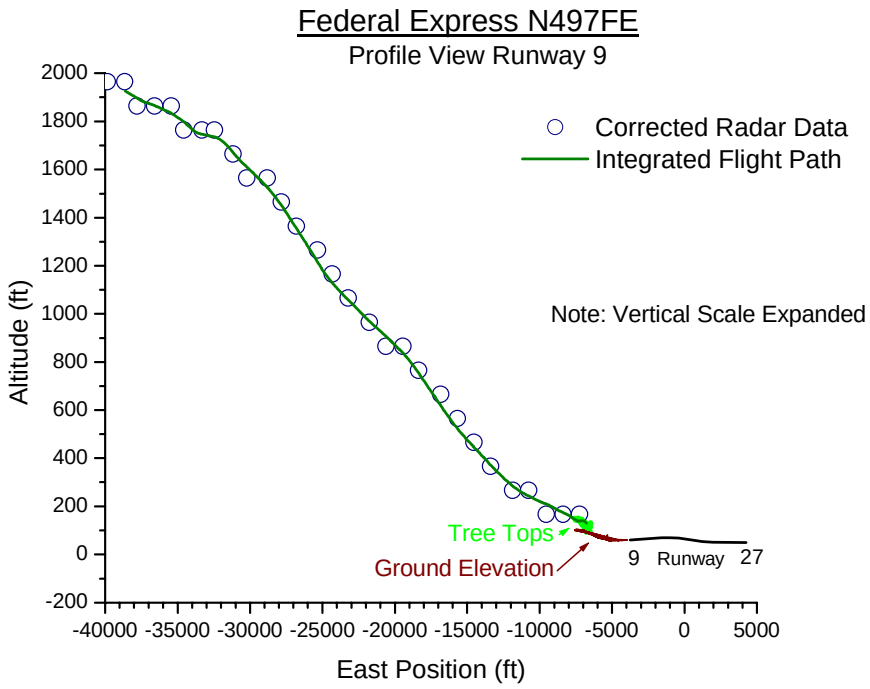


Figure 12: Altitude match

Because the accident occurred before daybreak, the only aid for the approach to runway 9 was a PAPI light system. When the aircraft is within 10 arc minutes of a 3-degree glide slope, the pilot will see 2 red and 2 white PAPI lights. When the aircraft is between 10 arc minutes and 30 arc minutes below the glide slope, the pilot will see 3 red and 1 white light. When the pilot is more than 30 arc minutes below the glide slope, the pilot will see 4 red lights[6].

The regions for the PAPI light combinations are compared to the integrated flight path in figure 13. Figure 13 also includes the Obstacle Clearance Surface (OCS)[7] for the Tallahassee airport.

[6] Ref: AC150/5345-28D Precision Approach Path Indicator (PAPI) systems, May 23rd, 1985, the operating tolerance is +/- 6 arc minutes for each light unit.

[7] A PAPI OCS is established to provide a clearance over obstacles on the approach. See AC 150/5345-28D pg 12

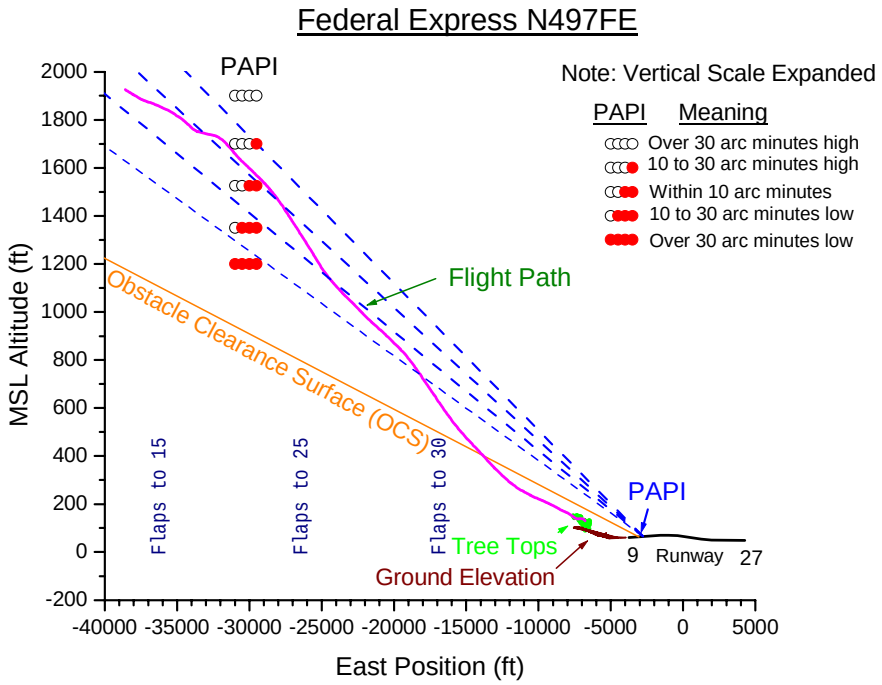


Figure 13: Glide slope

FDR & Derived Data

Recorded control wheel position is plotted together with bank angle in figure 14. A second version of the plot focusing on the last seconds of the flight is presented in figure 15.

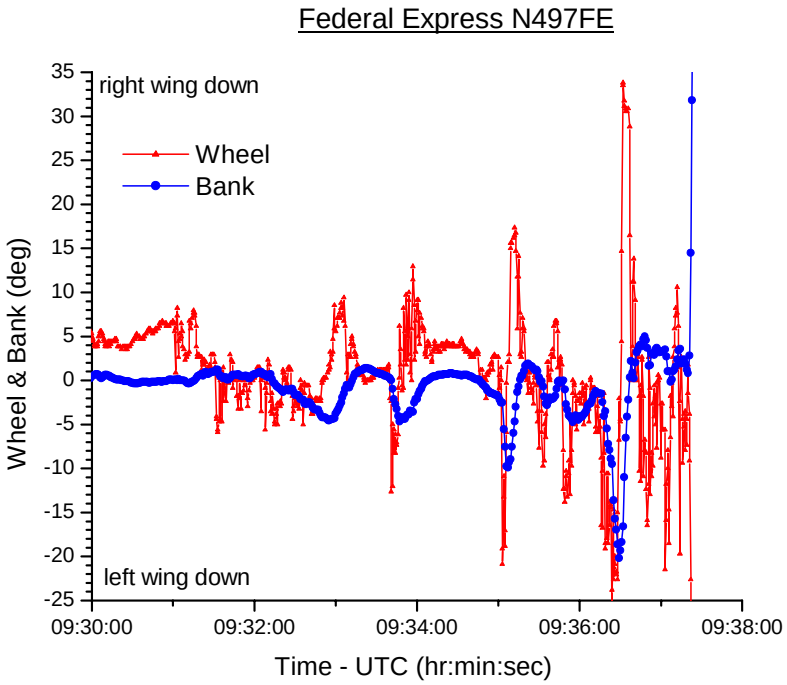


Figure 14: Wheel & Bank

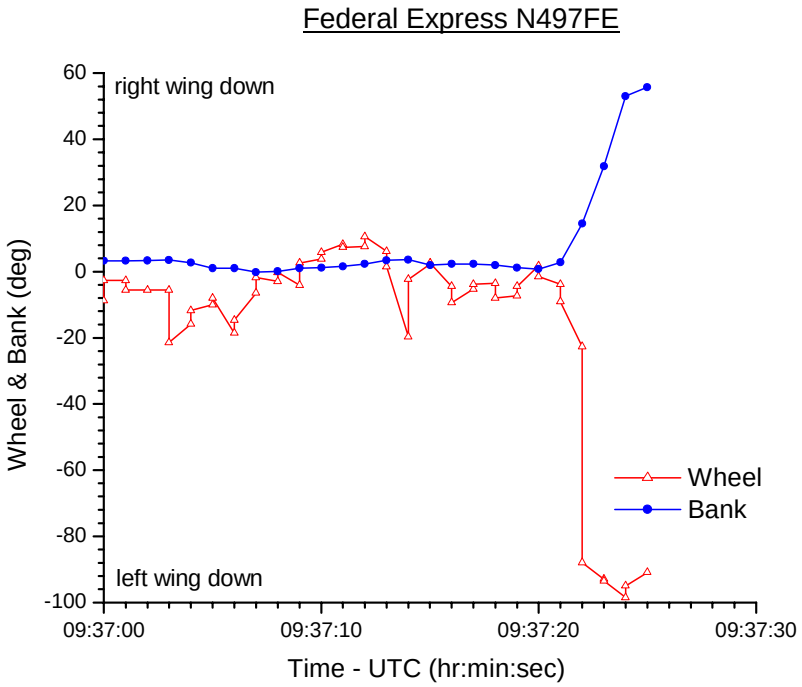


Figure 15: Wheel & Bank (last seconds)

Recorded magnetic heading is plotted in figure 16.

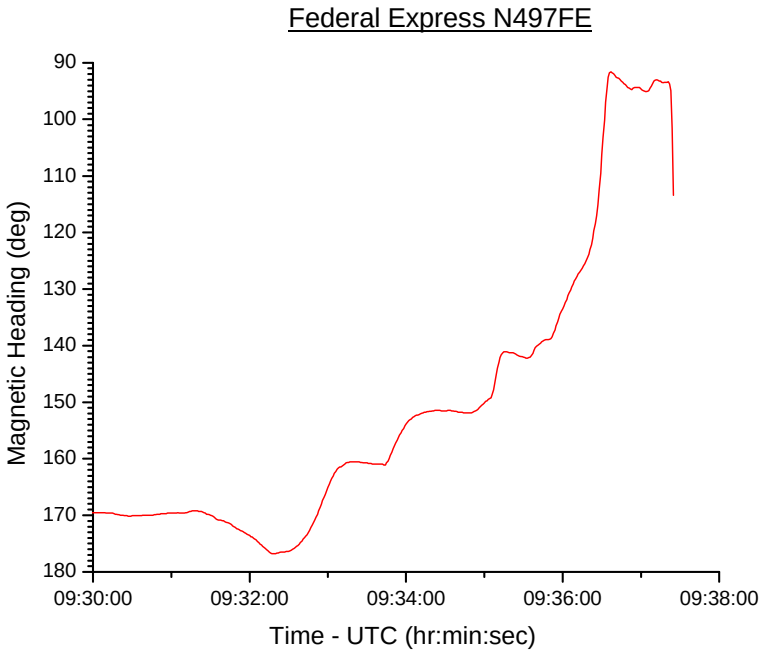


Figure 16: Magnetic heading

Recorded pedal & rudder surface position is plotted in figure 17. A second version of the plot focusing on the last seconds of the flight is presented in figure 18.

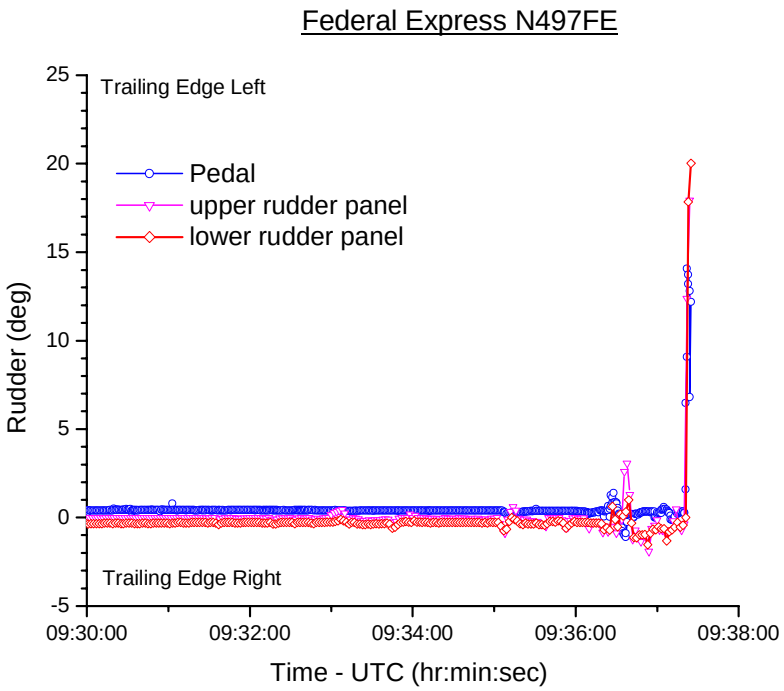


Figure 17: Rudder & Pedal

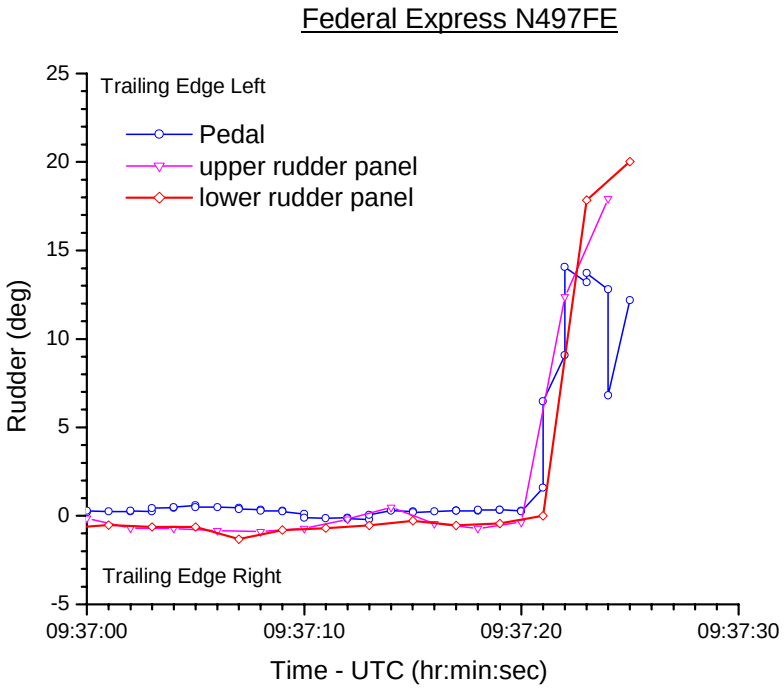


Figure 18: Pedal & Rudder (final seconds)

Recorded pitch angle is plotted together with recorded control column, stabilizer incidence and flap position in figure 19. A second version of the plot focusing on the last seconds of flight is presented in figure 20.

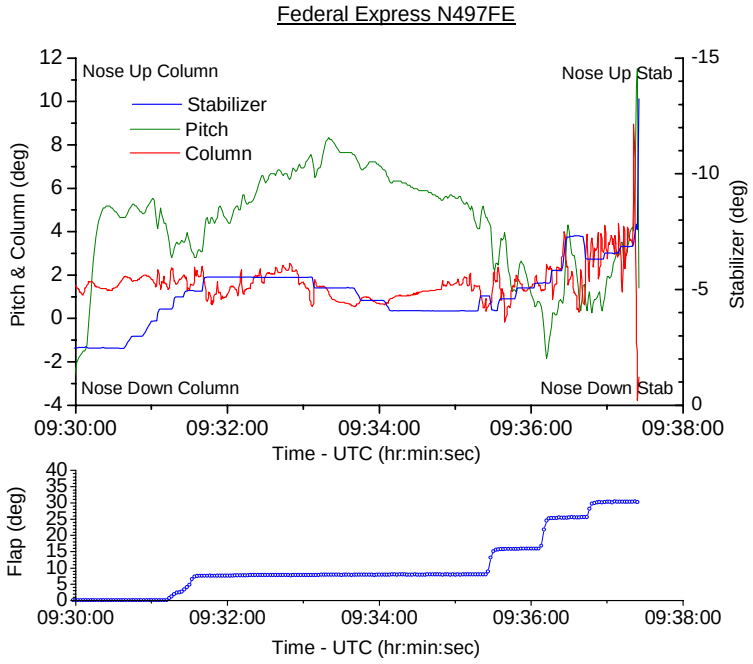


Figure 19: Pitch and control effectors

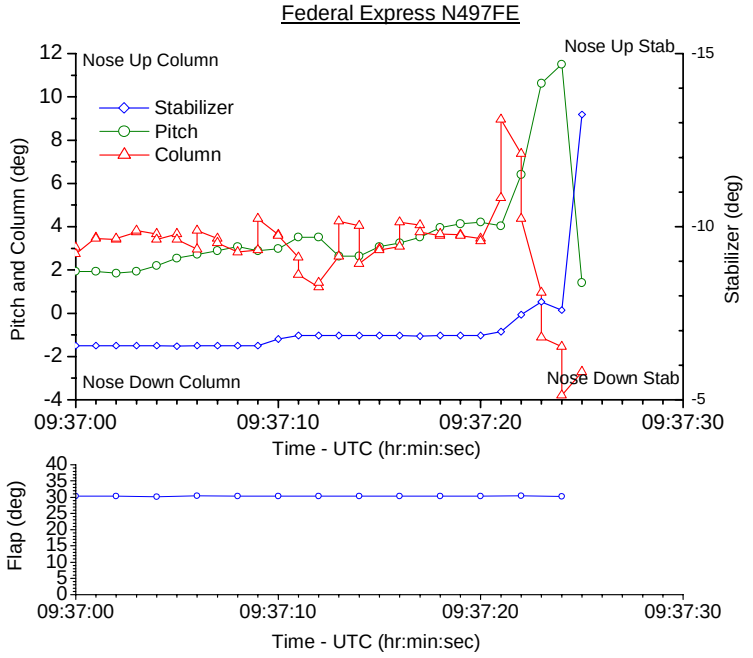


Figure 20: Pitch and control effectors (final seconds)

Recorded vertical, longitudinal and lateral load factors are plotted in figure 21. A second version of the plot focusing on the last seconds of the flight is presented in figure 22.

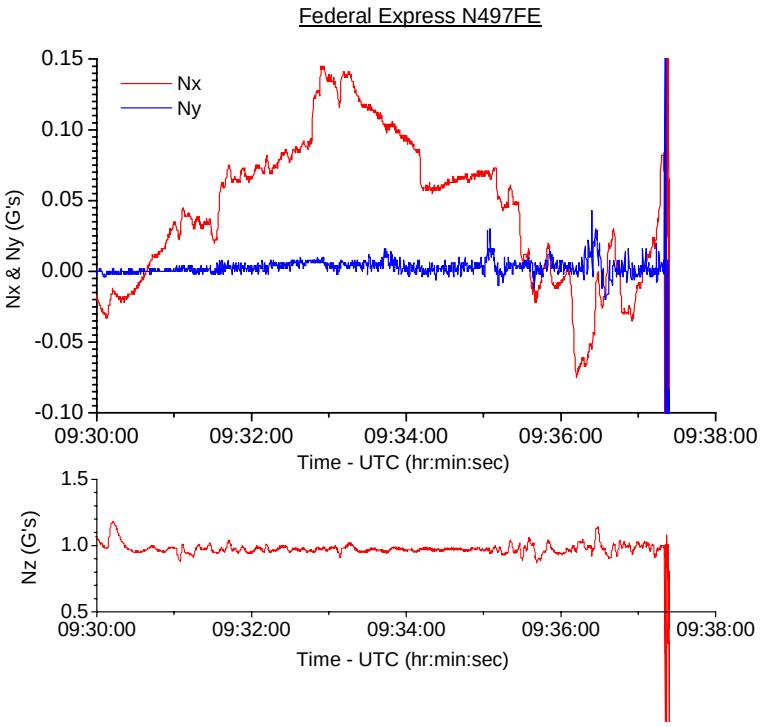


Figure 21: Load factors

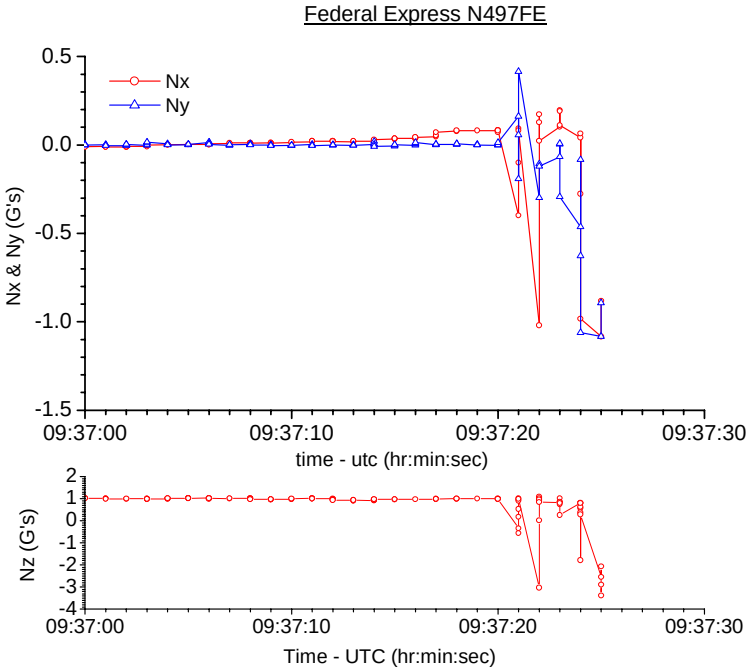


Figure 22: Load factors (last seconds)

Recorded Engine Pressure Ratios (EPR) for the three engines in plotted in figure 23 while recorded calibrated airspeed is plotted in figure 24.

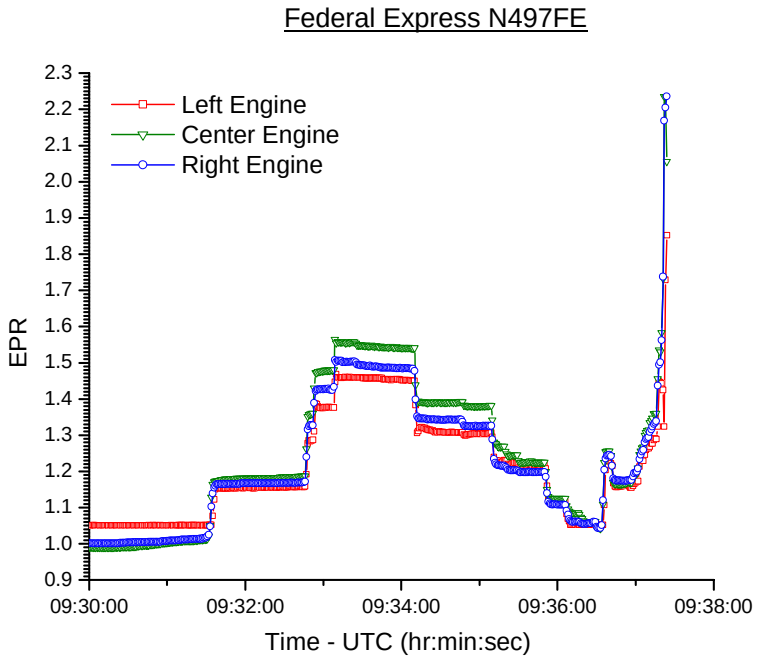


Figure 23: EPR

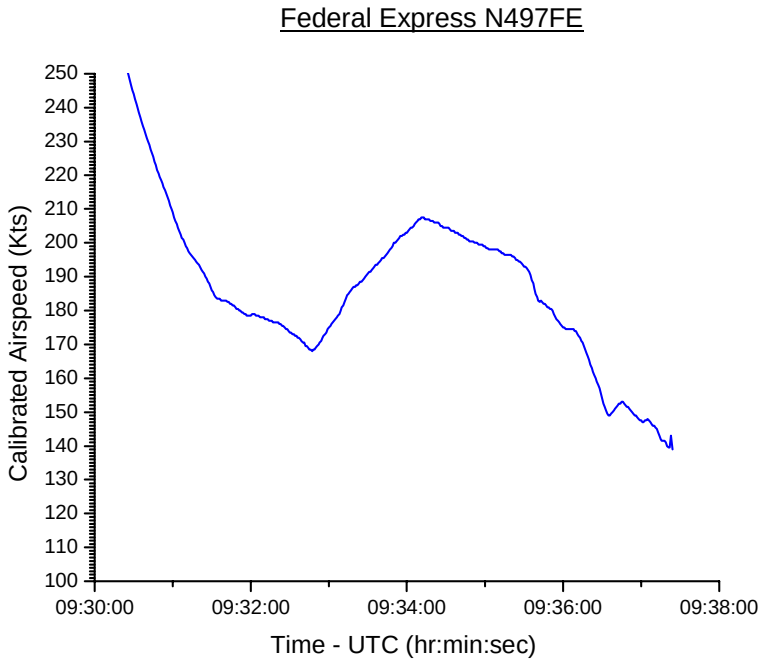


Figure 24: Calibrated airspeed

Descent rate for the approach was calculated from MSL altitude taking the slope from 2 seconds after to 2 seconds before the time of interest. The resulting descent rate is shown in figure 25.

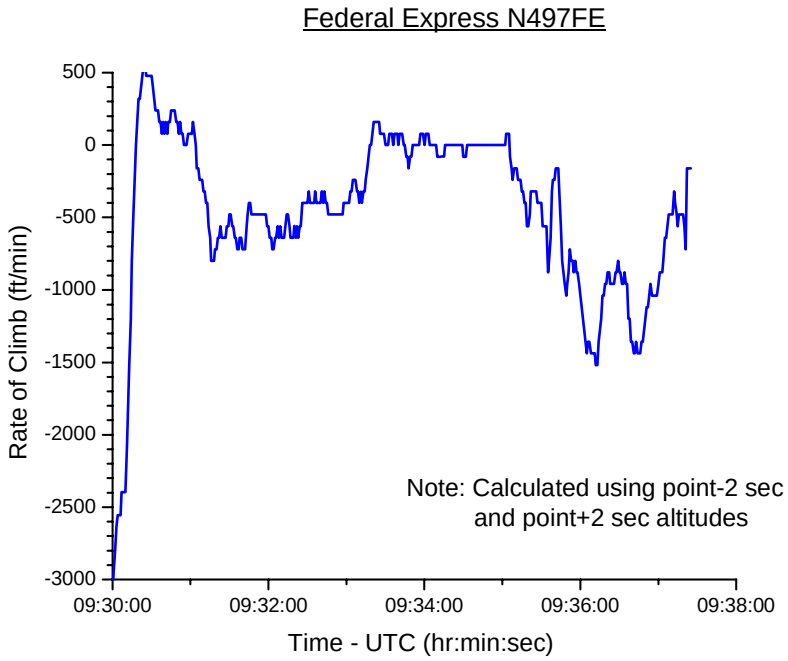


Figure 25: Rate of Climb

FDR Data on Profile View

Airspeed and EPR from the FDR were mapped into East position from the integration to allow comparison of these parameters to the position during the approach. Airspeed is plotted with the flight descent profile in figure 26. EPR is plotted with the flight descent profile in figure 27.

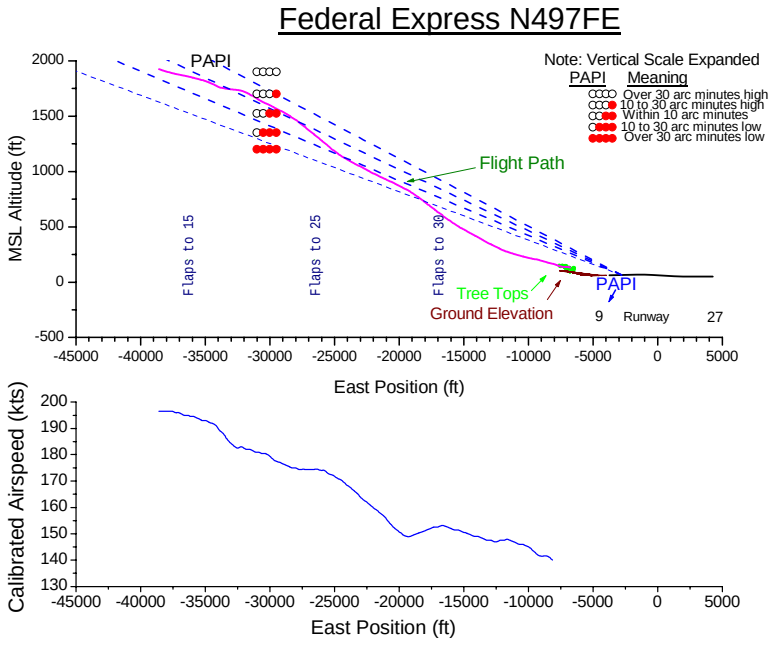


Figure 26: Flight Profile Airspeed Comparison

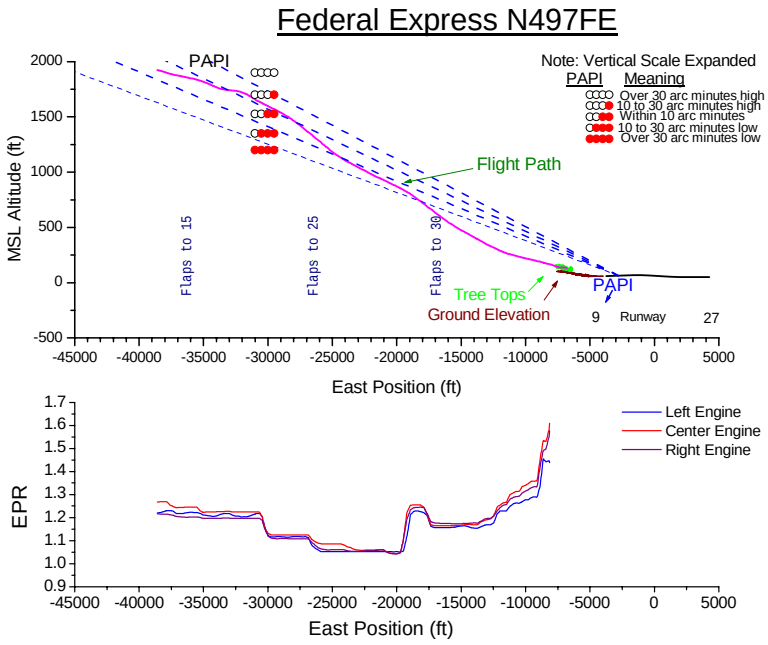


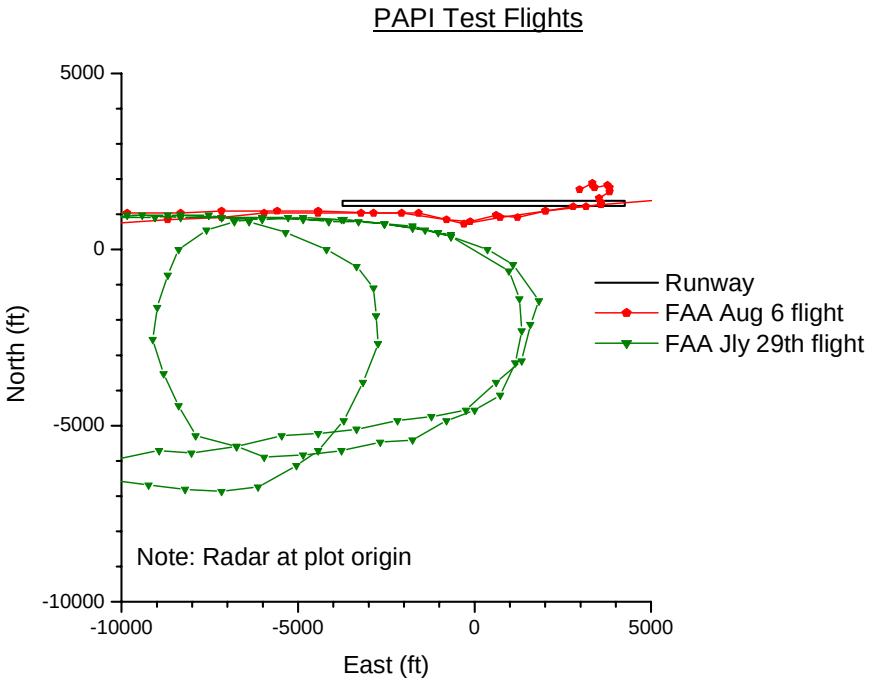
Figure 27: Flight Profile EPR Comparison

Dennis Crider
National Resource Specialist
Aircraft Simulation

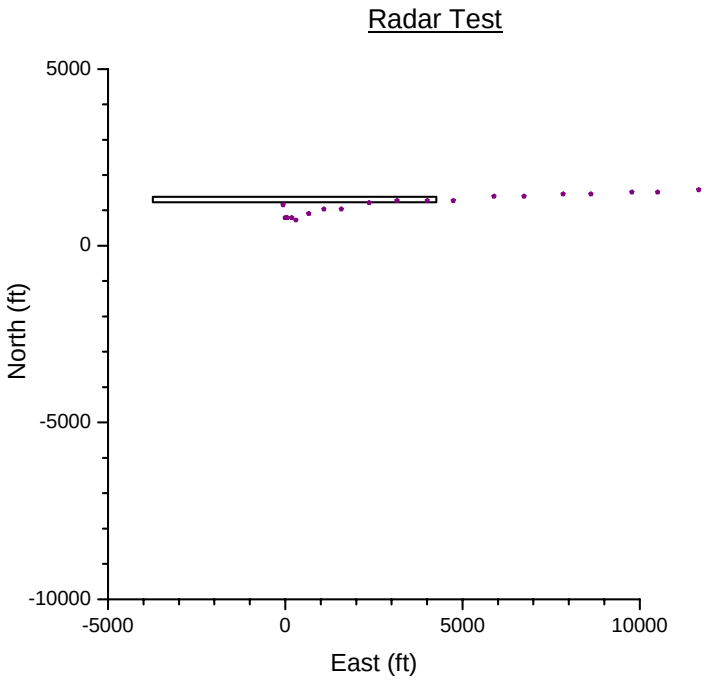
Appendix A
Radar Test

To investigate the repeatability of the range offset seen in the accident radar data, the FAA provided the NTSB with radar data for both the July 29th and August 6 PAPI flight test. As can be seen, the July 29th flight shows two approaches to runway 9. The radar records both approaches about the same distance south of the runway centerline as the uncorrected accident radar data. Similarly, the August 6th test shows two approaches to runway 9 south of the runway centerline. The second approach appears to be a full landing with a return to the ramp.

Radar returns consist of an azimuth and a range to a target. Consistent with the accident radar data, the south shift in the flight path in these flights indicates a correct azimuth but an incorrect range. The range offset of the same magnitude seen in the accident flight.



As a further diagnostic, the FAA provided the Safety Board with radar for an aircraft (a Dash 8) landing on runway 27. These data are shown below. Note that the radar antenna is at the origin for this plot. The bend of the recorded flight track towards the antenna near the end of the track is again consistent with a range offset.



Appendix B
Aircraft Accident Information Sheet

General

Accident #:	DCA02MA054
NTSB Keys #:	55303
Airline:	FedEx Express
Flight #:	1478
Date:	July 26, 2002
Location:	KTLH (Tallahassee, Florida)
Time (local):	5:37 a. m. (approximately)
Time (UTC):	0937z (approximately)
Equipment:	B727-200
Incident/accident description:	Tree/ground strike short of KTLH runway 9. Followed by ground fire.
Crew (total/injured/fatal):	3 crew injured
Passengers (total/injured/fatal):	None, cargo flight
Aircraft damage:	Total loss. Right wing disintegrated over 2100' interval. A/C burned on ground.

Aircraft History

Aircraft Model #:	B727-200
Line #:	1067
Registration #:	N497FE
Date manufactured:	1 September 1974
Engine make/model:	Pratt and Whitney JT8D-15 (1 & 2) JT8D-15A (3)
Ownership history:	TAP/Delta 1974 - 1990. FedEx 1990 - present

Aircraft Technical Data

Flight segment:	Landing
Altitude:	Below 1000'
Airspeed/Mach:	Vref 137, Vapp 147, F15 152, F5 162, F2 192, F0 202 (assumed WT = 159.0 k lbs)
Flaps:	30
Gear:	Down
Takeoff Weight & CG (aircraft load sheet):	172.2 17.2
Zero Fuel Weight & CG	140.0 17.8
Landing Weight & CG:	159.0

Location Information

Originating Airport:

ID:	KMEM
Time of Departure:	Out: 0824 Takeoff: 0836
Altimeter Setting:	30.02
Departure runway:	17
Wind/temp/dew point	170 at 9 knots magnetic/26/22C
Visibility	10NM Clear

Accident Site:

Altimeter Setting:	30.10
Lat/Long:	N30-23.401 W088-21.706
Elevation:	72’
General heading of wreckage distribution:	270
Winds/temp/dew point:	120 at 6 knots magnetic/22C/22C

Altitude (ft MSL)	Wind (True heading/knots)
1000	180/5
2000	230/10
3000	220/15

Destination Airport:

ID:	KTLH
Altimeter Setting:	30.10
Intended approach / landing runway:	Visual approach to RWY 9

Environment

Time of day of accident (day/dusk/night/etc):	Night, 95% trailing moon
IMC (y/n):	N
Visibility:	9 NM
Turbulence:	Reported by crew during interview.
Storms:	None
Precipitation:	None
Icing Potential:	None
Fog Potential	Yes, temperature and dew point were 22C. None reported.

DFDR Specific Items

Make / Model of DFDR / CVR / DFDAU:	Allied Signal Model SS UFDR, recorder removed same day as accident
Flight Itinerary:	KMEM – KTLH followed by crew rest.

For the flight prior to the accident flight, identify:

Originating Airport:

ID:	KFSD
Altimeter setting:	
Time of Departure:	
Departure runway:	

Destination Airport:

ID:	KMEM
Altimeter setting:	30.03
Time of Landing:	0443Z
Intended approach/landing runway:	35
Wind/temp/dew point	190 at 7 knots magnetic/28/25C
Visibility	Clear

Appendix C
Tabular Site Data and Calculations

The data from the performance group survey conducted on July 27th are summarized in the following tables. Note, the group only recorded minutes of latitude and longitude as the degrees latitude and longitude remained 30 North and 84 West, respectively, for all measurements.

GPS Location Description	Angle	Distance	Height	X (along path)	Y
Main Wreckage nose (sample 1)					
Main Wreckage nose (sample 2)					
Reference height	5.833333333	0			
Origin				0.00	0
Tree 1	29	61.70833333	40.03882106	0.00	-15
Tree 4	27.5	61	37.58792342	54.92	8
First Row (TREE 1)	25	59.33333333	33.50092105	156.42	-21
First Row (TREE 2)	28	57.5	36.40662566	156.42	64.83333333
2nd Row (Tree 1)	25	49	28.68240859	286.42	-24.33333333
2nd Row (Tree 2)	21.5	55	27.4984095	286.42	26.25
3rd Row (Tree 1)	25.5	52	30.63606104	394.42	-18.16666667
3rd Row (Tree 2)	19	53	24.08269684	394.42	12.41666667
Gap between surveys (to last of wings level)	26	40	25.34263688	458.42	0
Tree by Kevin in photo 20				708.42	
Tree by Grover in photo 20				837.42	
Beginning of ground scar				918.42	-43
Broken felled tree				1084.92	-60
Forest edge				1133.92	

GPS Location Description	Rockwell Lat	Long	Elevations	Garmin III Lat	Long	Elevation
Main Wreckage nose (sample 1)	23.39900	21.71000		23.39900	21.71200	
Main Wreckage nose (sample 2)	23.40100	21.70600	72.00000	Bad23.40000	Bad21.11600	93.00000
Reference height						
Origin	23.46600	22.11900	120.00000			
Tree 1	23.46200	22.12500	120.00000	23.45900	22.12700	135.00000
Tree 4	23.46600	22.11900	120.00000	23.46500	22.11400	150.00000
First Row (TREE 1)	23.46100	22.09600	121.00000	23.46200	22.09700	142.00000

First Row (TREE 2)	23.48200	22.09100	114.00000	23.47600	22.09200	123.00000
2nd Row (Tree 1)	Bad23.37600	Bad22.11700	114.00000	23.46400	22.06800	140.00000
2nd Row (Tree 2)	Bad23.37600	Bad22.11700	114.00000	23.47100	22.07000	113.00000
3rd Row (Tree 1)	23.46600	22.04700	114.00000	23.46600	22.04800	131.00000
3rd Row (Tree 2)	23.47100	22.04900	114.00000	23.47000	22.04900	130.00000
Gap between surveys (to last of wings level)	23.46600	22.03600	105.00000	23.46700	22.03500	165.00000
Tree by Kevin in photo 20	23.46300	21.99000	91.00000	23.46400	21.99000	130.00000
Tree by Grover in photo 20	23.46000	21.96500	90.00000	23.46000	21.96400	150.00000
Beginning of ground scar	23.455/23.462	21.949/21.953	88 / 88	23.46 / 23.458	21.949 /21.951	128 / 111
Broken felled tree	23.45700	21.91600	95.00000	23.45900	21.91800	120.00000
Forest edge	23.46300	21.90700	57.00000	23.46200	21.90800	110.00000

The data from the performance group survey conducted on July 28th are summarized in the following table. Note, the group only recorded minutes of latitude and longitude as the degrees latitude and longitude remained 30 North and 84 West, respectively, for all measurements.

				Rockwell			Garmin III		
Location Description	angle	distance	Height	Lat	Long	Elevations	Lat	Long	Elevation
2nd survey (7-28-02)									
Tree 1 (Sample 1)	34	67.5	53.36265823	23.45300	22.11900		23.46000	22.12600	135.00000
				23.46300	22.12600	142.00000			
Tree 4	25	64.16666667	37.7547414	23.46600	22.10400	107.00000	23.46700	22.10500	107.00000
3rd Row (Tree 1)	31	51.58333333	36.82772694	23.46300	22.04900	106.00000	23.46300	22.04700	189.00000
3rd Row (Tree 2)	23.5	54.83333333	29.67554523	23.47000	22.05100	101.00000	23.47000	22.05300	145.00000
Tree by Kevin in photo 20	23.5	48.33333333	26.84926479	23.46300	21.98900				
Tree by Grover in photo 20	5.5	44	8.070051455	23.46800	21.98800				

The group also measured sites around the airport. These data are summarized in the following table.

Location Description	notes	Lat	Long	Elevations	Lat	Long
Runway 90 PAPI (N PAPI)	73 ft 2 inches measured between N & S	23.51400	21.20300	58.00000	23.51700	21.20300
Runway 90 PAPI (S PAPI)		23.50300	21.20300	64.00000	23.50500	21.20300
Threshold N					23.49700	21.391
Threshold S					23.46500	21.391
Pavement End N	198' 3" threshold to end of pavement	23.57200	21.21500	54.00000	23.49700	21.42900
Pavement End S		23.46300	21.42600	54.00000	23.46400	21.42900
Runway 36 survey marker		23.67100	21.54200		23.67200	21.54100
Radar Site	USGS benchmark showed 30:23.267 N, 84:20.683 72 ft elevation	23.26500	20.70200		23.26200	20.68100