NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 14, 2015

Structures Group Factual Report of Group Chairman

A. ACCIDENT:	DCA15MA029
Location:	Gaithersburg, MD
Date:	December 8, 2014, 10:41 am EST
Aircraft:	Embraer EMB-500, Phenom Model 100, N100EQ

B. GROUP MEMBERS:

Group Chairman:	Robert L. Swaim National Transportation Safety Board Washington, DC
Member:	Daniel Marimoto Embraer Fort Lauderdale, Florida

D. SUMMARY:

On December 8, 2014, about 1041 Eastern Standard Time (EST), an Embraer EMB-500 Phenom 100, N100EQ, impacted terrain and houses about 0.75 miles short of runway 14 while on approach to Montgomery County Airpark (GAI), Gaithersburg, Maryland. The airline transport rated pilot and two passengers were fatally injured as well as three persons on the ground. The airplane was destroyed during the impact and ensuing fire. Marginal visual meteorological conditions prevailed at the time and the flight was operating on an instrument flight rules (IFR) flight plan. The airplane was registered to and operated by Sage Aviation LLC., of Chapel Hill, North Carolina, under the provisions of 14 Code of Federal Regulations Part 91 as a personal flight. The flight originated from Horace Williams Airport (IGX), Chapel Hill, North Carolina, with GAI as its intended destination.

The Structures Group Chairman arrived on-scene at about 11:30 am on December 8, 2014, and performed coordination duties until arrival of the Investigator In Charge, about four hours later. The ELT was turned off at about 2 pm and the combined flight data and voice recorder was removed. The Structures Group Chairman maintained possesssion of the recorder until placing it in the car of an NTSB employee who drove it to NTSB headquarters. The following morning, a

representative of Embraer joined the Group Chairman, creating the group. On-scene documentation was completed on December 9, 2014.

Portions of all major aircraft components were found at the accident site and evidence about the impact attitude was consistent with approximately -30° (nose down) and -110.5° left wing down roll. No aircraft structural anomalies consistent with pre-impact conditions were found, such as parts of the airplane not located at the accident site, left/right structure differences, or differences in left/right flight control surfaces.

E. DETAILS OF FIELD INVESTIGATION

FAA REGISTRY:

Model:	EMB-500
Serial:	50000082
Manufactured by:	EMBRAER-EMPRESA BRASILEIRA DE
Registered to:	SAGE AVIATION LLC 331 W BARBEE CHAPEL RD CHAPEL HILL, NC 27517-7513
MFR Year:	2009
Certificate Issue Date:	4/23/2014
Engine Manufacturer:	P&W CANADA
Engine Model:	PW617F-E

The aircraft data plate contained similar information. (See Figure 1)

Figure 1. Aircraft data plate on aft fuselage.

BASIC AIRCRAFT INFORMATION:

The airplane had a brown, white and orange paint scheme. (See Figure 2) and Embraer reported that on October 7, 2014, the owner provided the following aircraft usage data:

> Accumulated 633.10 flight hours and 551 flight cycles.
> Monthly 4.7 flight hours and 4 flight cycles.

Figure 2. Internet photograph of the airplane prior to the accident in the paint scheme found on-site.

The following airplane descriptions have been copied from the FAA Flight Standardization Board Report for the Embraer- Empressa Brasileira de Aeronatica S.A. Models EMB-500 and EMB-505, dated 09/15/2010, written by Douglas L. Edwards, Chairman, Embraer Phenom

Flight Standardization Board, for the FAA Kansas City Aircraft Evaluation Group, MKC-AEG. The text below is not the full text of the Standardization Board Report.

BACKGROUND

EMBRAER-EMPRESA BRASILEIRA de AERONAUTICA S.A., the Manufacturer, is headquartered in Sao Jose dos Campos, Sao Paulo state, Brazil.

EMB-500

The Embraer Model 500 (EMB-500), also called the PHENOM 100, is a low wing, T-tail and pressurized airplane, powered by two high by-pass ratio rear mounted turbofan engines. The tricycle landing gear is fully retractable, with single tire at each leg, to be operated on paved runways only. A glass cockpit panel has been developed with highly integrated onboard avionics. The passenger configuration consists of two seats abreast (one to each side of the aisle, aka: club seating) which allows carrying up to 5 passengers if the aircraft is operated single pilot and using the copilot seat as a passenger seat. The Embraer Model 500 is a twin-engine turbofan airplane certified in accordance with 14 CFR Part 23, in the normal category with Special Conditions requiring commuter category takeoff and landing performance. It is listed on Federal Aviation Administration (FAA) Type Certificate Data Sheet (TCDS) Number A59CE as the Model EMB-500. Embraer received their FAA type certificate on 12/12/2008.

The airplane has 1160 NM range utilizing NBAA criteria with high speed cruise of .70 Mach. Takeoff field length is listed as 3, 400 feet with a landing distance of 2,699 feet.

The minimum crew determination listed in the airplane flight manual (AFM) and on the TCDS is one pilot in the left seat. AFM limitations authorize a single pilot provided there is an operative autopilot. The pilot must utilize an operative headset mounted microphone. If either the autopilot or microphone is not operative, the EMB-500 must have a crew comprised of one pilot and one copilot.

The EMB-500 is certified for Day, Night, VFR and IFR flight conditions to a maximum operating altitude of 41,000 feet, and is approved for flight into reduced vertical separation minimum (RVSM) airspace if the aircraft meets the minimum equipment requirements contains in the Aircraft Flight Manual, Supplement 1. The EMB-500 is also approved for flight into known icing conditions.

The EMB-500 base model has a maximum certificated takeoff weight of 10, 472 pounds and a maximum landing weight of 9, 766 pounds. All models of the EMB-500 have a total seating density of up to six, with two crew seats and four passenger seats (standard).

The aircraft is powered by two Pratt & Whitney, PW617F-E engines, each producing approximately 1, 700 pounds of thrust. Engines are controlled by two

dual-channel, full authority digital engine controller (FADEC) units. Engines received type certification by Transport Canada and FAA on October 3, 2008.

The EMB-500 fuselage and major structural components are aluminum, and the aircraft employs conventional, mechanical flight controls. There are two ram's horn controls mounted in the center at each pilot station.

The aircraft fuel system is a pressurized wet-wing design. Total fuel capacity is 2,850 pounds with 2,806 pounds usable.

The EMB-500 relies on dual Garmin Integrated Avionics (GIA) units and an electronic power distribution system to control, monitor, and power its systems and components. The two GIA's and all electronic aircraft system buses and components, are interwoven and fully integrated.

The two GIA's in the EMB-500 each have independent architecture for redundancy to ensure availability for several important aircraft support functions, including the autoflight system (AFS). The AFS consists of an autopilot and autotrim system, flight director, yaw damper, stall warning and stick pusher, the flight mode annunciation (FMA) and crew alerting system (CAS) message reporting.

STALLS – The EMB-500 and the EMB-505 were found to have stall characteristics during flight testing which as a 14CFR Part 23 certification requirement, required a stick pusher system to be installed to mitigate these characteristics. The stick pusher in the EMB-500 is electric whereas the stick pusher in the EMB-505 is hydraulic. The EMB-505 stick pusher activation was demonstrated to be effective but less aggressive than in the EMB-500. The stick pusher in the EMB-505 must be tested before each flight after engine start. The EMB-500 sick pusher still must be tested before each flight but because it is electric it may be tested prior to engine start.

The EMB-500 has no unusual stall characteristics if stall recovery is initiated at the first indication of a stall, which is well above an aerodynamic stall. The stall speed in the clean configuration, with 0 degrees angle of bank is 100 KIAS. In the landing configuration, with gear and flaps fully extended with 0 degrees of bank, the stalling speed is 77 KIAS. The FSB noted that at low altitudes stall recovery can be completed with minimal altitude loss if initiated at the first indication of a stall, which is the aural stall warning and the stall warning visual indication on the PFDs.

An aerodynamic stall occurs at the same approximate airspeed as stick pusher activation. If the stick pusher activates, the loss of altitude during the stall recovery will be 300 to 500 feet. As a consequence, flight crews, training personnel and evaluators should be aware of the consequences of low altitude

stalls. The FSB did not evaluate stalls at high altitudes. Stalls at high altitudes may require much greater loss of altitude than stalls at low altitude.

An aerodynamic stall occurs at the same approximate airspeed as stick pusher activation. If the stick pusher activates, the loss of altitude during the stall recovery will be less than in the EMB-500. The FSB did not evaluate stalls at high altitudes. Stalls at high altitudes may require much greater loss of altitude than stalls at low altitude.

PATH DATA AND TEXT DESCRIPTIONS:

The airplane wreckage contained a mixture of impact and fire damage. (See Figure 3)

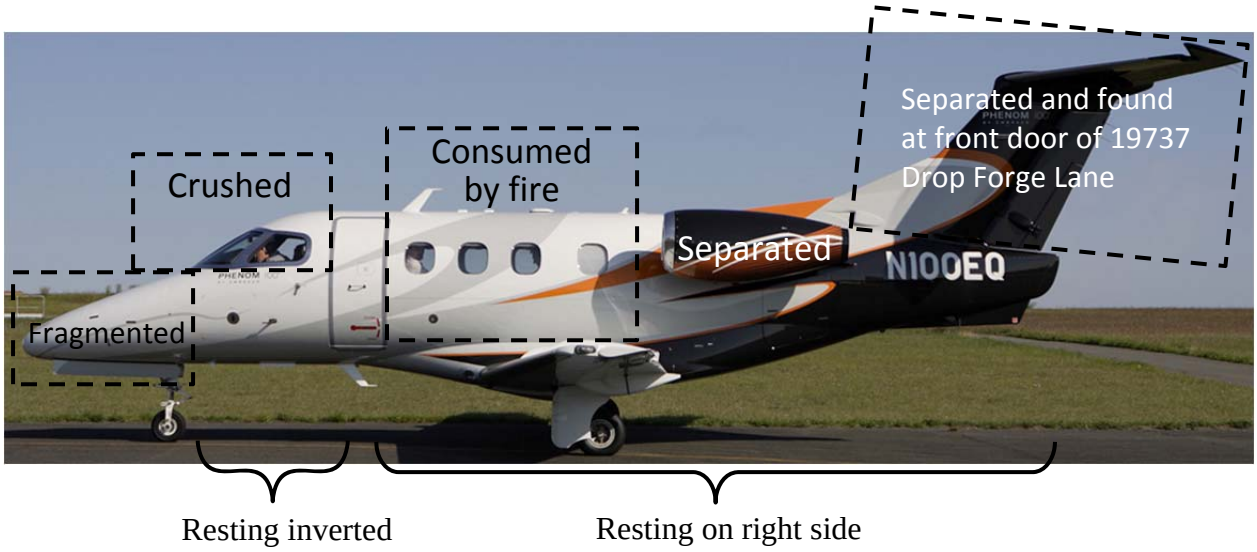


Figure 3. Generalized diagram of major damage areas to fuselage. The right side is approximately similar to this image of the left side. The top of the main cabin door was displaced aft. For reference, the original aircraft length was 42’ 2” and the height was 14’ 4”. The remaining length of fuselage from tailcone to the front of the remaining nose was 33’ 5”.

The following data and descriptions are based on the direction of travel. Two sources of latitude/longitude data were used with slight differences between the sets. For example, initial roof contact positional data was obtained with a hand-held GPS device which had view of 17 satellites. Google Earth showed this location to be several feet into the back yard of the same house. Therefore, both data sets are shown for many locations and the formats depict the origin of the data as follows:

Example format from Google Earth: 39.180155°, -77.180665°
Example format from hand-held GPS device: N39°, 10.815’, W 77° 10.840’

The three houses involved were located at the following addresses and are referred to by the house number in this document (See Figures 4 through 6):

19740 Drop Forge Lane, Gaithersburg, MD 20879
This ws the first house struck.

19737 Drop Forge Lane, Gaithersburg, MD 20879
This house had a strike mark matching the top of the horizontal tail at a bedroom window to the left of the front door, as viewed from the street.

19733 Drop Forge Lane, Gaithersburg, MD 20879
The left wing tip entered this house a major fire occurred at this house.

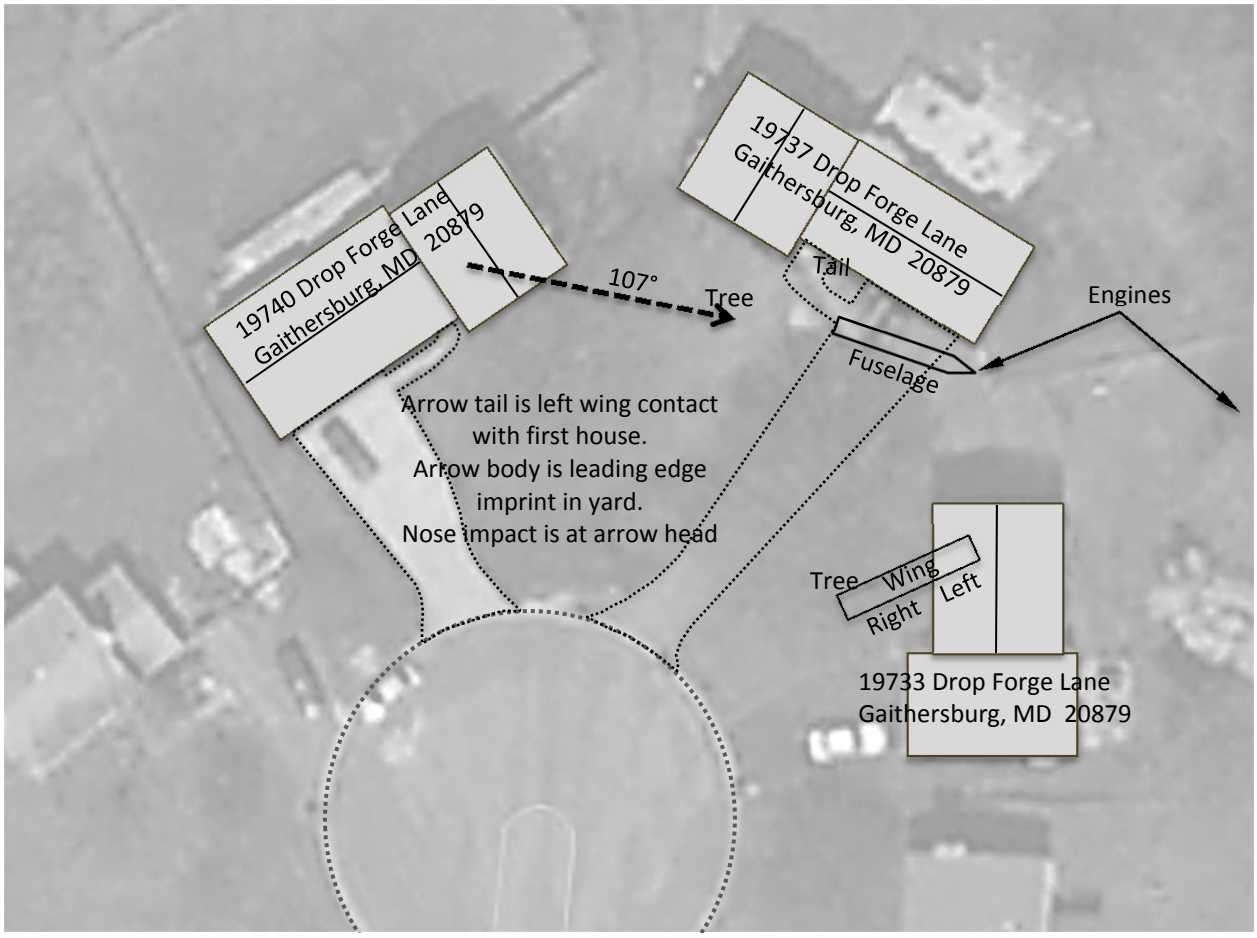


Figure 4. Diagram of houses and major features traced on to image from Google Maps. The nose of the fuselage was oriented toward the first house struck and the remnants of the wing rested with the top surface up..

Figure 5. Aerial photo of scene with relation to runway 14. The arrow points to the first house struck and is rotate to the approximate direction of the debris path.

Figure 6. Aerial view of houses on approximate orientation of airplane path.

The initial impact was to the roof of a house at 19740 Drop Forge Lane. (See Figures 7 through 9) The contact point to the house on Google Earth was at 39.180155°, -77.180665°
Inputting into Google Earth the following location from a hand-held GPS device viewing 17 satellites showed a location in the back yard of the 19740 house. The hand-held GPS coordinates were N39°, 10.815’, W 77° 10.840’

Figure 7. Cut in roof of 19740 Drop Forge Lane.

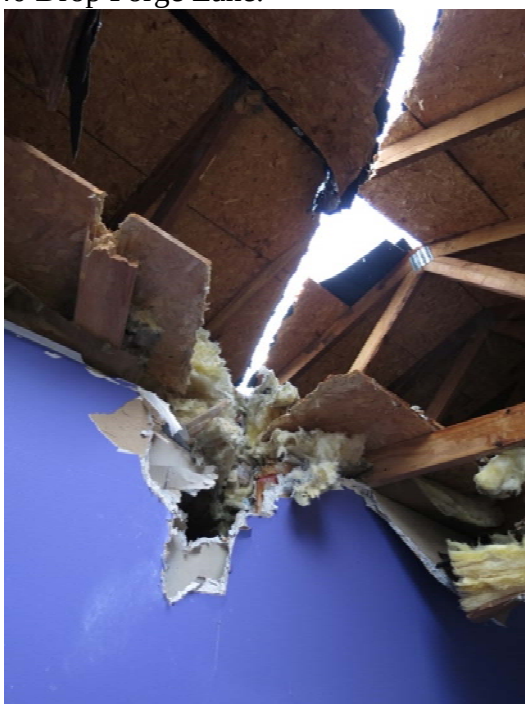


Figure 8. Initial contact of roof and interior bedroom wall inside 19740 Drop Forge Lane. This view is back toward the flight approaching the house, aligning the two contact points.

Figure 9. View back from nose of fuselage toward house at 19740 Drop Forge Lane, with debris trail leading to fuselage. The impact point is to the left of the heavily damaged tree in the debris trail.

The magnetic bearing from cut interior wall to airplane was 107° magnetic. The fuselage heading was twisted and bent, generally on the reciprocal heading of 287° magnetic. (See Figure 10)

Figure 10. From the bedroom of 19740 Drop Forge Lane, view of debris trail, showing 19737 at left and 19733 at right. The impact hole with a diameter of about that of the fuselage is to the right of the base of the heavily damaged tree in the yard of 19737 and the fuselage is in

the driveway, covered by a blue tarp. The airplane tail is at the front door of 19737 and the left elevator is at the far side of the impact hole.

Utilizing an optical inclinometer, the cut from roof to interior bedroom wall had a pitch angle of -36°. The angle from a cut in the interior wall to where the left wingtip contacted the ground was at a pitch angle of -26.5°.

Alignment of three points in the path of left wing tip cut through the roof and wall of the 19740 provided a roll attitude of 108° left wing down. (The third point was the wing tip contact hole in the front yard.) (See Figure 11) Broken tree branches above the house were at the approximate height corresponding to the path of the right wing and a line connecting the broken branches and cut in the roof was 113° left wing down. (See Figure 12) The Embraer frontal illustration of the airplane shows 5° dihedral and adding this to the above data results in the fuselage at a roll attitude at impact of 113° based in the left wing damage to the roof and 108° for the right wing damage to the trees. (approximate average of -110.5°)

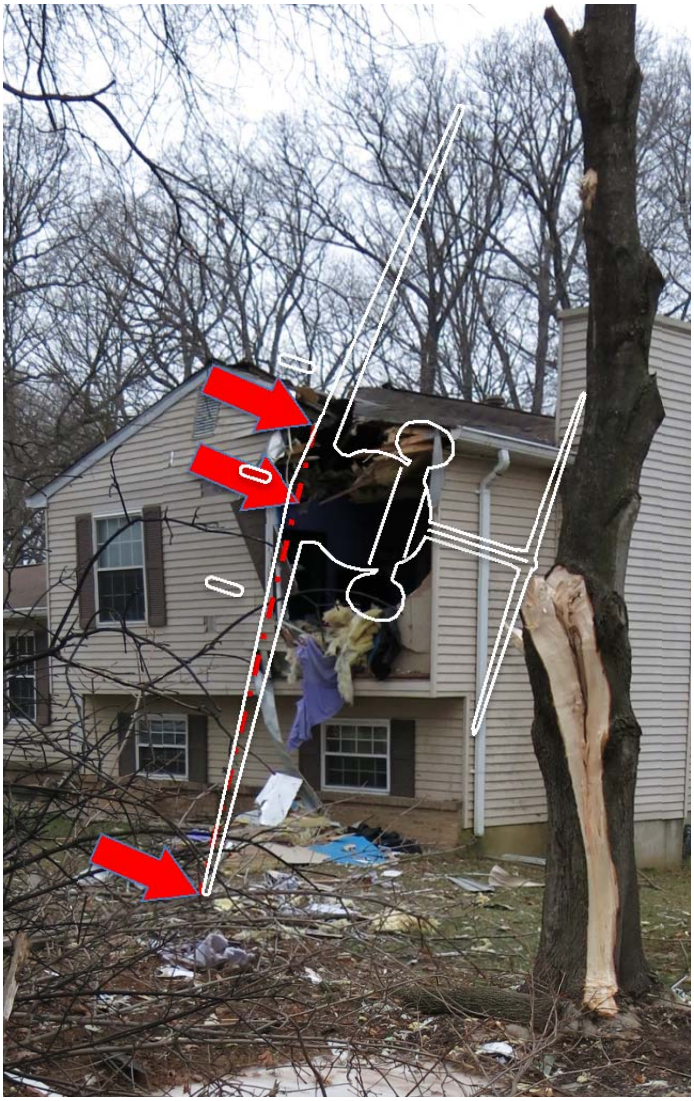
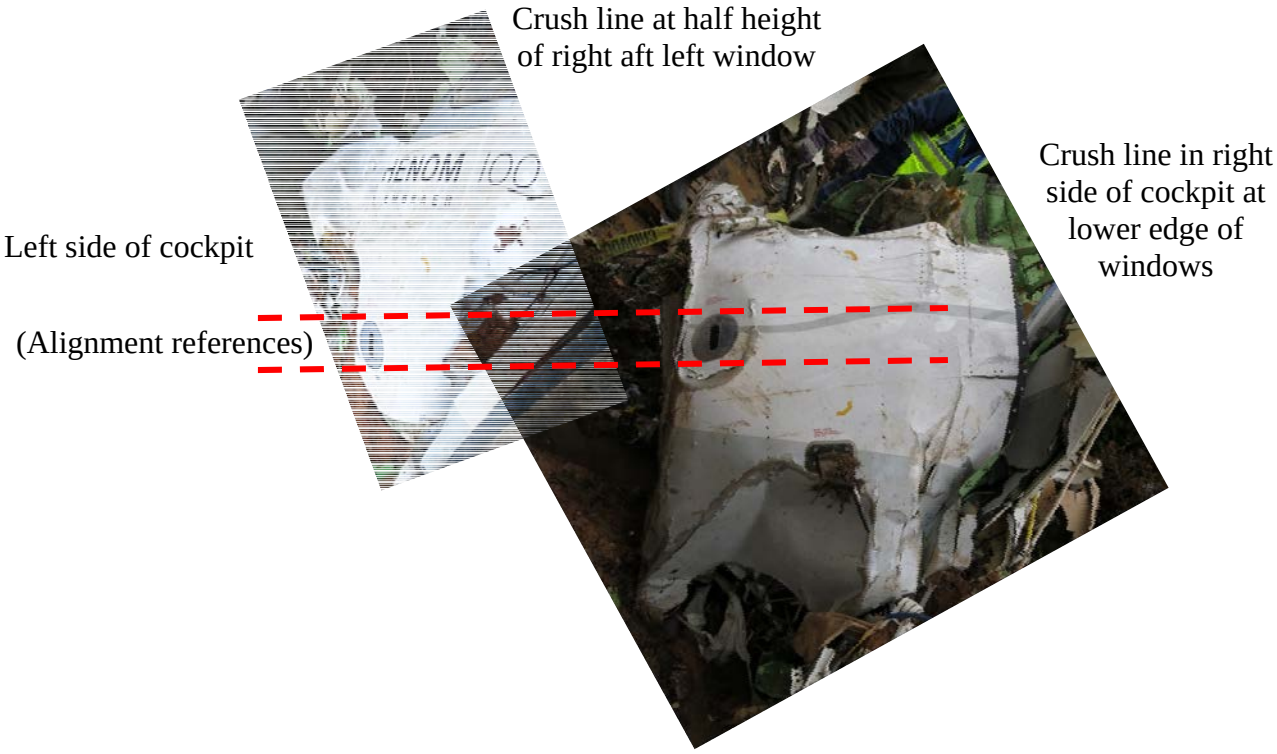


Figure 11. Aligning three points in path of left wing tip are the initial hole in the roof, the hole in the bedroom interior wall, and the hole in the yard. The dashed red line is along the wing leading edge and the airplane is shown only for rotational orientation. (The scale with respect to size is only correct for one point along the path toward the viewer.) At the bottom of the photo is a hole filled with water and the diameter of the hole is about that of the fuselage.

Figure 12. View is from the impact hole toward the broken branches above the house. A line connects the broken branches and cut in the roof.

Note: The following paragraph and photographs 12A and 12B are not in order of the debris trail. This has been done to bring together the references about roll attitude at impact.

Fragments of the windshield frame and glareshield were found at the tree and embedded in it, immediately uptrack of the hole in the 19737 front yard. Crush lines correspond to windshield strike marks on the tree and the difference in heights of damage were at about 121 degree left down in roll attitude. (See Figures 13A and 13B) This is a reference and imprecise value which incorporates an unknown amount of error, due to the irregular **c**urvature at the base of the tree which is visible in Figure 11.



Figures 13A and 13B. Sides of cockpit, rotated to a common top-up orientation.

The distance from corner of the 19740 house to initial ground impact and cut leading toward the fuselage was 9 feet. Toward the back yards of the 19740 and 19737 houses was metal from a wingtip. Between the houses were small fragments of wing leading edge with lengths of 3', 5', and 5' 9".

Distance between corners of the 19740 and 19737 houses was 32 feet.
Distance from 19740 Drop Forge Lane to tree (16 inch diameter) near front door of the 19737 house was 30 feet.

Distance from the 19740 house to impact hole in front yard of the 19737 house was 33 feet. The location of impact hole in ground near base of tree in yard of the 19737 house in Google Earth was 39.180136°, -77.180458°.

Toward the street from the impact hole were the nose landing gear assembly and fragments of the belly fairing from the wing/fuselage junction.

A cut and broad impact mark was found in the front wall and bedroom window of the 19737 house. (See Figures 14 and 15) A carbon composite fragment approximately one foot long from the outboard end of the left elevator was found caught inside the wall to the uptrack side of the damaged window in the front of the house. The torn edge of the fragment matched the left elevator. (See Figure 16) The top outboard portion of the left elevator had smears of color which matched the color of the house aluminum siding.

Figure 14. Overall view of 19737 Drop Forge Lane.

In shrubbery beneath the struck bedroom window of the 19737 house were the lower rudder, rudder trim actuator, and lower portions of the vertical stabilizer. (See Figure 15)

Figure 15. Exterior cut and damage to front of 10737 Drop Forge Lane at bedroom window. The airplane tail is at the right edge of the photo, partially blocking the front door. The arrow points to the carbon elevator fragment shown in the next photograph, from the trailing edge.

Figure 16. Carbon fiber trailing edge of elevator, found in wall of 19737 house.

At the front door of the 19737 house were the upper half of the vertical stabilizer, the horizontal stabilizer, and right elevator. The left elevator was at the downtrack end of the large impact hole near the base of the tree in the front yard. Organic material on the horizontal stabilizer was found at an angle other than the direction of flight, oriented further inboard toward the trailing edge than at the leading edge. The upper rudder hinge had embedded tree fibers on the right side.

Caught in and beneath the shrubbery to the driveway side of the 19737 front door were the standby attitude indicator, glareshield fragments, cockpit documentation, and other cockpit items. (See Figure 17)

Figure 17. Tail resting at 19737 front door and cockpit materials in shrubbery.

The leading edge of the right wing was found in two segments of 6 feet 9 inches and 9 feet. These were on the edge of the 19737 driveway, toward the 19740 house.

On the front roof of the 19737 house, above the front door was an airplane manual. (See Figures 18 and 19) Above the rear of the garage was a green tubular fragment. On the back deck of the house was material from the occupiable interior of the airplane and small aluminum shards.

The remaining nose of the airplane came to rest at the street side of the intersection of the driveway and walkway to the front door at 19737 Drop Forge Lane. (See Figures 17-20)

Nose on Google Earth: 39.180107°, -77.180354°
Nose on hand-held GPS viewing 19 satellites: N39° 10.811, W77° 10.823
Tape measure: 33 feet from the tree in the front yard, near the impact hole in the ground.

The fuselage came to rest on the driveway of the 19737 house and from approximately the cabin door aft was laying on the right side. The cockpit portion came to rest inverted, with extreme damage to the upper half.

Figure 18. Fuselage in driveway of 19737 Drop Forge Lane. The belly of the fuselage folds upward forward of the green area, which had been above the wing.

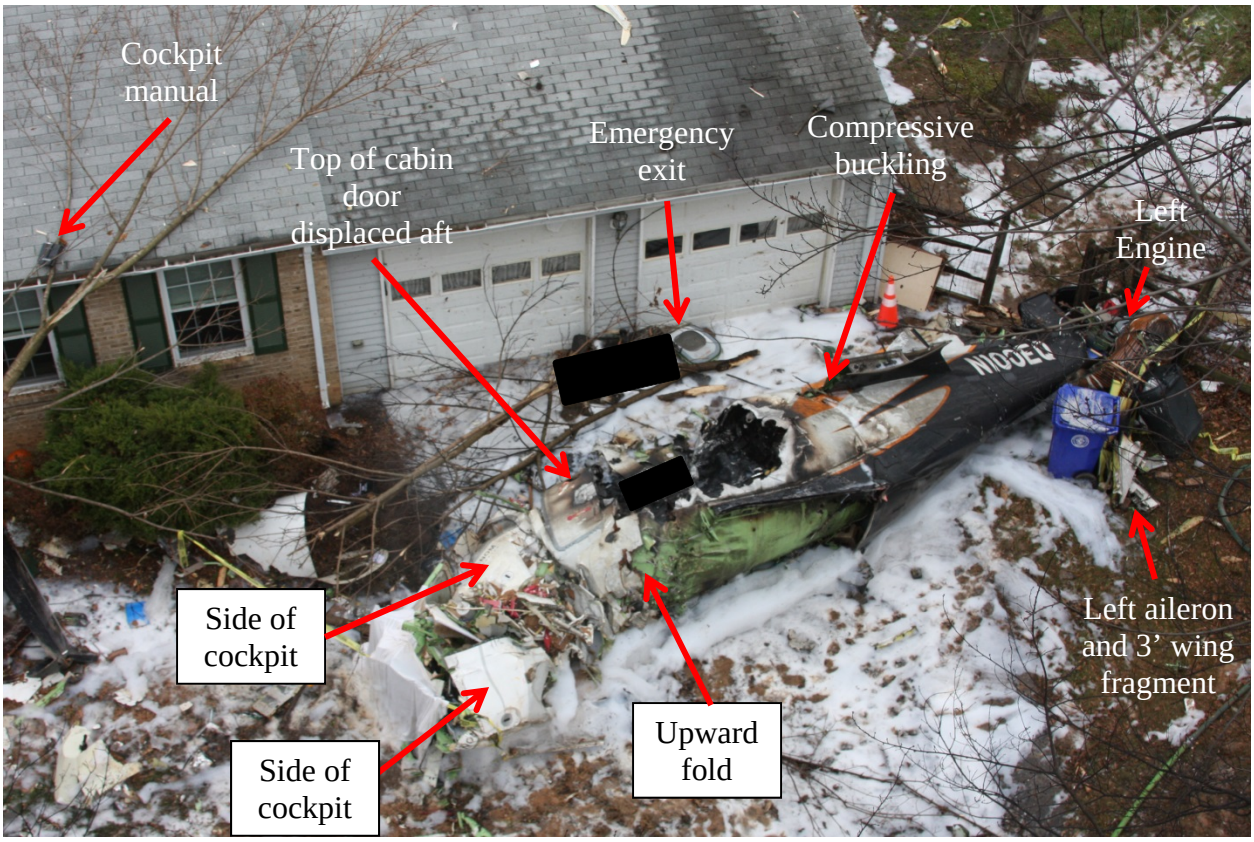


Figure 19. Fuselage as seen from above before fire fighting foam had cleared. As a dimensional reference, the width of the driveway at the garage was 19' 7".


Figure 20. Close up of fuselage from above.

The left cockpit seat was found outside of the airplane, at the base of the house wall between the two garage doors. Next to this was the emergency escape hatch, which had bent and damaged edges.

Facing the 19737 house garage doors, the top of the fuselage had been consumed by fire from an avionics rack at the rear of the occupiable cabin volume, forward to the cabin door. The sidewalls were missing on the right above the cabin floor forward of the aft-most cabin window, and to within six inches of the cabin floor on the left.

The crown of the fuselage had fore/aft compressive damage in a torsional orientation of the tail, with a displacement toward forward left.(See Figure 21) The interior right carbon fiber material at the base of the vertical stabilizer had tree material embedded. (See Figure 24)

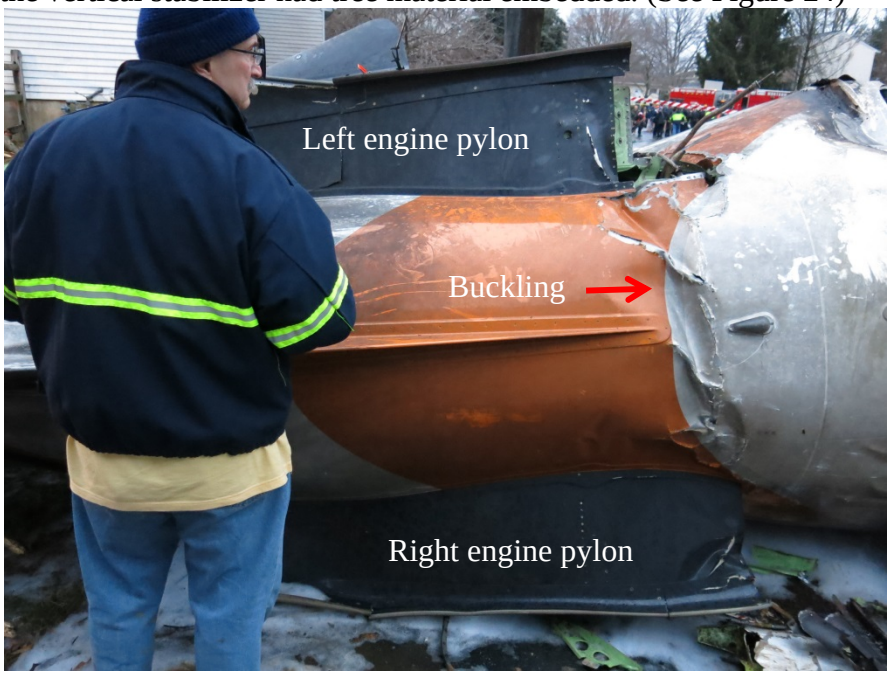


Figure 21. Compressive buckling in crown skin. This view looks down on the top of the crown.

The bottom of the fuselage was bent upward at the approximate location of the wingbox leading edge. The wing attach fittings were bent and broken with both left fittings displaced aft and the right fittings displaced forward. (See Figure 22) The corresponding wing center section found at the 19733 house fire had been consumed. The downward displacement of the wing from the fuselage had been far enough that the systems components on the bottom of the fuselage remained in approximately the original locations. The components did have some impact-related damage.

Figure 22. Center section of fuselage with wing attach fittings circled.

The tailcone of airplane and left engine were located two feet from the fencing gate to back yard of the 19737 house. (See Figure 23)

Tail cone on Google Earth: 39.180101°, -77.180271°

Tail cone with hand-held GPS viewing 18 satellites: N39° 10.809’ W77° 10.817’

Figure 23. Tail cone and inverted left engine. The arow orients where wood was embedded into carbon fibers at base of vertical stabilizer, as shown in Figure 24.

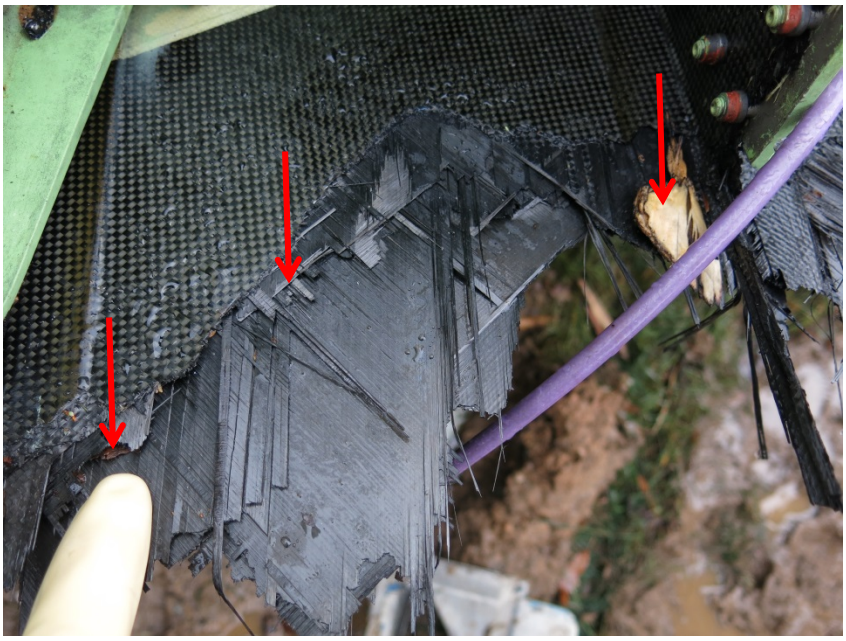


Figure 24. Embedded into the carbon fibers at the base of the vertical stabilizer were fragments of wood.

Three feet of left aileron with trim actuator and wing structure material was located near the bottom of the aft fuselage, near a household trash can. (See Figure 25)

Figure 25. Three feet of left wing structure and aileron.

Leaning against the fence between the 19737 and 19733 houses was the outboard end of a fragment with part number 500-14635-403, which the Embraer Aircraft Illustrated Parts Catalog (AIPC) showed to be the right aileron.

The right engine was found in the back yard of the 19733 house and a fuel burn was in the wet grass at the engine. (See Figures 26 and 27)

Google Earth: 39.180063°, -77.180037°

Hand-held GPS viewing 21 satellites: N39° 10.806, W77° 10.806

Figure 26. Right engine is next to the yellow children's slide, to the right of the person.

Figure 27. Fuel burn in grass at right engine.

Portions of all major wing sections were identified in 19733 house and on the the three lawns. (See Figure 28)

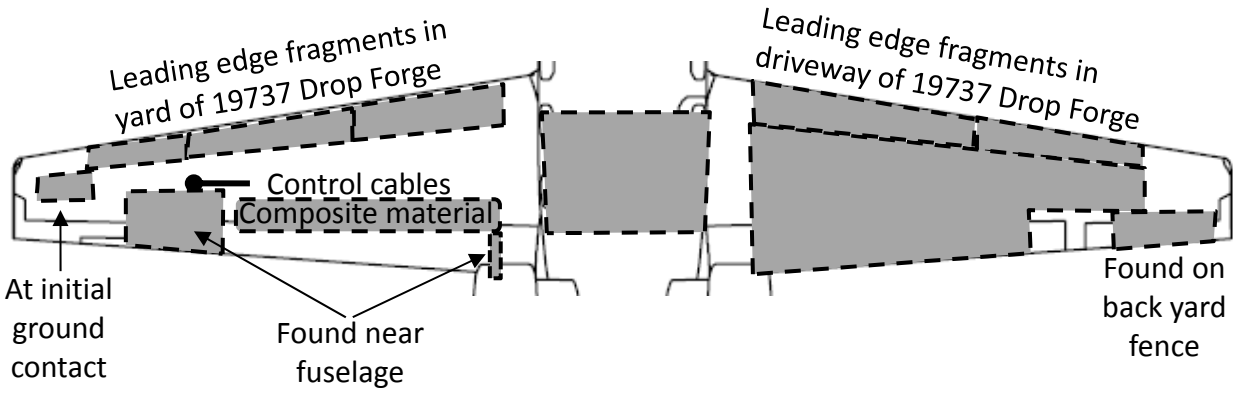


Figure 28. Identified wing components. For reference, the original wingspan was 40’ 5”.

Most of the wing was found at and within the front of the 19733 house, with both main landing gear extended. (See Figures 29-33) The left wing tip in Google Earth was at 39.179984°, -77.180292°. The right wing tip in front yard of the 19733 house in Google Earth was at 39.179955°, -77.180359°

Figure 29. Overall view of 19733 Drop Forge Lane.

Figure 30. The remnants of the wing are shown in this photograph, which faces the leading edge. The house in the background is 19737 Drop Forge Lane and the fuselage is in front of the garage doors.

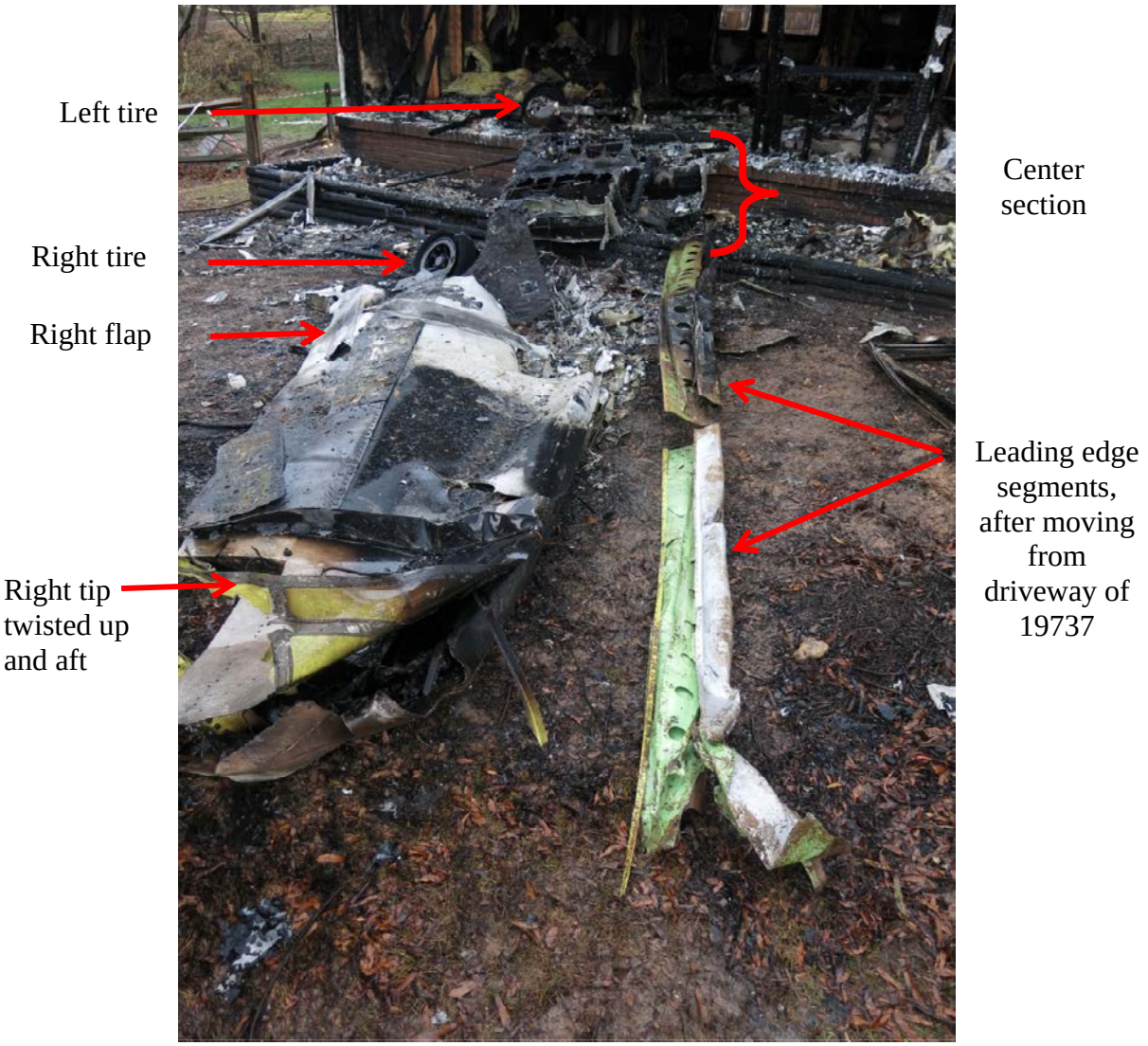


Figure 31. Wing at 19733 Drop Forge Lane, with captions added to show major features.

The remaining tip of the right end of the wing was next to a large tree in the front yard of the house. The right end of the wing included the inboard 2’5” of the aileron cut-out, with no aileron. The leading edge of the right wing structure was bent upward and was matched to the two sections of leading edge which had been brought from the driveway of the 19737 house. From the aircraft centerline, the end of the right wing measured 18 feet in span, and the two sections of leading edge matched this remaining length. The complete right flap was attached to the wing structure.

A loose autopilot servo was laying on the center-section of the wing, immediately outside of the 19733 house.


Figure 32. Wing center section, with left main landing gear inside of 19733 Drop Forge Lane.

Extending straight beyond the landing gear were remnants of composite material from above the left flap track and nine feet of control cable. (See Figure 33) Because of the instability hazard associated with the 19733 house, the three leading edge segments (3', 5', 5'9") from the yards of the 19740 and 19737 houses were not laid in front of the remnants of structure. A fragment of the left flap from the front yard of 19737 and the inboard flap track which had been near the bottom of the fuselage also were not brought to the 19740 house.

Figure 33. Dashed outline of the carbon fiber panel edges within the 19733 house, which are outboard of the visible left main landing gear tire. These left wing panels were similar to the accessible right wing panels which were above and ahead of the right wing flap.

Robert Swaim
National Resource Specialist
Aircraft Systems Engineer