

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ERA23FA352

AIRWORTHINESS

Group Chair's Factual Report

May 20, 2025

A ACCIDENT

Location: Pompano Beach, Florida
Date: August 28, 2023
Time: 0844 eastern daylight time
Helicopter: Airbus Helicopters Deutschland EC135 T1, registration N109BC

B AIRWORTHINESS GROUP

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C SUMMARY

On August 28, 2023, about 0844 eastern daylight time, an Airbus Helicopters Deutschland (Airbus) EC135 T1 helicopter, N109BC, was destroyed when it was involved in an accident in Pompano Beach, Florida (FL).¹ The commercial pilot sustained minor injuries. One paramedic on board and a resident of an apartment building were fatally injured, while a second paramedic on board was seriously injured. The helicopter was operated by the Broward County Sheriff's Office (BSO) as a Title 14 *Code of Federal Regulations* Part 135 air medical flight.

Ground witness and surveillance videos showed the accident helicopter flying with a smoke trail behind it, with some videos showing flames near the vicinity of the No. 1 engine exhaust and air conditioner condenser fans on the left side of the helicopter. Subsequently, the tail boom partially separated from the fuselage and the helicopter spun to the right while in an uncontrolled descent until it impacted an apartment building.

D DETAILS OF THE INVESTIGATION

1.0 Helicopter Information

1.1 Helicopter Description

The Airbus EC135 T1 helicopter is type certificated under FAA type certificate data sheet (TCDS) No. H88EU. The EC135 T1 has a four-bladed, rigid main rotor system that provides helicopter lift and thrust, and a 10-bladed fenestron (fan-in-fin) tail rotor that provides directional control of the helicopter. The EC135 T1 has a skid-

¹ The accident helicopter was an EC135 T1 equipped with a cockpit display system (CDS). Later versions of the EC135-series helicopters are equipped with a central panel display system (CPDS) with analogue backup instruments.

type landing gear. The EC135 T1 is equipped with two Safran Helicopter Engines Arrius 2B1 turboshaft engines mounted behind the main transmission.

In this report, all left, right, up, and down orientations as well as clock positions are in the aft-looking-forward frame of reference unless otherwise specified.

1.2 Accident Helicopter History

The accident helicopter, N109BC, was serial number (S/N) 139 and was manufactured in 1999. The No. 1 (left) engine was S/N 30175 and the No. 2 (right) engine was S/N 30182. The helicopter had a primarily red and black paint scheme (**Figure 1**). According to helicopter records, the helicopter had an aircraft total time (ATT) of about 5,578.4 hours, a No. 1 engine total time (ETT) of about 5,403.2 hours, and a No. 2 ETT of about 5,403.2 hours on August 27, 2023, the day before the accident.



Figure 1. N257BC, shown in this image, was a EC135 T2+ operated by BSO. The paint scheme of N109BC was similar to N257BC.

The accident helicopter had two cockpit seats (left and right) as well as two passenger seats in the cabin (forward-facing right and aft-facing left). The accident

helicopter had a search and rescue configuration that included a stretcher, medical equipment, an externally-mounted searchlight installed on the right [skid] step in the forward position, and an externally-mounted medical oxygen tank located at the bottom frame of the right-side cabin sliding door.

The accident helicopter was not equipped with, nor was required to be equipped with, a cockpit voice recorder or a flight data recorder. An Appareo Vision 1000 cockpit image recorder was installed onto the accident helicopter in April 2018 in accordance with Airbus service bulletin No. EC135-31-070. However, the Vision 1000 was not found in the wreckage and presumed destroyed in the postcrash fire.

2.0 On Scene and Post-Recovery Wreckage Examination

On August 29, 2023, members of the Airworthiness Group convened at the accident site to document the wreckage. On the same day, the wreckage was removed from the accident site and transported to Florida Air Recovery facilities in Fort Pierce, FL. From August 30-31, 2023, members of the Airworthiness Group continued documentation of the recovered wreckage in Fort Pierce, FL. From October 31 to November 1, 2023, members of the Airworthiness Group convened at Florida Air Recovery facilities in Fort Pierce, FL to conduct additional examination of the wreckage.

2.1 Structures

2.1.1 Airframe Overview

The airframe is composed of the main fuselage, primarily metal in construction, and the tail boom, primarily composite in construction. There are a total of six doors on the main fuselage: two hinged doors for the cockpit, two sliding doors for the cabin, and two hinged clamshell doors at the rear of the cabin. Major sections of the airframe include the subfloor structure, cabin frame, transmission deck, engine deck, and equipment deck (**Figure 2**). The tail boom is attached to the main fuselage at the tail cone, the latter of which is integral to the engine deck.

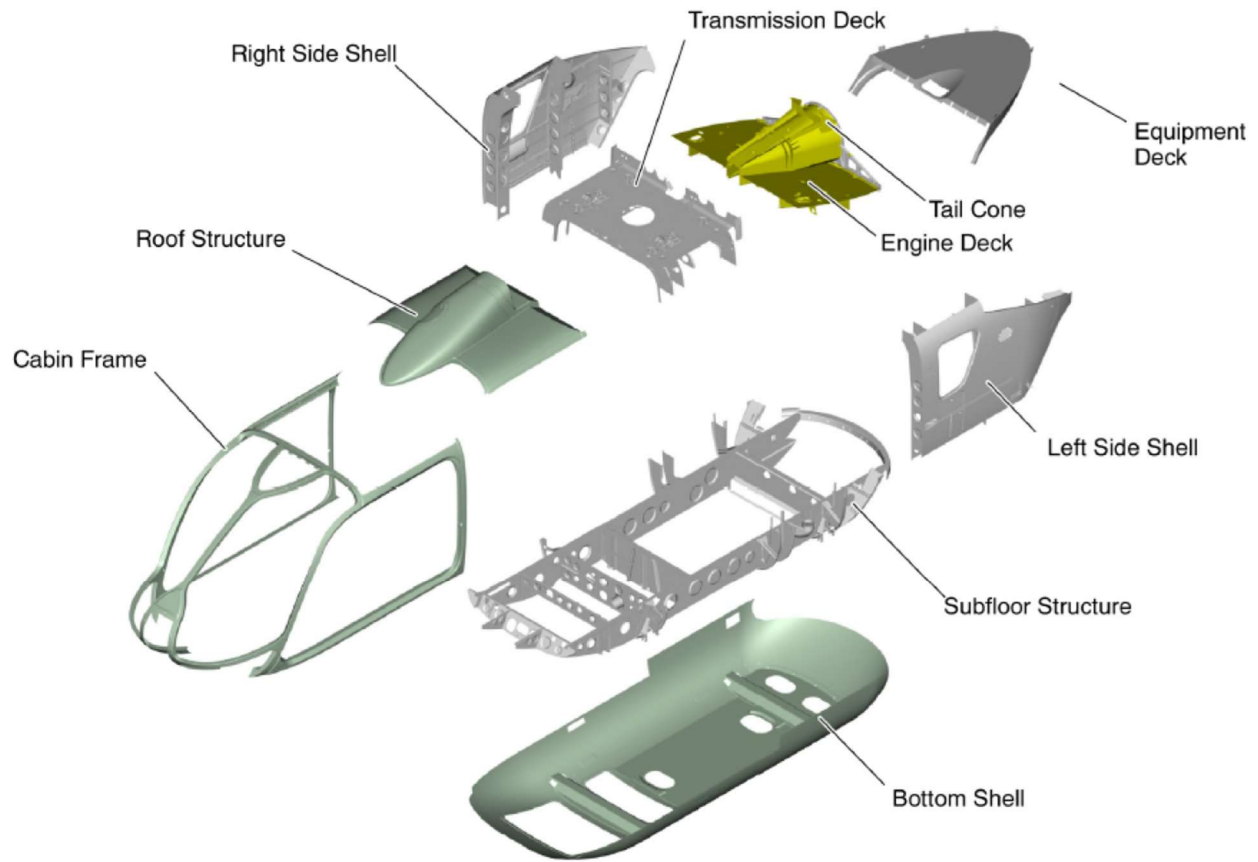


Figure 2. Sections of the airframe excluding the tail boom. (Image courtesy of Airbus)

The engine firewalls are constructed of titanium. The engine cowlings, surrounding the outboard sides of each engine, are constructed of composite materials, with fire-retardant paint on the interior surfaces of the cowling adjacent to the hot section of the engine. The standard design of the EC135-series helicopter has a common engine air intake between the Nos. 1 and 2 (left and right, respectively) engines that feeds air into the engine inlets (**Figures 3 and 4**). Air for the engines primarily enters forward of the main transmission, flows around the main transmission, and then into the common engine air intake.

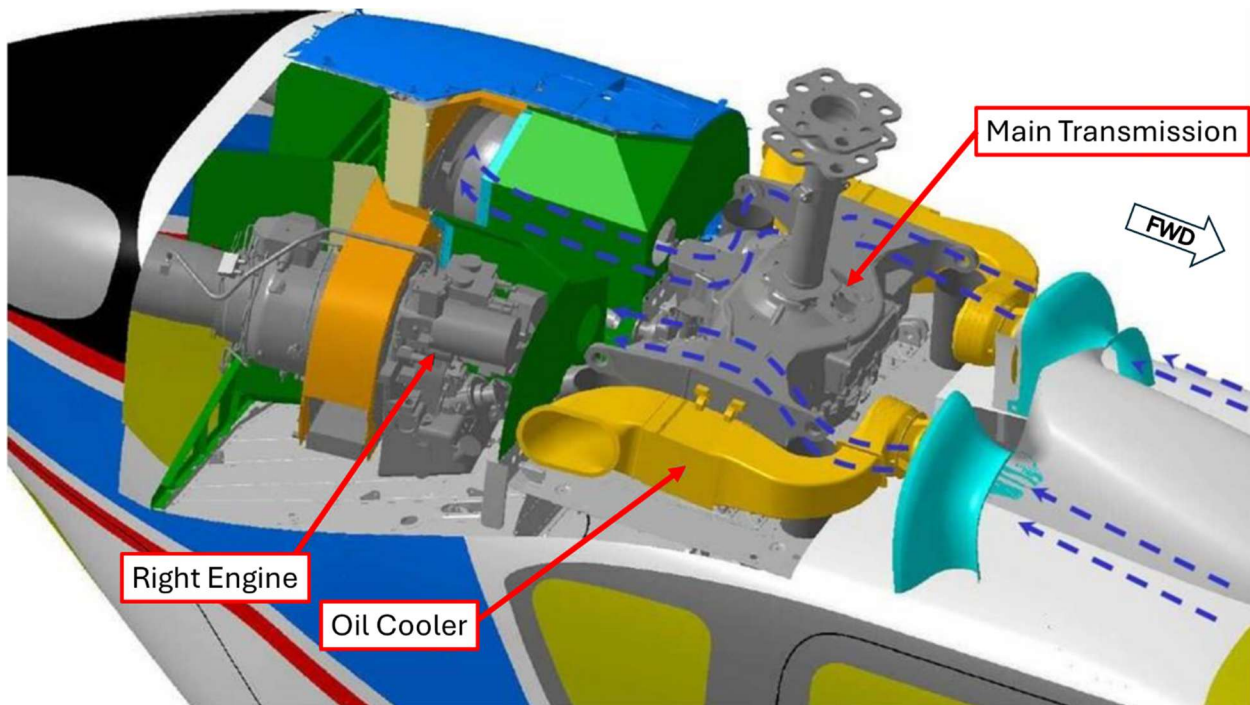


Figure 3. The airflow (blue dotted-line arrows) that feed the central engine air intake. The engine's titanium firewalls are shown in green. (Image courtesy of Airbus and modified by the NTSB)

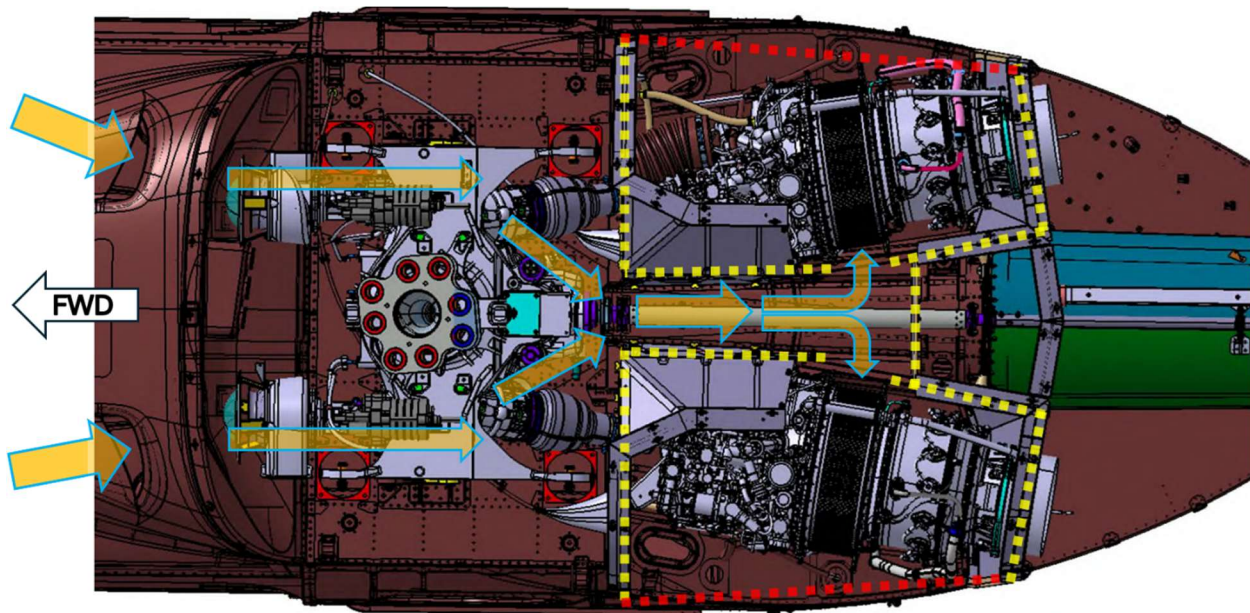


Figure 4. The airflow (orange arrows outlined in blue) that feeds the common engine air intake. The yellow dotted lines outline the engine compartment's titanium firewalls and the red dotted lines outline the engine cowlings. The composite tail rotor drive shaft is located between the two engine compartments. The composite tail boom is shown in a blue and green color on the right-side of the image. (Image courtesy of Airbus and modified by the NTSB)

The equipment deck, mounted aft of the engine deck and above the clamshell doors, is constructed of aluminum cover sheets with a Nomex core and glass fiber prepreg. The engine exhaust ejectors, part of the airframe firewall system, are above the left and right portions of the equipment deck. The right exhaust ejector has a secondary layer of material on the lower surfaces for additional thermal protection of the aircraft battery that is located on that side of the helicopter. The left exhaust ejector does not have the secondary layer of material.

The tail boom is made primarily of composites consisting of a Nomex core that is sandwiched with carbon and fiberglass skin. The tail boom supports a single-piece horizontal stabilizer, a vertical fin, a fenestron tail rotor housed within the vertical fin, and the tail rotor drive system (**Figure 5**). The horizontal stabilizer, identified in this report with a left side and a right side, has vertical end plates installed at outboard tip ends. A bulkhead is installed at the forward end of the tail boom. Additionally, an aluminum-alloy connecting [ring] frame at the forward end of the tail boom is bolted to the aft end of the engine deck's tail cone (**Figure 6**).

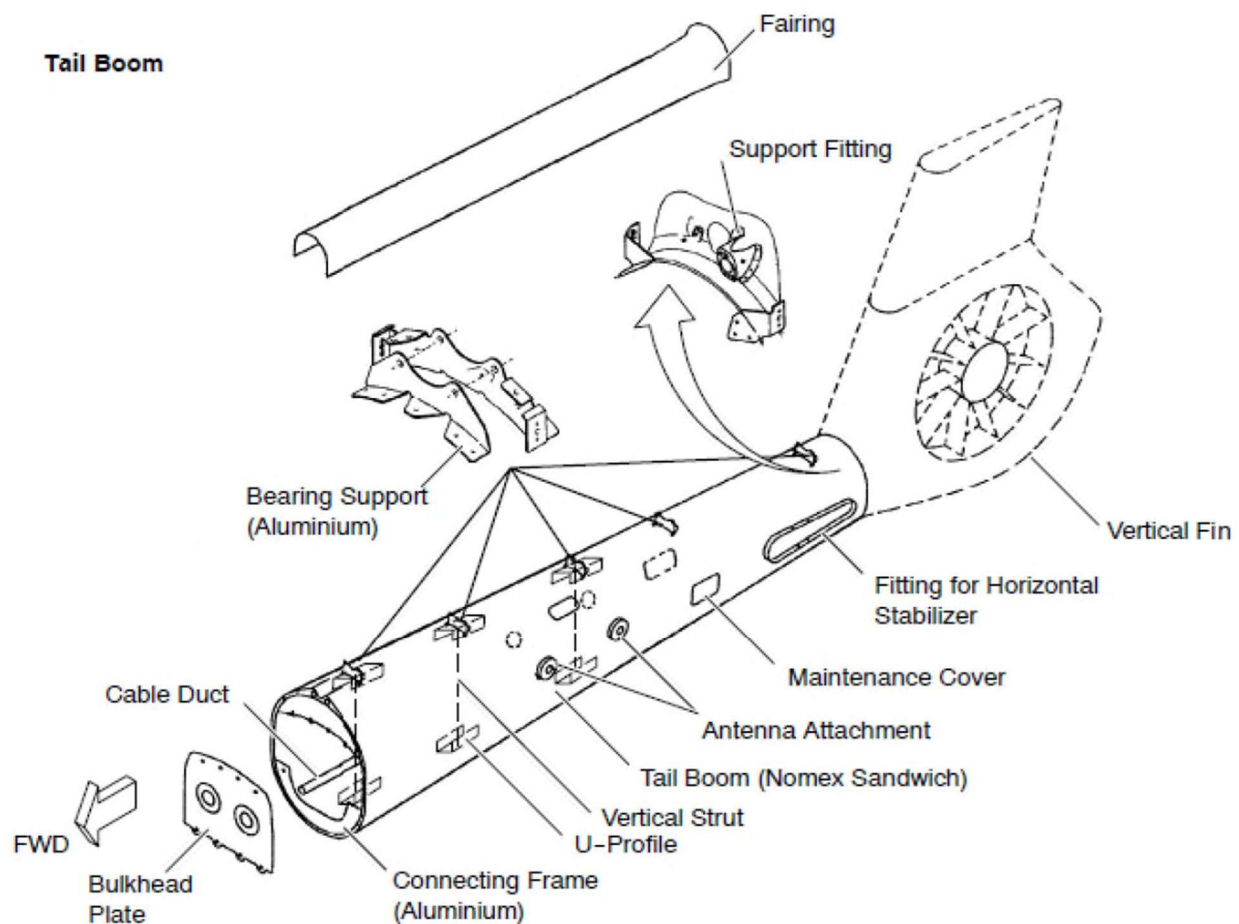


Figure 5. The tail boom structure showing the location of its major components.
(Image courtesy of Airbus and modified by the NTSB)

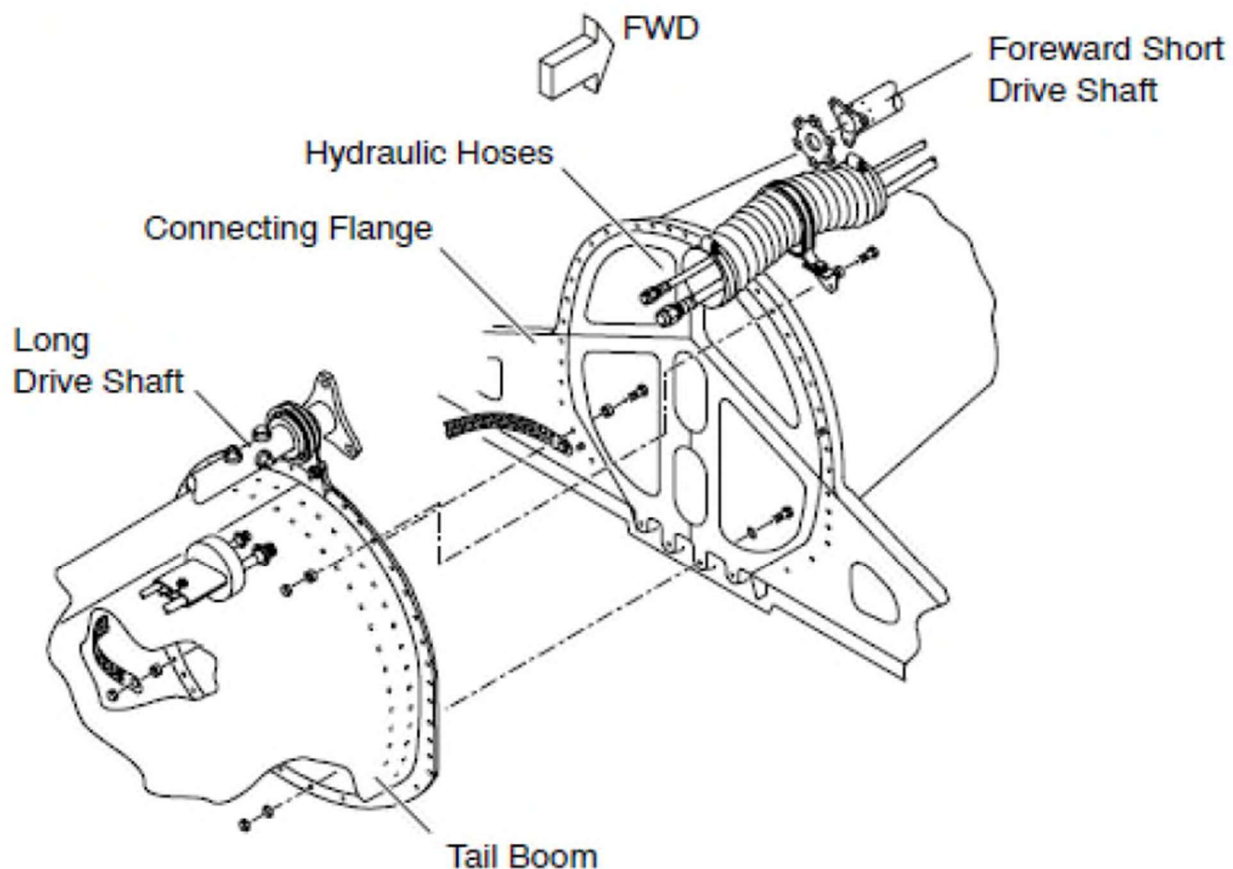


Figure 6. The tail boom connection to the tail cone. (Image courtesy of Airbus)

2.1.2 Main Fuselage Observations

The main fuselage was located about 26°14'24.67"N by 80° 7'19.92"W at a heading of about 200° magnetic, approximately ¼ mile southwest of Pompano Beach Airpark (KPMP) Runway 6 in Pompano Beach, FL (**Figure 7**). The main fuselage of the helicopter came to rest on its left side within a one-story apartment building. A postcrash fire consumed the majority of the main fuselage. Building materials were intermixed with the main wreckage.

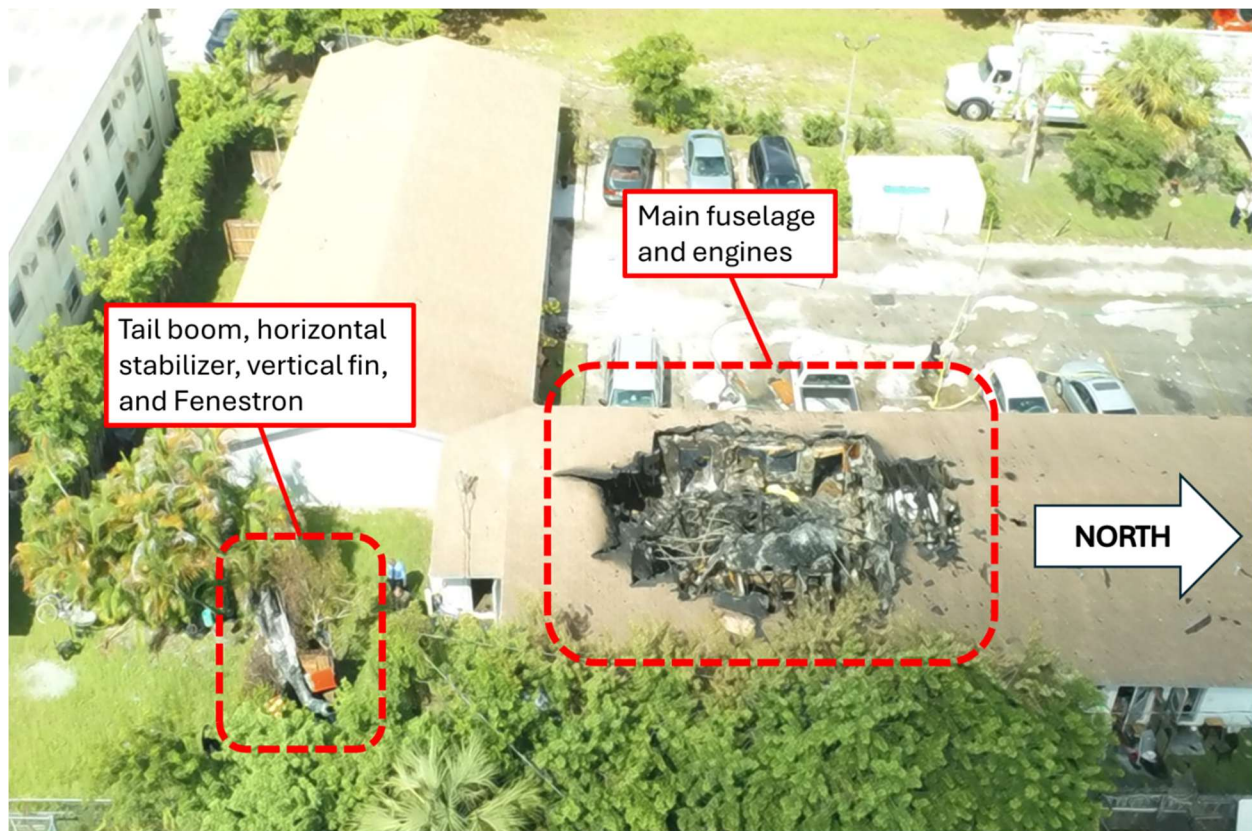


Figure 7. The accident site showing where the main fuselage, engines, and the tail boom wreckage were found. (Image courtesy of BSO and modified by the NTSB)

The engine deck, aft portion of the main fuselage, and fuselage floor remained partially attached to each other. The cabin roof, cockpit doors, cabin doors, and the rear clamshell doors were consumed by the postcrash fire (**Figure 8**). The equipment deck, above the clamshell doors, was not present and likely consumed by fire. The seats within the cabin were mostly consumed by the postcrash fire, but portions of their frames remained installed on their seat tracks in the fuselage.

The tail boom connecting frame exhibited significant thermal damage and the attachment flanges had melted. The forward end of the tail boom connecting frame, containing a double-row of rivets for the attachment flange, was located with the main fuselage wreckage and exhibited thermal damage from the postcrash fire (**Figure 9**). The forward end of the tail boom connecting frame separated from the main fuselage wreckage during recovery of the main fuselage. The skid landing gear had fractured in multiple locations and was partially consumed by the postcrash fire. The aft portion of the left skid remained attached to the aft crosstube.



Figure 8. The main fuselage wreckage after removal from the building. (Image courtesy of BSO)



Figure 9. The tail boom connection to the main fuselage as seen in the building.

2.1.3 No. 1 Engine Firewalls

The engine compartment, including firewalls, was significantly deformed from impact forces (**Figure 10**). All No. 1 engine firewall sections were present and exhibited significant thermal damage throughout all surfaces. Due to the thin-wall nature of the firewalls, an inflight fire in the vicinity of the firewalls versus postcrash thermal damage to the firewalls could not be discerned. On the aft firewall, adjacent to where the exhaust ejector attaches to the aft firewall, there was a fracture near the outboard edge that was about 1-inch in length. This fracture showed signatures consistent with overload. The tail cone attachment and the central firewall (aft of the engine air inlets) had no punctures or perforations. The No. 1 engine firewalls were removed from the wreckage and subsequently sent to the NTSB Materials Lab in Washington, DC for further evaluation. **Attachment 1** contains additional photos of the engine firewall system. For additional details of this evaluation, see NTSB Materials Laboratory Factual Report Nos. 24-027 and 24-032 in the docket for this investigation.



Figure 10. The Nos. 1 and 2 engine firewalls (top looking down).

2.1.4 No. 2 Engine Firewalls

All No. 2 engine firewall sections were present, and no material appeared to be missing. All sections sustained impact damage. Heavy soot and a powdery greyish-white material coated the interior surfaces of the firewall sections. An area of

oily residue was found on the lower firewall along the inboard edge. Blue thermal discoloration was present along the inboard and aft edges of the lower firewall. Several areas of bright blue and brass colored, splatter-shaped patterns of thermal discoloration found on both interior and exterior surfaces of the lower and aft firewalls. A bright yellow slightly oily substance was found just aft of the No. 2 engine aft firewall and below the hydraulic lines located adjacent to the driveshaft compartment. On the aft firewall, adjacent to where the exhaust ejector attaches to the aft firewall, there was a fracture, about 1-inch in length, near the outboard edge, similar in location to the fracture found on the No. 1 engine aft firewall. The No. 2 engine firewalls were removed from the wreckage and subsequently sent to the NTSB Materials Lab in Washington, DC for further evaluation. **Attachment 1** contains additional photos of the engine firewall system. For additional details of this evaluation, see NTSB Materials Laboratory Factual Report Nos. 24-027 and 24-032 in the docket for this investigation.

2.1.5 Tail Boom Observations

The tail boom, the left horizontal stabilizer, the majority of the right horizontal stabilizer, and the fenestron were located about 40 feet southeast from the main fuselage wreckage and resting against a fence (**Figure 11**). Foliage adjacent to the tail boom's forward end exhibited brown coloration from exposure to high heat, but the foliage and fence did not exhibit evidence of an active ground fire in the area. The tail boom had separated from the main fuselage about 12 inches aft of the tail boom attachment flange. Normally cylindrical in shape, the body of the tail boom had a collapsed and flattened appearance. The majority of the tail boom, the entirety of tail rotor drive shaft cowlings, the forward surfaces of the vertical fin, and the fenestron structure exhibited significant thermal damage. The forward surfaces of the vertical fin and fenestron structure exhibited four successive slash marks consistent with main rotor blade contact.

The left horizontal stabilizer exhibited thermal damage all over its horizontal surfaces. The left horizontal stabilizer end plate remained attached to the left horizontal stabilizer and its forward and inboard surfaces were thermally damaged but the paint on its outboard surface was mostly intact. The right horizontal stabilizer's horizontal surfaces exhibited thermal damage on a portion of its inboard end, but the paint on the remainder of the horizontal surfaces was mostly intact. The outboard end, including end plate, of the right horizontal stabilizer was fractured chordwise, possibly due to main rotor blade contact as a piece of the main rotor blade tip end skin was found near the tail boom. A fractured portion of the right end plate was found in the backyard of the building with the main fuselage wreckage.



Figure 11. The tail boom, horizontal stabilizer, vertical fin, and fenestron wreckage.

2.2 Main Rotor System

2.2.1 System Overview

The main rotor system is composed of a main rotor shaft with integral hub and four main rotor blades that are composite in construction. Each blade is attached to the main rotor hub via two bolts. The four main rotor blades are identified by color, presented in the order of advancing rotation: 'yellow', 'green', 'blue', and 'red'. Blade pitch control is achieved via pitch links that are connected between each blade's pitch control cuff and the rotating swashplate.

An input drive shaft provides power from each engine to the main transmission. A freewheeling unit is installed between each main transmission drive pinion and their engine input drive shaft. The main transmission has a two-stage speed reduction where a collector (bull) gear turns the main rotor shaft. The main transmission also provides power to the two transmission oil pumps, the Nos. 1 and 2 hydraulic systems, and the Nos. 1 and 2 oil cooling fans. Additionally, the main transmission powers the tail rotor drive system. A rotor brake is located at the tail rotor output drive pinion.

2.2.2 Wreckage Observations

The main transmission remained installed on the transmission deck of the main fuselage. The main transmission housing was covered in soot. Both left and right engine-to-transmission input shafts were present, but the splined connection between both engine-to-transmission input shafts and the respective engine output (power) drive shafts were disconnected due to the partial separation of the engine deck from the transmission deck. Manual rotation [by hand] of the input shafts in the counterclockwise direction resulted in a corresponding rotation of the main rotor shaft and rotor brake. However, the input shafts could not be manually rotated by hand in the clockwise direction.

The main transmission oil filter was removed and the residual oil that came out with the filter had a clean appearance and did not smell acrid or burned. The oil filter element contained no large pieces of debris or evidence of clogging. The main transmission oil level was observed within the sight glass and showed about midpoint between the low and high fluid level indicators on the sight glass. Forward firewall oil cooler connections on the left and right sides exhibited a loss of torque but were within a ¼ turn tight at its aft connection; the forward connections remained tight. The oil cooler connections at the left and right oil cooler heat exchangers remained tight.

The main rotor blades remained installed on the main rotor shaft. All four main rotor blades were fractured and exhibited significant thermal damage. The four main rotor blades were sectioned to facilitate recovery of the wreckage.

2.3 Tail Rotor System

2.3.1 System Overview

The EC135-series helicopter has a fenestron tail rotor to provide directional control of the helicopter. Power from the main transmission is transferred to the fenestron rotor via the tail rotor drive system. The tail rotor drive system is composed of three drive shafts installed in series, with flexible couplings between each drive shaft, and the tail rotor gearbox. The forward and aft drive shafts are constructed from composite materials and the center tail rotor drive shaft is composed of steel. The center tail rotor drive shaft is supported by six ball bearings with rubber sleeves. The flexible couplings are composed of packs of steel discs. The tail rotor gearbox, mounted in the hub of the fenestron, changes the direction of drive and reduces the output speed of rotation at the tail rotor.

The fenestron is a shrouded tail rotor that is installed in a duct within the vertical fin. The fenestron contains a total of 10 unevenly-spaced blades installed on the right side of the fenestron and whose collective pitch is changed via a pitch change spider. Additionally, 10 stator vanes are present on the left side of the fenestron to straighten the airflow generated by the fenestron rotor.

2.3.2 Wreckage Observations

The forward [composite] tail rotor drive shaft was found with the main fuselage wreckage at its normally installed location and was thermally damaged. At the forward end of the forward composite tail rotor drive shaft, the flexible coupling between the composite drive shaft and rotor brake had fractured, but the fractured portions of the coupling remained attached on the respective flanges (**Figure 12**). The full length of the composite tail rotor drive shaft was present, but the composite tube was partially splayed and exhibited more thermal damage near its aft flange about 20 to 32 inches from the forward flange (**Figure 13**). The aft flange of the composite tail rotor drive shaft was attached to the forward end of the steel tail rotor drive shaft via flexible coupling. The flexible coupling between the composite and steel tail rotor drive shafts was intact but exhibited slight opening of its laminates.

The steel tail rotor drive shaft was fractured in two locations, the first about 5 inches aft of the forward flange (where it was partially separated but still attached to the shafting) and the second about 28 inches aft of the forward flange (where it was completely fractured). The entire steel tail rotor drive shaft exhibited thermal discoloration. The remainder of the steel tail rotor drive shaft was found with the tail boom wreckage and was continuous to the aft [composite] tail rotor drive shaft. The steel tail rotor drive shaft remained connected to the aft composite tail rotor drive shaft via flexible coupling.

The full length of the aft composite tail rotor drive shaft was present. The forward half of the drive shaft was thermally damaged, but the aft end of the drive shaft did not exhibit significant thermal damage. Manual rotation of the fenestron resulted in a corresponding rotation of the aft composite and steel tail rotor drive shafts, but rotation was limited due to the thermally compromised aft composite tail rotor drive shaft.

The fenestron rotor was present within the vertical fin. All 10 fenestron blades remained installed and did not exhibit significant damage except for two blades that had a small nick on their trailing edge. The fenestron blades could not be manually feathered.

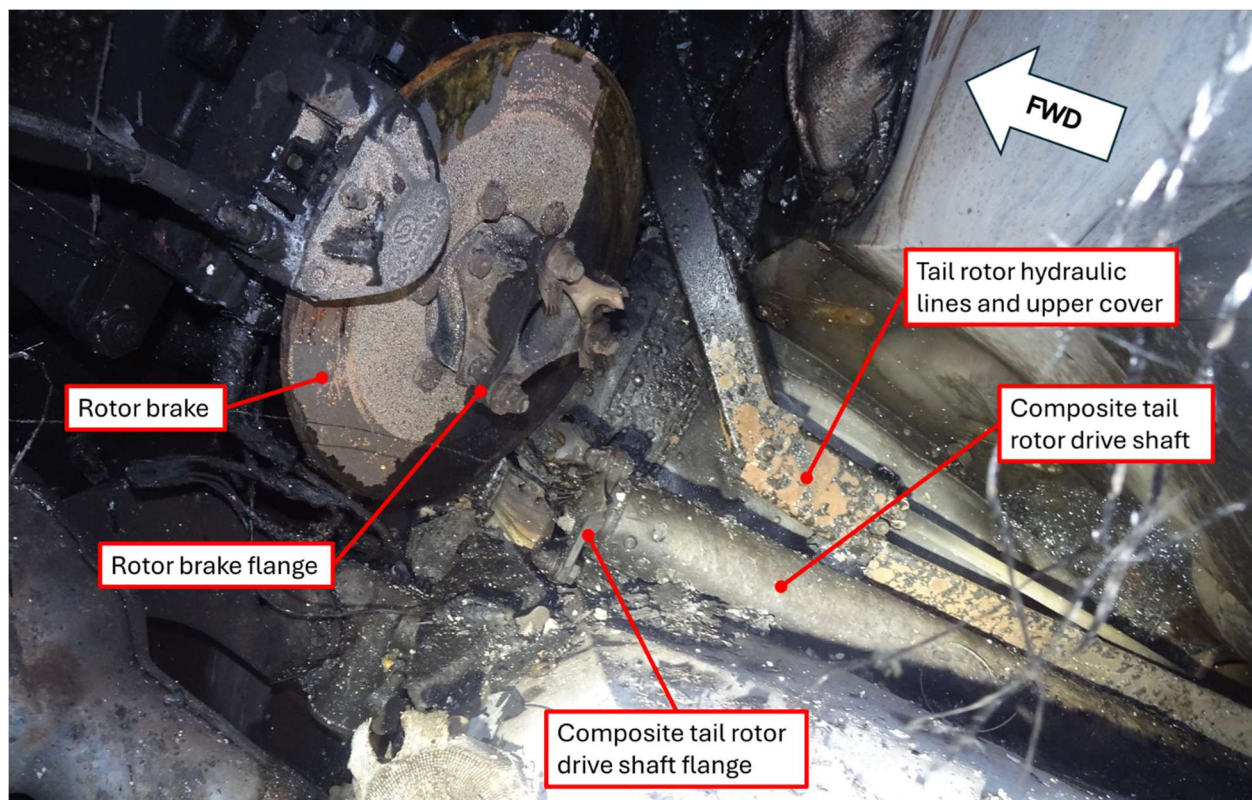


Figure 12. The fractured flexible coupling connection between the rotor brake and the composite tail rotor drive shaft.

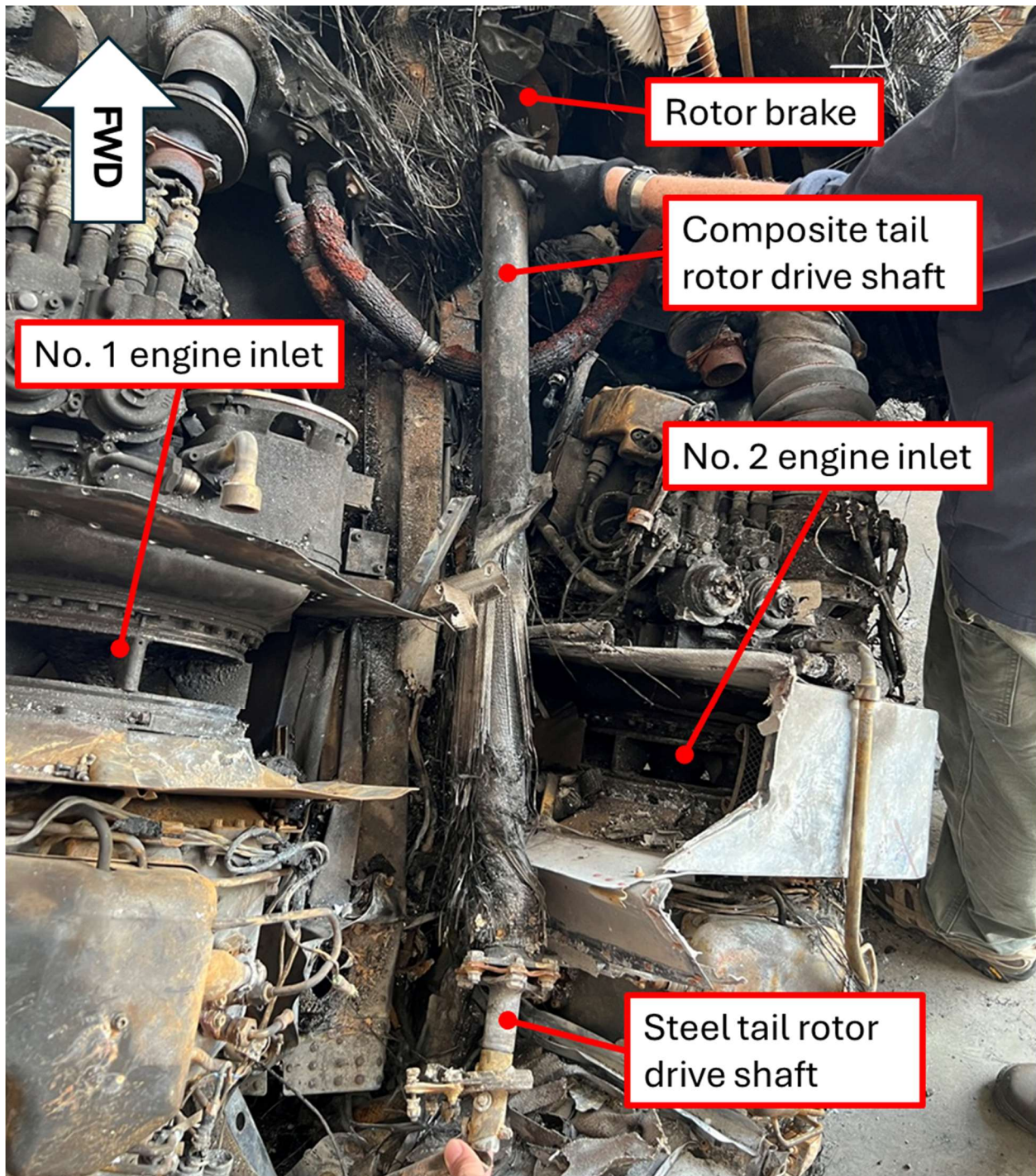


Figure 13. Damage to the aft portion of the composite tail rotor drive shaft exhibited more thermal damage than its forward portion. The aft flange of the composite tail rotor drive shaft is connected to the forward flange of the steel tail rotor drive shaft via flexible coupling. (Image courtesy of Airbus and modified by the NTSB)

2.4 Flight Control System

2.4.1 System Overview

The cockpit flight control system is composed of cyclic, collective, and pedal controls. The mechanical linkages from the pilot's cyclic and collective controls are routed below the pilot's seats to the lower guidance unit (a bellcrank assembly), vertically to the cabin roof to the upper guidance unit, then aft to the main rotor [hydraulic] actuators (MRA) assembly that is mounted to the front of the main transmission housing. Pedal inputs are transmitted to the tail rotor via a flexball-type control cable that connects the pedal bellcrank to the tail rotor [hydraulic] actuator (TRA).

The MRA assembly contains three hydraulic actuators: longitudinal cyclic (left), collective (center) and lateral cyclic (right). For the collective axis, a mechano-hydraulic actuator (MHA), composed of two independent systems mounted as a single unit, provide hydraulic assistance. For each actuator, the two independent systems drive a common output piston rod. For the longitudinal and lateral cyclic axes, an electro-hydraulic actuator (EHA) is integrated into their MHAs to convert electrical signals from the pitch and roll stability augmentation system (SAS) into mechanical control outputs. The longitudinal cyclic, collective, and lateral cyclic hydraulic actuators' output piston rods connect to the mixing levers. The mixing levers are connected to the swashplate assembly that ultimately transmit cyclic and collective changes, via pitch links, to the main rotor blades.

2.4.2 Cockpit and Fixed Flight Controls

The cyclic control and collective control remained installed in the cockpit but their grips were not present. Manual manipulation of the cyclic and collective controls resulted in movement of the control tubes within the vertical tunnel (broom closet), but the control tubes within the vertical tunnel were fractured where the broom closet had fractured. The majority of the control tubes that routed from the broom closet to the main rotor servo actuators were not found and likely consumed by the postcrash fire. The main rotor servo actuators remained attached to the main transmission housing and the output links (tie rods) remained installed between the main rotor servo actuators and the main rotor control levers.

The pedals were not found in the wreckage. The fenestron control cable was present but was fractured near where the tail boom separated from the main fuselage.

2.4.3 Main Rotor Rotating Controls

The main rotor swashplate remained installed, but portions of the rotating scissor links and pitch change links were consumed by the postcrash fire. All attachment hardware between the scissor links, the pitch change links, the swashplate, and main rotor blades were present.

2.5 Hydraulic System

2.5.1 System Overview

The EC135-series helicopter is equipped with a dual hydraulic system that is composed of two independent and redundant hydraulic systems. Each hydraulic system has a pressure supply system composed of a reservoir, hydraulic pump, valve block, filter, and hydraulic lines. The No. 1 hydraulic system's pressure supply system is located to the left of the main transmission and the No. 2 pressure supply system is located to the right of the main transmission. Each hydraulic system normally operates at a pressure of 103 bars (about 1,885 psi) and is serviced with MIL-H-5606 hydraulic fluid.

Both hydraulic systems provide hydraulic pressure to the MRA assembly. Hydraulic pressure to the TRA is supplied by only the No. 2 (right) hydraulic system. Hydraulic pressure to the pitch and roll SAS function for the longitudinal cyclic and lateral cyclic EHAs is supplied by the No. 1 (left) hydraulic system.

2.5.2 Wreckage Observations

The Nos. 1 and 2 hydraulic pressure supply systems remained installed but were thermally damaged. The hydraulic line for the TRA was present and continuous in the compartment between the two engines but was fractured near the tail boom separation point. The tail rotor hydraulic lines were present within the separated tail boom and continuous to the tail rotor actuator.

For the tail rotor hydraulic lines near the tail boom separation point, the ferrule connection for both pressure and return lines were loose and able to be turned about 2-3 complete rotations until the nut became tight. Additionally, the tail rotor hydraulic pressure line exhibited a burst-like fracture about 11 inches aft of the ferrule connection (**Figure 14**).

The No. 1 hydraulic reservoir fluid level indicator was extended about 1 7/8-inch (47.63mm). The No. 2 hydraulic reservoir fluid level indicator was extended about 1-inch (25.4mm). The No. 2 hydraulic filter was removed and the element showed no evidence of clogging. A small amount of residual fluid came out when the No. 2 hydraulic filter housing was removed, and the residual fluid had a color typical

of hydraulic fluid. The No. 2 hydraulic fluid reservoir indicator was manually pushed forward in order to eject residual fluid out through the filter orifice; however, there was not an appreciable amount of fluid that came out when the indicator was pushed.



Figure 14. The tail rotor hydraulic actuator pressure line that exhibited a burst-like appearance.

2.6 Powerplants

2.6.1 Engine Overview

The Safran Arrius 2B1 is a turboshaft engine that is composed of a single-stage centrifugal compressor; an annular, reverse flow combustor; a single-stage axial gas generator (compressor) turbine; and a single-stage axial power turbine. The gas generator turbine and the power turbine are not mechanically connected and rotate independently of each other. The reduction gearbox, mounted on the forward side of the engine, reduces the drive speed between the power turbine to the main output shaft (which powers the helicopter rotor system). The gas generator turbine drives the centrifugal compressor as well as the engine accessories, such as the fuel and oil pumps, the fuel management module, and the alternator.

The Arrius 2B1 is equipped with an electronic engine control unit (EECU) with a mechanical backup fuel metering module. An electrically operated stepper motor, located within the fuel control unit, works in conjunction with the EECU and changes fuel flow as required.

2.6.2 No. 1 (Left) Engine

The No. 1 engine was present in its normally installed location. The engine exterior exhibited thermal damage. The No. 1 EECU was found within the avionics deck and its housing exhibited heat distress, but was not burned through. The data plate for the No. 1 EECU showed P/N 70EMF01290 and S/N 8ALD0295CE.

The No. 1 engine and its EECU were removed and retained for further examination. For the details of the No. 1 engine findings, see the Powerplants Group Chair's Factual Report in the docket for this investigation.

2.6.3 No. 2 (Right) Engine

The No. 2 engine was present in its normally installed location. The engine exterior exhibited thermal damage. The No. 2 EECU was found within the avionics deck and exhibited thermal damage. The EECU housing was partially burned through. The data plate for the No. 2 EECU showed P/N 70EMF01290 and S/N 8ALD0258CE.

The No. 2 engine and its EECU were removed and retained for further examination. For the details of the No. 2 engine findings, see the Powerplants Group Chair's Factual Report in the docket for this investigation.

2.7 Fuel System

The No. 1 emergency fuel shutoff valve allows or restricts fuel flow from the left fuel supply tank to the No. 1 engine. The emergency fuel shutoff valve for the No. 1 engine remained installed below the engine deck and its fuel lines remained connected. The fuel shutoff valve assembly was removed from the wreckage (**Figure 15**). A flexible plastic rod was inserted through one of the fuel lines connected to the shutoff valve assembly and the plastic rod came out of the fuel line on the other end of the shutoff valve assembly.



Figure 15. The emergency fuel shutoff valve for the No. 1 engine after removal from the main fuselage wreckage.

The No. 1 fuel shutoff valve was subsequently examined using a computed tomography (CT) scan. The CT scan confirmed the valve was in the open position and found no separations of its internal wiring. Additional details of the findings from the CT scan of the No. 1 emergency fuel shutoff valve can be found in the Computed Tomography Specialist's Factual Report in the docket for this investigation.

2.8 Metro Aviation Air Conditioning System

2.8.1 System Description

The accident helicopter had a Metro Aviation air conditioning system that was installed under the provisions of supplemental type certificate (STC) No. SR09163RC.² The Metro Aviation air conditioning system utilizes about 36 ounces (1.06 liters) of R-134a refrigerant and 4 ounces (0.12 liters) of PAG-100 type refrigerant oil that is mixed into the refrigerant for lubrication. The refrigerant and refrigerant oil mixture is compressed to about 200-300 pounds per square inch (psi), or about 13.8-20.7 bar, and expanded to about 28-54 psi, or about 1.9-3.7 bar.

² N257BC also had the Metro Aviation air conditioning system installed under the provisions of STC No. SR09163RC.

The air conditioner compressor is mounted onto, and driven by, the main transmission (**Figure 16**). Refrigerant lines are routed to and from the compressor external to the common engine air intake, but enter into the area aft of the center-aft firewall, between the left and right engine exhaust ejectors (**Figure 17**). These refrigerant lines are routed around an air intake duct for the condenser. The upper portion of the air intake duct (black in color) is constructed of aluminum and the lower portion of the air intake duct (tan in color) is constructed of laminated fiberglass. A steel square-tube support frame is mounted aft of the circular aluminum-alloy connecting frame (connecting the tail boom to the fuselage). The condenser, constructed of aluminum, and two condenser fans, constructed primarily of plastics, are mounted to the support frame and are located underneath the No. 1 engine exhaust ejector, outside the engine firewall system (**Figure 18**). The two condenser fans are located outboard of the condenser. The condenser air duct, also mounted to the support frame, is located inboard of the No. 1 engine exhaust ejector and is constructed primarily of fiberglass. Two evaporators and their blowers are located below the cockpit and cabin areas.

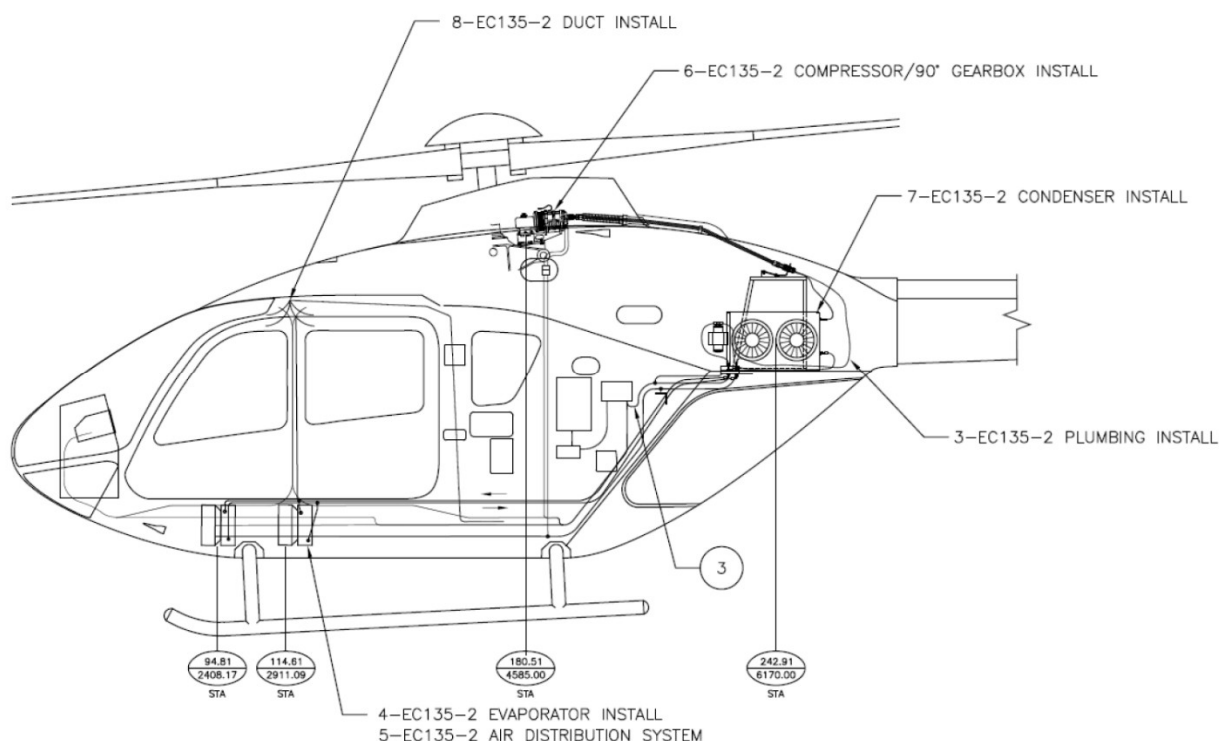


Figure 16. The Metro Aviation air conditioning system installation on the EC135-series helicopter. (Image courtesy of Metro Aviation)

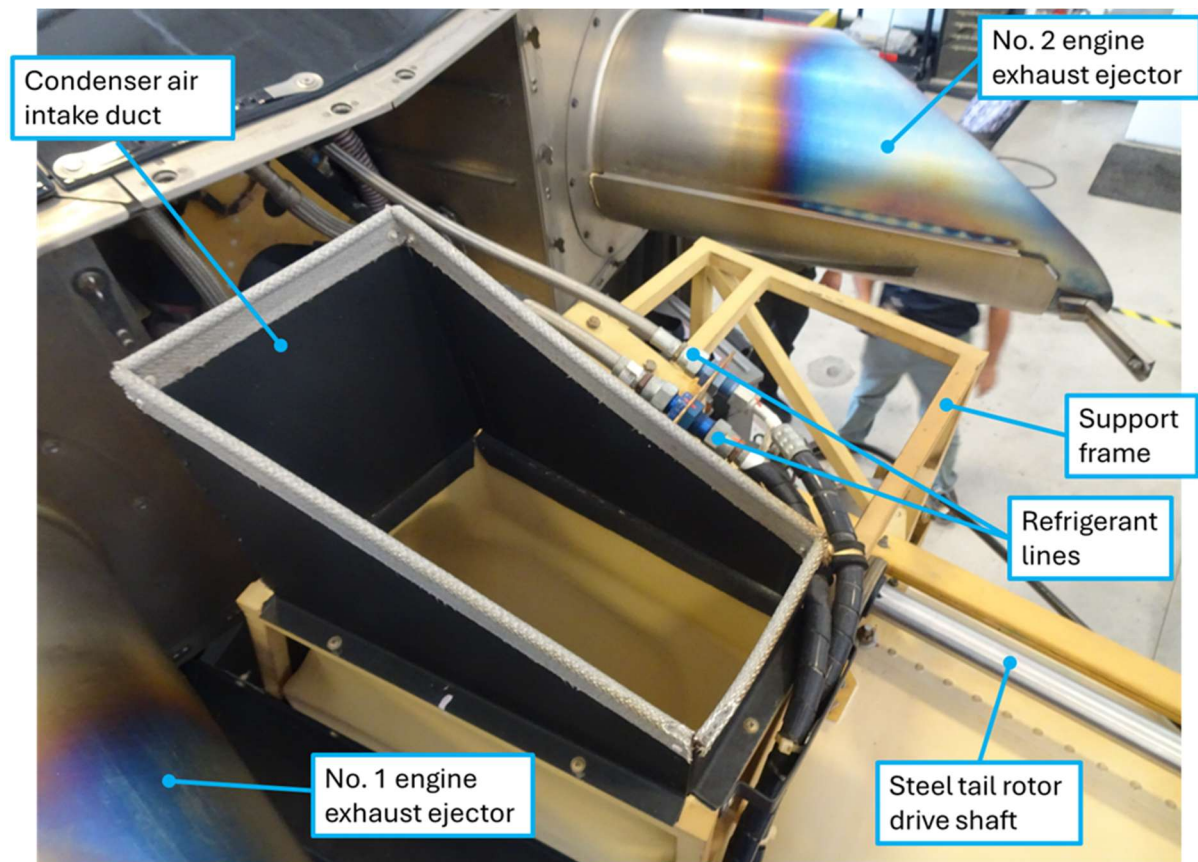


Figure 17. The routing of the refrigerant lines to the condenser as seen on N257BC.

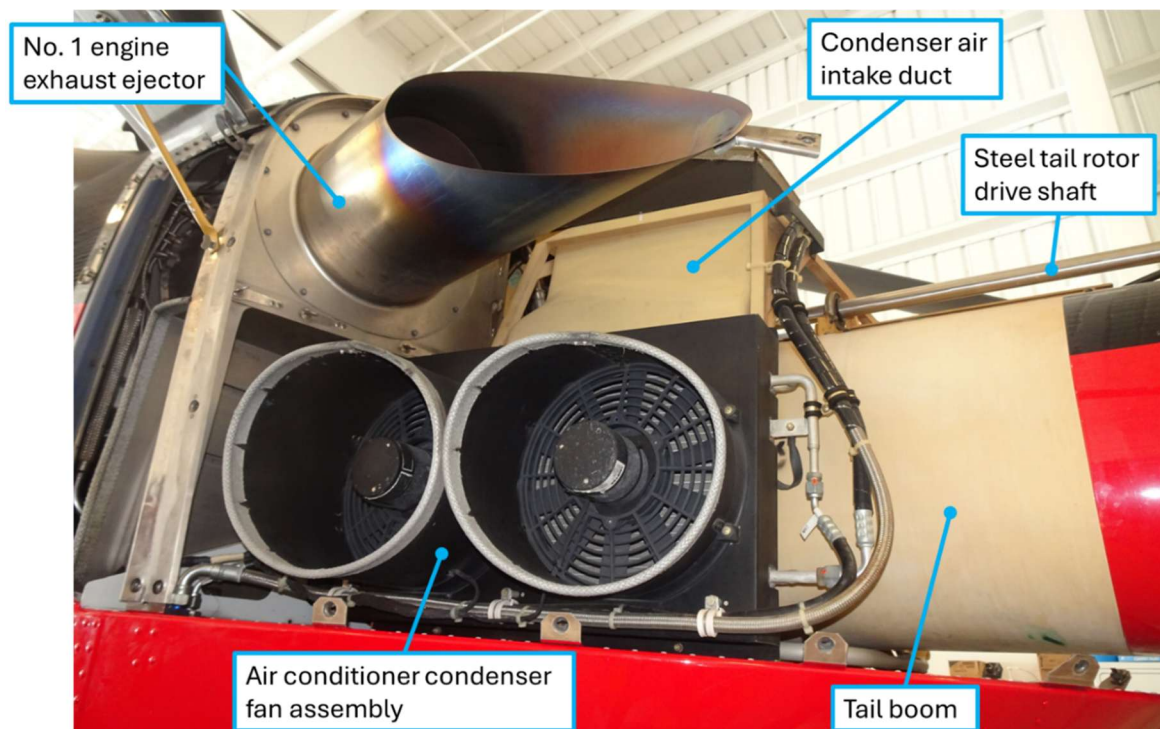


Figure 18. The air conditioner condenser and its air intake as seen on N257BC.

2.8.2 Wreckage Observations

The air conditioner compressor remained installed on the main gearbox and exhibited thermal damage. Two refrigerant lines remained connected to the air conditioner compressor but had fractured about 70 inches (pressurized line) and 72 inches (return line) from their connection to the compressor. These refrigerant lines exhibited thermal damage and only the steel sleeves remained. The air conditioner compressor was removed from its main transmission drive pad and its drive spline connection did not exhibit anomalous wear or damage. No evidence of looseness was observed between the air conditioner compressor and the main transmission drive pad, but both exhibited heat tinting on their mounting contact surfaces.

The support frame was present in the main wreckage, but the condenser assembly and its ducting were consumed by fire. Remnants of the two fan motors for the condenser assembly were found about 240 feet and 280 feet from the wreckage site (**Figure 19**).

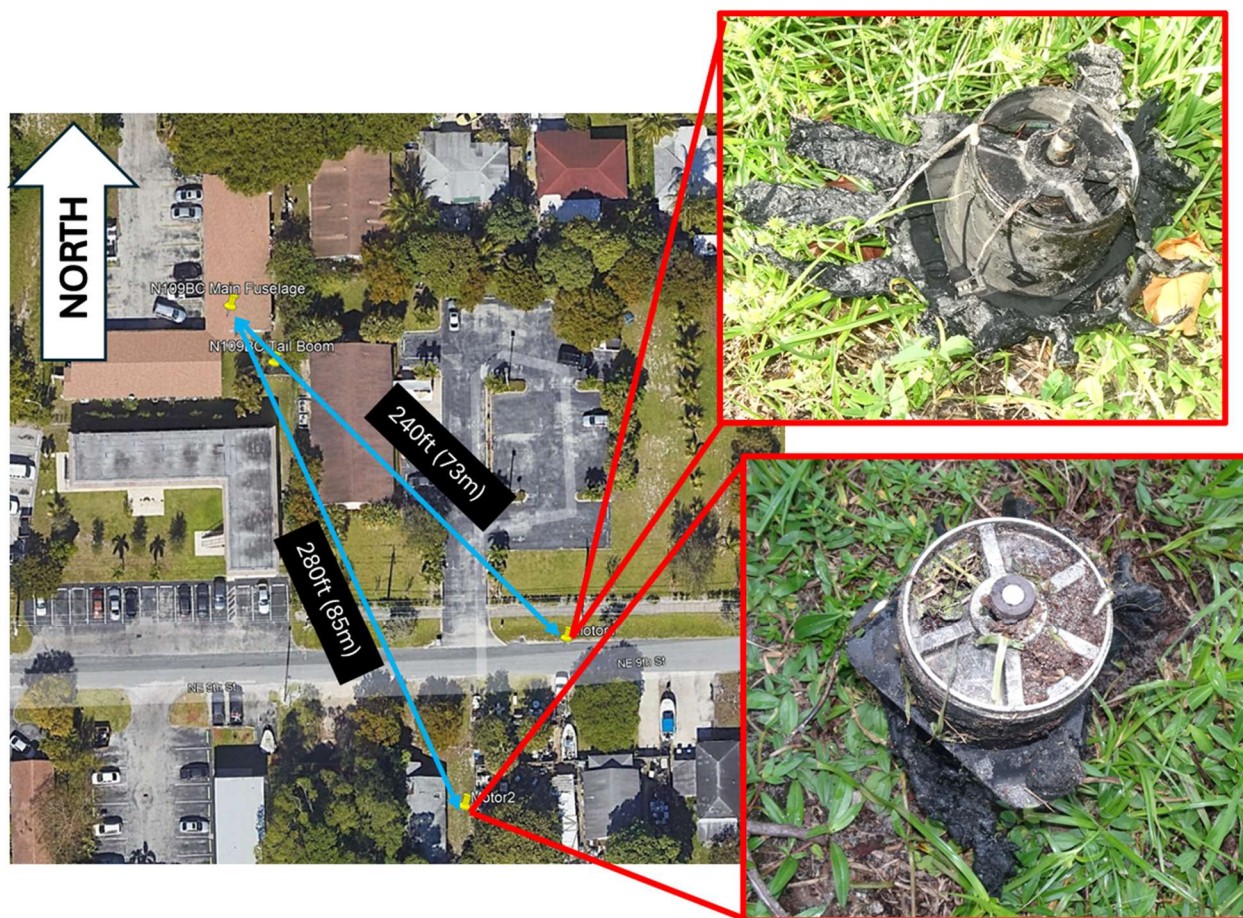


Figure 19. The two separated condenser fans found away from the area of the main fuselage and tail boom wreckage.

2.9 Miscellaneous Items

2.9.1 EC135 T1 Cockpit Description

The first variant of the EC135-series helicopter, including the accident helicopter, was equipped with a CDS. The CDS is located on the center of the instrument panel, with analogue engine instruments (gauges) to the right of the CDS (**Figure 20**). The upper portion of the CDS contains a display that provides caution and advisory messages for both engines and aircraft systems. The lower portion of the CDS provides selected engine parameters (such as torque and gas generator speed) and other aircraft systems information.

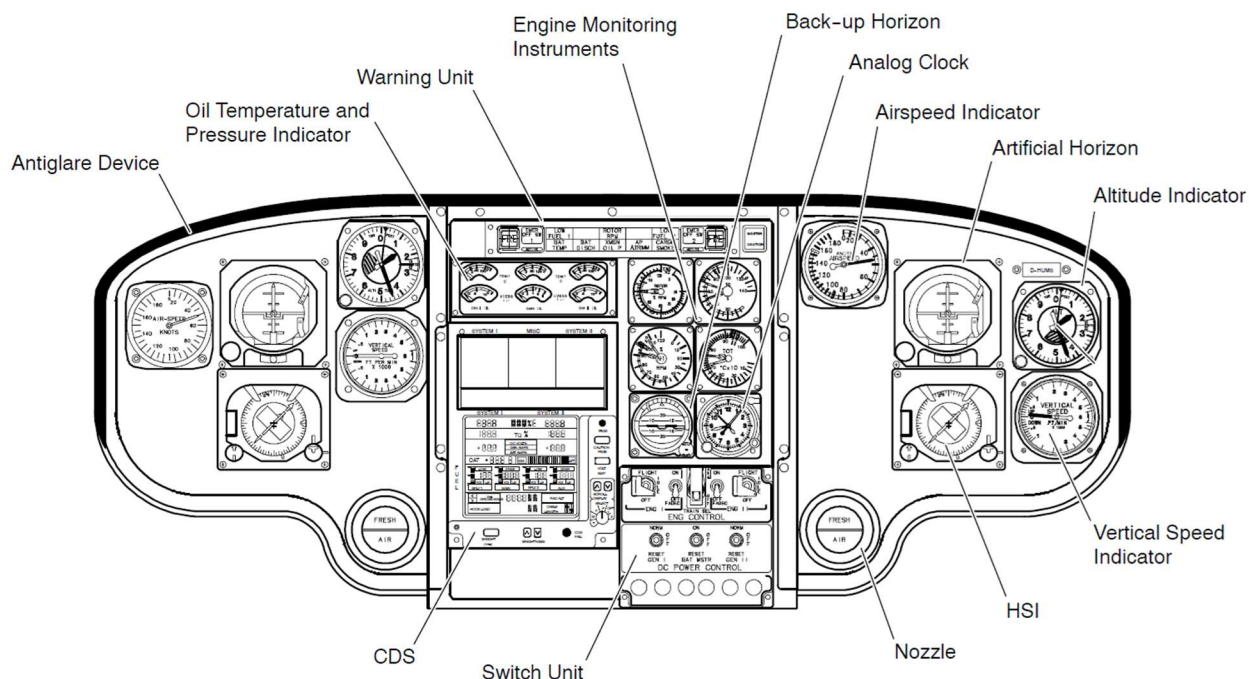


Figure 20. The EC135 T1 instrument panel when equipped with a CDS. (Image courtesy of Airbus)

All EC135-series helicopters are equipped with a warning unit, located at the center-top of the instrument panel. The center of the warning unit contains warning lights. The left and right sides of the warning unit contain engine fire warning lights, which also serves as a button for activating the fuel shutoff valves and the engine fire extinguishing system.

2.9.2 Engine Fire Extinguishing System Description

Each engine compartment is equipped with two fire detectors mounted to the outside of the engine. One fire detector is mounted near the 12 o'clock position on the engine gearbox housing, and a second fire detector is mounted near the 6 o'clock position on the engine combustion chamber case. The fire detector on the

engine gearbox housing will trigger an alarm at a nominal value of 410°F (210°C) while the fire detector on the combustion chamber will trigger an alarm at a nominal value of 520°F (271°C). For each engine, activation of only one of its two fire detectors will trigger a visual and aural annunciation. The fire detectors for each engine are wired to illuminate their respective engine fire warning light on the [cockpit] warning unit. The engine fire extinguishing system is composed of a single fire bottle and distribution pipes from the single bottle to both left and right engine compartments. Because there is only one fire bottle, the fire extinguishing system can only be activated once and for either the left or the right engine, but not both engines. The fire bottle contains extinguishing agent Halon 1301. The fire bottle is mounted to the right side of the equipment deck, near the vicinity of the No. 2 engine exhaust ejector (**Figure 21**).

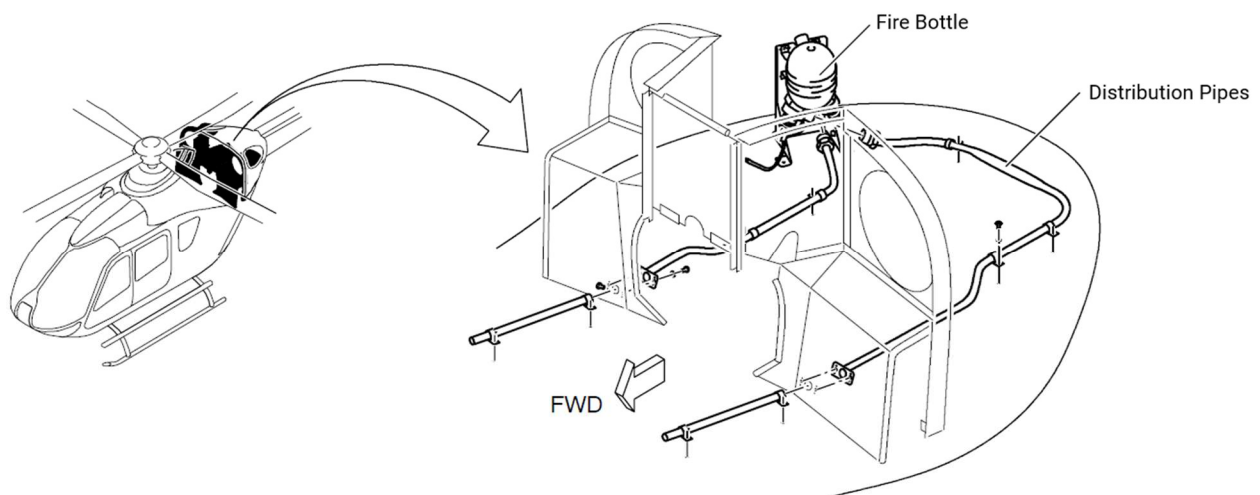


Figure 21. The fire extinguishing system installation on the EC135-series helicopter. (Image courtesy of Airbus and modified by the NTSB)

When a fire is detected within the engine compartment, the engine fire light on the warning unit illuminates and an aural tone that is unique for engine fires will annunciate. To activate the engine fire extinguishing system, the engine fire button's safety guard needs to be opened in order to press the engine fire button (**Figure 22**). The safety guard is a protective grill that covers the engine fire button. A breakable wire is affixed to each safety guard to prevent inadvertent opening of this safety guard, but also to allow for breaking the wire to open the safety guard in an emergency. Once the fire button is pushed, the engine fire button will extend, revealing a white border on the outer perimeter of the button. The engine's emergency fuel shutoff valve closes, illuminating the "EMER OFF SW" light next to the engine fire button that was pushed. The fire extinguishing system is armed until the respective engine gas generator speed (N1 or Ng) decreases to below 60%, at which time the fire extinguishing agent is released into the respective engine compartment. When the fire extinguishing agent is released, the light labeled "ACTIVE" will illuminate next to the engine fire button that was pushed.

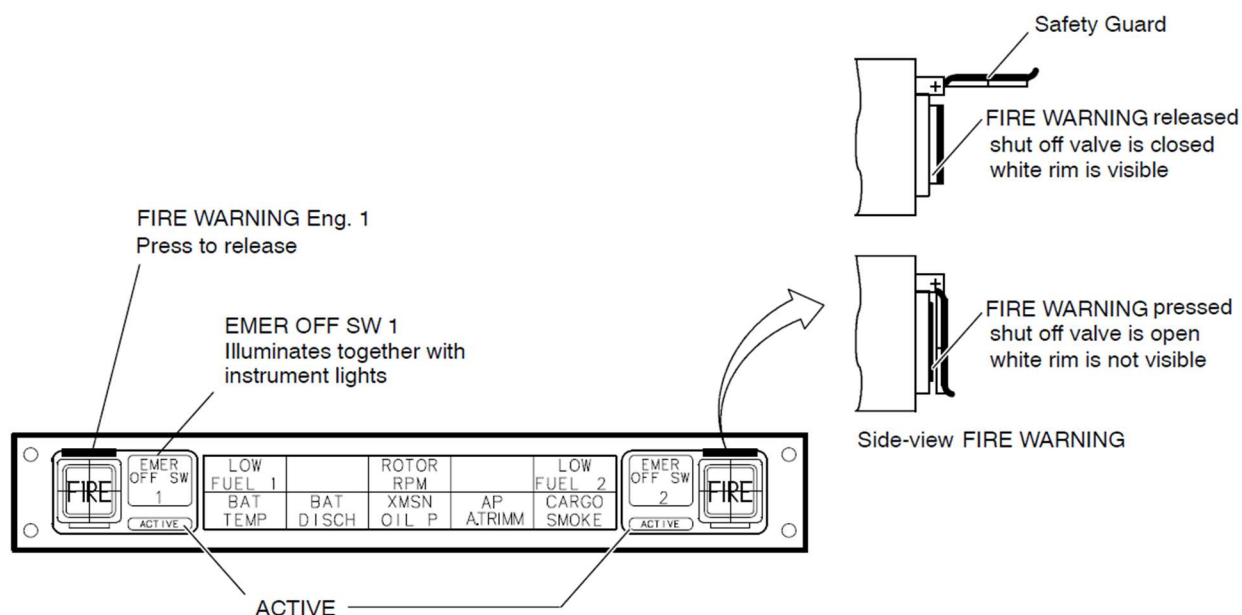


Figure 22. The warning unit on EC135-series helicopters and the fire indication system. (Image courtesy of Airbus and modified by the NTSB)

2.9.3 Cockpit Wreckage Observations

The instrument panel was present but exhibited thermal damage. Usable information could not be gleaned from the remainder of the cockpit instruments. The warning unit was present, but its housing was partially burned through (**Figure 23**). Thermal damage to the warning unit precluded recovery of its nonvolatile memory. The No. 1 and No. 2 engine fire button's breakable wire for the safety guards were found unbroken (**Figure 24**). The safety guards for both Nos. 1 and 2 engine fire buttons did not exhibit inward deformation, such as when the safety guard is forcefully pushed inward.

The CDS housing exhibited thermal damage. The glass screens were impact damaged. The CDS housing was opened and the internal circuit boards had a heat tinted appearance but otherwise appeared intact. The CDS was retained for data recovery. The Appareo Vision 1000 cockpit image recorder was not found in the wreckage and was likely consumed by the postcrash fire.



Figure 23. The instrument panel showing the CDS (blue outline) and warning unit (red outline).



Figure 24. The No. 1 engine fire button showing the breakable wire (red arrow) and the safety guard over the button.

2.9.4 Engine Fire Bottle Observations

The fire bottle, with remnant piping attached, was found separated in the main wreckage and exhibited significant thermal and impact damage. Remnants of the fire bottle pressure gauge remained installed, but there was no evidence of pressurized extinguishing agent within the fire bottle.

2.9.5 Aircraft Battery Observations

The aircraft battery was found in the backyard of the building unit containing the main fuselage and was not exposed to the postcrash fire. The battery housing remained intact and was not breached or punctured, but was covered in soot. The battery top cover was opened by the investigation group to examine the interior of the battery. The polymeric connector was melted with areas of missing material. The battery interior was intact and exhibited a small amount of thermal damage to aft, inboard corner (as installed in aircraft) to the polymeric cell separators located on the

top of the battery. The blue-colored cell caps did not exhibit significant thermal damage. The metal tie rods exhibited surface corrosion throughout. The interior of the case lid exhibited some thermal-related building of the polymeric liner. There was light thermal degradation to the lid seal on the edge (facing aft as installed in aircraft). The cells were not removed, but there were no visible signs of thermal runaway of the battery cells.

3.0 CDS Data Recovery

The CDS is designed to record onto nonvolatile memory (NVM) any cautions that have been activated in the previous 60 seconds. The CDS deletes from memory those cautions that are older than 60 seconds and no longer active. The CDS also stores up to 100 EECU failure memory codes. The CDS NVM is not crash-protected.

The accident helicopter's CDS housing was opened to reveal its internal circuit cards (**Figure 25**). The circuit cards exhibited tinting from thermal exposure but were otherwise whole without evidence of cracks or fractures. The central processing unit (CPU) A circuit card was removed from the CDS and the U16 erasable programmable read-only memory (EPROM) chip was removed from the CPU A circuit card. A blank U16 EPROM chip was provided to the NTSB by Ontic.³ The NTSB Recorders Lab downloaded the binary data from the accident U16 EPROM chip and loaded the binary data onto the blank U16 EPROM chip. The U16 EPROM chip, with the loaded binary file, was subsequently shipped to Ontic to install on an exemplar CDS, which was an engineering unit. The exemplar CDS was installed on a test bench and powered, but the CDS did not power up. After troubleshooting, it was determined that the CDS would not power up with the accident binary data loaded onto the U16 EPROM chip, which possibly indicated that the accident binary data may be corrupted. Since a binary file decoding tool did not exist for the CDS, further work on the accident flight CDS data was not conducted.

³ The CDS was originally manufactured by Grimes Aerospace, a subsidiary of Honeywell. The CDS product was subsequently sold to Ontic.



Figure 25. The accident CDS circuit cards upon opening its housing.

4.0 Accident Flight Timeline

4.1.1 Automatic Dependent Surveillance-Broadcast (ADS-B) Data⁴

ADS-B data of the accident flight began about 8:42:42 and ended about 8:44:55 (**Appendix A, Figure A-1**). The data showed the helicopter departed to the west from KPMP. At about 8:43:30, 1.23 miles from its departure point, the helicopter began a left turn. The helicopter reached a reciprocal heading at about 8:44:15. The helicopter continued the left turn until it was aligned with KPMP Runway 6. The flight path remained aligned with KPMP Runway 6 until about 8:44:49, when heading and position changes are observed in the data.

4.1.2 Air Traffic Control (ATC) Recordings

An audio file of the ATC that contained the accident flight, having a duration of 54 minute and 9 seconds, was provided to the NTSB. According to the FAA, the takeoff clearance was timestamped at 12:42:19Z (8:42:19 eastern daylight time).

Table 1 shows the times in the audio files containing transmissions of interest and the local time equivalent.

⁴ ADS-B data is normally recorded in coordinated universal time (UTC) but is presented in eastern daylight time in this report. At the time of the accident, eastern daylight time was offset from UTC by -4 hours, or UTC-4.

Table 1. Notable transmissions in the ATC audio file.

<i>Audio File Timestamp</i>	<i>Local Time</i>	<i>Transmission Summary</i>
29:00	8:42:19	KPMP tower granted clearance for takeoff
29:06	8:42:25	N109BC confirmed KPMP tower clearance for takeoff
29:46	8:43:05	N109BC confirmed frequency change
30:26	8:43:45	N109BC contacted KPMP tower
30:29	8:43:48	N109BC declared emergency for engine failure
30:39	8:43:58	N109BC confirmed clear to land on runway 6

4.1.3 Surveillance and Ground Witness Videos

A surveillance video of the operator's hangar at KPMP showed the accident helicopter was on a dolly when the operator received a call for an air medical flight (the accident flight). **Table 2** shows notable observations and their timestamps based on a review of the ramp surveillance video. A tractor towed the helicopter and dolly to the ramp. Another surveillance video of the ramp in front of the operator's hangar showed the helicopter's start up and departure (**Figure 26**). No flames or smoke was visible in the surveillance video showing the helicopter's departure from KPMP (**Figure 27**).

Table 2. Notable observations of the ramp surveillance video.

<i>Video Timestamp</i>	<i>Observation</i>
08:51:11	Pilot gets into right cockpit seat, but the front-right door remains open.
08:51:39	First flash observed of the vertical fin anticollision light.
08:52:12	Main rotor begins to turn.
08:52:54	Front-right door closes.
08:53:13	Right cabin sliding door closes.
08:53:53	Helicopter lifts off from dolly and hover taxis toward the taxiway.
08:54:25	Helicopter turns left to align with taxiway.
08:54:31	Start of acceleration to take off.
08:54:42	Helicopter leaves video frame.



Figure 26. A still image from the surveillance video of the operator's hangar at KPMP showing the accident helicopter (yellow arrow) after liftoff from the dolly. (Video courtesy of BSO, still image captured and modified by the NTSB)



Figure 27. A still image from the surveillance video of the operator's hangar at KPMP showing the departure of the accident helicopter. (Video courtesy of BSO, still image captured and modified by the NTSB)

A north-facing ground surveillance video from a camera located at the southwest corner of Annie Adderly Gillis Park in Pompano Beach, FL showed the helicopter after its departure from KPMP. The helicopter remains in view from the start of the video to about 17 seconds into the video, with no discernable smoke trail (**Figure 28**). The tree in the vicinity of this camera obscures the helicopter after 17 seconds. About 23 seconds later (40 seconds into the video), the helicopter becomes visible again and showed a light-colored line behind it. The light-colored line could be interpreted as a smoke trail (**Figure 29**). The helicopter exits the video frame 8 seconds later (48 seconds into the video). Based on the location of the surveillance camera and the field of view, the Airworthiness Group estimated these 8 seconds when the light-colored line was present was between 8:43:38 to 8:43:46 eastern daylight time (**Appendix A, Figure A-2**).

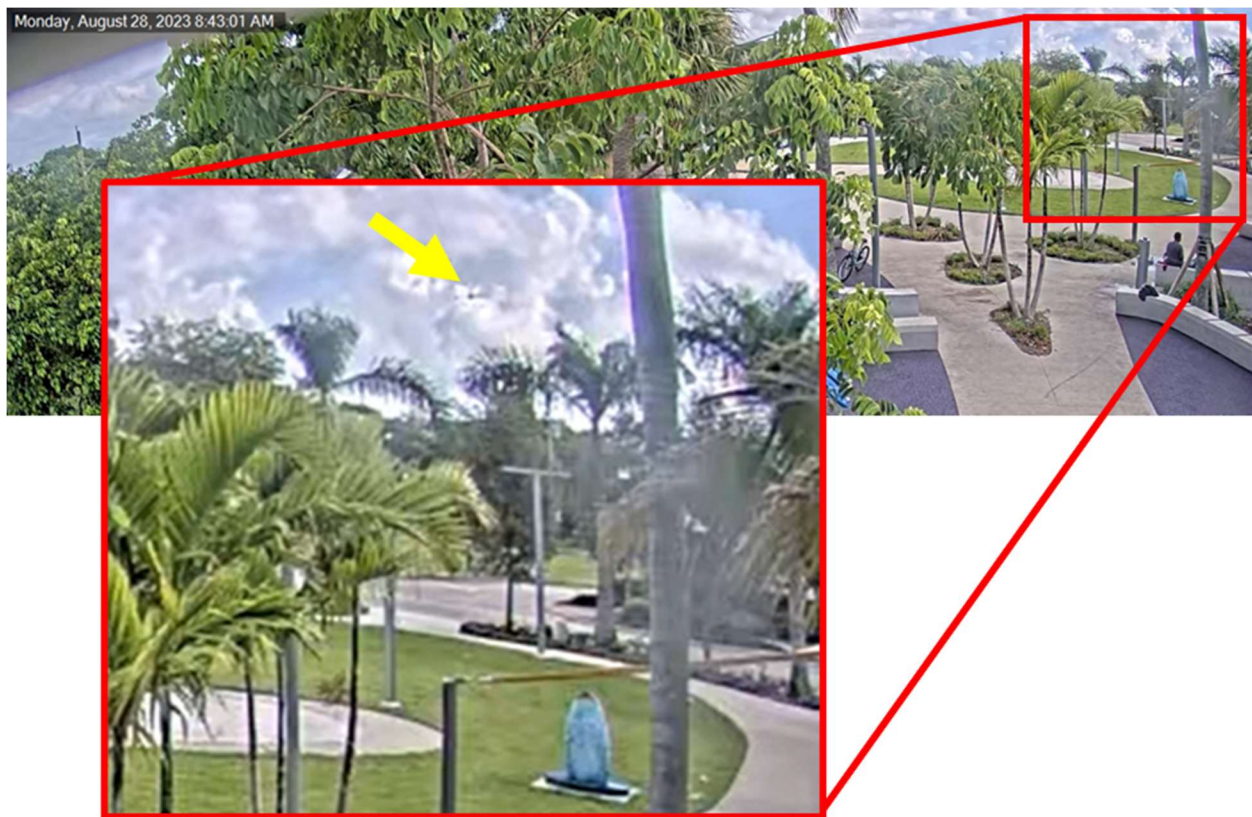


Figure 28. A still image from the ground surveillance video from Annie Adderly Gillis Park that shows the helicopter with no discernable smoke trail behind the helicopter (yellow arrow). (Video courtesy of BSO, still image captured and modified by the NTSB)



Figure 29. A second still image from the ground surveillance video from Annie Adderly Gillis Park that shows the helicopter with a possible smoke trail behind the helicopter (yellow arrow). (Video courtesy of BSO, still image captured and modified by the NTSB)

The Airworthiness Group reviewed several ground witness videos that showed the accident flight. The longest duration video showed visible flames and smoke emanating from the area of the No. 1 engine exhaust and the air conditioner condenser fans (**Figures 30 and 31**). About 1 minute after the start of the video, the helicopter abruptly yaws, the tail boom partially separates from the fuselage, and the helicopter descends toward the ground while spinning. The tail boom remains partially attached to the main fuselage during the spinning descent. Based on the 1-minute duration of the visible flames and smoke, the Airworthiness Group estimated the start time of the video was about 8:43:48 eastern daylight time (**Appendix A, Figure A-2**). Another ground witness video, about 36 seconds in duration, that showed the right side of the accident helicopter showed a smoke trail emanating from the helicopter for the duration of the video when the helicopter was visible (**Figure 32**). About 5 seconds before the helicopter's tail boom partially separated from the fuselage, and 16 seconds from the start of the ground witness video, visible flames were observed in the central area where the tail boom attaches to the main fuselage (**Figure 33**). In another ground witness video that shows the partial separation of the helicopter's tail boom and its uncontrolled descent, a small object separates from the helicopter about 5 seconds after the tail boom partially separates (**Figure 34**). This small object has a smoke trail as it descends with the helicopter (**Figure 35**). The small object was likely an air conditioner condenser fan motor found separated from the main wreckage (**Figure 19**).



Figure 30. A still image from the start of the ground witness video that showed the accident helicopter with a smoke trail and visible flames (red arrow) emanating from the area of the No. 1 engine exhaust and the air conditioner condenser fans. (Video courtesy of BSO, still image captured and modified by the NTSB)



Figure 31. A still image taken about 35 seconds after the start of the 1-minute long ground witness video. The area of the visible flames (red arrow) appears larger than compared to the beginning of the video. (Video courtesy of BSO, still image captured and modified by the NTSB)



Figure 32. Visible smoke emanating from the accident helicopter. This still frame was captured about 10 seconds from the start of the ground witness video. (Video courtesy of BSO, still image captured by the NTSB)



Figure 33. Visible flames emanating from the center tail boom area. This still frame was captured about 20 seconds from the start of the ground witness video, and about 5 seconds before partial separation of the tail boom. (Video courtesy of BSO, still image captured by the NTSB)



Figure 34. The small object that separated from the helicopter about 5 seconds after partial separation of the tail boom.



Figure 35. The visible smoke trail of the small object that separated from the helicopter.

A ground surveillance video near the accident site showed the main fuselage impact the roof of a building. At the time of impact, the helicopter was generally upright with a left bank angle. In this surveillance video, the tail boom had already separated prior to the main fuselage impacting the roof of the building, and the tail boom was seen descending behind the building to its final resting location as seen by investigators at the accident site. Immediately after the helicopter impacted the apartment building roof, thick light-colored smoke emanated and spread from the impact area. About 39 seconds after the impact, a person egressed from the helicopter and walked along the building roof. A second person egressed about 6 seconds after the first person. About 1 minute after impact, flames were clearly visible from the impact area.

5.0 Maintenance

The operator maintained the accident helicopter under the manufacturer's recommended inspection program. According to the accident helicopter flight log sheets, on August 27, 2023 (the day before the accident), the helicopter had an ATT of 5,578.4 hours. Within the accident helicopter's logbook, the last entry was dated August 1, 2023 (ATT 5565.3 hours), which was in reference to the installation of three STCs as well as maintenance performed by Metro Aviation in Shreveport, LA. The three STCs installed at that time were an air conditioning system (STC No. SR09163RC), optional equipment (STC No. SR09354RC), and emergency medical system (STC No. SR09164RC). The second-to-last entry in the logbook was dated May 23, 2023 (ATT 5557.1 hours) for a 100-hr inspection that was accomplished as well as replacement of the brake pads for the rotor brake. **Attachment 2** of this report contains the airframe logbook entries related to the air conditioning system STC installation at Metro Aviation. **Attachment 3** of this report contains the airframe logbook entry and checklist for the last 100-hr inspection.

E LIST OF ATTACHMENTS

Attachment 1 - Additional photographs of the engine firewalls

Attachment 2 - Airframe logbook entries for the installation of the air conditioner system on N109BC under the provisions of STC No. SR09163RC

Attachment 3 - Airframe logbook entry and checklist for the last 100-hr inspection for N109BC accomplished on May 23, 2023

Submitted by:

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Aerospace Engineer - Helicopters

APPENDIX A

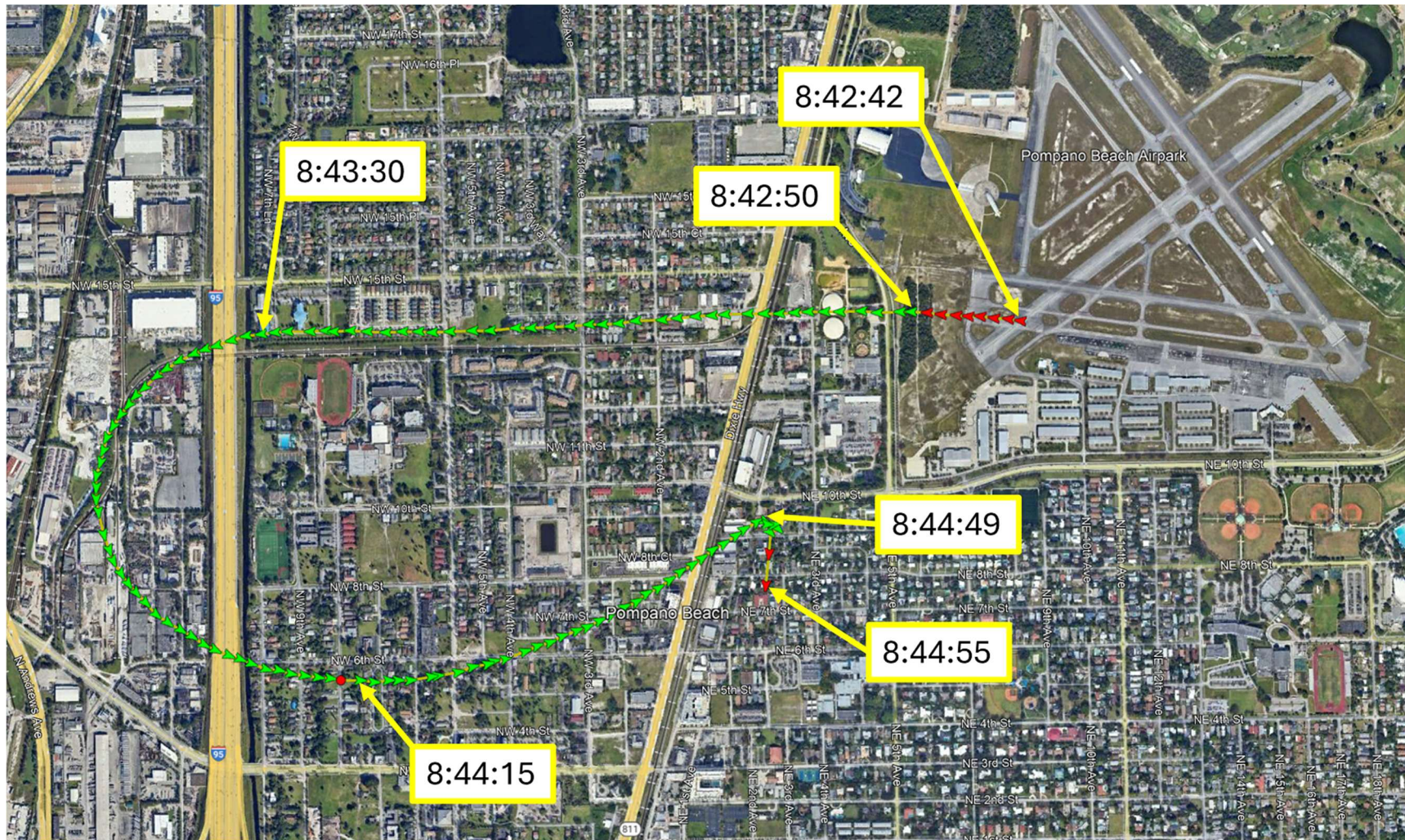


Figure A-1. The ADS-B data for the accident flight with notable datapoints marked with timestamps. The red-colored ADS-B data points signify those that are flagged for an “integrity/accuracy failure.”

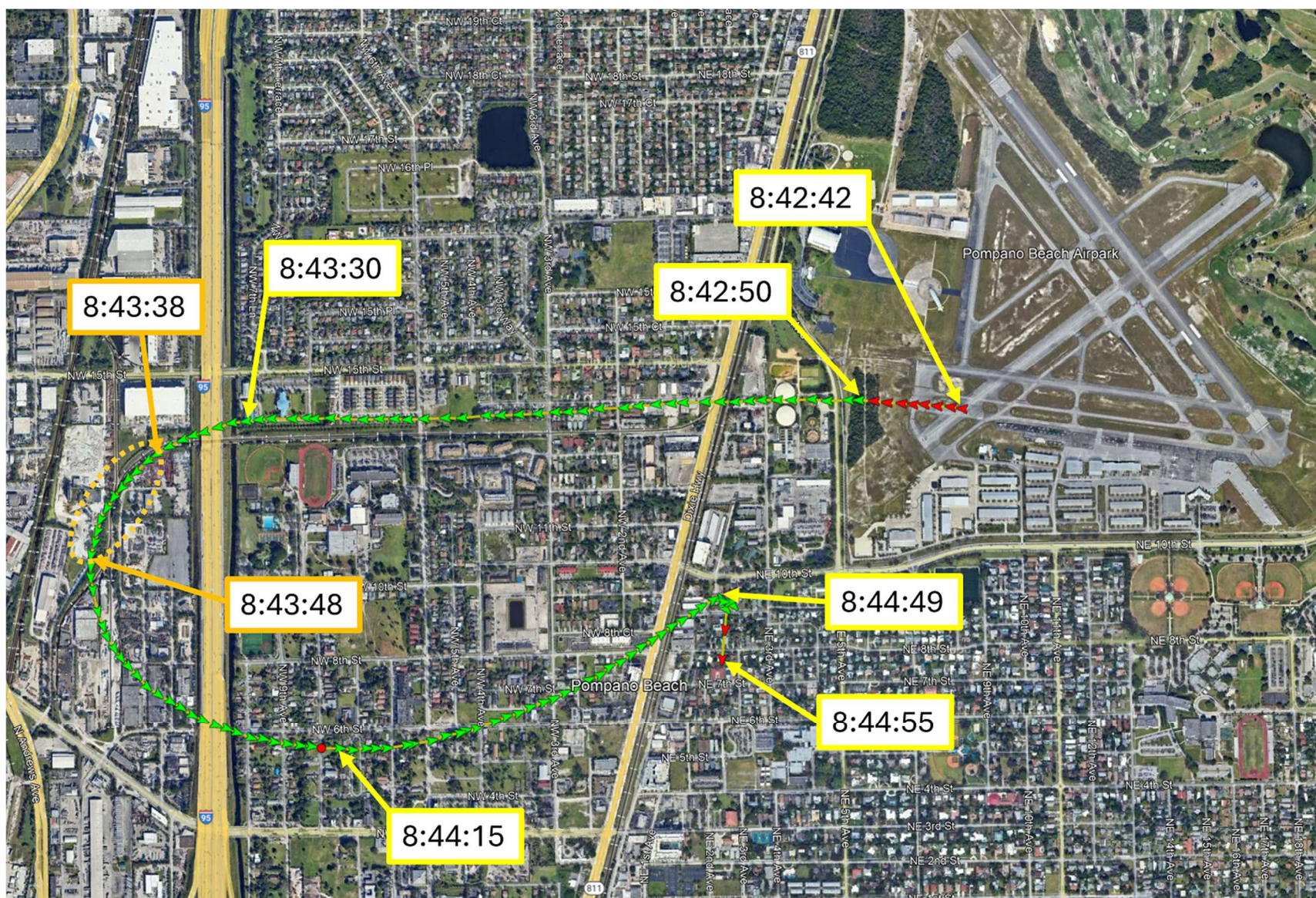


Figure A-2. The orange dashed oval (left side of the figure) and timestamps showing the ground witness and surveillance videos showing signs of smoke emanating from the accident helicopter.