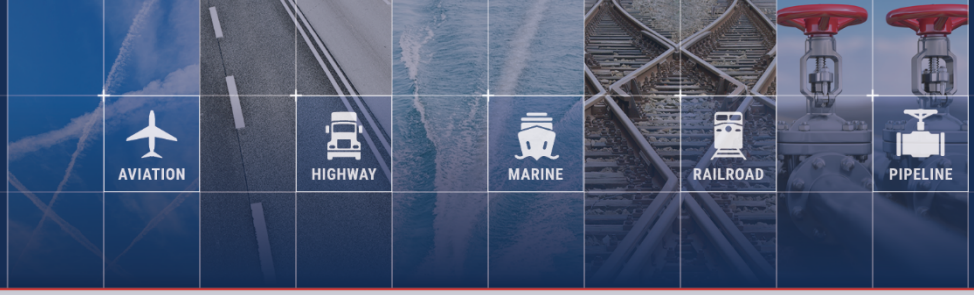

Aviation Investigation Final Report

Location:	Beaufort, North Carolina	**Accident Number:**	ERA22LA120
Date & Time:	February 13, 2022, 14:02 Local	**Registration:**	N79NX
Aircraft:	PILATUS AIRCRAFT LTD PC-12/47E	**Aircraft Damage:**	Destroyed
Defining Event:	Loss of control in flight	**Injuries:**	8 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

Before departing on the flight, the pilot of the turbo-propeller-equipped, single-engine airplane and student pilot-rated passenger seated in the right front seat of the airplane attempted to enter a flight plan into the airplane's integrated flight management system. They ultimately did not complete this task prior to takeoff with the pilot remarking, "we'll get to it later." The pilot subsequently departed and climbed into instrument meteorological conditions (IMC) without an instrument flight rules (IFR) flight plan. After entering IMC, he contacted air traffic control and asked for visual flight rules (VFR) flight following services and an IFR clearance to the destination airport. From shortly after when the airplane leveled after takeoff through the final seconds of the flight, the pilot attempted to program, delete, reprogram, and activate a flight plan into the airplane's flight management system as evidenced by his comments recorded on the airplane's cockpit voice recorder (CVR). After departing, the pilot also attempted to navigate around restricted airspace that the airplane had flown into.

The CVR audio showed that during the final 10 minutes of the flight, the pilot was unsure of the spelling of the fix he should have been navigating to in order to begin the instrument approach at the destination airport, and more generally expressed frustration and confusion while attempting to program the integrated flight management system. As the pilot continued to fixate on programming the airplane's flight management system and change the altimeter setting, the airplane's pitch attitude increased to 10° nose up, while the airspeed had decayed to 109 knots. As a result of his inattention to this airspeed decay, the stall warning system activated and the autopilot disconnected. During this time the airplane began climbing and turning to the right and then to the left before entering a steep descending right turn that continued until the airplane impacted the ocean. For the final 2 and 1/2 minutes of the flight,

the pilot was provided with stall warnings, stick shaker activations, autopilot disconnect warnings, and terrain avoidance warning system alerts.

The airplane impacted the ocean about 3 miles from the coast. Examination of the recovered sections of the airplane did not reveal evidence of any mechanical failures or malfunctions of the airframe or engine that would have precluded normal operation.

The instrument meteorological conditions present in the area at the time of the accident were conducive to the development of spatial disorientation. The airplane's erratic flight track in the final 2 minutes of flight, culminating in the final rapidly descending right turn, were consistent with the known effects of spatial disorientation. It is likely that the pilot's inadequate preflight planning, and his subsequent distraction while he unsuccessfully attempted to program the airplane's flight management system during the flight resulted in his failure to adequately monitor the airplane's speed. This led to the activation of the airplane's stall protection and warning systems as the airplane approached and entered an aerodynamic stall. The resulting sudden deactivation of the autopilot, combined with his inattention to the airplane's flight attitude and speed, likely surprised the pilot. Ultimately, the pilot failed to regain control of the airplane following the aerodynamic stall, likely due to spatial disorientation.

The pilot had a history of mantle cell lymphoma that was in remission and his maintenance treatment with a rituximab infusion was over 60 days prior to the accident. The pilot also had a history of back pain and had received steroid injections and nonsteroidal anti-inflammatory drugs. By self-report, he had taken oxycodone for pain management; it is unknown how frequently he used this medication or if he had used the medication on the day of the accident. While oxycodone can result in fatigue and dizziness, and may interfere with reaction time, given the information from the CVR, it could not be determined if the pilot had these side effects. A few weeks prior to the accident, the pilot reported having COVID-19 and receiving a 5-day treatment course of hydroxychloroquine and ivermectin. While there are some impairing side effects associated with the use of those medications, enough time had elapsed that no adverse effects would be expected.

There is an increased risk of a sudden incapacitating cardiovascular event such as a dysrhythmia, stroke, or pulmonary embolism in people who have recovered from their COVID-19 infection. The risk is slight for those not hospitalized for the infection. The pilot did not have an underlying cardiovascular disease that would pose an increased risk for a sudden incapacitating event and the CVR did not provide evidence of a sudden incapacitating event occurring. Thus, it could not be determined if the pilot's medical conditions of mantle cell lymphoma, back pain, and recent history of COVID-19 and the medications used to treat these conditions, including rituximab, oxycodone, hydroxychloroquine, and ivermectin, were contributing factors to this accident.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilot's inadequate preflight planning, inadequate inflight monitoring of the airplane's flight parameters, and his failure to regain control of the airplane following entry into an inadvertent aerodynamic stall. The pilot's likely spatial disorientation following the aerodynamic stall also contributed to the outcome.

Findings

Personnel issues	Aircraft control - Pilot
Aircraft	Airspeed - Not attained/maintained
Aircraft	Angle of attack - Not attained/maintained
Personnel issues	Spatial disorientation - Pilot
Personnel issues	Attention - Pilot
Environmental issues	Clouds - Effect on personnel

Factual Information

History of Flight

Enroute-cruise	Loss of control in flight (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On February 13, 2022, about 1402 eastern standard time, a Pilatus PC-12, N79NX, was destroyed when it was involved in an accident near Beaufort, North Carolina. The commercial pilot, and 7 passengers were fatally injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

Earlier on the day of the accident, the airplane departed Pitt-Greenville Airport (PGV), Greenville, North Carolina, about 1235, and landed at Hyde County Airport (7W6), Engelhard, North Carolina, at 1255.

According to data recovered from the airplane's combination flight data and cockpit voice recorder, before departing on the accident flight, when the passengers were boarding the airplane, the pilot was instructing the student pilot-rated passenger, who was seated in the right front seat of the airplane, on how to enter the flight plan information into the avionics. At one point, the passenger was told to enter W95 (Ocracoke Island Airport, Ocracoke, North Carolina) into the flight plan; however, he seemed unsure if he entered the information correctly. The pilot responded and stated that "we'll get it later." The passenger proceeded to insert Michael J. Smith Field Airport (MRH), Beaufort, North Carolina, into the flight plan, and then activate it. The data recorder data showed that the engine was started at 1329, and after taxi, the engine power was advanced for takeoff at 1334. The autopilot was engaged shortly after takeoff and the airplane climbed and leveled at the selected target altitude of 3,500 ft. The airspeed then stabilized around 220 knots from about 1337 to about 1343. Figure 1 depicts the airplane's flight track for the entirety of the accident flight overlayed onto a visual flight rules sectional chart.

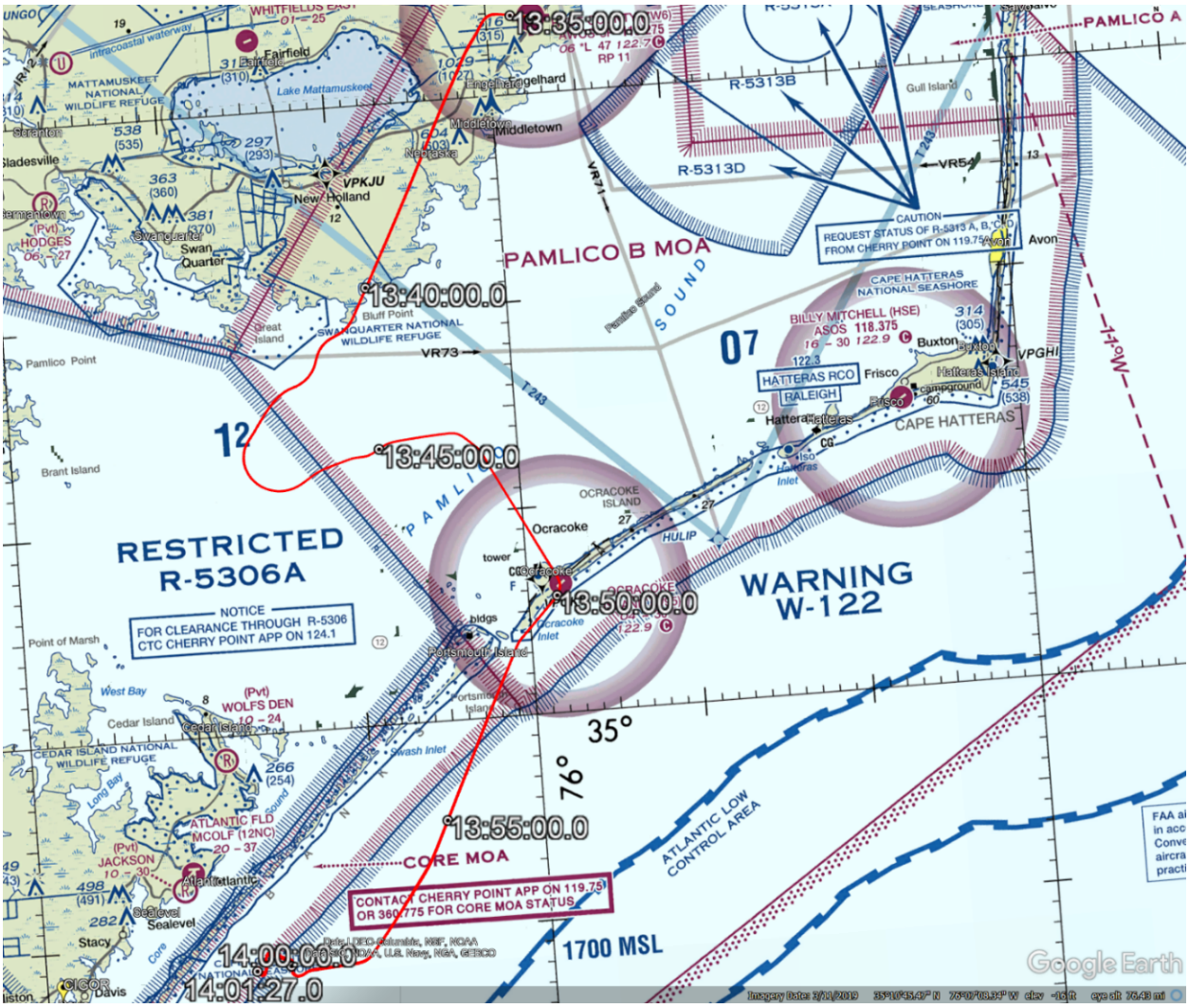

Figure 1. View of the airplane's flight track (red) overlayed onto a visual flight rules sectional chart. The airplane's position at various 5 minute time increments is also labeled.

After departure, the pilot and passenger spent several minutes amending and activating a flight plan into the airplane's integrated flight management system before the pilot contacted air traffic control and reported they were going to level off at 3,500 ft mean sea level (msl). He requested VFR flight following as well as an IFR clearance to MRH. At 1338, the controller advised the pilot that a nearby restricted airspace was active, and the pilot confirmed that they would remain clear of the airspace and fly to the east. After that, while still attempting to program the autopilot flight plan, he stated, "I don't know what I need to do. Just I almost [want] to take it all out and start from scratch."

According to air traffic control data, at 1341, the controller called the pilot and indicated that they were about to enter the restricted airspace. After multiple calls with no response from the accident pilot, the controller instructed the military aircraft that were operating in the restricted airspace to remain above 4,000 ft msl. Although the pilot never responded to the controller, the cockpit voice recorder indicated that the pilot and passenger continued to try and program the

flight plan into the flight management system. The pilot expressed concern to the passenger about entering the restricted area, and at one point the pilot stated, “what in the [expletive] am I doing?”

From 1341 to 1347, the pilot continued his attempts to program the flight plan into the integrated flight management system. At 1342:55 the selected altitude decreased to 3,000 ft and pitch control mode changed from altitude hold to vertical speed. The airplane began to descend, and the airspeed accelerated to 240 knots by 1343:42. Upon reaching 240 knots an overspeed warning was recorded. The “speed” (overspeed) alert sounded twice from the crew alerting system (CAS) and the pilot continued to enter waypoints into the integrated flight management system. After the first “speed” alert, the cockpit area microphone recorded a sound similar to a reduction in engine power, which correlated with the flight data recorder data that indicated the engine torque was reduced, and the airplane leveled at 3,000 ft. The torque setting remained unchanged until 1355. With the reduced torque setting, the airspeed stabilized at 147 knots. At 1346, the pilot stated, “I have – I have [got to] get a fricken flight plan in this thing.” At 1347, the pilot verbalized the weather conditions at the destination airport.

At 1348, the pilot called the controller and requested the RNAV approach to runway 26 but was denied the request because of the active restricted airspace. The controller then queried the pilot as to why he did not respond to the earlier radio calls, and the pilot responded that he “was trying to get out” and was unable to receive the radio transmissions. The controller offered an approach to runway 8 or runway 3, and the pilot chose runway 8. After that, the pilot talked about programing the avionics, and even mentioned “I’ve got to get my iPad out…. this is not good this way – I’m way behind the eight ball – [expletive] I hate it – I hate it when that happens.” The pilot asked the passenger to “bring up” runway 08 [instrument approach procedure], the passenger responded “here I got you” and “there you go,” to which the pilot stated, “I [do not have] my dang gone glasses either – there we go the lights help.”

At 1352, the controller reported that the restricted airspace was not active anymore and asked if the pilot wanted the RNAV approach to runway 26 instead. The pilot responded that he would appreciate that, and the controller cleared the pilot direct to CIGOR, the initial approach fix for the RNAV 26 approach. The pilot spent the next 3 minutes attempting to program the route of flight into the flight management system, and mentioned, “I can’t get [nothing] on this thing that I want.” On one occasion, the pilot asked the controller to clarify the name of the fix that they had been cleared to fly to in order to begin the approach (CIGOR or CIBAG), and on another occasion he asked the same question of the passenger. The passenger mentioned that he thought the correct waypoint was CIGOR.

At 1355, the controller called the pilot and asked to verify if they were proceeding direct to CIGOR because the airplane was still on a southwesterly track. The pilot responded “roger” and the controller said the pilot could proceed direct to CIGOR, to cross the waypoint at or above 1,900 ft msl, and was cleared for the runway 26 RNAV approach. The pilot read back the

instructions correctly and then the passenger stated to the pilot, “should we get [them] to spell CIGOR and just insert it.” The pilot continued to program, delete, and activate waypoints. At 1356:14, the vertical speed mode was engaged again, and the airplane descended to a new selected altitude of 1,800 ft, at 1357:33. During the descent, the engine torque was reduced slightly from its previous setting. After capturing the altitude, airspeed began to decrease at a rate of about 1 knot per second and pitch began a gradual increase of about 0.1 degree per second. Engine torque was reduced again during the slow decay of airspeed while the airplane’s pitch and angle of attack slowly increased.

At 1358, the controller contacted the pilot and issued a heading to CIGOR, but then indicated that he had observed that the airplane was “correcting now.” At 1358:46, the controller called the pilot and issued the local altimeter setting (the airplane was flying at 1,700 ft msl, but the pilot had been instructed to maintain 1,900 ft msl). The pilot read back the altimeter setting correctly, which was the last transmission from the pilot. At 1358:56, the airplane’s barometric altimeter setting changed from 29.98 inHg to 29.96 inHg. At that time, the pitch increased to 10° nose up, while the airspeed had decayed to 109 knots. At 1359:12, the “stall” alert sounded from the CAS, the stick shaker activated, and the autopilot automatically disengaged. The airspeed reached a low of 93 knots and the autopilot remained disconnected for the rest of the recording. At 1359:13, the engine torque increased, which was also correlated with a sound consistent with the engine power increasing. The autopilot disconnect warning sounded continuously at 1359:15 and over the next 2 minutes until the end of the recording. During this time the pilot also continued to make comments about the airplane’s navigation system including, “what are we doin’,” “it’ll navigate,” and “activate vectors.” At 1359:40, the passenger stated, “we’re sideways.” Following the stick shaker activation, at 1359:50, the engine power was increased to nearly full power, the stall alert sounded 8 times, the airspeed decayed to 83 knots and the pitch increased to 31.7° when the stick shaker and pusher activated again. At 1401:21, the sink rate alert sounded, and the terrain avoidance warning system announced “pull up” and “speed” before the recording ended at 1401:29. In the final moments of flight, the airplane rolled to a bank of more than 90° to the right and pitched more than 50° nose down. Figure 2 depicts the airplane’s horizontal and vertical flight track during the final 2 ½ minutes of the flight.

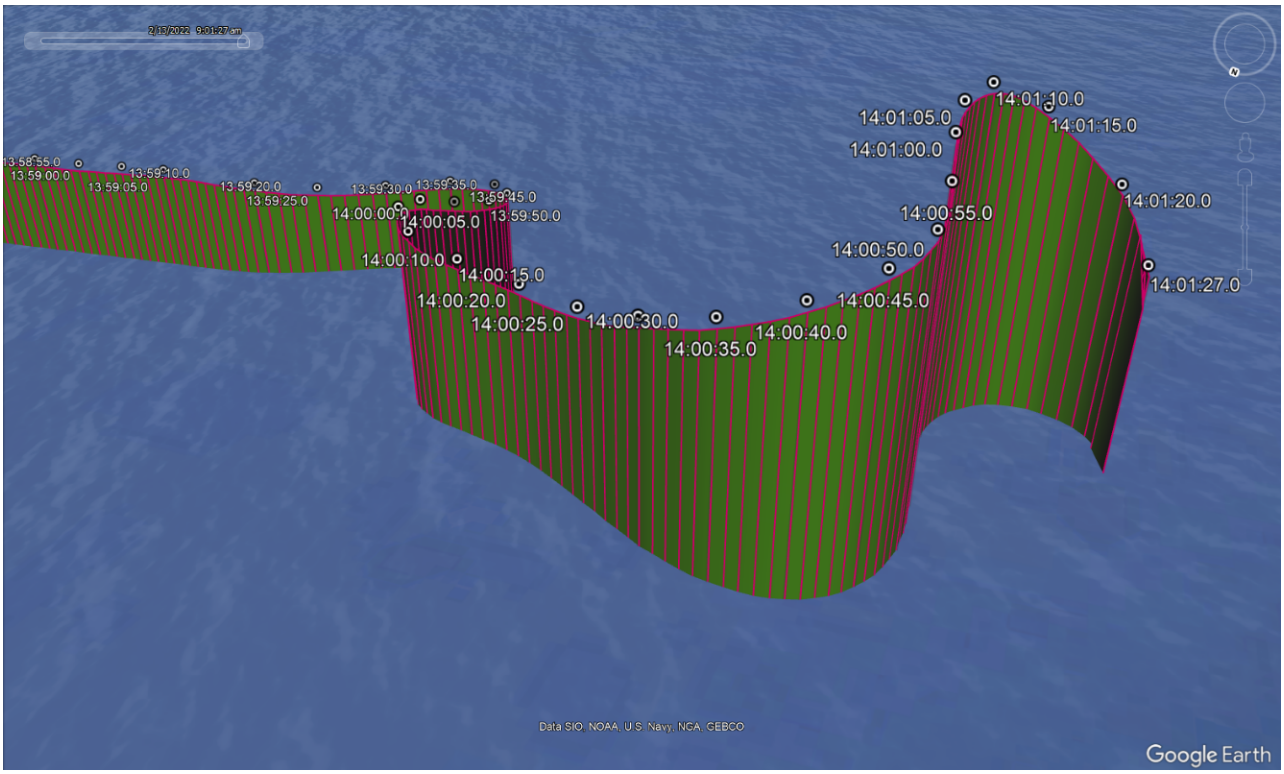

Figure 2. View of altitude variation during the final 2 ½ minutes of the flight.

At 1401, the controller attempted to contact the pilot to inquire about the airplane's altitude (the airplane was at 4,700 ft msl and climbing quickly). There was no response.

Radar contact with the airplane was lost about 1402 and an ALNOT was issued by air traffic control at 1429.

Pilot Information

Certificate:	Commercial	**Age:**	67,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	June 28, 2021
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	3000 hours (Total, all aircraft)		

Pilot-rated passenger Information

Certificate:	Student	**Age:**	28,Male
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	None	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 3 Without waivers/limitations	**Last FAA Medical Exam:**	July 6, 2021
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	97.4 hours (Total, all aircraft), 21 hours (Total, this make and model)		

According to Federal Aviation Administration (FAA) airman records, the pilot held a commercial pilot certificate with ratings for airplane multiengine land, airplane single-engine land, and instrument airplane. In addition, he held a ground instructor certificate and held a mechanic certificate with airframe and powerplant ratings. His most recent second-class medical certificate was issued June 28, 2021. At that time, he reported 3,000 total hours of flight experience.

According to FAA airman records, the passenger (who was seated in the right cockpit seat) held a student pilot certificate. His most recent third-class medical certificate was issued on July 6, 2021, and at that time he reported 20 hours of flight experience.

Aircraft and Owner/Operator Information

Aircraft Make:	PILATUS AIRCRAFT LTD	**Registration:**	N79NX
Model/Series:	PC-12/47E	**Aircraft Category:**	Airplane
Year of Manufacture:	2017	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	1709
Landing Gear Type:	Retractable - Tricycle	**Seats:**	11
Date/Type of Last Inspection:	January 7, 2022 Annual	**Certified Max Gross Wt.:**	
Time Since Last Inspection:	20 Hrs	**Engines:**	1 Turbo prop
Airframe Total Time:	1367.9 Hrs at time of accident	**Engine Manufacturer:**	Pratt & Whitney Canada
ELT:	C126 installed	**Engine Model/Series:**	PT6A-67P
Registered Owner:	EDP MANAGEMENT GROUP LLC	**Rated Power:**	
Operator:	EDP MANAGEMENT GROUP LLC	**Operating Certificate(s) Held:**	None

The airplane was equipped with an automatic flight control system. According to the airplane flight manual, “Autopilot disengagement is defined as either normal or abnormal. A normal disengagement is initiated manually by pressing the AP DISC push-button on the control wheel or by the AP push button on the [flight controller] or by activating the manual trim system. A normal disconnect will cause the AP indication on the PFD to flash red/white and the aural “Cavalry Charge” warning tone to be activated. After 2.5 seconds the AP indicator and audio are removed. Any disengagement due to a monitor trip or failure is considered abnormal. An abnormal disconnect will cause the AP indication on the PFD to flash red/white and the aural warning tone to be activated until acknowledged via the AP DISC push-button.”

In addition, it stated “Activation of the stick shaker disengages the autopilot if engaged, in order to give full authority to a possible stick pusher activation. The autopilot can be manually reconnected after the angle of attack is reduced and the stick shaker has ceased operation.”

Also, the airplane flight manual indicated that the wings level stall speed at the maximum takeoff weight with flight idle power was 95 knots with 0° of flaps in non-icing conditions.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument (IMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	MRH,8 ft msl	**Distance from Accident Site:**	19 Nautical Miles
Observation Time:	13:58 Local	**Direction from Accident Site:**	256°
Lowest Cloud Condition:		**Visibility**	10 miles
Lowest Ceiling:	Overcast / 900 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	13 knots / 18 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	20°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.93 inches Hg	**Temperature/Dew Point:**	7°C / 6°C
Precipitation and Obscuration:	Light - None - Rain		
Departure Point:	Engelhard, NC (7W6)	**Type of Flight Plan Filed:**	None
Destination:	Beaufort, NC (MRH)	**Type of Clearance:**	VFR flight following
Departure Time:	13:35 Local	**Type of Airspace:**	

The weather reported at the departure airport (7W6) around the time of departure indicated that there was a wind from 360° at 10 knots, gusting to 15 knots, visibility 10 miles, ceiling overcast at 2,100 ft above ground level (agl), a temperature of 6° C, a dewpoint temperature of 3° C, and an altimeter setting of 29.93 inches of mercury.

The weather reported at the destination airport, MRH, at 1258 included wind from 020° at 10 knots with gusts to 20 knots, visibility 7 statute miles, light rain, ceiling overcast at 1,000 feet agl, a temperature of 8° C and a dew point temperature of 6°C, with an altimeter setting of 29.96 inches of mercury.

At 1358, the automated weather reported at MRH included a wind from 020° at 13 knots with gusts to 18 knots, visibility 10 statute miles or greater, light rain, ceiling overcast at 900 feet agl, a temperature of 7° C and a dew point temperature of 6°C, and an altimeter setting of 29.93 inches of mercury. The weather report remarks included that the ceiling was variable between 600 and 1,200 feet agl, that there had been 0.02 inches of liquid-equivalent precipitation since 1258, and that there was a trace amount of ice accretion since 1258.

Infrared cloud-top temperatures over the accident site were about -29°C, which corresponded to cloud top heights of about 25,000 ft.

A text AIRMET SIERRA for IFR conditions, identifying ceilings below 1,000 feet, visibility below 3 statute miles in precipitation and mist, was issued at 1319 and was valid for the accident site at the accident time.

A review of preflight weather briefing information revealed that the pilot did not obtain preflight information from Leidos Flight Services. An account with ForeFlight associated with the airplane viewed airport information on February 12-13, 2022.

The airports viewed on February 12, 2022, were:

- Morgantown Municipal Airport (MGW), Morgantown, West Virginia
- Wilmington International Airport (ILM), Wilmington, North Carolina

The airports viewed on February 13, 2022, were:

- Hyde County Airport (7W6), Engelhard, North Carolina. Viewed at 0901.
- Michael J Smith Field Airport (MRH), Beaufort, North Carolina. View at 0902.
- Duluth International Airport (DLH), Duluth, Minnesota. Viewed at 0934.
- Manchester Boston Regional Airport (MHT), Manchester, New Hampshire. Viewed at 0934.

The Airports page in ForeFlight included airport information, METARs, TAF/MOS and other forecasts. However, ForeFlight did not have any logs about what information was viewed on the airports page.

No other information about the pilot's preflight weather briefing was located.

Airport Information

Airport:	MICHAEL J SMITH FLD MRH	**Runway Surface Type:**	Asphalt
Airport Elevation:	10 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:	26	**IFR Approach:**	RNAV
Runway Length/Width:	5000 ft / 100 ft	**VFR Approach/Landing:**	Unknown

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	7 Fatal	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	8 Fatal	**Latitude, Longitude:**	34.81355,-76.2871

The airplane impacted the Atlantic Ocean and was located by the US Coast Guard 3 miles offshore in about 60 ft of water about 5 hours after the accident.

Portions of the wreckage were recovered. Examination of the recovered wreckage revealed that the forward and aft sections of the main wing spar were separated, and that the fracture surfaces exhibited overload. The left and right main landing gear were recovered. A section of the left wing and left inboard flap actuator was recovered, along with a section of the left winglet. The 7.5 ft inboard section of the right-wing flap and a majority of the right winglet were located. Aileron control continuity could not be confirmed because a majority of the aileron flight control system was not recovered. The vertical stabilizer remained attached to the empennage. The pitch trim actuator extension was measured and corresponded to slightly nose up trim. The rudder was separated from the vertical stabilizer but remained intact. The rudder trim tab remained attached to the rudder. The rudder trim actuator extension and corresponded to a trim setting slightly in the nose right direction. The elevator flight control cables remained attached to the control rods. Elevator and rudder flight control continuity was confirmed from the flight control surfaces to the forward cabin area of the fuselage through multiple overstress breaks and cuts by recovery personnel. The clamps that attached the stick pusher servo to the elevator control cables were intact and exhibited no signs of slippage. There was no evidence of fire on any section of the airplane. The emergency locator transmitter (ELT) was removed from the empennage by divers who turned the ELT to the off position.

The engine was impact separated from the airframe. The accessory gear box and reduction gear box were not recovered. The power turbine housing and sections of the power turbine vanes exhibited rotational scoring. In addition, the power turbine vanes were bent the opposite direction of normal rotation. The fuel filter was removed, and no debris was noted in the screen. The P3 filter was removed from the engine. Water and corrosion were noted in the filter. The oil filter was removed and examined. Oil was noted in the screen, and no debris was noted.

The propeller governor and overspeed governor were not recovered. The propeller hub was not recovered. Three propeller blades were recovered with the wreckage, the two others were not. The three propeller blades were separated at the hub and about midspan of the blade.

Flight recorders

The airplane was equipped with an L-3 Lightweight Data Recorder (LDR), which provided both a flight data recorder (FDR) and cockpit voice recorder (CVR) function. The recorder was

recovered and 2 hours of voice data were successfully downloaded, along with 36 flights worth of parametric data from the airplane.

Medical and Pathological Information

The commercial pilot held a held a second-class medical certificate with a special issuance for mantle cell lymphoma (in remission). At his most recent FAA medical certification examination on June 28, 2021, he reported taking acyclovir daily and infusions of rituximab every 8 weeks for the lymphoma and reported no side effects from these medications. No autopsy report or toxicology testing results were available.

Review of the pilot's medical records showed that the pilot was diagnosed with mantle cell lymphoma in November 2019 and received a stem cell transplant in April 2020. His most recent visit to the oncologist for follow-up and rituximab infusion was on December 10, 2021, and he was reported to overall be doing well. The pilot had an acute injury to his back in August 2021 and over the next three months received three steroid injections for a bulging disc. In August 2021, he reported to his oncologist that he had taken oxycodone for the pain. In addition to the steroid injections, his primary care doctor had prescribed non-steroidal anti-inflammatory medications for his ongoing back pain. The pilot tested positive for COVID-19 in January 2022 and reported receiving a monoclonal antibody infusion and a five-day course of hydroxychloroquine and ivermectin in early February 2022.

The passenger held a held a third-class medical certificate without limitations. At his most recent and only exam July 6, 2021, he reported taking no medications and no medical conditions. No autopsy report or toxicology testing results were available.

Additional Information

Spatial Disorientation

The FAA's *Pilot's Handbook of Aeronautical Knowledge* contained the following guidance:

> *Under normal flight conditions, when there is a visual reference to the horizon and ground, the sensory system in the inner ear helps to identify the pitch, roll, and yaw movements of the airplane. When visual contact with the horizon is lost, the vestibular system becomes unreliable. Without visual references outside the airplane, there are many situations where combinations of normal motions and forces can create convincing illusions that are difficult to overcome.*

The FAA's *Airplane Flying Handbook* (FAA-H-8083-3) described hazards associated with flying when visual references, such as the ground or horizon, are obscured.

> *The vestibular sense (motion sensing by the inner ear) in particular tends to confuse the pilot. Because of inertia, the sensory areas of the inner ear cannot detect slight changes in the attitude of the airplane, nor can they accurately sense attitude changes that occur at a uniform rate over a period of time. On the other hand, false sensations are often generated; leading the pilot to believe the attitude of the airplane has changed when in fact, it has not. These false sensations result in the pilot experiencing spatial disorientation.*

The FAA's publication "Spatial Disorientation Visual Illusions" (OK-11-1550), stated in part the following:

> *False visual reference illusions may cause you to orient your aircraft in relation to a false horizon; these illusions are caused by flying over a banked cloud, night flying over featureless terrain with ground lights that are indistinguishable from a dark sky with stars, or night flying over a featureless terrain with a clearly defined pattern of ground lights and a dark starless sky.*

The publication provided further guidance on the prevention of spatial disorientation. One of the preventive measures was "when flying at night or in reduced visibility, use and rely on your flight instruments." The publication also stated the following:

> *If you experience a visual illusion during flight (most pilots do at one time or another), have confidence in your instruments and ignore all conflicting signals your body gives you. Accidents usually happen as a result of a pilot's indecision to rely on the instruments.*

The FAA publication "Medical Facts for Pilots" (AM-400-03/1) described several vestibular illusions associated with the operation of aircraft in low-visibility conditions. The somatogravic illusion, which involves the semicircular canals of the vestibular system, was generally placed into the "graveyard spiral" Category. According to the publication text, the graveyard spiral

> *"…is associated with a return to level flight following an intentional or unintentional prolonged bank turn. For example, a pilot who enters a banking turn to the left will initially have a sensation of a turn in the same direction. If the left turn continues*

(~20 seconds or more), the pilot will experience the sensation that the airplane is no longer turning to the left. At this point, if the pilot attempts to level the wings this action will produce a sensation that the airplane is turning and banking in the opposite direction (to the right). If the pilot believes the illusion of a right turn (which can be very compelling), he/she will reenter the original left turn in an attempt to counteract the sensation of a right turn. Unfortunately, while this is happening, the airplane is still turning to the left and losing altitude."

Administrative Information

Investigator In Charge (IIC):	Kemner, Heidi
Additional Participating Persons:	Alexandra Grady; FAA/FSDO; Greensboro, NC Les Doud; Hartzell Propellers; Piqua, OH Nora Vallee; Transportation Safety Board of Canada; Gatineau, OF Alexandre Gauthier; Pratt & Whitney Canada; Saint-Hubert, OF Florian Reitz; Swiss Transportation Safety Investigation Board; Payerne, OF Markus Kohler; Pilatus Aircraft, Ltd; Stans, OF
Original Publish Date:	January 30, 2024
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=104634