Flight AA77 on 9/11: New FDR Analysis Supports the Official Flight Path Leading to Impact with the Pentagon

Frank Legge, (B.Sc.(Hons.), Ph.D.) and Warren Stutt, (B.Sc.(Hons.) Comp. Sci.)
January 2011

Introduction

The official narrative of the events which have become known as 9/11 includes descriptions of attacks on the World Trade Centre towers and the Pentagon by aircraft on 11 September, 2001. The towers were eventually destroyed and the Pentagon was severely damaged. The account of the attack on the Pentagon includes the following: A Boeing 757, operated by American Airlines, took off from Washington Dulles International Airport at 8:20 a.m. At 8:54 it deviated from its assigned route and at 8:56 the transponder was switched off. The plane, under the control of hijackers, headed back toward Washington and descended. As it approached the Pentagon it performed a descending spiral to the right and finally dived toward the Pentagon while accelerating. It hit some light poles and other objects on the ground and then penetrated the west face of the building at 9:37:44,[1] or 9:37:46,[2] depending on source.

Various claims have been made about the attack on the Pentagon. Early claims included damage by a missile or a truck bomb.[3] However, as so many witnesses had reported seeing a large commercial aircraft approaching the Pentagon, these claims received little attention from the public. It was not until the data from the Flight Data Recorder (FDR) was received from the National Transportation Safety Board (NTSB) that serious consideration was given to alternative explanations of the damage. The data was received in two forms, following a number of Freedom of Information Act (FOIA) requests. One form could not be understood by inspection and the other, a readable comma-separated values (CSV) file, had some columns of data missing, a critical omission being radio height.[4] After considerable difficulty, assistance in interpreting the coded file was received and the result came into public hands.[5] Like the CSV file, it appeared to indicate that the flight terminated at a position which was too high to have struck the Pentagon in the described manner.

There has been much debate about the flight path of the plane. One group asserts that the plane approached from a direction which would not have permitted it to create the observed straight line of damage through the light poles and inside the Pentagon. This assertion is based on the group's discovery of 13 eyewitnesses who allegedly place the course of the plane to the north of the former Citgo service station. It is argued from this that the plane must have passed over the Pentagon, despite the existence of a large number of eyewitness reports that the plane hit the building,[6] including some of these 13 north-path witnesses,[7] and despite the absence of the many reports of the plane flying over the building that would be expected, given the large number of vehicles in traffic jams nearby.[8] This theory requires that the long, straight line of complex damage was done by some other means, and done in its entirety without any of the activity being reported.[9]

Another group which studied the FDR data claimed that it would have been impossible for the plane to pull out of the dive which was needed to arrive at the light poles and then level off to hit the Pentagon, as the g-force would produce a wing load greatly exceeding the structural strength of the plane. They assume the data finished close to the Pentagon and argue that the data file proves the official description of the flight false, apparently ignoring the alternative view that the many reports of the plane hitting the building might be indicating that there was a defect in the data.

There have, however, been other interested parties who looked at the available data and came to different conclusions. Researcher John Farmer concluded that there was indeed a defect in the file and that about 4 to 6 seconds of data was missing from the end.[10] If this is true it would be easy to find a flight path which would permit the plane to descend and pull up safely. Despite this finding the adherents of the contrary theories have remained adamant that the plane flew over the building or could not have survived the final pull-up. They continue to maintain that the official account of the path of the plane, which necessarily includes impact with the Pentagon, is false. A number of analyses have been presented which indicate that there are elements of the official account of the attack on the Pentagon which are false but it is our purpose to show that the FDR data is not one of them.[11]

The course of the plane as determined by radar[12] and the course calculated from the FDR are strikingly similar. This supports the view that these are reporting the same plane. Both sources indicate that the plane was approaching from a direction which would make the observed damage possible. Radar, however, is unable to provide accurate information when a plane is close to the ground and the FDR data apparently had the final section of data missing, thus the opportunity for controversy arose.

As people on both sides of this debate assert that a proper understanding of the Pentagon attack is essential if appropriate decisions are to be made, it is clear that collection and examination of further evidence is warranted in the hope that it will lead to a resolution of the dispute.

Some time ago one of the authors, Warren Stutt, who independently received a copy of the FDR file as a result of his FOIA request, discovered more data at the end of the file which had not previously been decoded. He recently managed to decode the last frame and has made the information freely available.[13] The file contains a vast amount of data, including the following essential information: the vertical acceleration every eighth of a second; longitudinal acceleration, roll angle and pitch every quarter of a second; air speed, ground speed, pressure altitude, radio height, heading and position every second; all finishing at points within the last second. The last time stated in the file is 9:37:49, which is in the 4th last subframe. Three more subframes were recorded, one second each, bringing the time of the last recording to 9:37:52, 6 or 8 seconds later than the two official times of impact. We do not assert that this accurately represents the time of impact as the clock in the aircraft may have been incorrect.

Discussion

Flight course and final manoeuvre

In the following image (Fig. 1),[14] it can be seen that impact with five light poles not only establishes the track through the damaged area, but also provides evidence that the wingspan of the plane, if it was a plane,[15] is consistent with that of a Boeing 757, 124 feet 10 inches.[16]

Fig. 1. Final track through light poles to the Pentagon.

If the position of the aircraft is plotted using latitude and longitude from the fully decoded FDR file, it becomes apparent that the course obtained is over 200 feet from the course defined by the trail of damage. A method for correcting the position reports was devised, which is described below.

The series of position reports, however, provides the track angle with considerable accuracy. Inspection of the last 20 reported positions prior to the Navy Annex, shows a track of about 61.3 degrees. The possible range of track just prior to impact is limited to about 61 to 63 degrees to ensure that all the correct light poles, and only the correct light poles, will be hit, and that the impact with the Pentagon will occur in the right place.

The above image may be a little inaccurate as it appears that the right wing tip may have brushed a VDOT camera pole, shown in the following photograph (Fig. 2).

Fig. 2. VDOT camera pole showing damage.

This pole is close to the light coloured mark near the two blue dots in the lower left corner of the image of the track (Fig. 1), where its position may be located by its shadow. If this contact did occur, the final track angle would be established at about 61.4 degrees, close to the lower end of the range determined by the light poles, and indistinguishable, given the limited accuracy of available measurements, from the track angle prior to the Navy Annex.

The data file shows a bank to the right, reaching about 6 degrees, while the plane is passing the Navy Annex. This apparently was so brief as to have had little effect. After passing the Annex, which occurs at about 4 seconds prior to impact, the bank declines to about 3 degrees. This is held for the last 3 seconds, and then the final recorded bank angle shows a sudden drop to zero. It is therefore surprising to see that the ASCE Pentagon Building Performance Report includes a sketch (Fig. 3) showing a left bank of about 7 degrees, presumably based on impact damage marks.[17]

Fig. 3. ASCE sketch of impact region.

It is clear from photographs however that this sketch is misleading, possibly due to a perspective effect arising from the artist's eye being above the aircraft, which has not yet reached the Pentagon. The left wing is shown at the bottom of the row of windows while the photographic evidence places the damage near the top.[18] If allowance is made for this effect, the crucial difficulty that the left engine appears to be partly below ground level is overcome. This engine impacted a low retaining wall, clearly establishing its height as within inches of the ground.[16] Many people have pointed out that the left engine did not mark the lawn.

The following graph (Fig. 4) shows final data file readings to the nearest quarter second. Positive values of roll and control wheel are to the right. Positive pitch is upward.

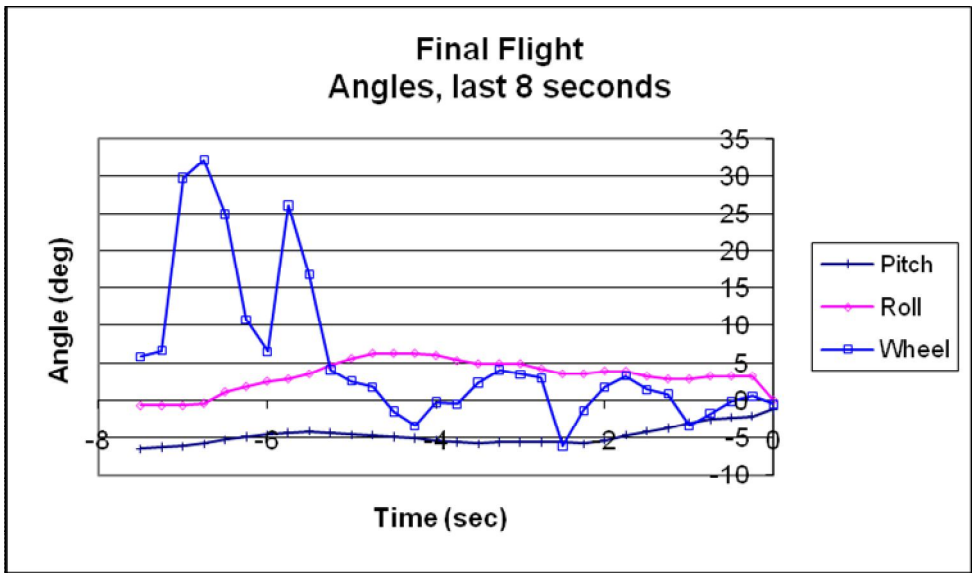

Fig. 4. Graphical presentation of some final FDR data.

A heavy generator trailer had been parked near the Pentagon. Its displacement toward the Pentagon, and damage to its housing, indicate a severe impact occurred with the right engine. As the control wheel is close to central, the very rapid rotation to the left was apparently not commanded and therefore must have been caused by this impact. The roll (bank) recorded in the data file at impact is zero, hence either the right wing, or portion of it, was severed or buckled and projected upwards, or there is some lag in recording the bank angle, or some combination of both. The damage mark of the left wing alone (Fig. 5), being near horizontal, indicates that there was appreciable bank to the left, approximately equal to the dihedral angle, 5 degrees. We see that the facing is fragile and its removal clearly delineates the upper edge of the wing impact area. This image is from a video which pans left and right and shows that the horizontal damage is much longer than shown here.[19] It seems the fuselage may not be banked left as much as might be assumed from the impact marks of the right wing, apparently relied upon by the ASCE.

Fig. 5. Left wing impact mark, near horizontal.

Height and altitude

We come now to the core argument of this paper. Data from the FDR file provides the graph below (Fig. 6) showing "true altitude"[20] as derived from the raw pressure altitude and "radio altitude" as calculated by adding radio height above ground to ground elevation at corrected positions.

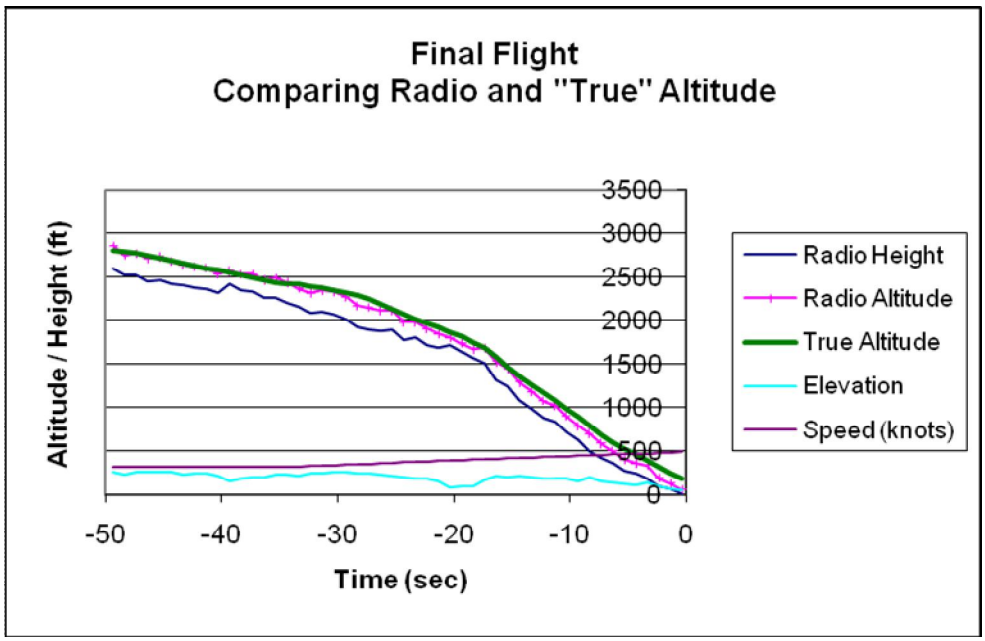

Fig. 6. Divergence observed between altimeter and radio altitude as plane descends.

The elevations were obtained using the *getElevation* method of the United States Geological Survey (USGS) Elevation Query Web Service.[21] The graphs stop short of the y-axis, illustrating that there is a gap of a fraction of a second between the last altitude records and the record of impact. It is immediately apparent that there is a divergence between these two measures of altitude, increasing as the plane descends and speed increases. As accurate knowledge of the altitude of the plane is essential for understanding this event, an investigation of the divergence was undertaken.

It was first necessary to find a means to assess the accuracy of the radio heights. The plane on the ground at Dulles, prior to the final flight, showed a radio height of -6 feet. This is reasonable as the instrument is intended to show zero when the plane is touching down for landing, at which moment the radio antennae will be raised as the plane will be nose-up and the suspension extended. Furthermore there are 11 previous landings recorded on the FDR data file and in every flight the radio heights fluctuate between -5 feet and -7 feet while the plane is taxiing after landing. Most are -6 feet. This is strong evidence that the system was accurate and reliable, at least at low levels. In calculations using radio altitude, 6 feet was added to all readings to remove this offset so that the height of a landed plane would be zero.

The last radio height in the FDR data file is 4 feet. It is clearly of special interest to know the location of the plane when this reading was taken. It was recorded in words 31 and 32 of the final subframe. The final longitudinal acceleration, recorded in word 225, registers impact, as it shows severe deceleration. Each word represents 1/256 of a second, so these readings are 0.758 of a second apart, based on word 31. The last recorded ground speed was 483 knots or 815 feet per second, so the plane has moved 618 feet between the readings. Adding the distance from the nose to the impact point on the wing, about 78 feet, gives 696

feet. This is close to the estimated distance along the plane's centerline from the Pentagon to the third light pole hit, about 692 feet.

As the FDR file provides the g-force on the plane, and its speed, it is possible to calculate the curvature of the flight path, and thus predict the path the plane will take from the first pole to the Pentagon, and thereby calculate the height of the impact point on the third light pole.

There do not appear to be any published measurements of the impact points on the poles, the vertical portion of which was 36 feet in height. There is, however, a photograph which suggests that about 5 feet was chopped off the first pole by the impact, showing that the plane's wing would have been about 31 feet above ground level.

Fig. 7. Taxi damaged by felled and severed light pole.

The vertical acceleration data in the FDR file shows the plane was experiencing a lift averaging 1.8g from the first light pole hit to the Pentagon. The motion of a body travelling in a circle can be specified by any four of the following five parameters: three positions on the circle, the velocity and the centripetal acceleration. In this case we have an estimate of the impact position on pole 1 and on the Pentagon and we also know the velocity and can derive the centripetal acceleration from the g-force, so can calculate a third position. Assuming a flight path which is circular in a vertical plane, calculation shows that, regardless of the exact angle of the plane at impact, the wing would have hit pole 3 between 25 and 26 feet above the ground.[22] Given the uncertainty of various estimates, this is consistent with the last radio height recorded, 4 feet, as an adjustment of 6 feet is needed to correct the reading for offset and a further 14 feet is needed to allow for the height of the wing at the impact point above the ground contact surface of the wheels, totaling 24 ft. The curvature of the final portion of the path, calculated in this way, is illustrated graphically below (Fig. 8). Photographs provide further support for the FDR data as they show the felled and severed poles becoming progressively shorter toward the Pentagon, consistent with the observed final impact point, close to the ground.[23]

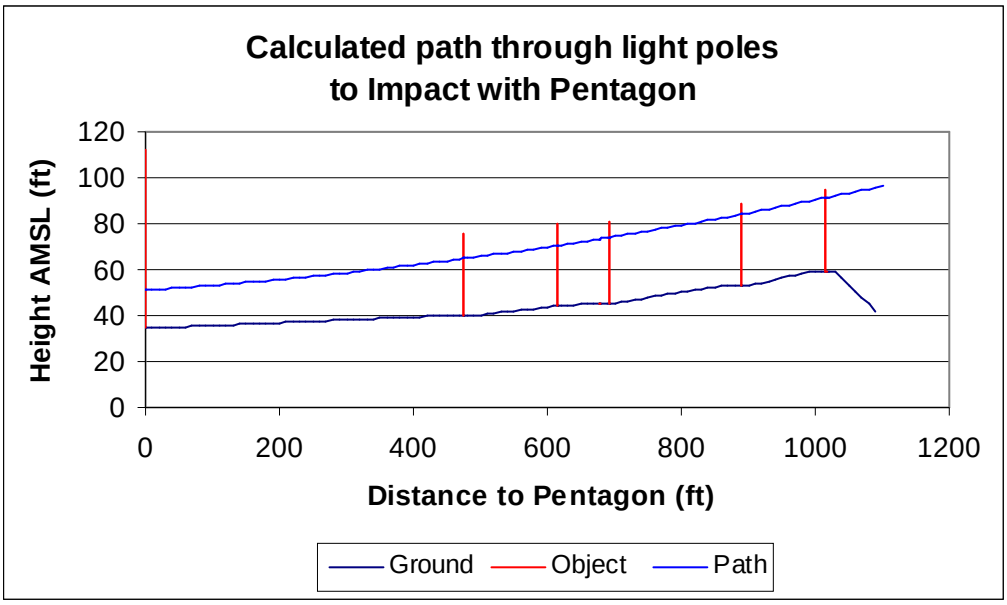

Fig. 8. Final path curvature, calculated using centripetal acceleration and velocity.

Note that the representation above is an approximation as no attempt is made to incorporate the 3 degree bank through the light poles, as recorded in the FDR file, or the final elimination or reversal of bank after impact with the generator, already mentioned.

The acceleration calculation also shows that the plane would be flying with a downward slope of about 1.2 degrees prior to impact. This provides further support to the FDR data as it shows that pitch has the same final value, -1.2 degrees. This slope would be hard to distinguish from horizontal, and therefore is not in conflict with the very unclear video which was released.[24]

The recording of radio heights commenced on descent at 2590 feet. From this level there were 14 consecutive data points where the air speed was between 312 and 314 knots, at which speed the altimeter should be calibrated to within maximum permitted error, as the speed and altitude are within the normal cruising range. These points, and also the corresponding radio altitudes, were averaged. The difference between these averages was less than 1 foot. The divergence displayed in the first graph in this section (Fig. 6) rises gradually during the descent, reaching 124 feet at the last reading. As the Pentagon is only 77 feet high, the pressure altimeter is indicating that the plane would have easily cleared the building but the series of radio altimeter readings is leading inevitably to impact close to the ground, in accordance with the impact damage.

In order to determine how this behaviour compared with normal operations, the same process was applied to several earlier landings recorded in the data file. In these cases it was noticed that the maximum divergence between true altitude and radio altitude occurred between 10 and 35 seconds before touch-down. To achieve a consistent measure, a running average of 5 points was taken and the maximum value found. Using this procedure, landing at Dulles, the flight prior to the flight to the Pentagon, shown below (Fig. 9), produced a divergence of 52 feet.

As the air speed does not decline much during these last few seconds it seems the sudden reduction in divergence, just prior to landing, may be due to some factor which affects the direction of airflow over the static port, perhaps as a result of the commencement of flare for landing. Alternatively the reduction in descent rate may have diminished the lag, if present. While speculation about airflow and lag may be relevant to research into altimeter performance, it is important to note that this paper does not rely on any knowledge of the

causes of altimeter error as it simply uses the radio height data, together with ground elevation, to assess the altimeter error. The technical term “true altitude” is conveniently brief but may be misleading. It is arrived at by a specific calculation which is no doubt highly accurate, but the value depends on the assumption that the “static pressure”, which is the pressure within the aircraft measuring system, is equal to the pressure outside the aircraft and that the instrument is properly calibrated. This is apparently far from true under some conditions studied here.

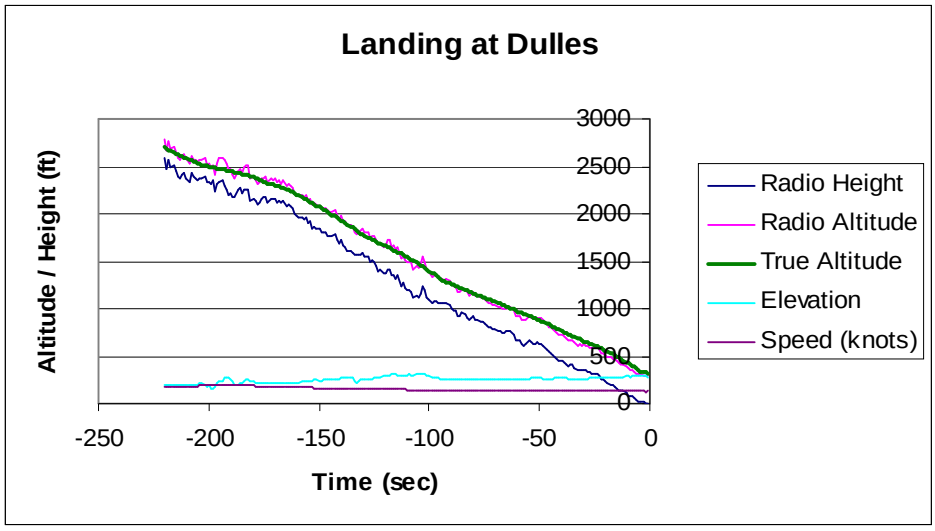

Fig. 9. Normal landing at Dulles, prior to final flight.

A selection of earlier flights is shown in the following graphs (Figs. 10 to 12):

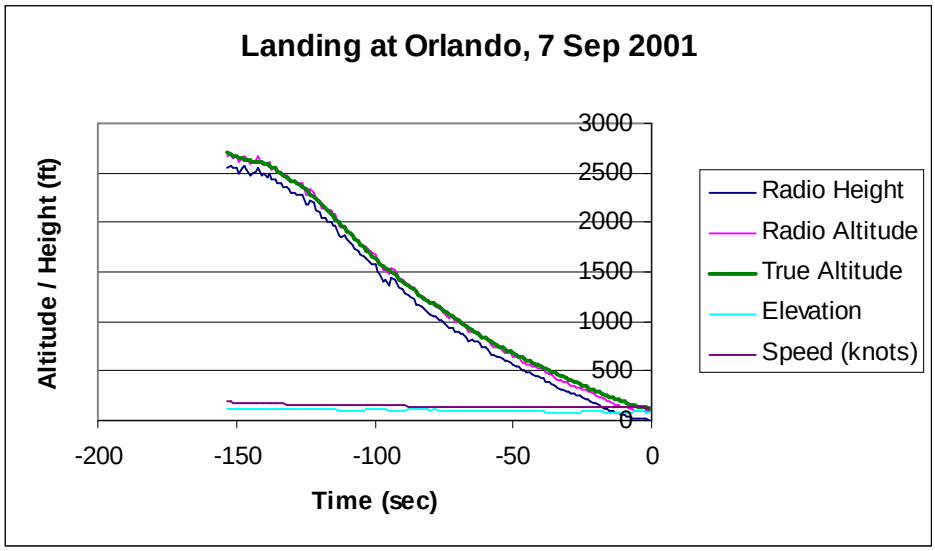

Fig. 10. Normal landing at Orlando.

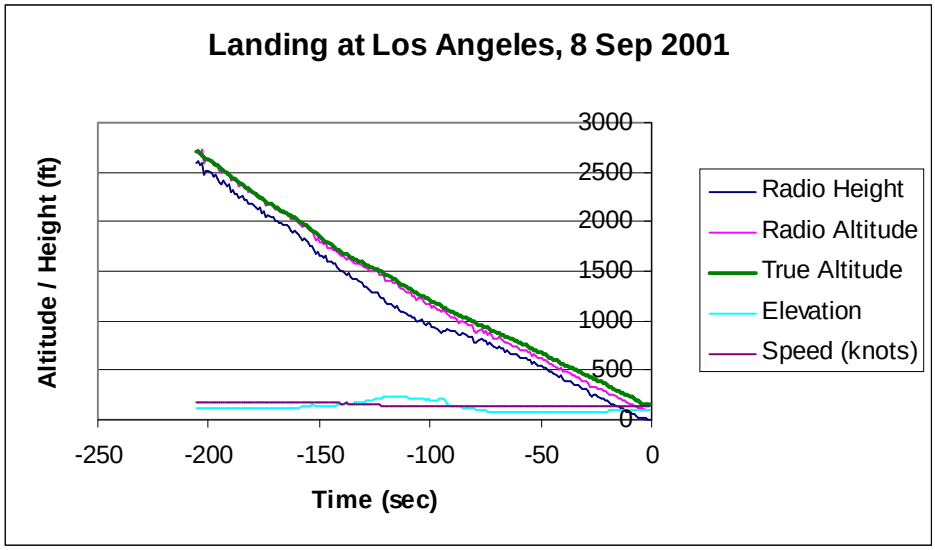

Fig. 11. Normal landing at Los Angeles.

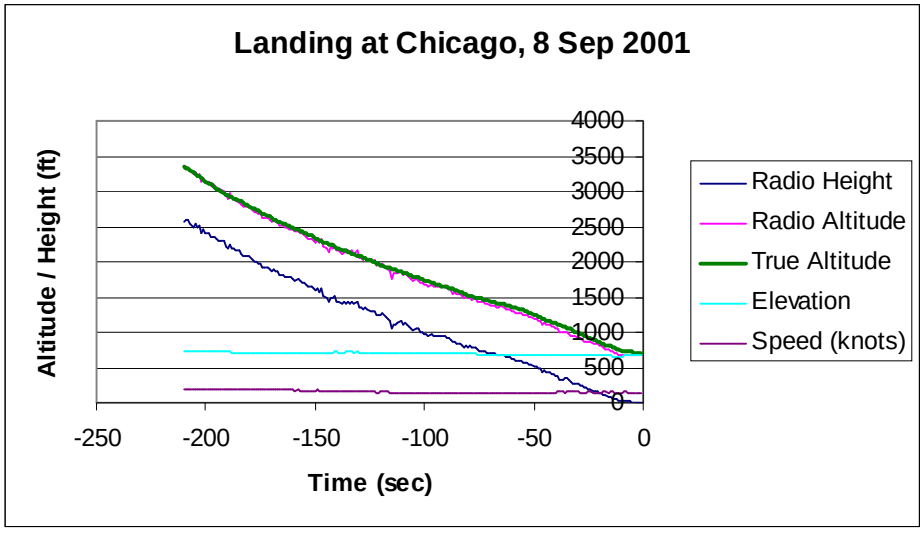

Fig. 12. Normal Landing at Chicago.

At Los Angeles the divergences were 52 and 83 feet; at Chicago, 52, 63 and 77 feet; and at Orlando, 50 feet. Thus even at normal speeds a significant error, increasing as the plane descends, is consistently found. Whether this is a feature of the Boeing 757, or just this particular aircraft, is not known. An error of this size is of no consequence during normal cruising operations and would cause no problems on final approach for landing as the radio height, and other instruments, would then be used.

It was also noticed that corrections were needed to align the average true altitude with the average radio altitude over the first few data points after the radio height system commenced to operate. These corrections ranged from 1 to 17 feet. In effect the radio altitude was used to calibrate the pressure altimeter. These calibration errors are small and insignificant for normal operations, but slightly increase the uncertainty of the pressure altimeter.

While it may be argued that the radio altitude can have a significant error under cruise conditions, the likely error close to the ground, less than 1 foot, is well established and confirmed here by the study of data in the FDR file, produced while the aircraft was taxiing, as described above.

Inspection of the graphs shows that there are occasional random errors in the radio altitudes. The fourth last radio altitude may be an example of such an error, or it may be the result of an error in the elevation, as it is out of step with its neighbours and with the trend of the altimeter. No such random errors are seen in the altimeter data. The general consistency of the radio trace over the last few seconds, shown in the graph below (Fig. 13), together with the very uniform descent shown by "true" altitude, totally rules out any possibility that the last unadjusted radio height, 4 feet, was recorded while passing over the Pentagon, as has been suggested.

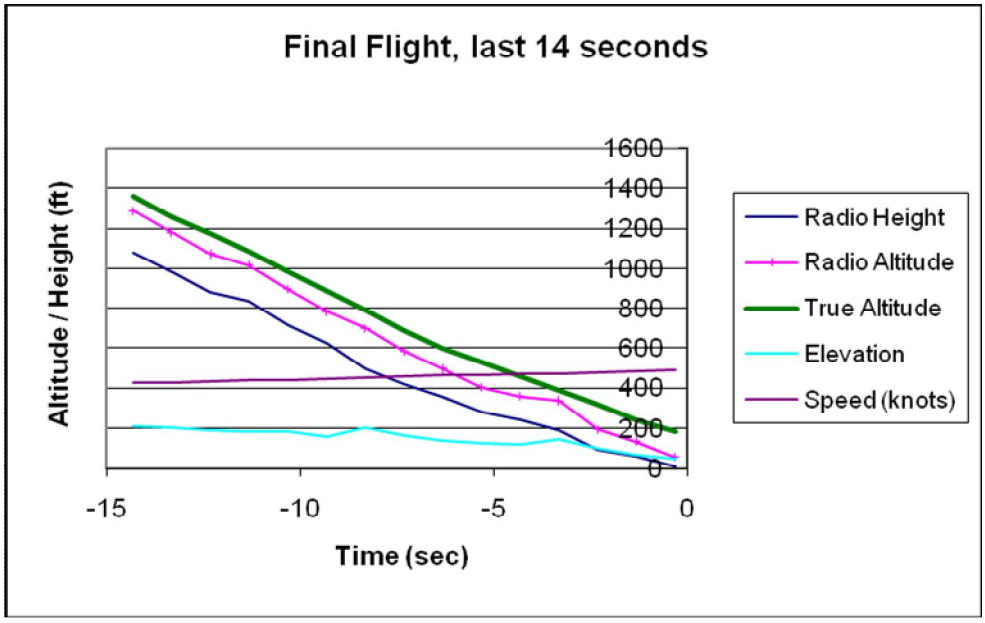

Fig. 13. Final moments of flight showing divergence between altimeter and radio height, increasing as plane descends and speed increases.

This analysis clearly shows that the claim that the FDR file provides evidence that the plane was too high to hit the Pentagon is without foundation. It is true that the altimeter indicated that the plane was too high but the radio height system did not. Based on the data and analysis presented above, there is no reason to distrust radio height but there is ample reason to distrust the altimeter on descent at low altitudes, especially at very high speeds.

Accelerations

The vertical acceleration near the end of the flight shows very high, but not excessive, g-force, indicating that the descent rate is being rapidly reduced, as shown in the following graph (Fig. 14). The longitudinal acceleration shows a severe negative deviation at the end; the maximum value possible in the data file, as would be expected from collision with a substantial object. There is also a dip during the last second, which may be the result of a shock wave running through the structure of the aircraft due to impact with a light pole.

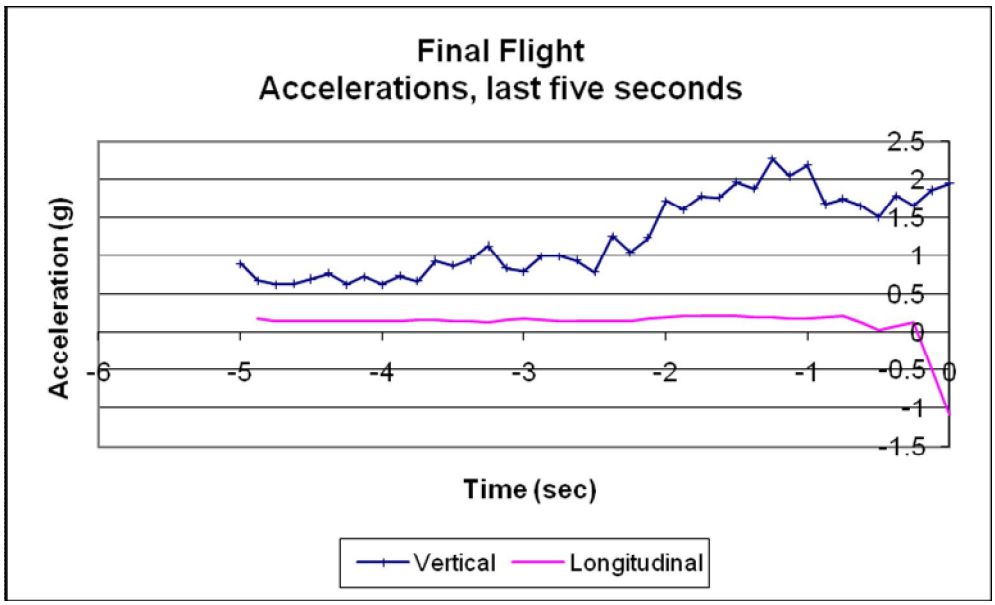

Fig. 14. The flight terminates, as shown by the severe negative longitudinal acceleration. The vertical acceleration, finally high, is never above the legal limit of 2.5g.

The vertical acceleration shows a curious pattern. It is not possible for the plane to be controlled in such a way as to produce a motion with the observed high frequency of reversal. It therefore seems likely that some part of the plane is fluttering, as occurs with excessive speed. It is interesting that this does not appear till about 4.5 seconds before impact, at which point the plane has accelerated to about 470 knots, significantly above the "maximum dive velocity", 410 knots. As fluttering will eventually damage or destroy an aircraft, this observation may give an indication of the size of the air speed safety margin, a figure which does not appear to be available to the public.

As already mentioned, it has been asserted by one group that it would be impossible for the plane to survive pull-up after passing over the Virginia Department of Transportation (VDOT) radio antenna tower, as it would require a wing loading of over 10.14g. This claim is, however, easily shown to be incorrect. It results from an unfounded assumption that the plane would have travelled in a straight line from the tower to the first light pole before commencing the pull-up. The graph above (Fig. 14) shows that this assumption is not justified, as a strong g-force commences at about 2 seconds prior to impact, while the first pole is not hit until about 1.3 seconds prior to impact. Also their calculation has been shown to contain a large mathematical error, which more than doubles the force required.[25]

The FDR data also shows that vertical acceleration drops below 1 passing by the VDOT tower, which occurs at about 4.25 seconds prior to impact (Fig. 14). This observation indicates that the descent steepened as the plane passed the tower, thus setting up a curved course which would have enabled avoidance of excessive g-force. The data file confirms that pull-up commenced before the first pole, already identified by the increased g-force, as it shows the downward pitch declining during the last two seconds (Fig. 4).

If the plane is allowed to pass over the antenna at a steeper angle and fly a curved path, spreading the pull up over a wider arc, calculation shows that the g-force required can be reduced to a level substantially below the plane's legal limit of 2.5g.[25] This calculation is in accordance with the data file as the peak force, experienced briefly, is 2.26g (Fig. 14).

The FDR file, after correcting the position reports as described below, shows the plane passing above and a little to the south of the VDOT antenna tower and then continuing to follow a course corresponding with the official account.

Altimeter errors

It is a requirement in the USA that above 18,000 feet the pilot must set the altimeter to standard pressure, 1013.25 hPa, but prior to take-off it is set so that it reads the elevation at the airport. The data file recorded the altitude of the plane on the ground at Dulles, from where the final flight began, as 40 feet. Atmospheric pressure at the time was 1023.23 hPa and temperature was 18^{o}C, 3 degrees above standard temperature. If the pressure and temperature difference from standard atmosphere is allowed for, calculation shows the displayed altitude would rise 272 feet, reaching 312 feet, which is the published elevation for Dulles International Airport.[26] The adjustment may be confirmed using this calculator: http://www.luizmonteiro.com/Learning_ALT_Errors_Sim.aspx

It is therefore apparent that the data file recorded raw altitude at Dulles in terms of standard pressure and that no error was present at the time. It was as though standard pressure had been set on the altimeter. Examination of the previous flights on the file showed that the recordings were all based on standard pressure, as no transitions between local and standard pressure are observed.

US Federal Aviation Regulations appear to permit an altitude error up to +/- 30 feet per 100 knots,[27] which would give a maximum permitted error on final approach, ranging from 130 to 140 knots in the data file, of 39 to 42 feet. In none of the sets of landing data examined was the discrepancy with radio height greater than 17 feet when recording of radio height commenced, hence there is no reason to suspect that the altimeter was malfunctioning or badly out of calibration, yet the observed errors were 50 to 83 feet just prior to normal landings. It therefore appears that this calibration standard is not applied at low altitudes.

Position report errors

The data file shows that the course position error at take-off from Dulles is much greater than the error at the end of the final flight. The large error at the beginning may have resulted from drift of the inertial navigation system while the plane was on the ground. These errors are apparently largely corrected during flight, presumably by reference to Distance Measuring Equipment (DME) and VHF Omnidirectional Radio Range (VOR), which provide distance and direction from ground stations. Also available at the time was the Global Positioning System (GPS). Significant position errors were nevertheless noticed in the data from most of the normal landings described above, and corrections were made. It was noticed that the errors became larger while the plane was taxiing toward its parking spot, at which time it would presumably be too low to receive DME and VOR correcting signals. It may seem surprising that GPS was not correcting drift, but the NTSB has released a document which lists GPS as “not working or unconfirmed”.[28]

The errors in the data file position reports were corrected by creating a file consisting of every fifth position report and applying the positions to Google Earth maps. In the case of the 11 landings prior to flight 77, each plot was inspected to identify the position where the plane turned off the runway onto a taxiway. The differences in latitude and longitude between the plotted position where the plane turned and the junction with the taxiway were used to adjust the data file values. Only landings in which the turn off position could be clearly established were used in this work. The average latitude error was 329 feet and the maximum error was 1197 feet. The average longitude error was 663 feet, maximum error 1410 feet. It is clear from this study that the position reports produced by this aircraft were prone to error, producing recorded tracks which were parallel with, but offset from, their real tracks. It is therefore not surprising that this was also found to be the case with the final flight.

A method similar to that used to correct landings was used to correct the final flight. The last position report is recorded 166 words prior to the recording of impact. This represents a distance travelled of 528 feet, as may be determined using the details in the calculation at the foot of page 6. Adding the distance from the nose to the accelerometers, about 75 feet, gives 603 feet. The last position report was therefore created about 603 feet along the centerline of the aircraft from the face of the Pentagon. There is of course appreciable uncertainty in this figure as there may have been some crushing of the nose before the high deceleration was recorded. Also we have been unable to determine whether there is any software adjustment made to the position reports within the plane before they are recorded. Any such errors would be small and would have negligible effects on the calculations and conclusions of this paper as their only effect would be to alter by a few feet the location at which each ground elevation was taken. The latitude error was found to be about 42 feet and the longitude error about 392 ft, well below the averages for the previous flights.

The last DME distance from the facility at Reagan National Airport was 1.25 nautical miles. As these measurements have a resolution of 0.25 nautical miles, this is consistent with the calculated position of the final DME report, being 1.3 nautical miles, as measured using Google Earth.

Time discrepancies

After adjusting the timeline in the CSV file by adding 4 seconds throughout, the data lines up with the FDR file. This file still finishes 4 seconds earlier than the FDR file, due to omission of the last four seconds of data. We do not assert that either of these files has the timeline correct. It could be that the clock in the plane was incorrect, hence adjustment might have been appropriate.

Decoding errors

It is perhaps not surprising that the unofficial decoding, utilized in previous studies, failed to recognize and provide information from the incomplete final frame. It must be common, however, for the last frame of a data file to be incomplete when the recording is terminated by a crash, hence one would expect the official procedure, used by the NTSB, to provide a complete decoding. Apparently, in this case, it failed to do so.

Warren Stutt has now taken the study of the FDR data a stage further. He discovered that the failure of the NTSB to decode the last frame was caused by unrecorded error correction codes towards the end of the FDR data. Apparently the software used to decode the file was unable to handle this situation correctly. His initial decoding was successful because it did not use error correction. He then found that if he put the correct codes into the last two pages of the original file, the ROSE software produced a complete decoding which exactly matched his previous decoding. Some earlier flights recorded in the FDR file also had incomplete final frames but these contained error correction codes and were properly decoded. It is apparent that proper error correction codes are necessary for the software available at the time to correctly decode a final partially written frame. It appears that the NTSB may not have been aware that final error correction codes could, in some cases, be missing, causing truncation of the data.[29] It seems likely that the previous unofficial decoding was also affected by the same problem.

The ROSE software is supplied by the firm which manufactures the FDR. This firm has not confirmed that the problem described here has been addressed in the current version of their software. This is clearly an important issue as the last frame could be vital to a crash investigation.

As the range of possible errors is very large it may be difficult to design software which will always operate correctly. Rather than use software designed to correct errors it may be safer to use software designed to simply flag errors for human analysis.

Summary and Conclusion

In response to FOIA requests the NTSB provided a CSV file and a coded FDR file. All contradictions between the official account of the course of flight AA 77 and these files appear to be traceable to missing data. In the case of the CSV file the data stopped about four seconds short of the impact. In the case of the FDR file the final frame was not initially decoded. Some researchers recognized that data was missing, while others claimed that the files proved the official account was false, as it appeared the flight terminated at a point too high to have created the observed damage trail on the ground.

Previous analyses were further confounded by uncertainty of the position of the last data point; failure to consider possible calibration errors in the pressure altimeter data, caused by high speed and low altitude; and false information in the NTSB flight animation.

The recent complete decoding of the FDR file has enlarged and clarified the information available and has thereby enabled resolution of the contradictions. It is clear that this file supports the official account of the course of flight AA 77 and the consequent impact with the Pentagon. The file thus also supports the majority of eyewitness reports.

---

[1] Wikipedia on American Airlines Flight 77, gives impact time 2 seconds earlier than the 9/11 Commission: http://en.wikipedia.org/wiki/American_Airlines_Flight_77 based on the NTSB report: http://www.ntsb.gov/info/AAL77_fdr.pdf

[2] 9/11 Commission Report, page 10: http://www.9-11commission.gov/report/911Report.pdf

[3] 9/11 Research, general discussion of alternative theories: http://911research.wtc7.net/pentagon/analysis/theories/index.html
Discussion of the 5 video frames, the confusing nature of which promotes unscientific speculation: http://911research.wtc7.net/pentagon/analysis/videoframes.html

[4] The technical term "radio height" is used throughout this paper. This is often called "radar height" but that is confusing as the type of signal used is not conventional radar, which measures the time taken for a reflected pulse to return. The radio altimeter uses a continuous frequency modulated beam and measures the phase shift of the returning signal. This is far more accurate for short distances. The system measures, records and displays to the pilot, the height of the aircraft above the ground.

[5] Calum Douglas explains how the files were obtained and dealt with here: http://video.google.com/videoplay?docid=2833924626286859522# The animation obtained from NTSB, which he shows speeded up and complete, is clearly flawed as the track is incorrect and, like the CSV file, it terminates too soon. The NTSB has stated that this animation was not used for any official purpose.

[6] 9-11Research, Analysis of eye witness reports: http://911research.wtc7.net/pentagon/analysis/conclusions/jetliner.html

[7] Sarns, C, a study of eyewitness video interviews: http://csarnsblog.blogspot.com/. Of the 13 north path witnesses claimed, the 5 who were in a position to see the Pentagon reported they saw the plane hit the Pentagon or fly so low it could not miss. One has to ask whether the traumatic image of the plane hitting the Pentagon, or the image of the prior path of the plane, would be more reliably held in memory.

[8] Hoffman, J, "*Critiquing the Pentacon*": http://911research.wtc7.net/essays/pentacon/index.html

[9] Damage at the Pentagon: A very large number of small fragments of what appeared to be the lighter parts of a plane were scattered over a wide area and a massive amount of larger fragments was found inside the Pentagon. These included a wheel and motor parts identified as from a Boeing 757. The damage trail included 5 light poles, a fence and a generator trailer. The hole in the wall of the Pentagon. estimated to be 96 feet wide, was ample to admit the heavy parts of the plane. Within the Pentagon the support columns were bent and broken in the direction of travel. See photographs and discussion here: http://www.journalof911studies.com/volume/2009/WhatHitPentagonDrLeggeAug.pdf. The depth and spread of debris which flowed out through the "exit hole" indicated that a substantial avalanche of material had hit the wall. See http://911research.wtc7.net/essays/pentagon/docs/punchout_rv.jpg

[10] It appears Farmer has removed links to his work. His conclusion however has been quoted in numerous places, for example: http://arabesque911.blogspot.com/2009/07/misinformation-flight-77-flight-path.html

[11] It is not our position that we have proved the data file authentic. It is of course impossible to do so. However the file is such a vast collection of inter-related information that it would be extremely difficult to manipulate without leaving evidence in the form of items which did not correlate correctly. We have not found any such evidence. That is sufficient for the case we develop.
[12] Radar data displayed on map: http://i27.tinypic.com/1zgrimq.png
[13] Stutt, W: http://www.warrenstutt.com/
[14] Bart, E: http://www.historycommons.org/events-images/317_pentagon_approach.jpg
Later versions of this image have additional "exit holes" marked. It is important to note that these are incorrectly labeled. They are not places where plane debris broke through the wall but doors through which smoke escaped, as can be seen in this photograph:
http://i14.photobucket.com/albums/a327/lytetrip/Pentagon/rollupdoor3.jpg
[15] It would be painfully tedious to repeat the phrase "if it was a plane" every time the word "plane" or "aircraft" is used. It is to be understood, where relevant, throughout.
[16] Hoffman, J on the physical evidence: http://911research.wtc7.net/essays/pentagon/index.html
[17] ASCE Pentagon Building Performance Report: http://fire.nist.gov/bfrlpubs/build03/PDF/b03017.pdf
[18] 9/11 Review.com, see the Will Morris photo: http://911review.com/articles/stjarna/eximpactdamage.html
[19] Left wing impact mark. This image was taken from the video recently released as a result of a FOIA request: http://911blogger.com/news/2010-12-22/new-pentagon-videos-foia-release
[20] As static pressure was not available from the FDR file two steps were required. First, static pressure was calculated from the raw altitude data, then true altitude was calculated from static pressure.
Static pressure (in Hg) = 29.9213 * (1 – 0.0019812 * A / (273.15 + 15)) ^ (32.174 / (0.0019812 * 3089.8))
where A = raw altitude (ft).
True Altitude (ft) = ((273.15 + T) / 0.0019812) * (1 – (P / S) ^ (0.0019812 * 3089.8 / 32.174))
where T = temperature at sea level (deg C); P = static pressure (in Hg); S = altimeter setting (in Hg).
[21] USGS Data Service: http://gisdata.usgs.gov/XMLWebServices2/Elevation_Service.asmx?op=getElevation
[22] Assumptions used in calculation: Elevation at the base of pole 1 is estimated to be 59 feet AMSL using the embankment height each side of Columbia Pike. The impact point on pole 1 appears to be about 31 feet above ground level. Ground level at pole 3 is 46 feet and at the Pentagon 34 feet We assume the impact with the generator simply rotates the plane about its C of G and has negligible vertical effect. The impact point on the wings would be about 39 ft from the centerline and 14 feet above ground when parked. The lowest part of the motors is 2 ft above ground when parked. While the sketch in the ASCE Pentagon Building Performance Report indicates the plane was banked left about 7 degrees, presumably based on wing tip damage, the FDR data file shows a bank of zero. It is therefore appropriate to find the sensitivity of the calculation to the bank at impact. Varying the assumed bank from 3 to 7 degrees alters the calculated impact point on pole 3 over the range 25.2 to 25.7 feet; not significantly different, given the uncertainty in various estimates. Assuming a left bank of 5 degrees and a ground clearance of 0.5ft, the fuselage would be centred about 15 feet above ground on impact with the Pentagon. The distance from pole 1 to pole 3 is 335 feet. From pole 3 to the Pentagon is 692 feet. These distances were obtained using Google Earth, care being taken to select the archived map from September 2001, which shows the impact damage. The elevations are from USGS.
[23] Pentagon light poles: http://www.scienceof911.com.au/pentagon
[24] Judicial Watch FOIA request: http://www.judicialwatch.org/archive/2006/flight77-1.mpg
[25] Clinger, W: http://www.cesura17.net/~will/Ephemera/Sept11/Balsamo/balsamo2.html
[26] Dulles International Airport: http://www.airnav.com/airport/KIAD
[27] Wikipedia, Altimeter errors: http://en.wikipedia.org/wiki/Position_error#cite_ref-5
[28] NTSB factual report on Digital Flight Data Recorder: http://www.ntsb.gov/info/AAL77_fdr.pdf
[29] Stutt, W, Apparent bug in ROSE software: http://www.warrenstutt.com/ROSEBugReport24-10-10/index.html An update on this problem to reflect the findings reported in this paper has now appeared on his web site: http://www.warrenstutt.com. Expect further reports on receipt of responses to his correspondence with NTSB.