



National Transportation Safety Board Aviation Accident Final Report

Location:	Amarillo, TX	Accident Number:	CEN17FA168
Date & Time:	04/28/2017, 2348 CDT	Registration:	N933DC
Aircraft:	PILATUS AIRCRAFT LTD PC 12	Aircraft Damage:	Destroyed
Defining Event:	Loss of control in flight	Injuries:	3 Fatal
Flight Conducted Under:	Part 135: Air Taxi & Commuter - Non-scheduled - Air Medical (Medical Emergency)		

Analysis

The pilot and two medical crewmembers departed on an air ambulance flight in night instrument meteorological conditions to pick up a patient. After departure, the local air traffic controller observed the airplane's primary radar target with an incorrect transponder code in a right turn and climbing through 4,400 ft mean sea level (msl), which was 800 ft above ground level (agl). The controller instructed the pilot to reset the transponder to the correct code, and the airplane leveled off between 4,400 ft and 4,600 ft msl for about 30 seconds. The controller then confirmed that the airplane was being tracked on radar with the correct transponder code; the airplane resumed its climb at a rate of about 6,000 ft per minute (fpm) to 6,000 ft msl. The pilot changed frequencies as instructed, then contacted departure control and reported "with you at 6,000 [ft msl]" and the departure controller radar-identified the airplane. About 1 minute later, the departure controller advised the pilot that he was no longer receiving the airplane's transponder; the pilot did not respond, and there were no further recorded transmissions from the pilot. Radar data showed the airplane descending rapidly at a rate that reached 17,000 fpm. Surveillance video from a nearby truck stop recorded lights from the airplane descending at an angle of about 45° followed by an explosion.

The airplane impacted a pasture about 1.5 nautical miles south of the airport, and a postimpact fire ensued. All major components of the airplane were located within the debris field. Ground scars at the accident site and damage to the airplane indicated that the airplane was in a steep, nose-low and wings-level attitude at the time of impact. The airplane's steep descent and its impact attitude are consistent with a loss of control.

An airplane performance study based on radar data and simulations determined that, during the climb to 6,000 ft and about 37 seconds before impact, the airplane achieved a peak pitch angle of about 23°, after which the pitch angle decreased steadily to an estimated -42° at impact. As the pitch angle decreased, the roll angle increased steadily to the left, reaching an estimated -76° at impact. The performance study revealed that the airplane could fly the accident flight trajectory without experiencing an aerodynamic stall. The apparent pitch and roll angles, which represent the attitude a pilot would "feel" the airplane to be in based on his

vestibular and kinesthetic perception of the components of the load factor vector in his own body coordinate system, were calculated. The apparent pitch angle ranged from 0° to 15° as the real pitch angle steadily decreased to -42°, and the apparent roll angle ranged from 0° to -4° as the real roll angle increased to -78°. This suggests that even when the airplane was in a steeply banked descent, conditions were present that could have produced a somatogravic illusion of level flight and resulted in spatial disorientation of the pilot.

Analysis of the performance study and the airplane's flight track revealed that the pilot executed several non-standard actions during the departure to include: excessive pitch and roll angles, rapid climb, unexpected level-offs, and non-standard ATC communications. In addition to the non-standard actions, the pilot's limited recent flight experience in night IFR conditions, and moderate turbulence would have been conducive to the onset of spatial disorientation. The pilot's failure to set the correct transponder code before departure, his non-standard departure maneuvering, and his apparent confusion regarding his altitude indicate a mental state not at peak acuity, further increasing the chances of spatial disorientation.

A postaccident examination of the flight control system did not reveal evidence of any preimpact anomalies that would have prevented normal operation. The engine exhibited rotational signatures indicative of engine operation during impact, and an examination did not reveal any preimpact anomalies that would have precluded normal engine operation. The damage to the propeller hub and blades indicated that the propeller was operating under high power in the normal range of operation at time of impact.

Review of recorded data recovered from airplane's attitude and heading reference unit did not reveal any faults with the airplane's attitude and heading reference system (AHRS) during the accident flight, and there were no maintenance logbook entries indicating any previous electronic attitude director indicator (EADI) or AHRS malfunctions. Therefore, it is unlikely that erroneous attitude information was displayed on the EADI that could have misled the pilot concerning the actual attitude of the airplane. A light bulb filament analysis of the airplane's central advisory display unit (CADU) revealed that the "autopilot disengage" caution indicator was likely illuminated at impact, and the "autopilot trim" warning indicator was likely not illuminated. A filament analysis of the autopilot mode controller revealed that the "autopilot," "yaw damper," and "altitude hold" indicators were likely not illuminated at impact. The status of the "trim" warning indicator on the autopilot mode controller could not be determined because the filaments of the indicator's bulbs were missing. However, since the CADU's "autopilot trim" warning indicator was likely not illuminated, the mode controller's "trim" warning indicator was also likely not illuminated at impact.

Exemplar airplane testing revealed that the "autopilot disengage" caution indicator would only illuminate if the autopilot had been engaged and then disconnected. It would not illuminate if the autopilot was off without being previously engaged nor would it illuminate if the pilot attempted and failed to engage the autopilot by pressing the "autopilot" pushbutton on the mode controller. Since the "autopilot disengage" caution indicator would remain illuminated for 30 seconds after the autopilot was disengaged and was likely illuminated at impact, it is likely that the autopilot had been engaged at some point during the flight and disengaged within 30 seconds of the impact; the pilot was reporting to ATC at 6,000 ft about 30 seconds before impact and then the rapid descent began.

The airplane was not equipped with a recording device that would have recorded the operational status of the autopilot, and the investigation could not determine the precise times at which autopilot engagement and disengagement occurred. However, these times can be estimated as follows:

- The pilot likely engaged the autopilot after the airplane climbed through 1,000 ft agl about 46 seconds after takeoff, because this was the recommended minimum autopilot engagement altitude that he was taught.
- According to the airplane performance study, the airplane's acceleration exceeded the autopilot's limit load factor of +1.6g about 9 seconds before impact. If it was engaged at this time, the autopilot would have automatically disengaged.
- The roll angle data from the performance study were consistent with engagement of the autopilot between two points: 1) about 31 seconds before impact, during climb, when the bank angle, which had stabilized for a few seconds, started to increase again and 2) about 9 seconds before impact, during descent, at which time the autopilot would have automatically disengaged. Since the autopilot would have reduced the bank angle as soon as it was engaged and there is no evidence of the bank angle reducing significantly between these two points, it is likely that the autopilot was engaged closer to the latter point than the former. Engagement of the autopilot shortly before the latter point would have left little time for the autopilot to reduce the bank angle before it would have disengaged automatically due to exceedance of the normal load factor limit.

Therefore, it is likely that the pilot engaged the autopilot a few seconds before it automatically disconnected about 9 seconds before impact.

The operator reported that the airplane had experienced repeated, unexpected, inflight autopilot disconnects, and, two days before the accident, the chief pilot recorded a video of the autopilot disconnecting during a flight. Exemplar airplane testing and maintenance information revealed that, during the flight in which the video was recorded, the autopilot's pitch trim adapter likely experienced a momentary loss of power for undetermined reasons, which resulted in the sequence of events observed in the video. It is possible that the autopilot disconnected during the accident flight due to the pitch trim adapter experiencing a loss of power, which would have to have occurred between 30 and 9 seconds before impact.

A postaccident weather analysis revealed that the airplane was operating in an environment requiring instruments to navigate, but it could not be determined if the airplane was in cloud when the loss of control occurred. The sustained surface wind was from the north at 21 knots with gusts up to 28 knots, and moderate turbulence existed. The presence of the moderate turbulence could have contributed to the controllability of the airplane and the pilot's inability to recognize the airplane's attitude and the autopilot's operational status.

Probable Cause and Findings

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

The pilot's loss of airplane control due to spatial disorientation during the initial climb after takeoff in night instrument meteorological conditions and moderate turbulence.

Findings

Aircraft	Heading/course - Not attained/maintained (Cause)
	Pitch control - Not attained/maintained (Cause)
	Lateral/bank control - Not attained/maintained (Cause)
Personnel issues	Aircraft control - Pilot (Cause)
	Spatial disorientation - Pilot (Cause)
Environmental issues	Turbulence - Not specified
	Dark - Not specified

Factual Information

History of Flight

Initial climb	Loss of control in flight (Defining event)
	Loss of visual reference

On April 28, 2017, about 2348 central daylight time, a Pilatus PC-12 airplane, N933DC, impacted terrain near Rick Husband Amarillo International Airport (AMA), Amarillo, Texas. The airline transport pilot and the two medical flight crewmembers were fatally injured. The airplane was destroyed. The airplane was registered to and operated by Rico Aviation LLC under the provisions of Title 14 *Code of Federal Regulations (CFR)* Part 135 as an air ambulance flight. Instrument meteorological conditions prevailed at the time of the accident, and the flight was operated on an instrument flight rules (IFR) flight plan. The flight was originating at the time of the accident and was en route to Clovis Municipal Airport (CVN), Clovis, New Mexico.

The AMA-based flight crew was first notified of an air ambulance mission by the Rico Aviation medical dispatcher at 2248. The mission was to transport a patient from Clovis, New Mexico, to Lubbock, Texas. The mission was delayed until receiving arrangements were made for the patient at the destination medical facility. During the delay, the pilot continued his flight preparation, including requesting and receiving his air traffic control (ATC) clearance.

A review of Federal Aviation Administration (FAA) ATC data revealed that, at 2332:15, the pilot contacted AMA ground control, said that he had received automatic terminal information service Oscar, and requested an IFR clearance to CVN. At 2332:40, the ground controller issued the pilot a clearance to CVN "as filed" with a climb to a final altitude of 8,000 ft mean sea level (msl); the assigned transponder code was 4261. The pilot correctly read back the clearance.

Final acceptance of the mission by the Rico Aviation medical dispatcher and the pilot came at 2334. The pilot contacted AMA ground control at 2341:54 and requested to taxi to the runway for departure. The ground controller instructed the pilot to taxi to runway 4. At 2343:50, the local controller cleared the flight for takeoff and instructed the pilot to turn right on course after departure. The pilot acknowledged the takeoff clearance and instructions.

After departing runway 4, the local controller observed a primary target with an associated transponder code of 4254, which was the code that had been assigned to the airplane on its previous flight. The local controller observed the 4254 target climb through 4,400 ft msl and instructed the pilot to reset the transponder to 4261. The pilot reset the transponder code to 4261. The local controller observed the beacon code change from 4254 to 4261, then advised the pilot "I've got you now," and instructed him to contact AMA departure control.

At 2346:54, the pilot contacted AMA departure control and reported "with you at 6,000 [ft msl]." The west radar departure controller radar-identified the airplane. At 2348:12, the

departure controller advised the pilot that he was no longer receiving the airplane's transponder; the pilot did not respond. The departure controller made three more transmissions to the pilot without response. There were no further recorded transmissions to or from the airplane. The local controller reported to the departure controller that he had observed a fireball and reported a potential crash.

Figure 1 shows the plotted AMA radar data illustrating the accident flight path. The red targets are from transponder code 4254, and the blue targets are from transponder code 4261. The last eight recorded targets are labeled with their mode C reported altitudes.

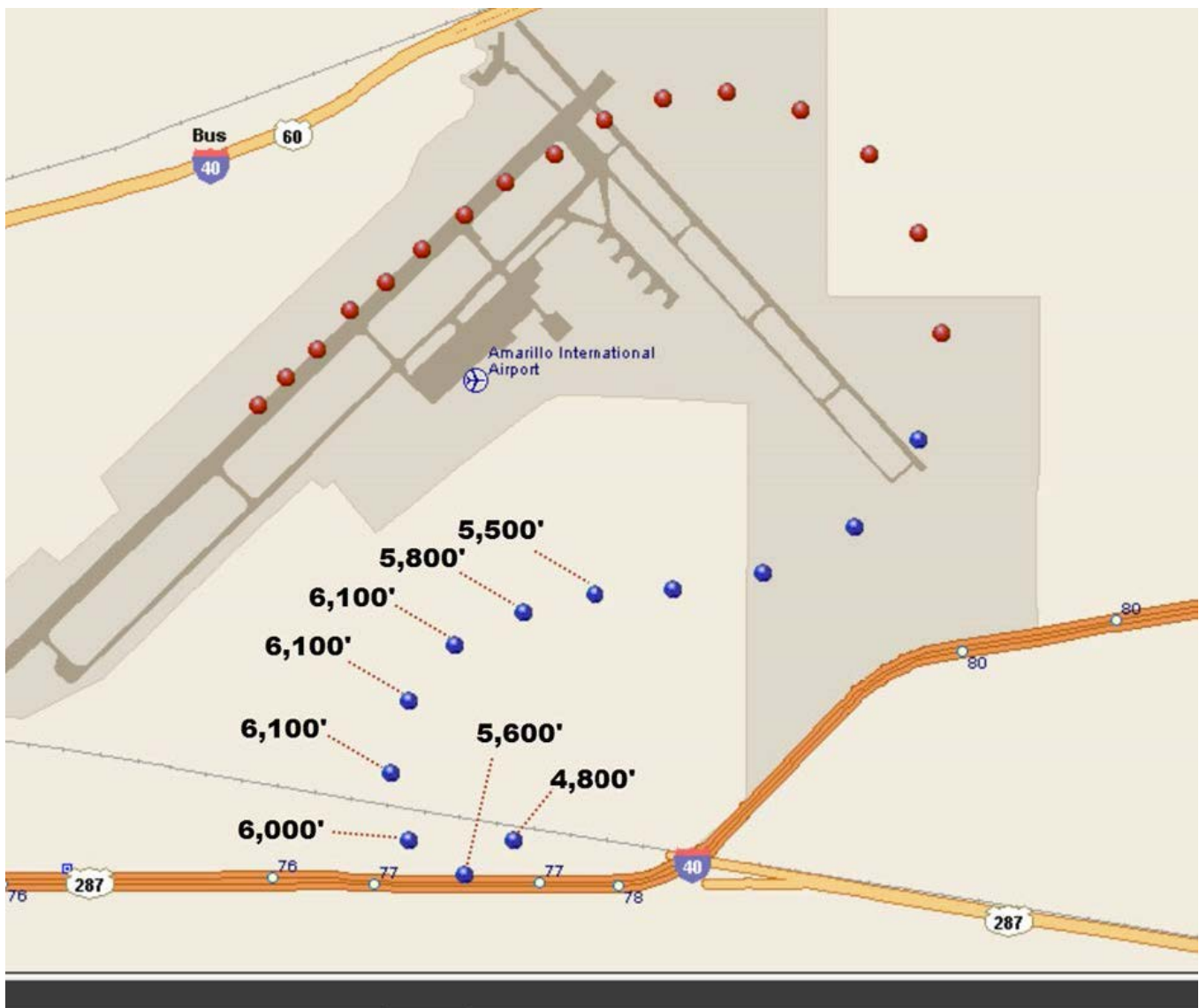


Figure 1 – Plotted radar data illustrating the accident flight path

Surveillance video from a nearby truck stop, located about 400 yards southwest of the accident

site, recorded lights from the airplane followed by an explosion. Still images were taken from the video and layered to produce figure 2, which depicts the airplane's final flight path. The images show the airplane descending about a 45° angle to ground impact.

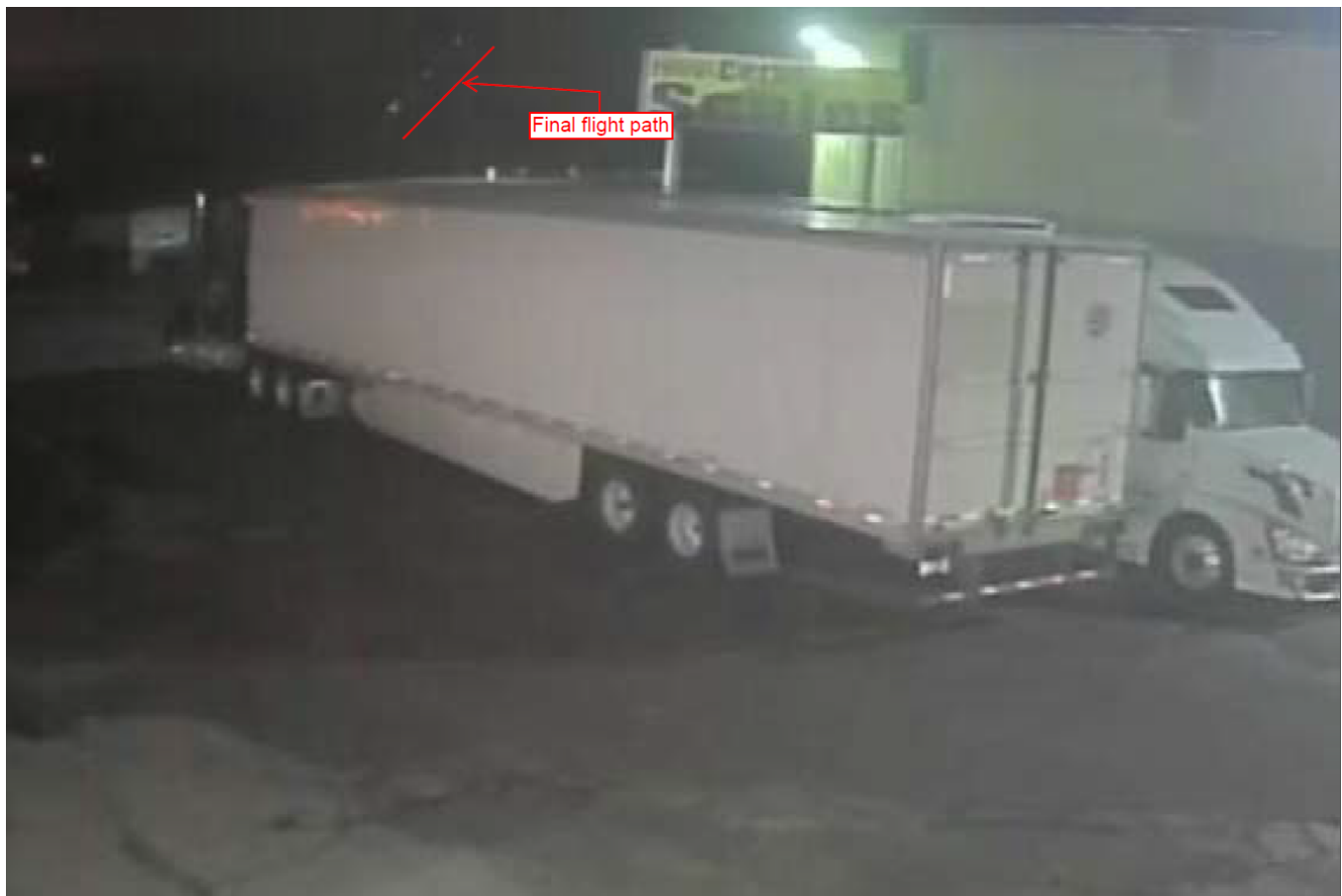


Figure 2 – Accident airplane's final flight path

Pilot Information

Certificate:	Airline Transport; Commercial	Age:	57, Male
Airplane Rating(s):	Multi-engine Land; Multi-engine Sea; Single-engine Land; Single-engine Sea	Seat Occupied:	Left
Other Aircraft Rating(s):	Gyroplane	Restraint Used:	Unknown
Instrument Rating(s):	Airplane	Second Pilot Present:	No
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Gyroplane; Instrument Airplane	Toxicology Performed:	Yes
Medical Certification:	Class 2 With Waivers/Limitations	Last FAA Medical Exam:	01/19/2017
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	12/21/2016
Flight Time:	5866 hours (Total, all aircraft), 73 hours (Total, this make and model), 5759 hours (Pilot in Command, all aircraft), 28 hours (Last 90 days, all aircraft), 15 hours (Last 30 days, all aircraft), 0.3 hours (Last 24 hours, all aircraft)		

The pilot-in-command (PIC), age 57, had been employed at Rico Aviation since November 2016. While employed at Rico Aviation, he had flown with the company's director of operations (DO), the chief pilot, and the contracted flight instructor who trained Rico Aviation pilots in the PC-12, none of whom reported any concerns or issues with the pilot's flying skills. They also stated that there were no difficulties during the pilot's PC-12 training. For Pilatus PC-12 airplane-specific ground and flight training, Rico Aviation contracted with ACFT Services, LLC. Rico Aviation training records did not show the dates of the PC-12 ground training that ACFT Services provided to the pilot. Rico Aviation records indicated that the pilot's initial flight training in the PC-12 occurred between October 26 and 28, 2016, and was conducted by the ACFT Services instructor. ACFT Services issued the pilot a certificate of completion of training dated October 28, 2016. The training records showed satisfactory completion of maximum rate climbs, stalls in multiple configurations, and unusual attitude recovery. Also, high speed descents were discussed during this training. Further flight training was provided by the Rico Aviation DO on December 14, 2016, and by the Rico Aviation chief pilot on November 15, 2016, and December 15, 2016.

Autopilot Use, Procedures, and Training

According to the ACFT Services instructor who provided the PC-12 flight training to the pilot, pilots were taught to follow the manufacturer's limitation as to when to engage the autopilot after takeoff. The PC-12 airplane flight manual stated that the autopilot must not be engaged when the airplane is below 1,000 ft above ground level (agl). The standard procedure at Rico Aviation, confirmed by the Rico Aviation chief pilot, was to engage the autopilot at 1,000 ft agl after takeoff or when comfortably established in the climb.

The chief pilot had flown with the accident pilot on several occasions and had provided flight instruction to him in preparation for his Part 135 proficiency check, which was completed on December 21, 2016. He stated that the pilot used the autopilot normally and showed good

knowledge of the autopilot but could fly fine without it.

The Rico Aviation training records indicated that the DO had flown with the pilot 7 days before the pilot's proficiency check. The DO stated that he had also flown with the pilot after the pilot's proficiency check as well as about a month before the accident on a repositioning flight. During these flights, he noticed no areas in which the pilot needed extra training. He thought the pilot would rather hand-fly the airplane than use the autopilot.

The DO, the chief pilot, and a medical crewmember all reported that they had not heard any negative comments from other Rico Aviation employees about the pilot's performance. The medical crewmember and the chief pilot each reported no known personal or medical issues that could have affected the pilot's performance.

The pilot's logbooks were not recovered during the investigation, and the pilot's recent flight experience was obtained from the Rico Aviation PC-12 airplane flight logs, which were kept at the company's Amarillo base.

The pilot had flown 28 hours in the preceding 90 days and 115 hours in the last year, 73 hours of which were in the PC-12. A review of the pilot's duty records from the operator indicated he had 4.2 hours of IFR flight time in the preceding 90 days, with 1.4 hours of this time at night. The pilot had accumulated a total of 2.6 hours of night IFR time, and 5.9 hours total IFR time since his last instrument proficiency check on December 21, 2016.

Pilot's Preaccident History

The pilot worked the night shift, from 1900 to 0800, on April 25th through April 28th and had logged 2 hours during those 3 shifts; he rotated between the Amarillo base and the Dalhart base during those dates. While on duty in Amarillo, he stayed at the Rico Aviation hangar at AMA. While on duty in Dalhart, he stayed at a crew house. When off-duty in Amarillo, he stayed at a local motel. The chief pilot stated that the pilot had checked out of the motel the morning of April 28, and he had no knowledge of the pilot's activities during the day.

In correspondence with the pilot's wife, who resided in another state, she reported that the pilot did not have any problems adapting to the overnight duty schedule. She stated that he would sleep during the day and stay awake when on duty overnight. When preparing to start an overnight duty schedule, he would acclimate to that sleep/work schedule 1 or 2 days before. She was not aware of any sleep or health issues relating to his schedule. In the 3 days before the accident, she reported nothing unusual or out-of-the ordinary in any of her routine daily contacts with the pilot.

Aircraft and Owner/Operator Information

Aircraft Make:	PILATUS AIRCRAFT LTD	Registration:	N933DC
Model/Series:	PC 12	Aircraft Category:	Airplane
Year of Manufacture:	1994	Amateur Built:	No
Airworthiness Certificate:	Normal	Serial Number:	105
Landing Gear Type:	Retractable - Tricycle	Seats:	4
Date/Type of Last Inspection:	03/02/2017, Annual	Certified Max Gross Wt.:	
Time Since Last Inspection:		Engines:	1 Turbo Prop
Airframe Total Time:	4407.5 Hours as of last inspection	Engine Manufacturer:	P&W CANADA
ELT:	Installed, not activated	Engine Model/Series:	PT6A-67B
Registered Owner:	RICO AVIATION LLC	Rated Power:	500 hp
Operator:	RICO AVIATION LLC	Operating Certificate(s) Held:	On-demand Air Taxi (135)

Airplane Background Information

The airplane was a nine-passenger, single-engine, turboprop airplane. It was configured as an air-ambulance with pilot and copilot seats, four seats in the cabin, and a patient bed. According to the last available flight logs, the airplane had accumulated 4,466.9 total hours and 3,769 total cycles.

Airplane Maintenance Information

According to the company's FAA-issued operations specifications, Rico Aviation was to maintain aircraft that were type-certificated with nine or fewer passenger seats in accordance with the manufacturer's maintenance documents and 14 *CFR* Parts 43, 91, and 135. All maintenance, preventive maintenance, and alterations to the aircraft, engines, propeller, and appliances were to be performed in accordance with current FAA regulations; manufacturer's service manuals, recommendations, and specifications; manufacturer's service bulletins and service letters; and airworthiness directives.

Chapters 4 and 5 in the Pilatus PC-12/45 Aircraft Maintenance Manual (AMM) contained the maintenance intervals for each airworthiness limitation item, 100-hour inspection, annual inspection, supplemental structural inspections, and progressive inspection requirements.

On March 2, 2017, a set of routine maintenance inspections and tasks was accomplished at an airplane total time of 4,407.5 hours and 3,658 total cycles. In addition to the routine maintenance inspections and tasks, 21 discrepancies (non-routine items) were corrected during this maintenance visit, including the following item:

- Autopilot disconnecting on approaches – Removed Autopilot Computer P/N 065-0064-15, S/N 2175. Installed "Modified" Autopilot Computer P/N 065-0064-15, S/N X1898

There was one additional log entry for an autopilot discrepancy reported by a Rico Aviation pilot on April 26, 2017:

- Autopilot disconnects on climb and cruise. Maintenance troubleshot the system and suspect Autopilot Trim Adapter to be causing issue. Removed Autopilot Trim Adapter P/N: 065-00164-0100, S/N: 1745. Installed Tested Autopilot Trim Adapter (KTA336-100) P/N 065-00164-0100, S/N: 1794. System ops check good. All work performed in accordance with the Pilatus PC-12 Maintenance Manual Ch. 22-10-07.

The maintenance records did not reveal any write ups or logbook items indicating any issues with the electronic attitude director indicator (EADI) or attitude and heading reference system (AHRS).

For a full list of the maintenance completed see the Maintenance Factual Report in the public docket associated with this report.

Autopilot System Description

The PC-12's primary flight control system for pitch, roll, and yaw is controlled by push-pull rods and/or cables. The secondary flight control system for roll and yaw consists of electrically-actuated trim tabs installed on the primary flight control surfaces; for pitch, the horizontal stabilizer is trimmed electrically. Trim positions for pitch, roll, and yaw are visually depicted on a triple trim indicator on the center console. The horizontal stabilizer, rudder, and aileron trim systems share a trim interrupt switch, which, if pressed due to a trim runaway of any of the respective systems, disconnects power from the pitch trim adapter and the aileron, rudder, and horizontal stabilizer trim actuators. The rocker-type switch is installed on the center pedestal and protected by a safety cover. The two-position switch is labeled "INTR" for the interrupt position and "NORM" for the normal position.

The airplane was equipped with a Honeywell (formerly Bendix/King) KFC-325 digital automatic flight control system (AFCS), which provided 3-axis (pitch, roll, and yaw) control. This system provided flight director guidance, autopilot functionality, and autopilot system monitoring. According to Honeywell, the system consists, in part, of a single KCP 220 autopilot computer, a mode controller, an altitude preselector, a pitch trim adapter, pitch, roll, and yaw servo-actuators, a control wheel steering (CWS) switch, a go-around switch, an autopilot

disconnect switch, an EADI, and an electronic horizontal situation indicator. The autopilot computer processes flight environment and navigation data from a variety of sensors to compute pitch and roll steering commands. The pilot provides input to the AFCS through the KMC 321 mode controller, located on the forward instrument panel.

The AFCS requires the successful completion of a pilot-activated preflight test (PFT) as a prerequisite for autopilot mode engagement. A momentary depression of the self-test button on the mode controller will start a 5-second check of the functionality of the autopilot system, the auto trim system, including the KTA 336 trim adapter, and their system monitors.

Indications to the pilot of successful PFT completion is four flashes of the "TRIM" caption on the mode controller as the system is driven twice in each direction with the drive request being interrupted. This operation simulates a trim runaway and checks the ability of both monitors to detect it. After the test sequence, the aural warning tones are annunciated, and the autopilot annunciator on the mode controller flashes twelve times. If the PFT circuit detects a failure, the red "TRIM" caption on the mode controller stays on, and the red "A/P TRIM" warning on the Central Advisory and Warning System (CAWS) display unit illuminates.

After the successful completion of the PFT, the autopilot can be engaged by the pilot during flight by depressing the "AP" pushbutton on the mode controller. The autopilot will disengage when any of the following occur:

- On the mode controller, the "AP" pushbutton is pushed to turn off the autopilot.
- On the control wheels, the "A/P DISC" pushbutton is pushed.
- The trim trigger on either control wheel is depressed (manual trim engaged).
- The trim interrupt switch is pushed.
- The alternate stabilizer trim switch is set to "UP" or "DOWN."
- A loss of power to the autopilot computer or the trim adapter occurs.
- The monitors within the autopilot computer detect a failure.
- The following autopilot monitor limit(s) are exceeded:
 - Roll rates more than 10° per second (Except when the CWS switch is held depressed.)
 - Pitch rates more than 5° per second (Except when the CWS switch is held depressed.)
 - Accelerations outside of a +1.6g to +0.3g envelope (Disengagement will take place regardless of whether the CWS switch is activated.)

When the autopilot is disengaged, manually by the pilot or automatically when a problem is detected, the following captions and warnings are displayed:

- On the mode controller, the "AP" caption flashes four times then turns off.
- On the CAWS display unit, the amber "A/P DISENG" caution message will illuminate 3 seconds after the signal input to the CAWS changes from 28V (autopilot engaged) to 0V (autopilot disengaged) and the CWS button is not pressed. The caption will remain illuminated for about 26 to 27 seconds; it extinguishes at a maximum of 30 seconds from the initial time of the autopilot disconnect.
- On the EADI, the red "AP" caption flashes five times then turns off.
- The autopilot disconnect warning tone is annunciated in the loudspeakers and the headsets.
- The CAWS gong warning tone is annunciated.

The autopilot system incorporates an automatic electric pitch trim system that provides pitch autotrim during autopilot operation via the stabilizer pitch trim actuator and automatic rudder trim relief during yaw damper and autopilot operation. No aileron autotrim function is available on the installed autopilot system. Annunciation of pitch and rudder autotrim occurs on the triple trim indicator by illumination of each respective pitch or rudder trim light and annunciation to the CAWS to make the autopilot trim advisory caption illuminate.

According to Honeywell, the maximum bank angle that the autopilot can command is 25°. Additionally, if the airplane is in a steady-state condition above 25° of bank, or above the pitch limit, the autopilot will engage. However, upon engagement, the autopilot will bring the airplane back to wings level maintaining the existing pitch attitude. If the airplane is in a condition that exceeds the following autopilot monitor limit(s), the autopilot will not engage:

- Roll rates more than 10° per second (except when the CWS switch is held depressed)
- Pitch rates more than 5° per second (except when the CWS switch is held depressed)
- Accelerations outside of a +1.6g to +0.3g envelope

If a pilot were to override the autopilot while it was engaged and the CWS switch was not depressed, the autopilot would attempt to return the aircraft to the state before the override condition. However, if the autopilot monitors are tripped while attempting to return to the previous state, the autopilot will disengage.

The AHRS senses the magnetic heading of the aircraft and its pitch, roll, and yaw attitudes. The AHRS processes the data and sends it to other aircraft systems to use for display and control. An attitude and heading reference unit (AHRU) is one of the components of the AHRS. The AHRU has built-in test equipment that continuously monitors the AHRS. The memory of the AHRU keeps a history of the failures that occur. If a power failure occurs the memory of the AHRU keeps the last available satisfactory data.

The autopilot wiring terminal blocks found in the wreckage were a non-sealed type.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument Conditions	Condition of Light:	Night
Observation Facility, Elevation:	KAMA, 3604 ft msl	Distance from Accident Site:	2 Nautical Miles
Observation Time:	2353 UTC	Direction from Accident Site:	1°
Lowest Cloud Condition:		Visibility	10 Miles
Lowest Ceiling:	Broken / 700 ft agl	Visibility (RVR):	
Wind Speed/Gusts:	21 knots / 28 knots	Turbulence Type Forecast/Actual:	/
Wind Direction:	360°	Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	29.78 inches Hg	Temperature/Dew Point:	7° C / 7° C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Amarillo, TX (AMA)	Type of Flight Plan Filed:	IFR
Destination:	CLOVIS, NM (CVN)	Type of Clearance:	IFR
Departure Time:	2345 CDT	Type of Airspace:	Class C

Preflight Weather Briefing – ForeFlight

At 2303, the pilot retrieved a ForeFlight weather briefing for the accident flight and he filed an IFR flight plan. The ForeFlight briefing would have displayed in the ForeFlight app and been emailed to the pilot immediately after the flight plan was filed. The pilot also viewed multiple weather images before the flight, but the specific items viewed by the pilot are not logged by ForeFlight.

Archived Weather Data

At 2353, AMA reported wind from 360° at 21 knots with gusts to 28 knots, visibility of 10 statute miles or greater, ceiling broken at 700 ft agl, overcast cloud base at 1,200 ft agl, temperature of 7°C, dew point temperature of 7°C, and an altimeter setting of 29.78 inches of mercury. The remarks section of the 2353 observation included: station with a precipitation discriminator, peak wind of 32 knots from 360° occurred at 2326, lightning more than 10 miles away to the west, rain began at 2314 and ended at 2325, and ceiling variable between 500 ft agl and 900 ft agl.

Data from the AMA weather radar indicated light values of reflectivity around the accident location. A radial velocity image from around the time of the accident identified veering wind (wind that turns clockwise with increasing height) in the lowest 10,000 ft msl around the accident location. A wind profile for AMA around the accident time indicated that, near the accident location, the wind at 4,000 and 5,000 ft msl was from the north-northeast at 35 knots; the wind at 6,000 ft msl was from the northeast at 30 knots; the wind at 7,000 ft msl was from the east at 30 knots; the wind at 8,000 ft msl was from the southeast at 35 knots; and the wind at 9,000 ft msl was from the south-southeast at 45 knots.

The graphical turbulence guidance (GTG) depicted the probability of clear air turbulence at altitudes of 3,000, 5,000, 7,000, and 9,000 ft msl, applicable to times surrounding the accident. These images depicted mainly light-to-moderate turbulence over AMA. The GTG is not intended to predict turbulence associated with convection and thunderstorm clouds but may provide some guidance in areas of properly predicted thunderstorms when the convection is widespread.

A high-resolution rapid refresh model sounding for the accident location at 0000 on April 29, 2017, revealed that the near-surface wind was from the north-northeast about 20 knots. About 5,500 ft msl, the wind was from the northeast about 30 knots. Above this level, the wind veered with height and increased in magnitude to a south wind at 45 knots about 11,000 ft msl. A temperature inversion was noted between 6,200 ft and 7,800 ft msl, and the freezing level was near 13,000 ft msl. Calculations made by the rawinsonde observation program identified a layer of significant turbulence between about 5,500 and 12,600 ft msl. Relative humidity was greater than 90% between near the surface and about 10,000 ft msl and in a layer between about 16,000 and 18,000 ft msl.

The warning coordination meteorologist for the National Weather Service (NWS) Weather Forecast Office (WFO) in Amarillo, Texas, provided a 3D image (figure 3, which shows AMA at the center of the 3D box) that showed a wind shear zone between 2,500 and 3,500 ft msl as seen from the AMA weather radar about 2355. The red area indicates wind away from the radar, and the green area indicates wind toward the radar. The image shows a northerly wind near the surface and a 40 to 60 knot southerly wind above 4,000 ft msl.

There were no publicly disseminated pilot reports for AMA for altitudes below 10,000 ft msl between 2100 on April 28, 2017, and 0300 on April 29, 2017.

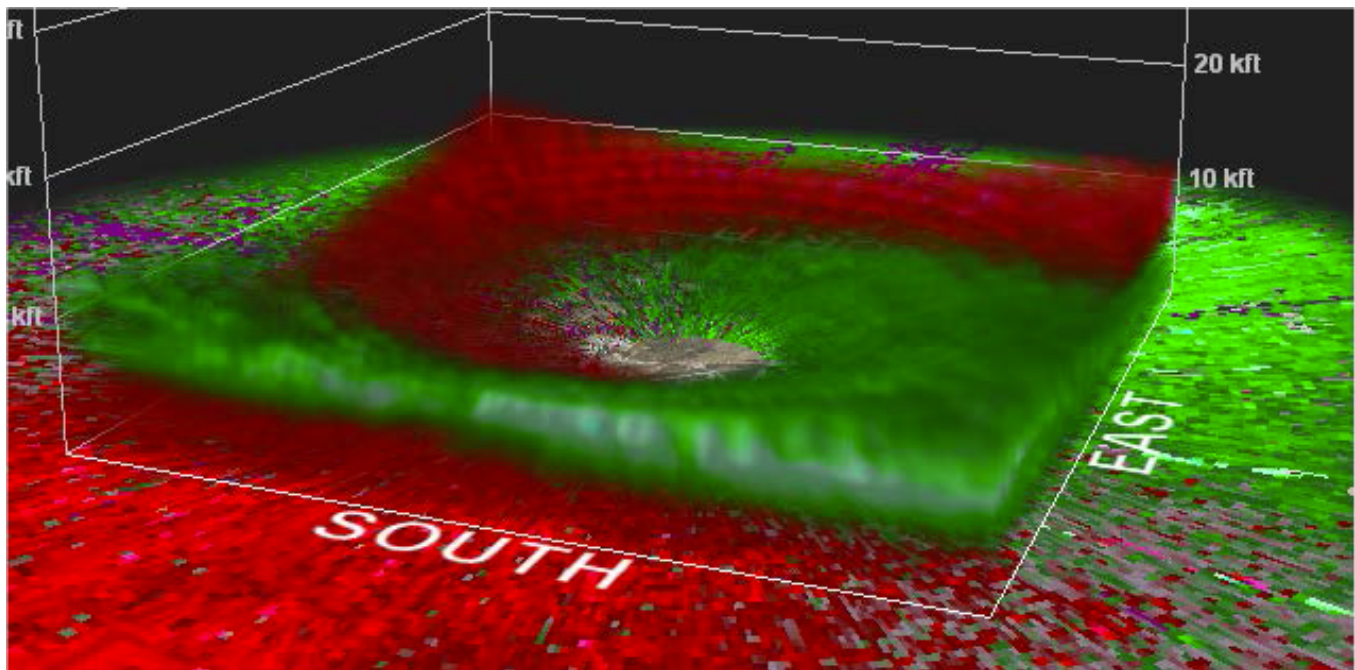


Figure 3 – Wind profile, 3D view

At 2036, a terminal aerodrome forecast was issued for AMA by the NWS WFO in Amarillo that forecasted for the accident time: wind from 020° at 17 knots with gusts to 25 knots, visibility greater than 6 miles, light rain showers, scattered clouds at 3,000 ft agl, and ceiling overcast at 5,000 ft agl.

At 2145, an AIRMET SIERRA was issued for IFR conditions and precipitation/mist below 10,000 ft msl for an area that included the accident location. At the accident time, there were no AIRMETs active for turbulence or low level wind shear potential below 10,000 ft msl that included the accident location. At 2145, an AIRMET TANGO was issued for moderate turbulence between 10,000 ft msl and FL180 for an area that included the accident location.

There were no convective or non-convective SIGMET advisories active at the accident time that included the accident location. A convective SIGMET was issued at 2255 for an area that was very close to the accident location.

According to the National Oceanic and Atmospheric Administration's Aviation Weather Center (AWC), "any Convective SIGMET implies severe or greater turbulence, severe icing, and low level wind shear." Further, according to discussion with AWC staff, convective SIGMETs are not geographically static for their valid period, rather they should move with any movement vector included in that convective SIGMET. NWS Instruction 10-811 and FAA Advisory Circular (AC) 00-45H both address the "movement" field (e.g., "MOV FROM 24045KT") in the text of a convective SIGMET. AC 00-45H provides the following translation for the portion of the convective SIGMET containing the movement field: "an intensifying area of severe thunderstorms moving from 240° at 45 knots (to the northeast)." According to the Domestic Operations Branch Chief at the AWC, "on occasion when the thunderstorm cells contained in the [convective SIGMET] are moving in vastly different direction than the [convective

SIGMET], we add a comment at the bottom of the [convective SIGMET] something like 'CELL MOV FROM 22040KT.' Of course, we don't include all comment options in the NWS Directives, so most people don't know this."

Other Flight Crew Reports

Flight crewmembers of several different airplanes that arrived and departed AMA within about 1 hour of the accident time were contacted regarding turbulence and/or weather conditions encountered on the approach to/departure from AMA.

The first officer of an Embraer 170 airplane that landed at AMA about 40 minutes before the accident time reported no significant weather conditions.

The flight crew of an Embraer 145 airplane that landed at AMA about 25 minutes before the accident time reported that they encountered light chop to light turbulence. The crew did not remember giving or being asked for any PIREPs.

The flight crew of a Boeing 737 airplane that departed AMA about 1 hour after the accident time reported that they were concerned about the weather in the area. There was some drizzle as they taxied out. They were concerned about ice and storms in the area. They experienced moderate to heavy turbulence during the climb-out, and there were isolated storm cells to the east. They did not experience ice buildup on the airplane, but they deviated for weather as they departed to the east. The captain said, "it wasn't the worst turbulence he had been in, but it was close." The first officer said that the moderate- to-heavy turbulence from the time they departed until climbing through 10,000 ft msl was some of the worst turbulence he had experienced. The onboard weather radar was solid green, and they deviated around some yellow cells.

The Boeing 737 flight crew further reported that they did not know to expect significant turbulence during the departure. Since the AMA control tower was closed when they departed, they were communicating solely with the air route traffic control center controller, and they did not receive any weather information. Their flight was after midnight so there was very little air traffic in the area, and no one was communicating about the turbulence over AMA. They did not give a pilot report about the turbulence encountered near AMA. They stated that the severity of turbulence they encountered is the type they would want to be aware of in advance.

Flight data recorder (FDR) data from the Boeing 737 was provided by the operator. Plots of wind information recorded on the FDR as well as the wind profile derived from additional FDR data are included in the Meteorology Factual Report in the public docket associated with this report.

WRECKAGE AND IMPACT INFORMATION

The airplane impacted a pasture (figure 4) adjacent to several stationary train cars about 1.5 nautical miles south of AMA, and a postimpact fire ensued. The wreckage debris path was generally oriented along a northeast-southwest line, and the airplane impacted the ground facing southwest. All major structural components of the airplane were located within the debris field.



Figure 4 – Accident site viewed from the south

Ground scars at the accident site and damage to the airplane were consistent with the airplane impacting in a steep, nose-low and wings-level attitude. The top soil was dark and relatively soft extending 3 to 4 ft deep, and the subsoil was a relatively hard clay. The impact crater was about 5 ft deep. A section of the left winglet, the left pitot tube, and the angle of attack sensor from the left wing were found embedded in the ground; the winglet is noticeable on the far right side of figure 4. The vertical stabilizer remained attached to the fuselage and sustained relatively minor damage compared to the rest of the airplane structure. The horizontal stabilizer separated near mid-span, and both sides were identified. The left side was severely crushed from the leading edge aft; a corresponding impact mark was observed in the ground near the center and in front of the impact crater.

Airframe Examination

The wreckage was documented at the accident site and then relocated to a secure hangar at AMA for a full layout and detailed examination. The airplane was heavily fragmented (figure 5).



Figure 5 – Wreckage organized in hangar

A postaccident examination of the flight control system did not reveal evidence of any preimpact anomalies that would have prevented normal operation. The flap actuator jackscrews indicated that the flaps were fully retracted at the time of impact. The landing gear were retracted at the time of impact.

Engine Examination

The engine was found separated from the airplane and adjacent to the initial impact crater. The engine exhibited significant impact and compression deformation and was partially covered in soot from the postimpact fire. The propeller had separated from the engine, and a fractured section of the propeller hub flange remained attached to the propeller shaft. The engine was recovered to a secure hangar for examination and disassembly.

The engine exhibited rotational signatures indicative of engine operation during impact. The examination did not reveal any pre-impact anomalies that would have precluded normal engine operation.

Propeller Examination

All four propeller blades separated from the hub assembly and were found at the accident site; two blades were in the impact crater; one blade shank was just forward of the impact crater with its corresponding tip section about 100 yards forward and to the right of the debris path; and the fourth blade was about 50 yards to the right of the debris path. About 90% of the hub fragments were recovered.

The propeller blades (figure 6) exhibited damage consistent with engine operation during impact.



Figure 6 – Propeller

There were no preimpact anomalies found that would have prevented or degraded normal propeller operation.

Autopilot Component Examinations

The autopilot components found in the wreckage were examined. Of the components recovered, the CAWS display unit, KMC 321 mode controller, KCP 220 autopilot computer, autopilot pitch/roll/yaw servos, autopilot pitch trim adapter, KMH 820 multi-hazard computer, altitude preselector, and AHRU were subjected to additional examinations and testing for evidence and data extraction.

A download of the AHRU data revealed that the elapsed time of the unit was 2,936.5 hours, and the last recorded fault, a "Roll Synchro Fail" fault, was recorded at elapsed time 2,923.4 hours.

The CAWS display unit and the KMC 321 mode controller could not be functionally tested due to impact-related damage; however, a light bulb filament examination was conducted on both

units at the NTSB Materials Laboratory. The CAWS "A/P DISENG" amber annunciator contained two light bulbs, and the filaments from both bulbs were intact and stretched, consistent with illumination at the time of impact. Also, the CAWS "A/P TRIM" red annunciator contained two light bulbs, and the filaments from both bulbs were broken but not stretched. The KMC 321 mode controller autopilot (AP), yaw damper (YD) and altitude hold (ALT) light bulb filaments were broken but not stretched. The two lightbulbs for the red "TRIM" warning annunciator were found broken with their respective filaments missing. Broken but unstretched filaments are indicative of the light not being illuminated at impact.

For additional details on the examination of the autopilot components, see the System Factual Report in the public docket associated with this report.

MEDICAL AND PATHOLOGICAL INFORMATION

A review of FAA medical records indicated that the pilot reported no significant medical concerns to the FAA, and as of the most recent medical examination the medical examiner identified no significant conditions on physical examination.

South Plains Forensic Pathology, P.A., Lubbock, Texas, completed an autopsy on the pilot. The autopsy report concluded that the cause of death was multiple blunt impact injuries.

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed toxicological tests on specimens that were collected during the pilot's autopsy. Results were negative for all tests conducted.

TESTS AND RESEARCH

Aircraft Performance Study

An aircraft performance study for this accident used AMA airport surveillance radar data, measurements made at the accident site, historical AMA weather observations, wind data derived from the FDR of the Boeing 737 that departed about 1 hour after the accident, and ATC communications to estimate the position and orientation of the airplane during the accident flight. The entire study with all figures is available in the public docket associated with this report.

The simulation indicated that, after lifting off from AMA runway 4, the airplane accelerated to about 193 knots calibrated airspeed (KCAS) while climbing between 600 and 1,200 ft per minute (fpm) to an altitude of about 4,400 ft msl, or about 800 ft agl (figure 7). The airplane leveled about 4,300 to 4,400 ft msl for about 30 seconds; at 23:46:30, it resumed climbing, reaching 6,000 ft msl (2,400 ft agl) at 23:46:52. During this climb, the airplane decelerated

from 193 KCAS to 122 KCAS. At 23:47:02, the airplane started an increasingly rapid descent from 6,000 ft msl to the ground (elevation 3,600 ft msl). Based on the simulation, the estimated rate of descent and airspeed at impact were about 17,000 fpm and 220 KCAS, respectively. The estimated time of impact was 23:47:19.

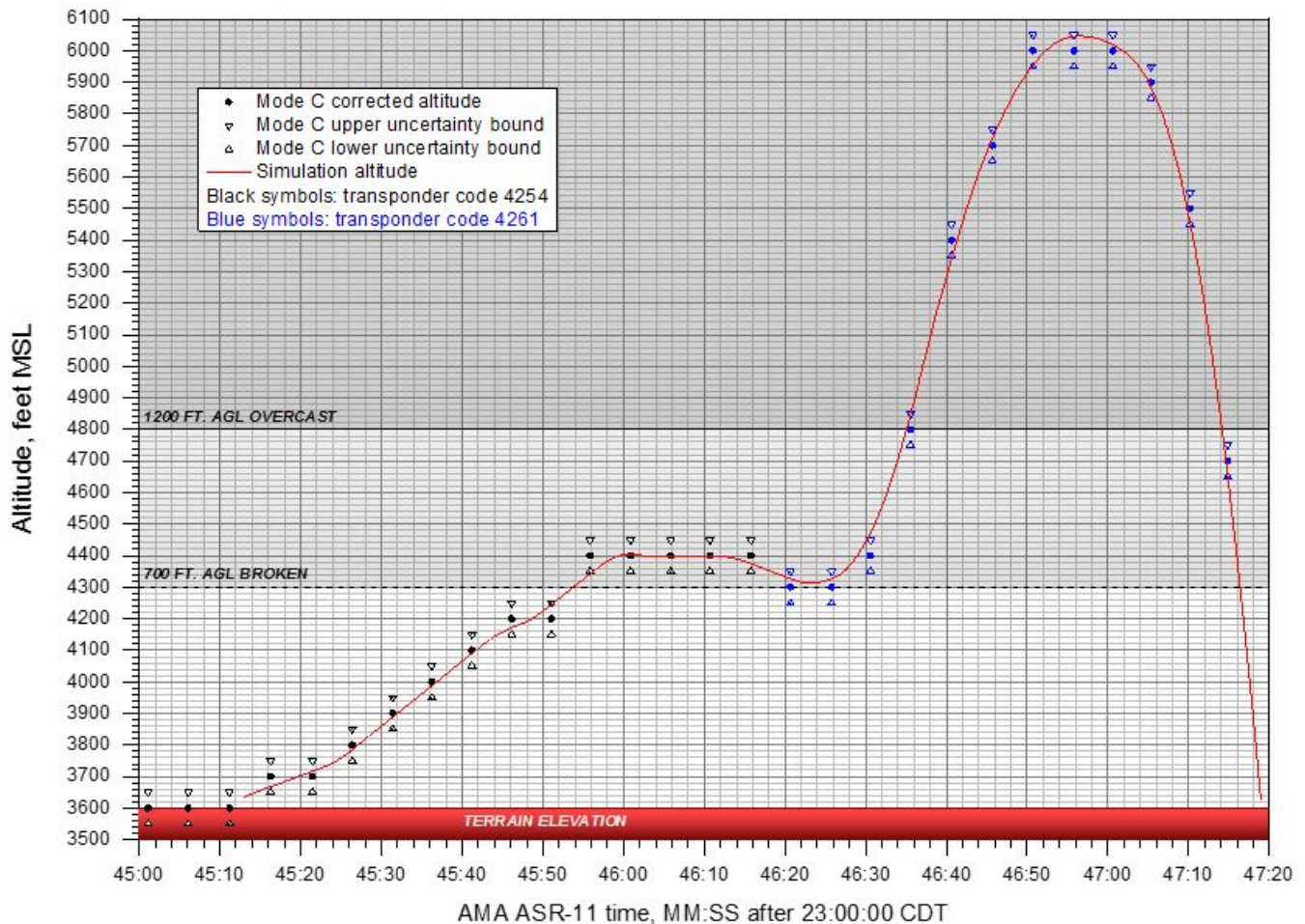


Figure 7 – Simulation of accident flight, altitude vs time graph

At 23:45:42, while climbing through 4,100 ft msl (500 ft agl), the airplane started a slow right roll (figure 8), reaching a roll angle of about 42° at 23:46:10. At 23:46:24, the roll angle had decreased to 36° , and the pitch angle started to increase steadily, which was consistent with the climb to 6,000 ft msl. At 23:46:32, when the roll angle was 30° , the airplane started rolling more quickly to the left, rolling through wings level at 23:46:40, then on a ground track of 267° true.



Figure 8 – Google Earth view of radar data and simulation trajectory

The simulation required full throttle from 23:45:24 through 6,000 ft msl, except for two brief power reductions, one between 23:45:48 and 23:45:56 when there was a pause in the increase in airspeed and another between 23:46:28 and 23:46:30 when the airplane leveled briefly at 4,400 ft msl.

The simulation control inputs were well within the airplane's control travel limits, and the computed column and wheel control forces required were generally (until the last 7 seconds of the flight) within the one-hand, short-term force limit prescribed in 14 *CFR* 23.143.

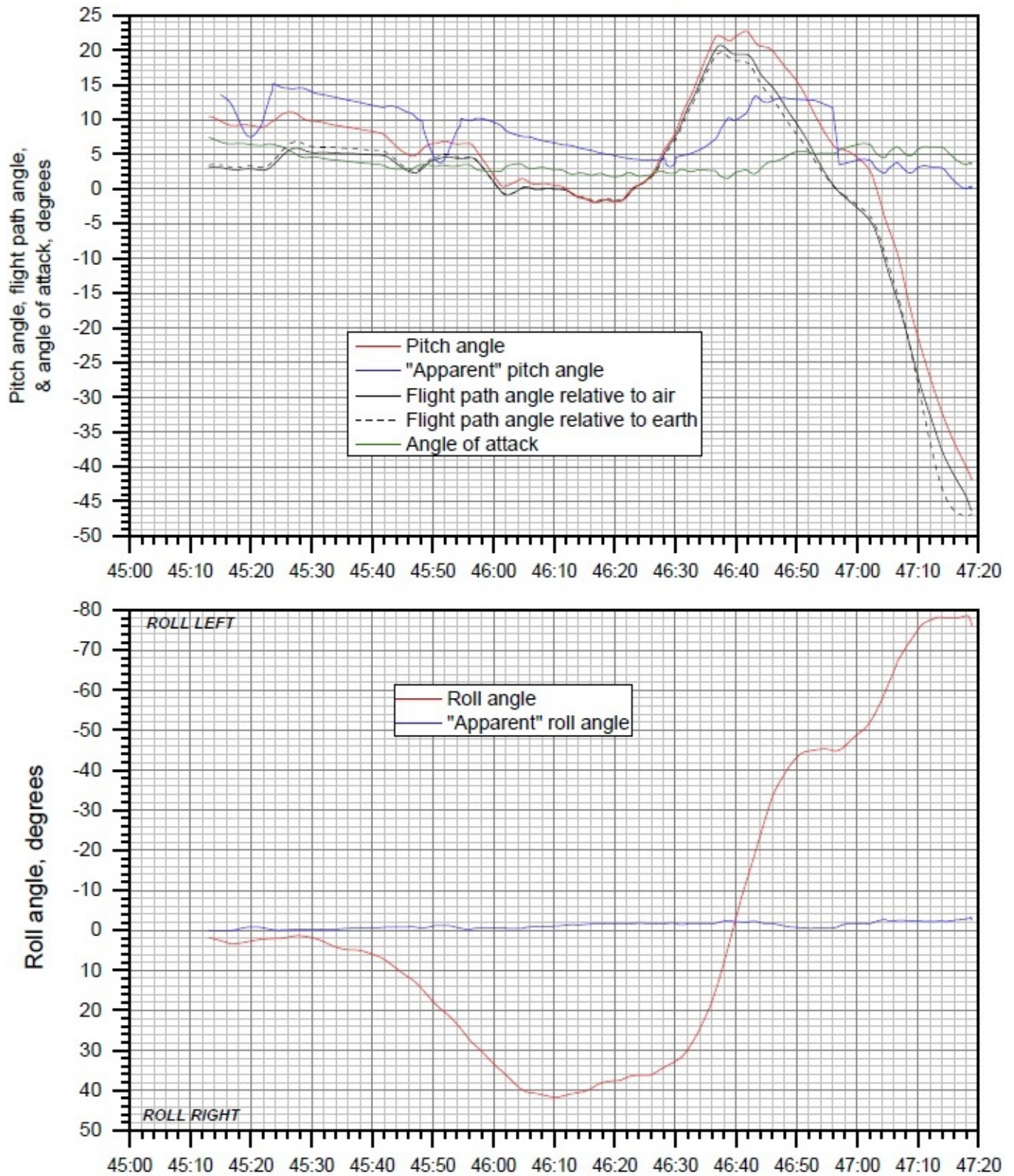
The simulation maximum normal load factor reached at impact was about 2.6g.

Throughout the simulation, the airplane was not at risk of an aerodynamic stall.

The airplane achieved a peak pitch angle of about 23° at 23:46:42 (figure 9), after which the pitch angle decreased steadily to an estimated -42° at impact. As the pitch angle decreased, the

roll angle increased steadily to the left, reaching an estimated -76° at impact.

An estimate of the "apparent" pitch and roll angles, which represent the attitude a pilot would "feel" the airplane to be in based on his vestibular/kinesthetic perception of the components of the load factor vector in his own body coordinate system, was made based on the simulation load factors. The "apparent" pitch angle ranged between 0° and 15° , and the "apparent" roll angle ranged between 0° and -4° (figure 9).



AMA ASR-11 time, MM:SS after 23:00:00 CDT
Figure 9 – Simulation apparent pitch and roll angles

Autopilot Testing and Results

The Rico Aviation chief pilot indicated that "there was a continuing issue with the airplane's autopilot." The autopilot "would often disconnect unexpectedly, triggering a master warning tone. It would require the pilot to reset the system by pushing the autopilot test button, then re-engaging the autopilot." On April 26, 2017, the chief pilot captured the airplane's autopilot issue on video during a flight, and the video was reviewed during the investigation.

The video began with a view of the instrument panel showing the amber "A/P DISENG" caution message illuminated on the CAWS display unit indicating that the autopilot had recently disengaged. The video continued with the pilot re-engaging the autopilot in navigation and altitude hold mode by depressing the AP, navigation, and altitude hold pushbuttons on the mode controller; the amber "A/P DISENG" message extinguished when the AP button was pressed. About 5 seconds after autopilot re-engagement, a red "TRIM" warning illuminated on the autopilot mode controller along with a master warning and a red "A/P TRIM" warning on the CAWS display unit; the autopilot remained engaged. The pilot then momentarily depressed the self-test button on the mode controller, which started the 5-second PFT. After the PFT was completed, the red trim warnings extinguished, and the amber "A/P DISENG" caution message on the CAWS display unit illuminated after 3 seconds. This was the end of the video. According to Pilatus, the action of re-engaging the autopilot after it has automatically disconnected is contrary to instructions in the AFM. The AFM in several instances prohibits continued autopilot operation following abnormal operation or malfunctioning.

Testing on an exemplar Pilatus PC-12/45 airplane found that the issue with the autopilot, as described by the chief pilot and as observed in the video, could occur only when the following three sequential events occurred:

The autopilot disconnected automatically when electrical power was removed from the pitch trim adapter for less than 10 seconds, which resulted in the amber "A/P DISENG" caution message illuminating after 3 seconds and no trim warning messages being displayed.

The autopilot was re-engaged contrary to AFM procedures.

The autopilot commanded a pitch trim input.

The testing revealed that when these three events occurred, a red "TRIM" warning was displayed on the mode controller along with a continuous autopilot trim fail warning tone, the red master warning, and a red "A/P TRIM" warning on the CAWS display unit, and the autopilot remained engaged. The results of this test were consistent with the events that occurred in the video.

The testing also revealed that, if electrical power was removed from the pitch trim adapter for more than 30 seconds, the autopilot would immediately disconnect with the proper

annunciations, but 13.5 seconds after the removal of power, the following three indications would illuminate at the same time:

The red master warning

The red "TRIM" caption on the mode controller

The red "A/P TRIM" annunciator on the CAWS display unit

The continuous autopilot trim fail warning tone was not annunciated. The results of this test were not consistent with the events recorded on the video because the red trim warnings in the video occurred more than 14 seconds after the autopilot had disconnected.

Testing revealed that the "A/P DISENG" caption would only illuminate if the autopilot had been engaged and then disconnected, either manually or automatically. It would not illuminate if the autopilot was off without being previously engaged nor would it illuminate if the pilot attempted and failed to engage the autopilot by pressing the AP pushbutton on the mode controller.

Airport Information

Airport:	RICK HUSBAND AMARILLO INTL (AMA)	Runway Surface Type:	
Airport Elevation:	3606 ft	Runway Surface Condition:	Unknown
Runway Used:	04	IFR Approach:	None
Runway Length/Width:	13502 ft / 200 ft	VFR Approach/Landing:	None

Wreckage and Impact Information

Crew Injuries:	3 Fatal	Aircraft Damage:	Destroyed
Passenger Injuries:	N/A	Aircraft Fire:	On-Ground
Ground Injuries:	N/A	Aircraft Explosion:	On-Ground
Total Injuries:	3 Fatal	Latitude, Longitude:	35.196389, -101.704722 (est)

Organizational And Management Information

According to the company's FAA-issued operations specifications, Rico Aviation was authorized to conduct 14 *CFR* Part 135 on-demand operations carrying nine passengers or less. The company was based at AMA. In addition to the accident airplane, the company operated 2 Cessna Conquest CE-441 airplanes and 1 Cessna Citation CE-525A airplane. Rico Aviation had been operating for 20 years. The owner and president was the current DO. The Lubbock Flight Standards District Office provided oversight for Rico Aviation. Both the chief pilot and the DO had been designated by the FAA as company flight instructors. Rico Aviation operated air-ambulance flights typically consisting of one pilot, one to two medical crewmembers, and a patient.

Administrative Information

Investigator In Charge (IIC):	Joshua D Lindberg	Adopted Date:	09/04/2018
Additional Participating Persons:	Gordon Morris; Federal Aviation Administration; Lubbock, TX Bob Hendrickson; FAA AVP-100; Washington, DC Jeff Davis; Pratt & Whitney; WV Markus Kohler; Pilatus Michael Foster; Honeywell; KS Les Doud; Hartzell Propellers; Piqua, OH Richard Coon; Rico Aviation; Amarillo, TX Zachary Forsberg; Rico Aviation; Amarillo, TX		
Publish Date:	09/04/2018		
Note:	The NTSB traveled to the scene of this accident.		
Investigation Docket:	http://dms.nts.gov/pubdms/search/dockList.cfm?mKey=95076		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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