NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, DC

December 30, 2004

PERFORMANCE STUDY

Specialist's Report of Investigation
By Abdullah K. Kakar

DCA05MA004

A. ACCIDENT

Location: Kirksville MO
Date: October 19, 2004
Time: Approximately 1937 central daylight time (CDT[1])
Aircraft: British Aerospace Jetstream 32, N875JX

B. GROUP

Chairman: Abdullah Kakar
Aerospace Engineer
National Transportation Safety Board
Washington, DC 20594

Members: Dennis Crider
National Resource Specialist
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Washington, DC

Alistair Scott
Chief Airworthiness Engineer & Head of Flight Safety
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Ayrshire Scotland

[1] All future time references will be in CDT unless otherwise specified.

C. SUMMARY

At approximately 1937 central daylight time, October 19, 2004, a Corporate Airlines, Inc operating as American Connections flight 5966, BAE Systems Jetstream 3200, N875JX, operating in accordance with 14 CFR Part 121, crashed while the flight was on approach to the Kirksville Regional Airport (KIRK), Kirksville, Missouri. The flight was conducting a non-precision LOC/DME Runway 36 approach. Eleven of the 13 passengers and the 2 flight crewmembers were fatally injured. The two surviving passengers received serious injuries. The airplane was destroyed by impact and post-impact fire. The reported weather was visibility 3 miles in mist and an overcast ceiling at 300 feet.

Data available pertaining to the accident included a five parameter Flight Data Recorder (FDR), Cockpit Voice Recorder (CVR), radar data from the Kirksville Air Route Surveillance Radar (ARSR), atmospheric data from the Automated Surface Observing System (ASOS), and evidence from the accident scene collected by the investigation team.

This study used the available data to calculate the aircraft's flight path, angle of attack, and power settings leading to the accident. Plots of various parameters including, altitude, speeds, acceleration, and angles were presented to illustrate the findings.

D. RESULTS

The J32 commuter airplane was flying at an altitude of about 2,500 feet, (ft) mean sea level (MSL) when it crossed the final approach fix (FAF), Kemmy, and began its final descent at approximately 1,200 feet per minute (fpm), never deviating in heading or pitch attitude until just prior to the initial tree impact. The evidence from the accident scene revealed the airplane's initial impact occurred with trees about 50 ft above ground level (AGL) or 1,000 ft MSL[2]. The airplane then struck numerous other trees leaving a trail of aircraft debris and finally the main wreckage came to rest at about 775 ft due north of the initial impact location and 1.2 nautical miles (nm) south of landing runway 36 threshold.

E. DETAILS OF INVESTIGATION

1) Data Source

I. Atmospheric Data

The surface weather conditions at KIRK were reported at 1719 CDT with winds from 040 degrees (deg) at 05 knots (kts); visibility 03 miles; overcast ceiling at 300 ft AGL with temperature at 09 deg Celsius; altimeter setting at 29.96 inches of Mercury

[2] All future altitudes reference MSL unless otherwise specified.

(inHg). The nearest location reporting winds aloft was the Lincoln, IL sounding taken at 1500 CDT and is listed in table 1[3].

Table 1.
Aircraft Sounding Display

Pressure Altitude (Feet)	**Direction True** (Degrees)	**Speed** (Knots)
1000	105	09
2000	040	12

II. Aircraft Data

Relevant data for performance calculations were obtained from BAE, the airplane manufacturer. These data included aerodynamic data and aircraft dimensions. This data was used to construct a simplified longitudinal only simulation model.

For the approach, the airplane was configured with 20 deg of flaps, landing gear down, and the weight was calculated to be 15,185 pounds. The appropriate approach speed per the airlines standard operating procedure for the given weight and flap setting was 130 kts indicated airspeed.

III. Radar Data

The radar data used for this study was retrieved from the Kirksville ARSR-3 antenna. Beacon code 4761 was assigned to N875JX to identify and track this particular airplane.

The ARSR-3 antenna has the capability of tracking targets up to 200 nautical miles (nm). The antenna rotates at about 5.0 revolutions per minute therefore providing a status of the Range, Azimuth, Mode C altitude and a time stamp of the returns every 12.0 seconds. The resolution of the Range, Azimuth, and Altitude are ± 1/16 nm (~ ± 380 ft), ± 0.176 deg, and ± 50 ft, respectively. The data was converted to north and east range position relative to the main wreckage location at N 40^{o} 03.842’ and W 092^{o} 32.663’ and also converted to latitude and longitude position. Figure 1 shows the ground track map overlay.

[3] Source: Weather Group Chairman’s Factual Report

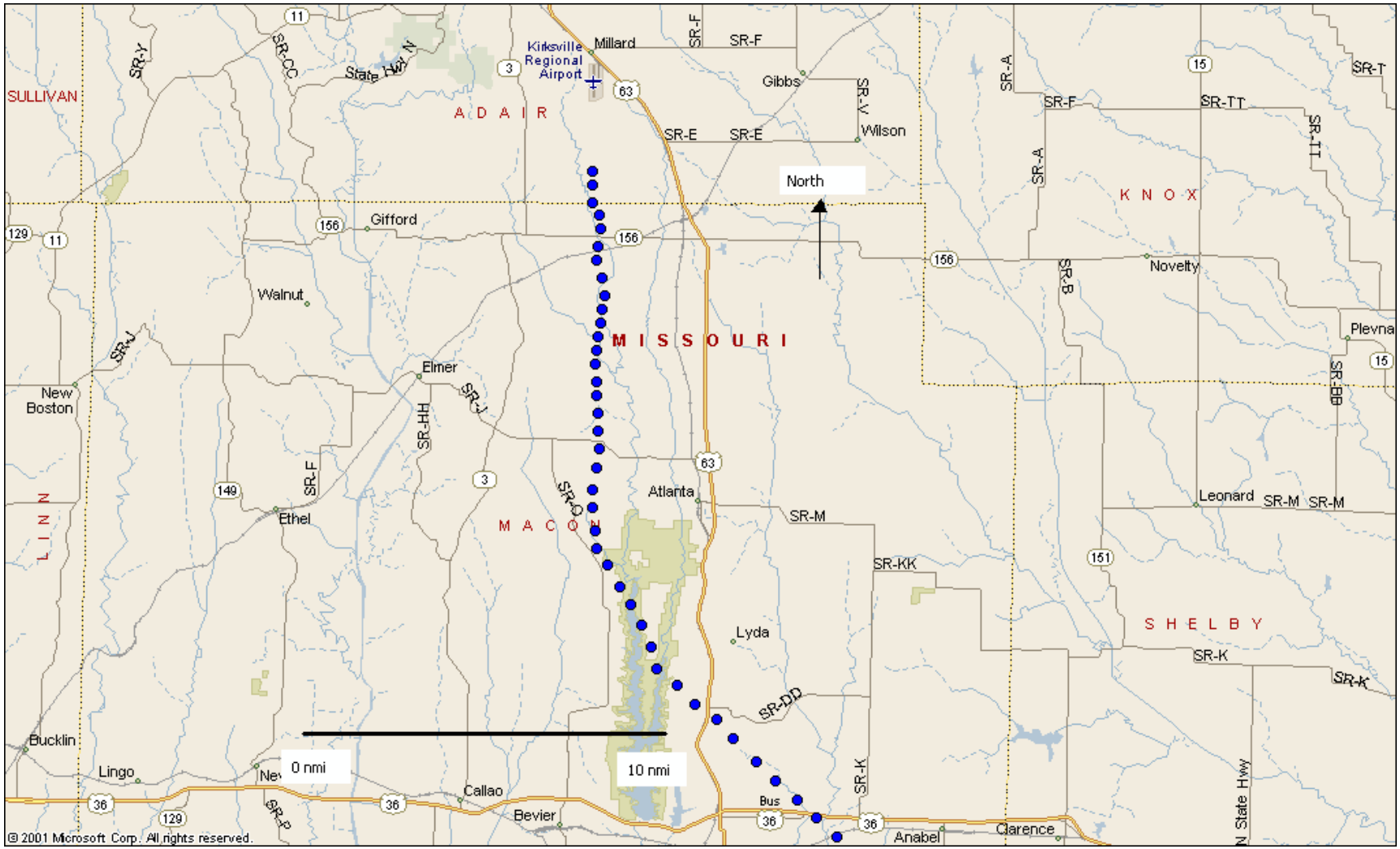

Figure 1. Ground track Kirksville radar expanded scale

The time range of data in the file was from 1902:56.5 to 1936:36.4. The radar data used in this report is included in table 1A of the appendix.

IV. FDR Data[4]

There were five parameters recorded on the FDR which included: indicated airspeed, pressure altitude, vertical acceleration, magnetic heading, and microphone keying.

Time on the FDR is measured in terms of Subframe Reference Number (SRN), with one SRN equivalent to one second of time. Each subframe, depending on the frequency of the parameter being recorded, will contain from one to eight samples of a parameter. The vertical acceleration parameter was recorded at eight times a second so the rest of the FDR data was interpolated using a cubic spline to eight times a second and to the same time reference and smoothed for calculation purposes.

V. CVR Data

Sounds recorded on the CVR were used to help determine and or validate aircraft configuration and location.

VI. Wreckage Survey Data

The Federal Bureau of Investigation's (FBI) Evidence Response Team using their total station system conducted the site wreckage survey. The location of all the tree strikes is included in table 2A of the appendix and the Structures Group Chairman's Factual Report contains a more detailed diagram with the coordinates and distances of all the witness marks. The FBI referenced all measurements to a set datum point, which they set to have an elevation of 1,000 ft. However, for higher precision, the measured elevation of 925 ft recorded by the Aircraft Performance Group was used. This value was the average of the two measurements recorded with the Global Positioning System handheld receivers to within ±20 ft. This measurement closely matches the value of 920 ft obtained from a US Geological Survey map by the Structures Group Chairman. The initial tree strike marks, figure 2, were noted at about 775 ft south of main wreckage figure 3, and various debris (airplane parts) were found between the two locations.

[4] FDR data is included in the FDR Group Chairman's Factual Report

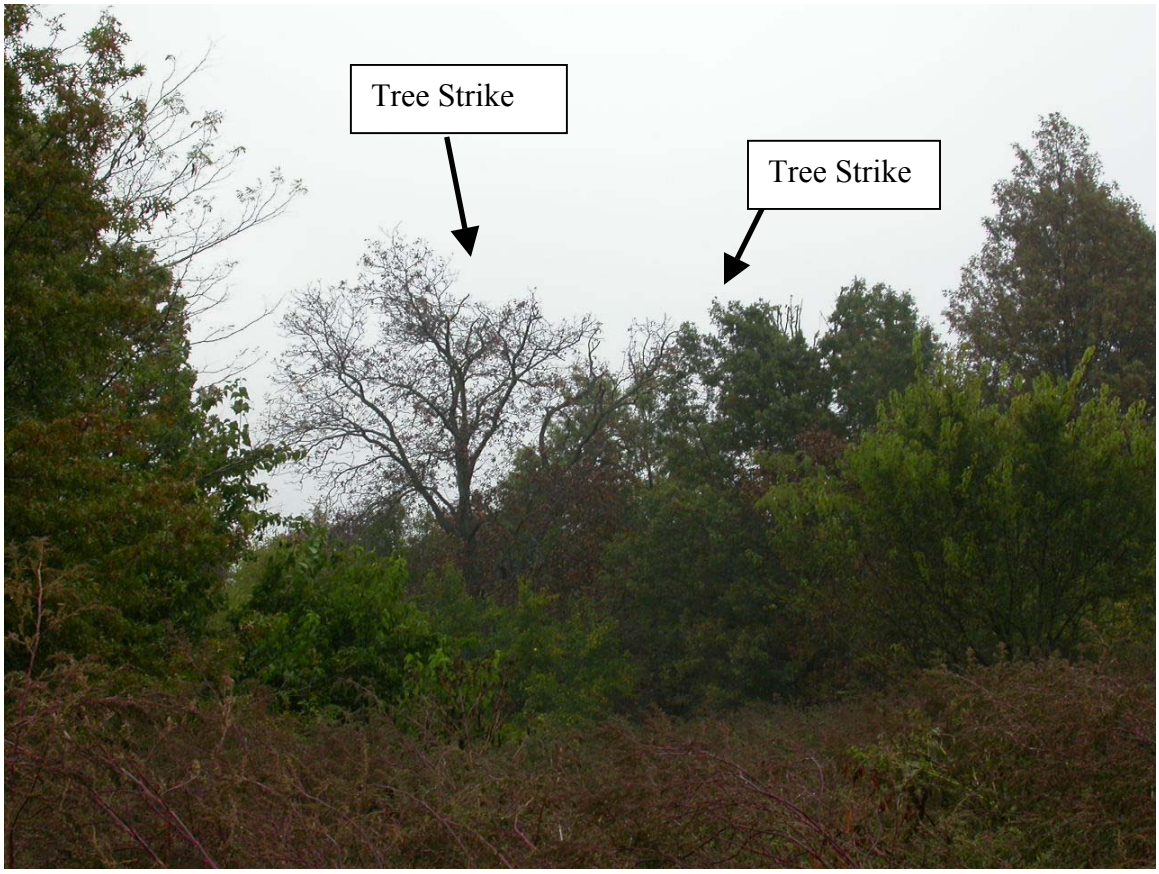

Figure 2; Initial tree strike (looking north).

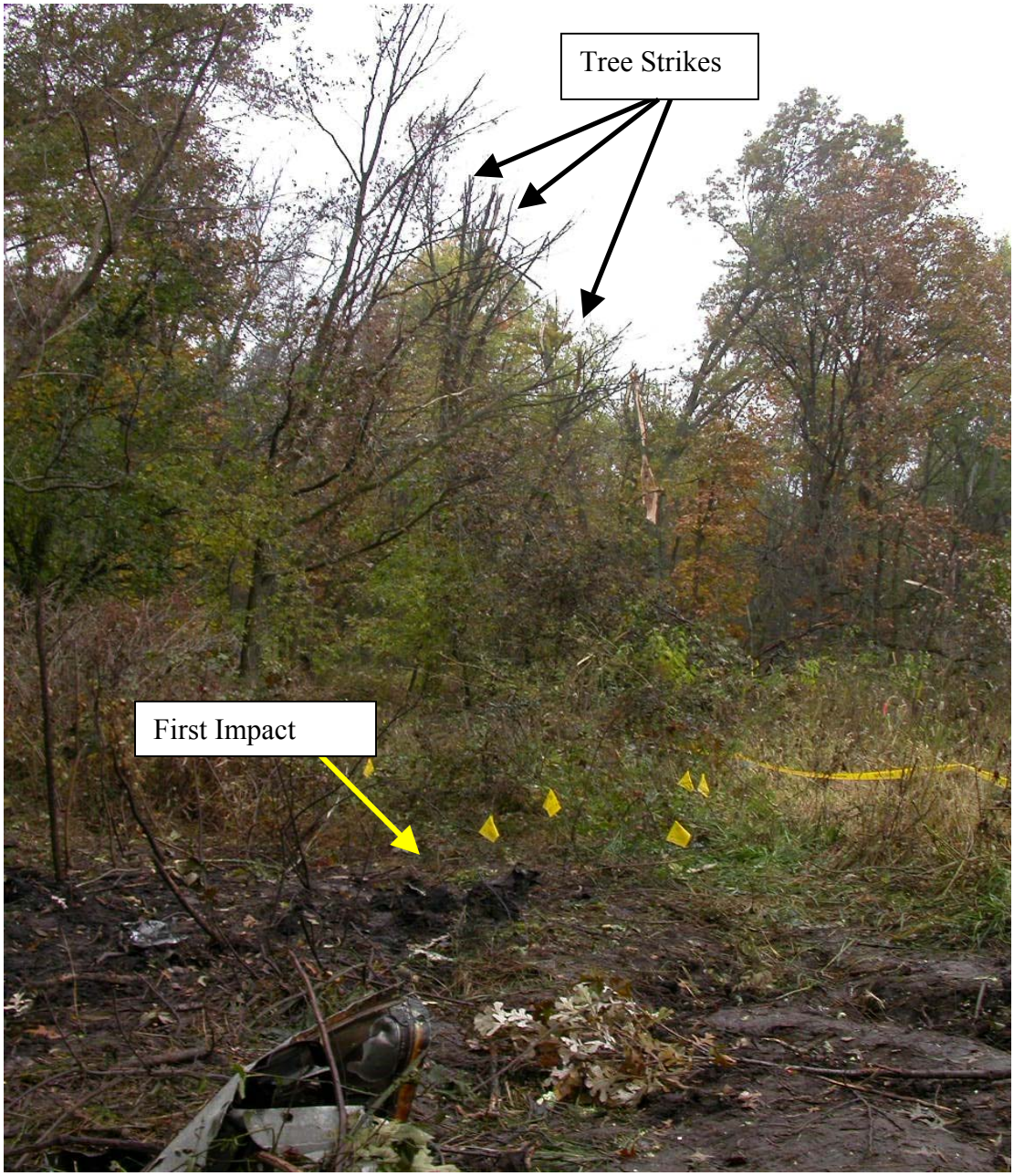

Figure 3. Initial ground impact (looking south).

VII. FDR, Radar, and CVR Time Correlation

The time the data was recorded on the FDR, CVR, and by the Radar were all in different formats. To use these data sources together their times were synchronized to a common time reference. The pressure altitude data was common to both the FDR and radar data and it was used to perform the correlation of the FDR time to radar time. The FDR altitude time was shifted to match the radar data and/or at least fit through the ±50 ft uncertainty bands (figure 4). The shifting amounted to 464,919 seconds (see equation 1), which was the offset value to correct FDR data to radar time. Additionally, examination of level flight revealed that the radar data reported lower altitude than the FDR data. Since the FDR altitude data has higher precision the radar data was shifted plus 50 ft to match the FDR data.

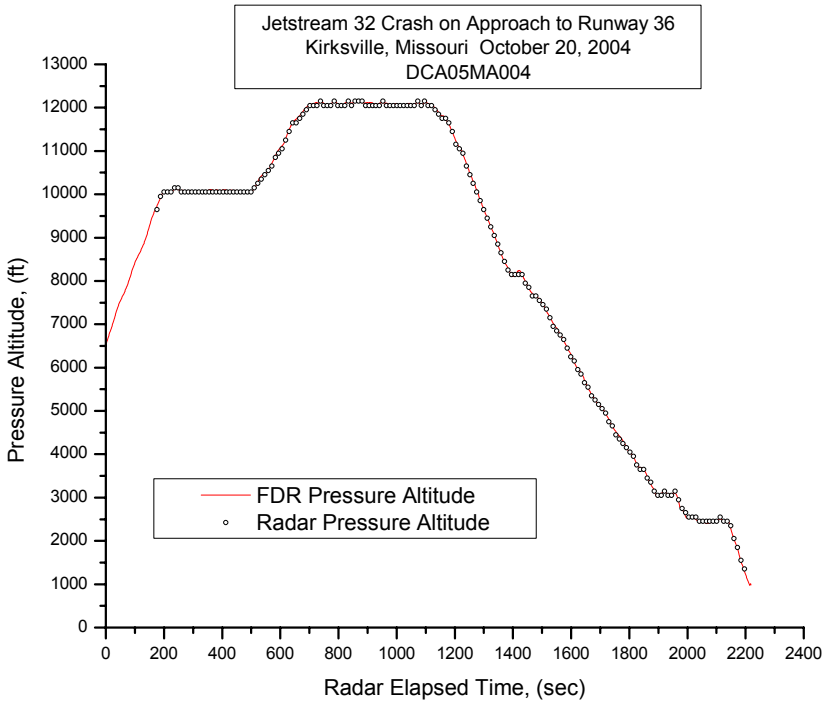

Figure 4. Radar FDR Correlation

(FDR subframe - 396,519)/86,400 = Decimal days CDT eq. 1

All times were then converted to hh:mm:ss format.

Next the FDR and CVR times were correlated. One commonality between the FDR and CVR is that the keying of the microphone is recorded on the FDR. These events have associated FDR and CVR times. All the mike key events were selected and used to correlate CVR to FDR time. Once all three data sources were correlated to a common time reference it was possible to interrelate the events from each source.

2) Performance Study

I. Basic Performance Parameters

The synchronized radar and FDR pressure altitude based on 29.92 inHg were converted to MSL altitude using the local altimeter setting of 29.96 inHg at the time of the accident. All the plots presented will only show the last few minutes of the flight. The radar and FDR MSL altitudes are shown in figure 5.

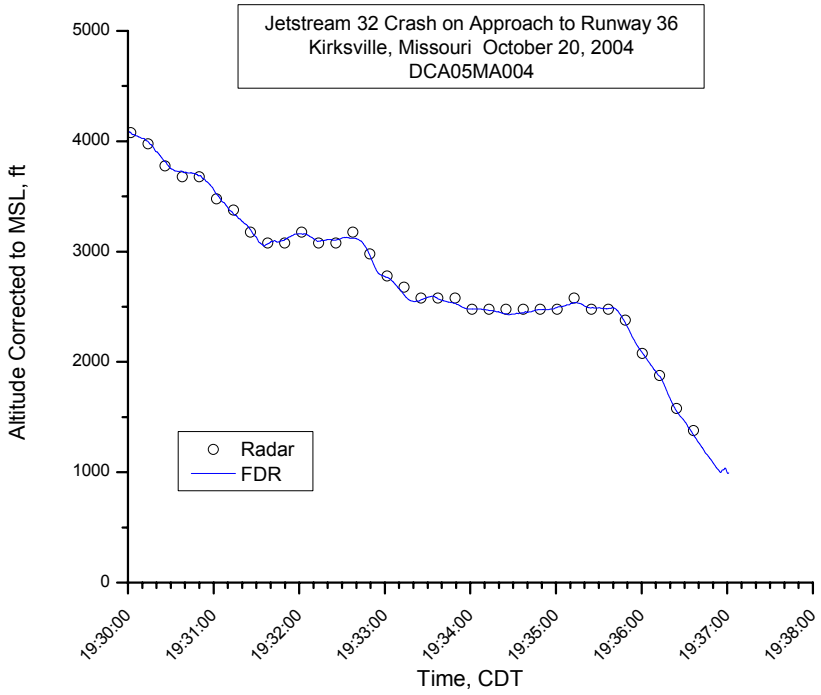

Figure 5. Altitude Profile for last seven minutes

Figure 6 is the radar altitude profile plotted versus the distance from the main wreckage. Included in the figure for reference purpose is the Visual Approach Slope Indicator (VASI) inclined at 3 deg.

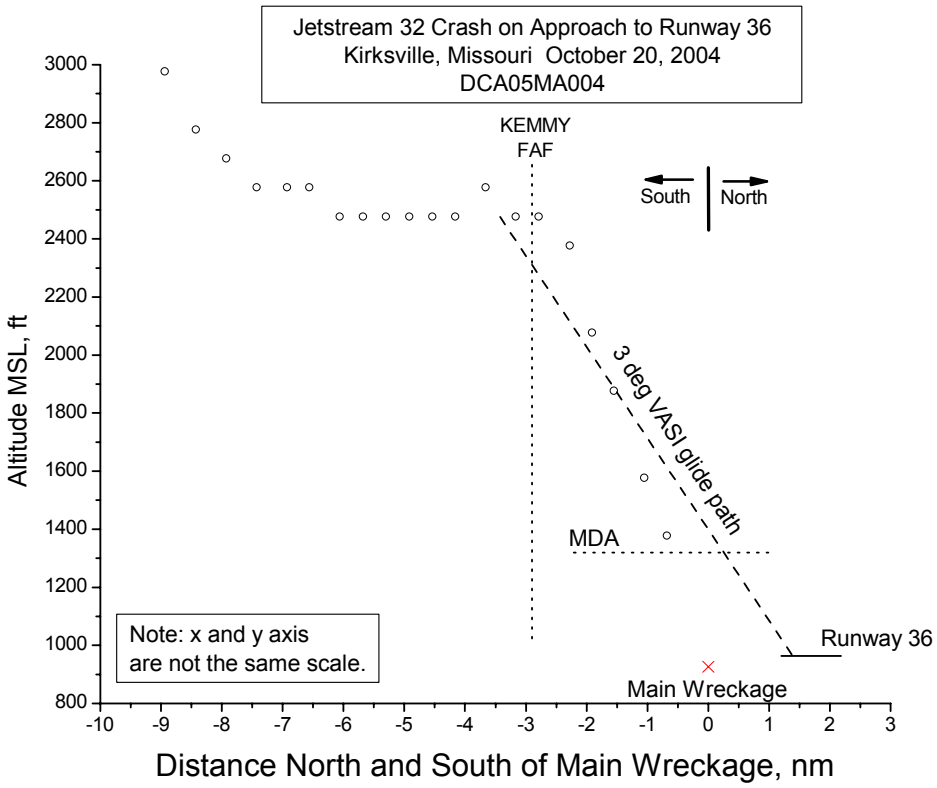

Figure 6. Kirksville Radar data

FDR vertical acceleration, magnetic heading and indicated airspeed for the last seven minutes of the flight are shown in figure 7.

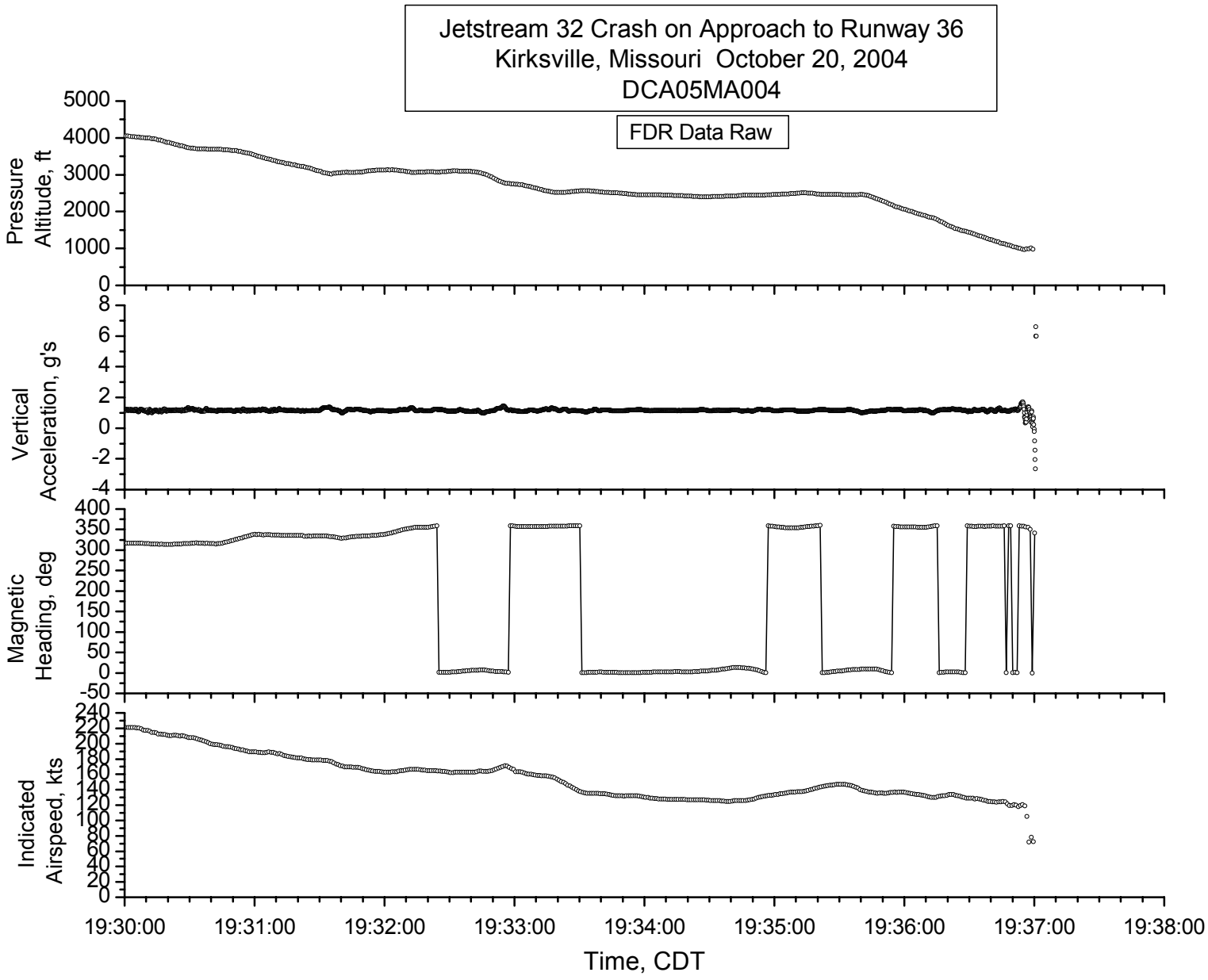

Figure 7. FDR Data

Figure 8 shows the vertical speed calculated from the 5 point running average smoothed FDR altitude data.

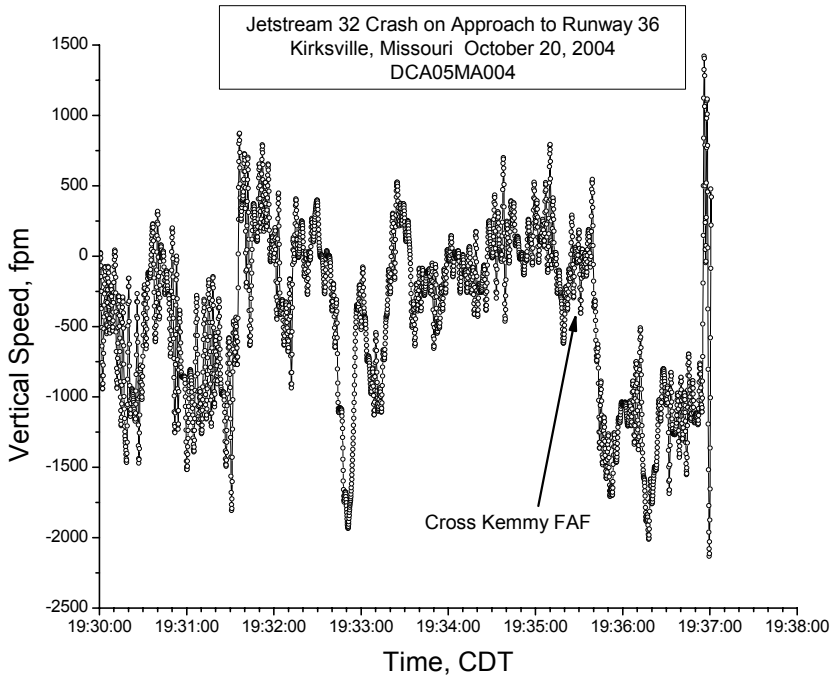

Figure 8. Vertical speed, FDR data

II. Simulation

A simplified longitudinal only simulation (sim) was conducted using lift, drag, and pitching moment data provided by the manufacturer[5] to determine the flight path beyond the last radar point from 1,400 ft down to the initial tree strike. In addition, the angle of attack and power setting for that period were derived. Three input parameters, elevator position, bank angle, and power setting, were adjusted to match the simulation with the FDR altitude, speed, and vertical acceleration profiles shown in figures 9, 10, and 11 respectively. Examination of the vertical g's when the airplane was on the ground revealed that the data was offset by about +0.15 g's. Additionally the wind data was adjusted to ensure that the ground track passed through the uncertainty box (the uncertainty of the radar data is described in the Data Source section in subpart III) and the initial tree strike shown in figure 12.

[5] This simulation was not matched to flight test data.

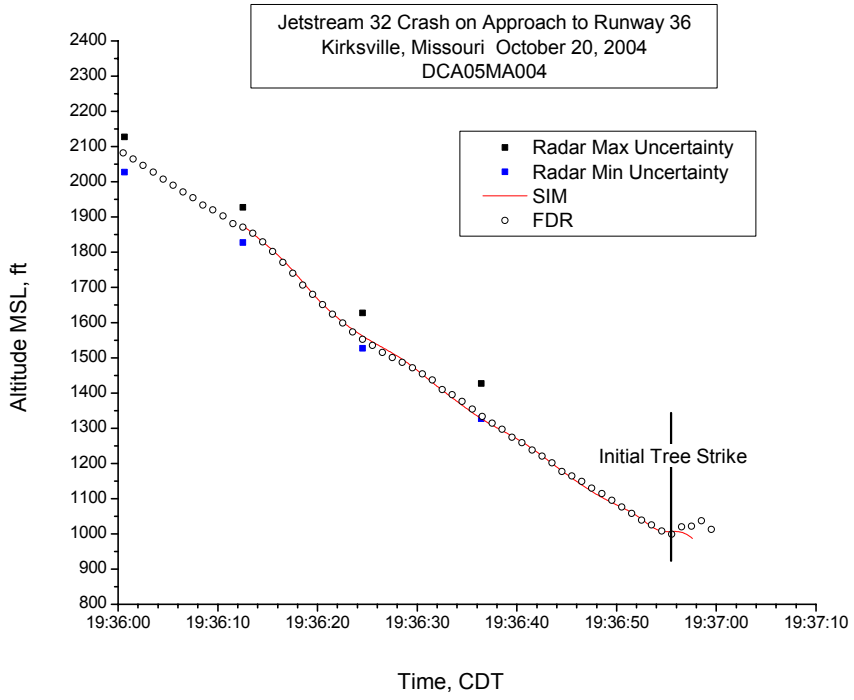

Figure 9. Simulation altitude match profile

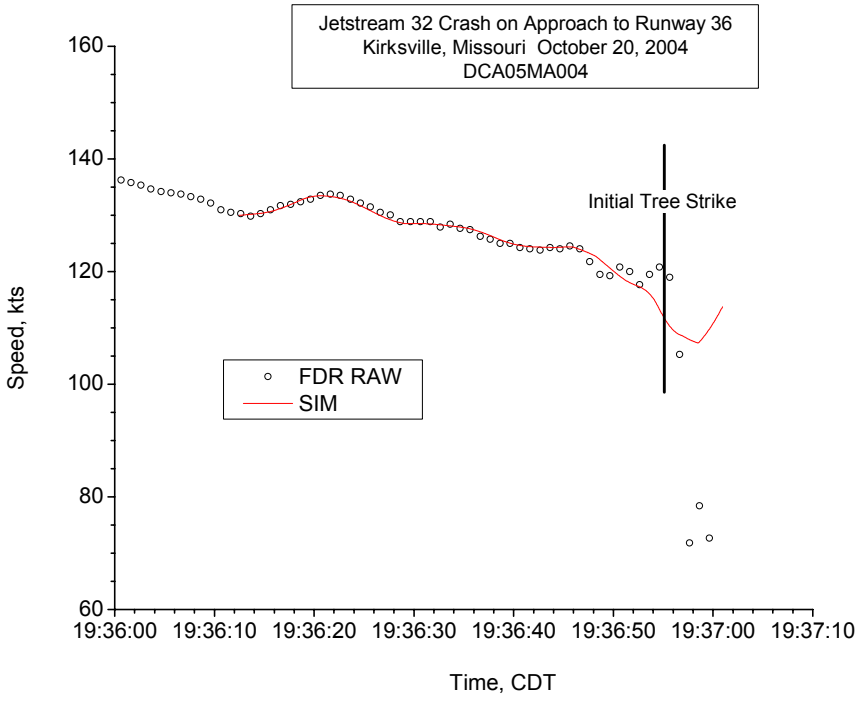

Figure 10. Simulation speed match profile

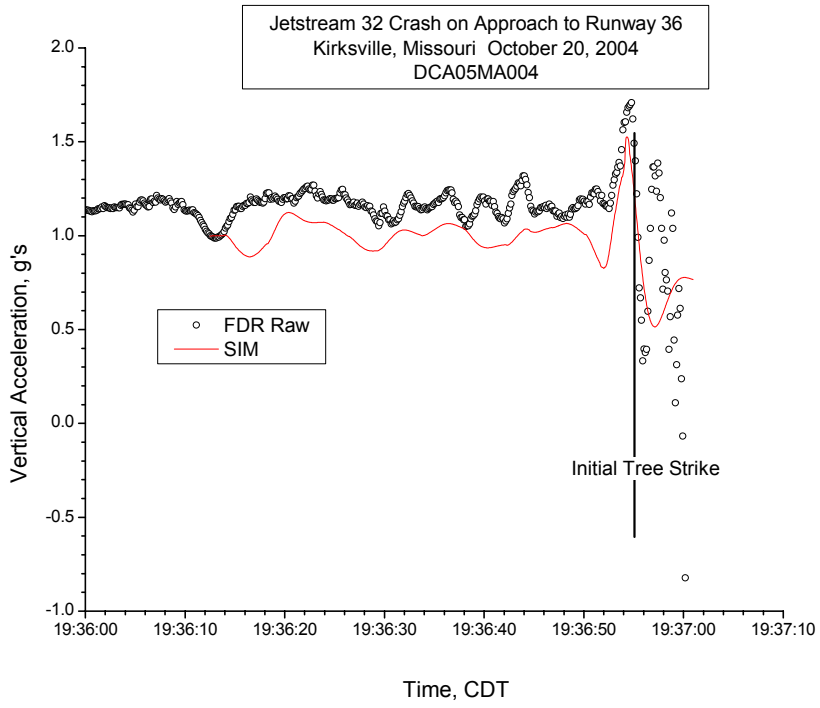

Figure 11. Simulation vertical acceleration match profile

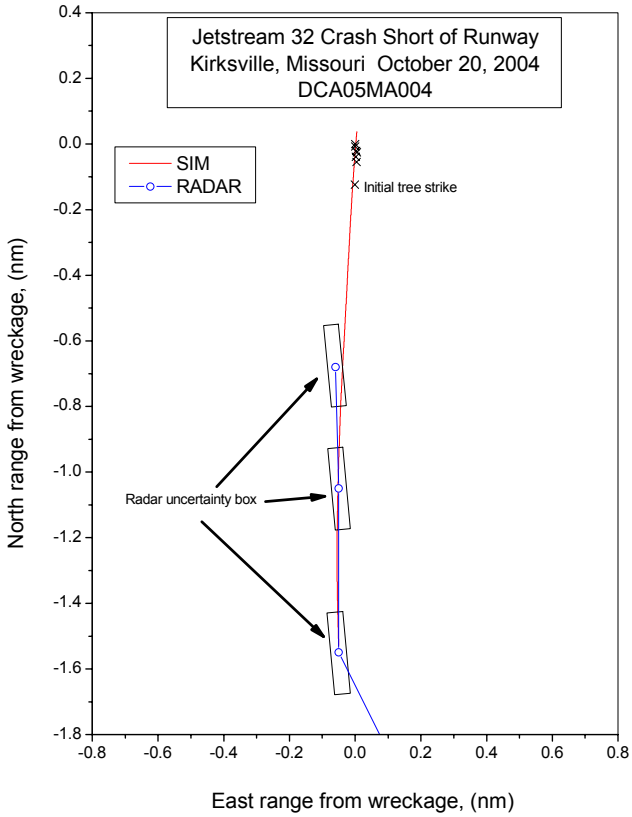

Figure 12. Simulation ground track profile

Figure 13 is the sim altitude profile plotted versus distance from the main wreckage, and figure 14 shows the same profile on an expanded scale, which includes the radar data and the three degree VASI glide slope. Examination of figure 14 shows that the airplane's flight path angle did not appear to change at any time during that segment of the approach except when very close to the initial tree strike.

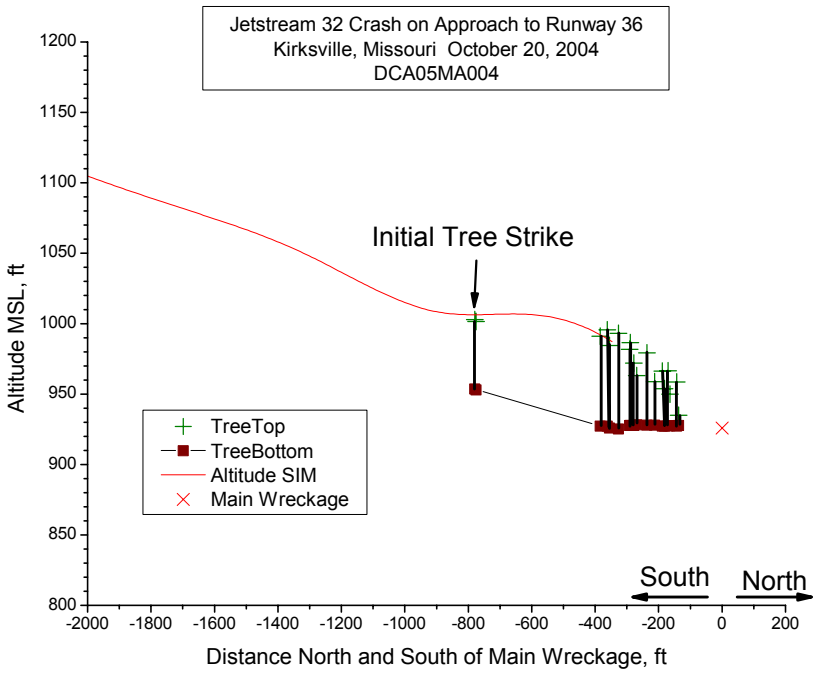

Figure 13. Simulation altitude versus distance from main wreckage

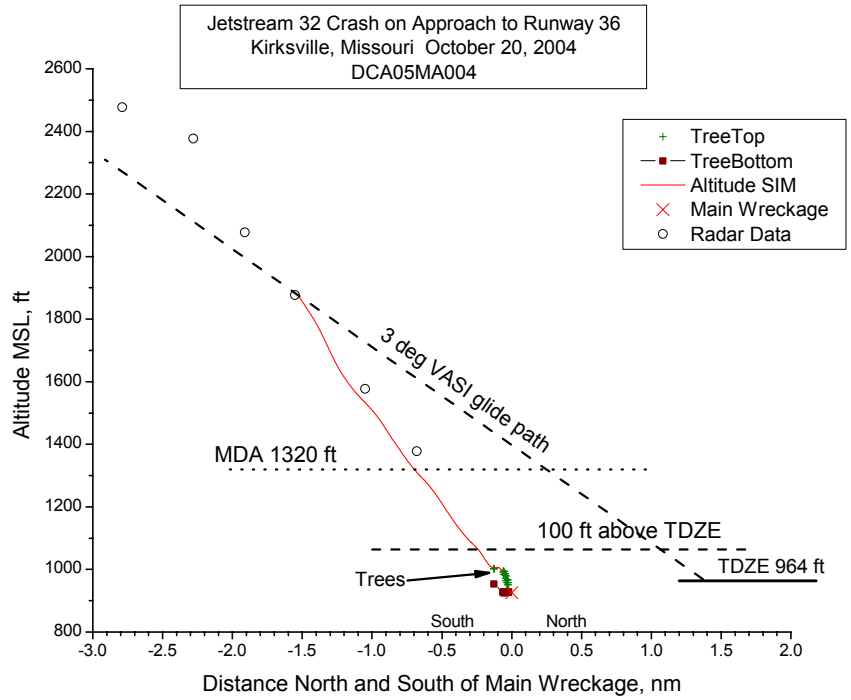

Figure 14. Simulation altitude versus distance from main wreckage expanded scale

Figure 15 is a plot of the airplane angle of attack and pitch angle, which shows that the airplane's angle of attack was fairly constant and within the typical 3 deg glide path until just prior to the initial tree strike where the angle of attack increased to about 11 deg. The airplane's wing mounted vane stall warning angle of attack is around 13 deg within ±2- 3 deg depending on the center of gravity location, flap position, power setting and approach rate.

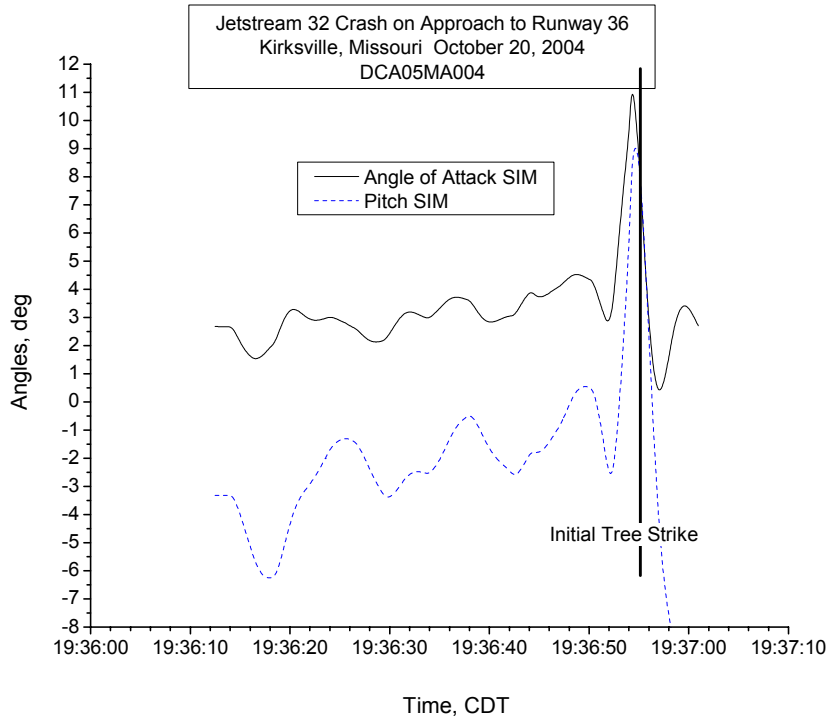

Figure 15. Simulation angle of attack and pitch angle

The thrust horsepower in figure 16 shows a fairly constant low setting during the approach. The negative values, which indicate more drag than thrust produced, are to be expected for an idle power setting per the aircraft manufacturer.

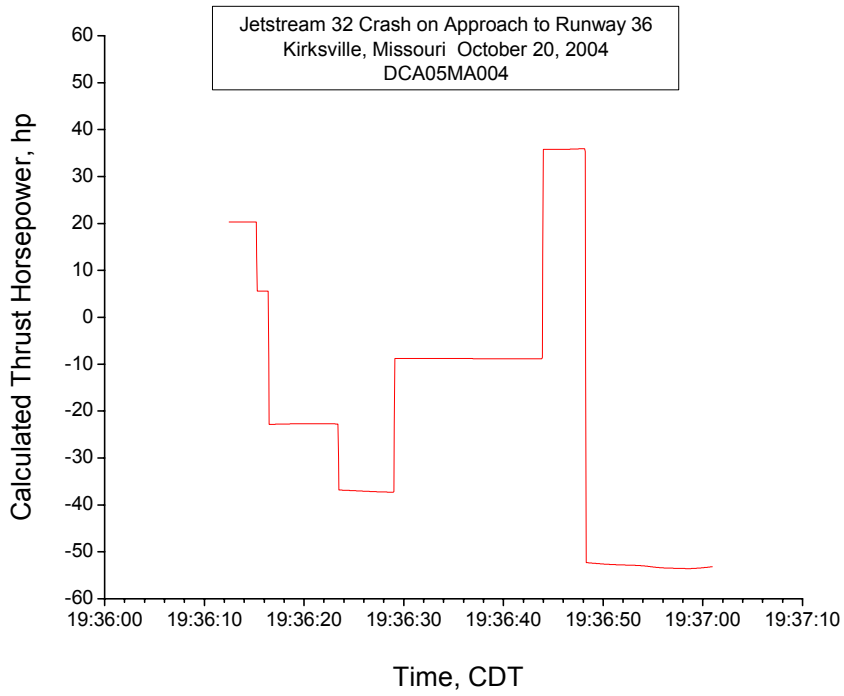

Figure 16. Simulation thrust horsepower

The sim input parameters elevator and bank angle are shown in figure 17 and 18 respectively.

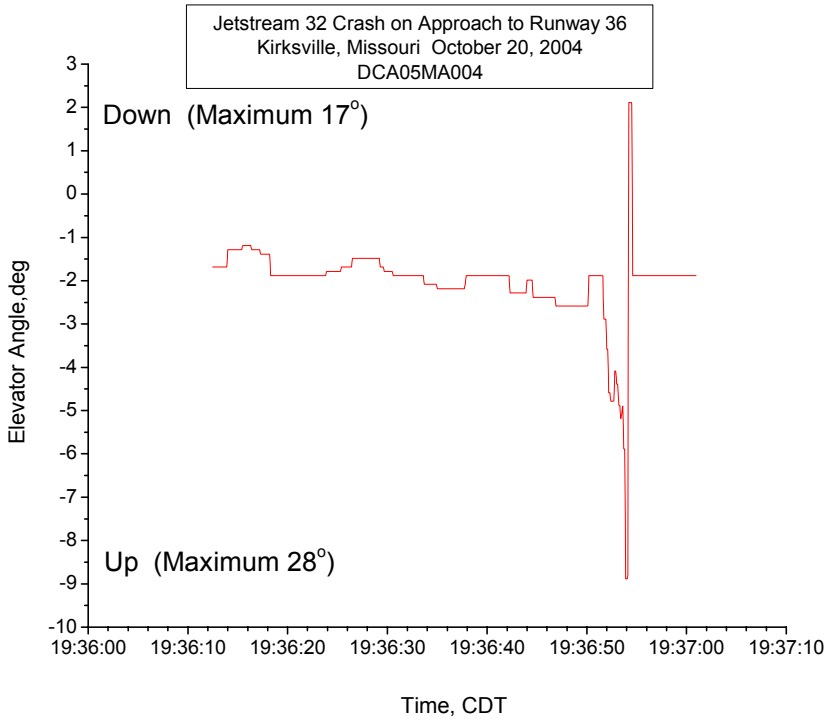

Figure 17. Simulation Input Elevator Angle

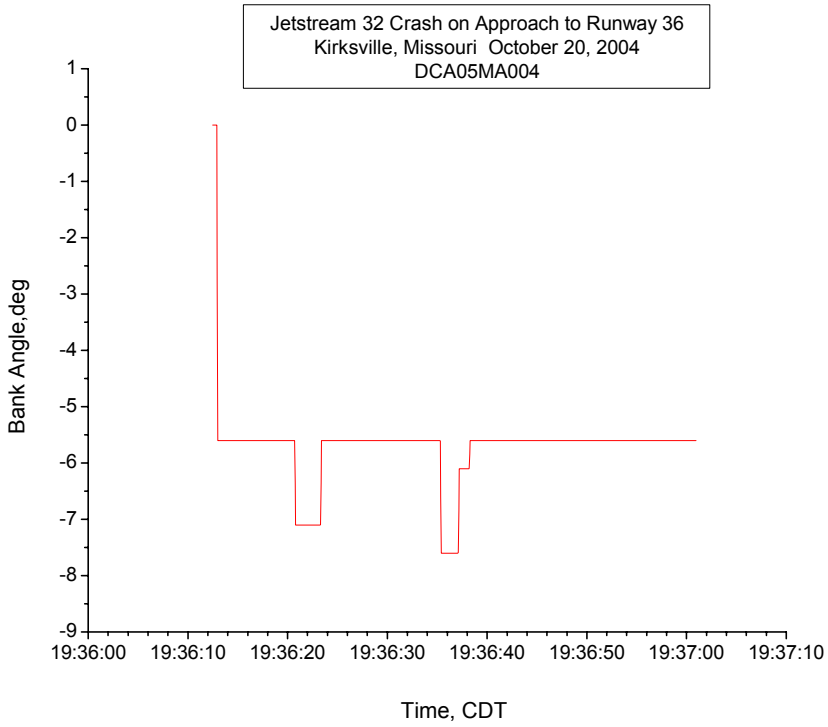

Figure 18. Simulation Input Bank Angle

Observing figures 11, 13, and 15, at 19:36:55 the angle of attack and vertical acceleration showed an increase in magnitude, which corresponded approximately to the location where the airplane's trajectory was very near the initial set of tree strikes. Prior to the initial tree strike the flight appeared to be within the normal flight envelop.

F. CONCLUSION

The J32 commuter airplane began descending from an altitude of 2,500 ft to the airport at a rate of approximately 1,200 fpm. The flight continued to descend through the minimum decision altitude and did not appear to deviate in flight path angle or heading until just prior to impact with the first set of trees at an altitude of about 1,000 ft. The airplane was within its angle of attack envelope until just prior to the impact. The power setting was minimal through this descent phase. Numerous debris departed the airplane as it struck the trees and finally struck the ground 1.2 nm short of runway 36 threshold.

Abdullah Kakar
Aerospace Engineer

Appendix A

DCA05MA004
BAE J32 N875JX Crash on Approach to Runway 36 Kirksville, MO
October 19, 2004

Table 1A.
Kirksville ARSR-3 COMDIG Radar Data
Kirksville, MO October 19, 2004

Time (Seconds since midnight)	**Azimuth** (Degrees)	**Range** (Nautical Miles)	**Pressure Altitude** (Feet)
176.5	136.3184	122.875	9600
188.5	136.4063	122.5	9900
200.4	136.4941	122	10000
212.4	136.6699	121.5	10000
224.3	137.1094	120.875	10000
236.3	136.7578	120.25	10100
248.2	136.4941	119.5	10100
260.1	136.6699	118.75	10000
272.1	138.252	118	10000
284	136.4941	117.25	10000
296	136.4941	116.5	10000
307.9	136.4063	115.75	10000
319.9	136.582	115	10000
331.8	136.582	114.25	10000
343.8	136.582	113.5	10000
355.7	136.4063	112.875	10000
367.7	136.4063	112.125	10000
379.7	136.3184	111.375	10000
391.6	136.3184	110.625	10000
403.5	136.2305	109.875	10000
415.5	136.2305	109.125	10000
427.4	136.1426	108.375	10000
439.3	135.9668	107.625	10000
451.3	136.0547	106.875	10000
463.2	135.8789	106.125	10000
475.2	135.8789	105.375	10000
487.1	136.0547	104.625	10000
499.1	136.0547	103.875	10000
511	136.2305	103.25	10100
523	136.2305	102.5	10200
534.9	136.0547	101.75	10300
546.8	136.2305	101.125	10400
558.8	136.0547	100.375	10500
570.7	136.1426	99.75	10600
582.7	136.1426	99	10800
594.6	135.791	98.375	10900
606.6	136.2305	97.625	11000
618.5	136.2305	97	11200
630.5	136.4063	96.25	11400
642.4	136.4063	95.625	11600

Table 1A Continued.
Kirksville ARSR-3 COMDIG Radar Data
Kirksville, MO October 19, 2004

Time (Seconds since midnight)	**Azimuth** (Degrees)	**Range** (Nautical Miles)	**Pressure Altitude** (Feet)
654.4	136.582	95	11600
666.3	137.0215	94.25	11700
678.3	136.8457	93.625	11800
690.2	136.9336	93	11900
702.2	137.1094	92.25	12000
714.1	137.373	91.625	12000
726	137.1094	90.875	12000
738	137.2852	90.125	12100
749.9	137.5488	89.5	12000
761.9	137.9883	88.875	12000
773.9	138.1641	88.125	12000
785.8	138.1641	87.5	12100
797.7	138.0762	86.875	12000
809.7	138.5156	86.25	12000
821.7	138.6035	85.625	12000
833.6	139.043	85	12100
845.5	139.043	84.375	12000
857.5	139.043	83.75	12100
869.4	139.3945	83.125	12100
881.4	139.7461	82.375	12100
893.3	139.9219	81.75	12000
905.3	140.0977	81.125	12000
917.2	140.2734	80.375	12000
929.2	140.625	79.75	12000
941.1	140.7129	79.125	12000
953.1	140.8008	78.5	12100
965	141.0645	77.875	12000
977	141.416	77.25	12000
988.9	141.8555	76.625	12000
1000.9	141.9434	75.875	12000
1012.8	142.1191	75.25	12000
1024.8	142.207	74.625	12000
1036.7	142.4707	73.875	12000
1048.7	142.7344	73.25	12000
1060.6	142.8223	72.625	12000
1072.6	143.1738	71.875	12100
1084.5	143.1738	71.25	12000
1096.5	143.4375	70.625	12100
1108.4	143.6133	69.875	12000
1120.4	143.7891	69.25	12000
1132.4	144.3164	68.5	11900

Table 1A Continued.
Kirksville ARSR-3 COMDIG Radar Data
Kirksville, MO October 19, 2004

Time (Seconds since midnight)	**Azimuth** (Degrees)	**Range** (Nautical Miles)	**Pressure Altitude** (Feet)
1144.3	144.3164	67.875	11800
1156.2	144.5801	67.125	11700
1168.2	144.5801	66.5	11700
1180.1	145.0195	65.75	11600
1192.1	145.3711	65	11400
1204.1	145.7227	64.375	11100
1216	145.9863	63.625	11000
1228	146.1621	62.875	10900
1239.9	146.6016	62.25	10600
1251.8	146.6016	61.5	10400
1263.8	146.6895	60.875	10200
1275.8	147.2168	60.125	10000
1287.7	147.5684	59.5	9800
1299.7	147.9199	58.75	9600
1311.6	148.2715	58.125	9400
1323.6	148.7988	57.375	9200
1335.5	148.9746	56.75	9000
1347.5	149.4141	56	8800
1359.4	149.502	55.375	8600
1371.4	150.2051	54.625	8400
1383.4	150.3809	54	8200
1395.3	150.8203	53.25	8100
1407.3	151.084	52.625	8100
1419.2	151.4355	52	8100
1431.2	152.0508	51.375	8100
1443.1	152.1387	50.75	7900
1455.1	152.666	50	7800
1467.1	153.1934	49.375	7600
1479	153.457	48.75	7600
1491	154.0723	48.125	7500
1503	154.5996	47.375	7400
1514.9	155.0391	46.75	7300
1526.9	155.7422	46.125	7100
1538.8	156.0059	45.5	6900
1550.8	156.5332	44.875	6800
1562.8	157.1484	44.25	6700
1574.7	157.6758	43.5	6600
1586.7	158.3789	42.875	6400
1598.7	158.9063	42.25	6200
1610.6	159.5215	41.625	6100
1622.6	160.2246	41	5900

Table 1A Continued.
Kirksville ARSR-3 COMDIG Radar Data
Kirksville, MO October 19, 2004

Time (Seconds since midnight)	**Azimuth** (Degrees)	**Range** (Nautical Miles)	**Pressure Altitude** (Feet)
1634.6	160.8398	40.375	5800
1646.5	161.4551	39.625	5600
1658.5	161.8066	39	5500
1670.5	162.334	38.25	5300
1682.4	162.9492	37.5	5200
1694.4	163.4766	36.875	5100
1706.4	164.0918	36.25	5000
1718.3	164.9707	35.625	4900
1730.3	165.5859	34.875	4700
1742.3	166.1133	34.25	4600
1754.2	166.8164	33.625	4400
1766.2	167.5195	33	4300
1778.2	168.3984	32.375	4200
1790.1	169.1016	31.75	4100
1802.1	170.0684	31	4000
1814.1	170.7715	30.375	3900
1826.1	171.7383	29.875	3700
1838	172.6172	29.25	3600
1850	173.584	28.75	3600
1862	173.7598	28.125	3400
1873.9	174.1992	27.5	3300
1885.9	174.7266	26.875	3100
1897.9	175.2539	26.375	3000
1909.8	175.957	25.75	3000
1921.8	176.5723	25.25	3100
1933.7	176.5723	24.75	3000
1945.7	176.6602	24.125	3000
1957.6	176.5723	23.625	3100
1969.5	176.2207	23	2900
1981.5	175.957	22.5	2700
1993.4	175.957	22	2600
2005.4	175.8691	21.5	2500
2017.3	175.7813	21	2500
2029.3	175.7813	20.625	2500
2041.2	175.7813	20.125	2400
2053.1	175.6055	19.75	2400
2065.1	175.3418	19.375	2400
2077	175.0781	19	2400
2088.9	174.8145	18.625	2400
2100.9	174.5508	18.25	2400
2112.8	174.6387	17.75	2500

Table 1A Continued.
Kirksville ARSR-3 COMDIG Radar Data
Kirksville, MO October 19, 2004

Time (Seconds since midnight)	**Azimuth** (Degrees)	**Range** (Nautical Miles)	**Pressure Altitude** (Feet)
2124.8	174.9902	17.25	2400
2136.7	174.7266	16.875	2400
2148.7	174.1992	16.375	2300
2160.6	174.2871	16	2000
2172.5	174.8145	15.625	1800
2184.5	174.6387	15.125	1500
2196.4	174.5508	14.75	1300

Table 2A
Tree Witness Marks
FBI Evidence Response Team, October 19, 2004

Base Coordinate
N 40° 03.848' W 92° 32.667' X= 122.8003 Y= 286.3509

Plane Debris Name	X Coordinate	Y Coordinate
31' 4" shear	X= 254.0369	Y= 288.8041
7' 2" shear or impact	X= 248.1352	Y= 270.9983
39' shear	X= 281.7787	Y= 274.4516
22' 7" shear	X= 275.9508	Y= 272.2428
26' 5" shear	X= 292.5251	Y= 287.1371
39' 1" shear	X= 299.5943	Y= 276.7014
31' shear	X= 324.3579	Y= 281.9584
51' 4" shear	X= 347.9322	Y= 270.9438
21' 1" shear	X= 357.4689	Y= 272.8759
35' 1" shear	X= 380.2830	Y= 284.7122
44' 5" shear	X= 389.9664	Y= 287.3148
59' shear	X= 400.6598	Y= 267.4864
54' 1" shear	X= 403.0788	Y= 264.4577
68' shear	X= 437.7245	Y= 292.3267
58' 7" shear	X= 465.9896	Y= 270.2357
68' 5" shear	X= 473.4681	Y= 289.5740
63' 9" shear	X= 495.5687	Y= 280.8544
49' 4" shear	X= 890.6718	Y= 255.0344
48' 6" shear	X= 887.3501	Y= 227.8662