Aviation Investigation Final Report

Location:	Gallatin, Tennessee	**Accident Number:**	ERA14FA461
Date & Time:	September 28, 2014, 15:20 Local	**Registration:**	N7062U
Aircraft:	EAGLE R&D INC HELICYCLE	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The private pilot of the experimental amateur-built, single seat, helicopter departed his home airport, flew to a friend's property, and landed uneventfully. After his visit, the pilot started the helicopter, lifted off, and departed to the southwest. About 1 minute later, his friend observed the helicopter coming toward him in a nose-low attitude, about 400 ft above ground level, and at a "high rate of speed." The helicopter suddenly pitched over, began to tumble, and impacted in an inverted attitude; a postcrash fire ensued. Sound spectrum analysis of a video of the accident flight indicated that the helicopter was flying at an airspeed of at least 83 knots when the loss of control occurred.

The pilot did not possess a rotorcraft helicopter rating. Review of the pilot's logbook revealed entries that indicated the pilot had been endorsed for solo flight in the Robinson R22 and had flown an R22 solo. However, according to the flight instructor who had given the pilot about 21 hours of flight instruction in an R22, he had not endorsed the pilot for solo flight in the R22, and he had observed that the pilot had some "bad habits" and would occasionally lose control of the helicopter. It is likely that the pilot made the logbook entries to indicate that he had soloed because they were required by the helicopter kit manufacturer before he could receive a factory checkout of the helicopter, which he had purchased about 6 months before the accident.

The factory checkout was conducted on the day before the accident. According to the factory check pilot, during the checkout, the pilot kept making mistakes and advised the check pilot that he was very tired because he had not slept for 2 days due to anticipation of the checkout. Also, during the checkout, the check pilot determined that the weight and balance of the helicopter was not correct, and the pilot would need to fly the helicopter so they could check the position of the cyclic stick during hover. The pilot advised the check pilot that, because of his lack of sleep and nervousness, he did not feel it safe to fly the helicopter that day. As a result, the check pilot reminded him that he would need to check the weight and balance and the position of the cyclic stick during hover before operating the helicopter, since it was not accomplished that day.

Examination of the wreckage did not reveal evidence of any preimpact failures or malfunctions of the helicopter or engine that would have precluded normal operation. A piece of angle iron was discovered in the debris field, which, according to the pilot's friend, the pilot had attached to the helicopter's tailboom for weight and balance purposes. However, calculations revealed that the helicopter's center of gravity was outside the forward edge of the weight and balance envelope approved by the kit manufacturer. It is likely that the out of balance condition combined with the high speed of the low-altitude pass resulted in the loss of control.

The pilot had therapeutic levels of the antidepressant sertraline in his blood at the time of the accident. Although any psychoactive medications can be impairing, sertraline is not known to directly cause sleepiness or other impairing symptoms. Therefore, it is unlikely that effects from sertraline impaired the pilot. However, sertraline is prescribed for treatment of depression, and major depression itself is associated with significant cognitive degradation, particularly in executive functioning. The cognitive degradation may not improve even with remission of the depressed episode, and patients with severe disease are more significantly affected than those with fewer symptoms or episodes.

The pilot demonstrated poor decision-making and executive function when he decided to fly the helicopter without having soloed in the R22 and without adequately addressing the identified issue with the helicopter's weight and balance. Additionally, flying the helicopter at high speed and low altitude further demonstrated his impaired executive function. One month before the accident, the pilot's personal physician described inappropriate demeanor and unkempt appearance; this is the most recent description of the pilot's executive function and further suggests the depression was not well controlled. Therefore, the pilot's depression and resulting degradation of executive function likely contributed to his decision to fly the poorly balanced helicopter in a high-speed, low-altitude maneuver and contributed to the accident.

The pilot had provided his aviation medical examiner (AME) with a letter from his physician documenting his anxiety/depression as well as its treatment. According to Federal Aviation Administration (FAA) guidance, depression treated for less than 6 months is disqualifying, and a medical certificate should not have been issued. Therefore, the investigation determined the AME failed to follow FAA guidelines for depression and inappropriately provided the pilot with a medical certificate. The AME forwarded the records of the pilot's depression to the FAA 19 days before the accident; therefore, there was insufficient time for the FAA to identify the issue and recall an improperly issued medical certificate.

Additionally, the pilot had used diphenhydramine before the accident. Compared to other antihistamines, diphenhydramine causes marked sedation. Altered mood and impaired cognitive and psychomotor performance may also be observed. The diphenhydramine in cavity blood tested by two laboratories was not consistent (0.828 and 2.171 ug/ml), but the results were well above the therapeutic range of 0.0250 to 0.1120 ug/ml. Diphenhydramine undergoes postmortem redistribution, and postmortem central blood levels may increase by about three times with cavity blood levels even higher. However, even divided by seven or eight, the postmortem levels measured suggest that the pilot likely had impairing levels at the time of the accident. Although the pilot had been able to fly the helicopter for a short distance earlier in the day, the subsequent high-speed pass with the helicopter outside of weight and balance specifications required a much higher degree of flight skill to complete safely. Therefore, the pilot's use of diphenhydramine likely degraded his flight skills and contributed to his inability to safely control the helicopter.

Probable Cause and Findings

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

The pilot's decision to fly the improperly balanced helicopter at high speed and low altitude, which resulted in a loss of control and collision with terrain. Contributing to the accident were the pilot's depression and resulting degradation of executive function and the pilot's use of a sedating antihistamine, which resulted in impaired mental and motor skills.

Findings

Personnel issues	Decision making/judgment - Pilot
Aircraft	(general) - Not attained/maintained
Aircraft	CG/weight distribution - Not attained/maintained
Personnel issues	(general) - Pilot
Personnel issues	OTC medication - Pilot
Personnel issues	Decision making/judgment - FAA or designated personnel

Factual Information

History of Flight

Prior to flight	Aircraft maintenance event
Prior to flight	Preflight or dispatch event
Maneuvering-low-alt flying	Loss of control in flight (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)
Post-impact	Fire/smoke (post-impact)

On September 28, 2014, about 1520 central daylight time, an experimental amateur-built Eagle R & D Helicycle helicopter, N7062U, impacted terrain after a loss of control while maneuvering in Gallatin, Tennessee. The private pilot was fatally injured and the helicopter was substantially damaged. Visual meteorological conditions prevailed, and no flight plan was filed for the personal flight conducted under 14 *Code of Federal Regulations* (CFR) Part 91. The flight departed from a private residence about 1519 and was destined for Sumner County Regional Airport (M33), Gallatin, Tennessee.

According to a friend of the pilot, the pilot had departed M33 earlier in the day and flown to the friend's property. The landing was uneventful, and, while the pilot was there, he borrowed some tools and increased the tension on the helicopter's drive belts. According to the friend, about 1519, the pilot started the helicopter, lifted off, and departed to the southwest. The friend assumed that the pilot was heading back to M33, but, about 1 minute later, he observed the helicopter flying toward him in a nose-low attitude, about 400 ft above ground level, and at a "high rate of speed." The helicopter then suddenly pitched over, began to tumble, and impacted in an inverted attitude, and a postcrash fire ensued.

Pilot Information

Certificate:	Private	**Age:**	61,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Single
Other Aircraft Rating(s):	None	**Restraint Used:**	4-point
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 With waivers/limitations	**Last FAA Medical Exam:**	August 19, 2014
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	1225 hours (Total, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Federal Aviation Administration (FAA) and Pilot Records

According to FAA records, the pilot was first certificated in 1973 and held a private pilot certificate with a rating for airplane single-engine land. The pilot owned a Cessna 150, and although he also owned an

experimental amateur-built Bensen B-8M gyrocopter, and the Helicycle, he did not possess a rotorcraft gyroplane rating or rotorcraft helicopter rating. His most recent FAA third-class medical certificate was issued on August 19, 2014. He reported on that date that he had accrued about 1,200 total flight hours.

Review of the pilot's logbook indicated that he had received 21.3 total hours of dual instruction in a Robinson R22 helicopter. The last entry in the logbook was dated August 14, 2014, and showed 1.0 hours in the dual instruction column and 0.5 hours in the pilot-in-command column. The entry also showed 1.5 hours in the columns for day flight and total duration of flight, and it appeared that the number "5" in these two entries had been written over. The word "solo" had been written in the remarks column to the left of the instructor's entry for the flight, and the handwriting of the word appeared to be different than the handwriting of the instructor's entry.

Review of endorsements in the pilot's logbook showed that the handwriting in the pilot's "Initial Solo Endorsement" for the R22 was different from the handwriting in the pilot's 49 CFR 1552.3 (h) and Special Federal Aviation Regulation (SFAR) 73 Awareness endorsements. The date of his initial solo endorsement in the R22 was August 4, 2014, but there was no flight time entry for that date.

Flight Training

According to the flight instructor who provided helicopter flight instruction to the pilot in the Robinson R22, they flew a total of about 21 hours together between March 31, 2014, and August 15, 2014.

All flights were conducted in an R22 helicopter. The instructor stated that he never endorsed the pilot's logbook to authorize solo flight in a helicopter. The flight instructor added that he had no contact with the pilot after their last flight together on August 15, 2014. He was unaware of any past or planned flight attempts in the Helicycle, although he knew the pilot had purchased it.

During the flight lessons, the flight instructor observed what he considered to be the pilot's "bad habits" on several maneuvers, which he believed originated from the pilot's gyrocopter and airplane experience. The pilot would also occasionally lose control of the helicopter while hovering and during maneuvers.

After each instructional flight, the flight instructor reviewed the flight lesson with the pilot and discussed with him his negative habits and instances of loss of control as they worked to improve his helicopter piloting skills. In their discussions, the flight instructor told the pilot that his skills were not yet sufficient for solo flight, including flight in his Helicycle.

Aircraft and Owner/Operator Information

Aircraft Make:	EAGLE R&D INC	**Registration:**	N7062U
Model/Series:	HELICYCLE	**Aircraft Category:**	Helicopter
Year of Manufacture:	2008	**Amateur Built:**	Yes
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	4-13-E2413
Landing Gear Type:	Skid	**Seats:**	1
Date/Type of Last Inspection:	May 15, 2011 Condition	**Certified Max Gross Wt.:**	850 lbs
Time Since Last Inspection:		**Engines:**	1 Turbo shaft
Airframe Total Time:	15 Hrs as of last inspection	**Engine Manufacturer:**	Solar
ELT:	Not installed	**Engine Model/Series:**	T-62-32
Registered Owner:	On file	**Rated Power:**	91 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

The Helicycle was a single-seat, experimental amateur-built helicopter. It was equipped with a two-blade, semi-rigid main rotor and was powered by a Solar T62-32, 150 shaft horsepower, turboshaft engine.

The main rotor was fully harmonized, and the flight control system included a modulated collective pitch system. The helicopter was also equipped with elastomeric thrust bearings, control friction devices, and an electronic throttle control.

According to FAA records, the helicopter was issued a special airworthiness certificate on October 6, 2008, after it had been assembled from a kit. It was purchased by the pilot on March 10, 2014.

According to maintenance records, the helicopter's most recent condition inspection was completed on May 5, 2011. At the time of accident, the helicopter had accrued about 51 total hours of operation.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	BNA,605 ft msl	**Distance from Accident Site:**	21 Nautical Miles
Observation Time:	15:53 Local	**Direction from Accident Site:**	208°
Lowest Cloud Condition:	Scattered / 4200 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	Broken / 6000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	30.07 inches Hg	**Temperature/Dew Point:**	26°C / 16°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Gallatin, TN	**Type of Flight Plan Filed:**	None
Destination:	GALLATIN, TN (M33)	**Type of Clearance:**	None
Departure Time:	15:19 Local	**Type of Airspace:**	Class G

At 1553, the reported weather at Nashville International Airport (BNA), Nashville Tennessee, located 21 nautical miles southwest of the accident site included: calm winds, 10 miles visibility, scattered clouds at 4,200 ft, broken clouds at 6,000 ft, temperature 26° C, dew point 16° C, and an altimeter setting of 30.08 inches of mercury.

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	36.424999,-86.484169

Examination of the accident site and wreckage revealed that, during the impact sequence, the helicopter first made ground contact with the forward portion of the cockpit. It then tumbled along the ground on a magnetic heading of about 030° for about 90 ft before coming to rest on its left side.

Examination of the engine revealed no evidence of any preimpact failure or malfunction that would have precluded normal operation of the engine. Examination of the helicopter's structure and flight control system did not reveal evidence of any preimpact failures or malfunctions which would have precluded normal operation of the flight control system.

A piece of angle iron was discovered in the debris field along with numerous broken cable ties. Review of the helicopter manufacturer's published information did not indicate that it was part of either the helicopter's structure or drive train. According to the pilot's friend, he observed that the piece of angle iron was attached to the helicopter when the pilot landed and took off from his property. He said that the pilot had attached it to the helicopter's tail boom for weight and balance purposes.

Flight recorders

The helicopter was not equipped with a cockpit voice recorder or flight data recorder, nor was it required to be by federal regulations. However, a camcorder that was being operated by the pilot's friend whose property the accident occurred on captured most of the liftoff and accident flight.

Five files from the camcorder were provided to the NTSB. Each file contained video and audio of the helicopter on the day of the accident; however, only two of the five files were used by investigators. (The remaining three files did not have sufficient content for analysis.) The audio was extracted from each file at its native sample rate of 48,000 kHz and converted to a mono wave file for sound spectrum analysis.

The first video, which was 26 seconds long, captured the pilot seated inside the helicopter with the engine powered on at the start of the video with the observer directly facing the helicopter. The helicopter began a hover from standstill at 8 seconds and then started moving forward 4 seconds later. The helicopter flew past the observer at 21 seconds and continued off into the distance. Only the last 12 seconds of this file were used for sound spectrum analysis.

The second video, which was 11 seconds long, captured the helicopter coming towards the observer from a distance. The helicopter was heard passing by the camera when the camera panned out at 6 seconds. An unidentified sound was heard, and the camera panned back to the helicopter at 8 seconds and showed the helicopter descending in an inverted attitude until impact.

A spectrogram was generated for the extracted audio track of each file. The frequencies associated with the turbine and main rotor rpm were identified from the first file and used as a baseline of analysis for second file. Doppler effect was present in the first file and was used to calculate airspeed during forward flight.

Evaluation of Takeoff

The main rotor frequency was determined to be 20.3 Hz, which resulted in a main rotor rpm of about 615 rpm. This value remained constant before and after passing the observer. The speed of the helicopter as it passed the observer was estimated to be 33 knots. The frequencies identified were consistent with a normal takeoff under takeoff power.

Evaluation of Event

In the second video, the airspeed was determined to be about 83 knots. The orientation between the

observer and the helicopter could not be established; therefore, the actual airspeed may have been higher than calculated.

The main rotor frequency was determined to be between 20.3 Hz and 23.3 Hz, which resulted in a main rotor rpm of about 699 rpm at its peak. The ratio of the calculated rpm to the nominal main rotor rpm (from the first video) was 113%.

Medical and Pathological Information

According to the FAA medical certification file, at the time of the pilot's most recent FAA medical certification examination on August 19, 2014, he reported high blood pressure treated with benazepril, a prescription high blood pressure medication that is marketed as Lotensin. He reported no other chronic medical conditions or medications to the aviation medical examiner (AME).

The AME noted no side effects or complications from the high blood pressure, identified no abnormal physical findings on examination, and issued a third class medical certificate with the following limitation: must have available glasses for near vision.

About 1 month before the accident, the AME forwarded a letter written by the pilot's primary care provider to the FAA Medical Certification Division as part of the medical certification package. In this letter, which was dated 2 days after the medical certificate was issued, the pilot's primary care provider noted his elevated blood pressure and recommended lifestyle modifications and continued use of benazepril with hydrochlorothiazide. Benazepril with hydrochlorothiazide is a combination prescription medication used to treat high blood pressure that is marketed as Lotensin HCT. Additionally, the letter noted that the pilot appeared disheveled, was agitated and fidgety, and his mood was described as very anxious and irritable. The primary care provider had diagnosed longstanding anxiety/depression and prescribed vilazodone, a medication used to treat major depression that is marketed as Viibryd. Vilazodone carries a warning regarding increased risk of suicide in adolescents and young adults.

Depression is a disqualifying condition for pilot medical certification, and, according to the Guide for Aviation Medical Examiners, an aviation medical examiner should not issue a medical certificate to a depressed pilot. The FAA will consider a special issuance of a medical certificate for depression after 6 months of treatment if the applicant is clinically stable on one of four approved medications; vilazodone is not one of these medications.

Autopsy

According to the Nashville Tennessee Office of the Medical Examiner autopsy report, the cause of death was multiple blunt force injuries. No significant natural disease was identified.

Toxicology

Toxicological testing on specimens from the pilot was conducted at the FAA Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma. The specimens were negative for carbon monoxide,

cyanide, ethanol, and basic, acidic, and neutral drugs, with the exception of diphenhydramine and sertraline, which were detected in liver and blood. Diphenhydramine was detected in cavity blood (2.171 ug/ml) and liver. Additionally, sertraline was detected in cavity blood (0.101 ug/ml) and liver, and its metabolite desmethylsertraline was also detected in blood and liver. According to an email to the NTSB medical officer dated May 23, 2016, the FAA's laboratory testing would not identify vilazodone. Aegis Crimes Laboratory toxicology testing performed as part of the medical examiner's death investigation identified 0.828 ug/ml of diphenhydramine in cavity blood.

Diphenhydramine is a sedating antihistamine used to treat allergy symptoms and as a sleep aid. It is available over the counter under the trade names Benadryl and Unisom. Diphenhydramine's accepted therapeutic range is from 0.0250 to 0.1120 ug/ml, and it carries the following FDA warning: may impair mental and/or physical ability required for the performance of potentially hazardous tasks (e.g., driving, operating heavy machinery). Compared to other antihistamines, diphenhydramine causes marked sedation; it is also classed as a central nervous system depressant, and this is the rationale for its use as a sleep aid. Altered mood and impaired cognitive and psychomotor performance may also be observed. In a driving simulator study, a single dose of diphenhydramine impaired driving ability more than a blood alcohol concentration of 0.100 percent.

Sertraline is a prescription medication used to treat several conditions including depression, obsessive-compulsive disorder, panic disorder, and social anxiety disorder; it is marketed as Zoloft. Sertraline carries a warning regarding increased risk of suicide in adolescents and young adults. The accepted therapeutic range is from 0.0100 to 0.2000 ug/ml.

Additional Information

Pilot's Rotorcraft Forum Posts

The pilot was a member of an internet rotorcraft forum and posted regularly. On September 19, 2014, he posted that he had flown the Helicycle about 3 hours that day but still needed the factory check pilot "to come and help me work out little kinks here and there, but overall the flight was great."

During the flight, he noticed that there was "a little stick shake" and "had a problem with belt slippage" that he attributed to oil leaking from the transmission filter housing onto the belts.

He stated that the factory check pilot was going to come out to install new elastomeric bearings on the rotor hub, and he was sure that "we will balance and tweak everything."

Elastomeric Bearings

According to the kit manufacturer, the elastomeric bearings were excluded from the purchase price of a Helicycle kit. The elastomeric bearings, which were part of the Helicycle rotor hub and necessary to operate the helicopter, would be withheld from the kit until the kit was assembled and ready for the

customer's factory checkout. The installation of the elastomeric bearings would be performed by an authorized factory test pilot during the factory checkout, and the kit manufacturer reserved the right to withhold the elastomeric bearings until the customer had sufficiently prepared for the factory checkout.

In the case of the accident helicopter, the Helicycle had been purchased from a previous owner so it already had the elastomeric bearings installed when the pilot purchased it. On September 27, 2014, the elastomeric bearings were replaced to track and balance the main rotor during the pilot's factory checkout.

Kit Manufacturer's Requirements for Flight

According to the kit manufacturer, their policy was that customers would agree to have a factory checkout performed on their Helicycle before flight. The factory checkout consisted of a multi-day process during which the Helicycle was "checked out" and then test flown by a factory check pilot.

During the checkout, the customer also will fly the Helicycle for the first time. The factory checkout would only be scheduled following the receipt of the following items by the kit manufacturer:

- Proof of aircraft registration.
- Airworthiness certificate.
- A completed factory checkout checklist.
- Proof of solo flight in the pilot's logbook.

Factory Checkout

The pilot had contacted the check pilot about 2 months before the accident and advised him that he had purchased a previously owned Helicycle and needed a "checkout." The check pilot advised him that he would be able to do one, but the pilot would have to meet the factory requirements and have a helicopter-rotorcraft certificate or an endorsement for solo in a Robinson R22 helicopter. The pilot advised him that he had not soloed yet but was working on it.

The pilot later contacted the check pilot and stated that he had received an endorsement for solo in the Robinson R22 helicopter. As such, the check pilot made arrangements to do the checkout at M33 where the pilot had a hangar where he kept the helicopter.

On September 27, 2014, the check pilot met the pilot at M33. Per the check pilot's instructions, the pilot had not installed the main rotor blades on the helicopter as he needed them off the helicopter to make it easier to install the new elastomeric bearings in the rotor head.

The check pilot and the pilot installed the new bearings and then re-installed the rotor blades. Before they began the dynamic balancing of the rotor system, the check pilot reviewed the preflight check with the pilot. According to the check pilot, the checklist was similar to most helicopters where you check mechanical components, control linkages, and control operation. During the review, he showed and explained to the pilot how to check all the items on the checklist. They next attached a dynamic rotor blade balancer to the helicopter, rolled the helicopter out of the hangar, and began balancing the main rotor blades.

During the blade balancing, the pilot was in the helicopter and was in charge of starting the helicopter, engaging the blades, and running the helicopter up to flight speed, so that balance readings could be taken. (Balancing is done on the ground not in the air.) The check pilot noticed that the pilot was having trouble remembering the correct starting procedure, kept referring to a start procedure that he had printed up to help him, but still kept making mistakes. The pilot told the check pilot that he was very tired because he had not slept for 2 days due to the anticipation of having the checkout done.

They performed about seven starts and shutdowns before the dynamic balancing was complete. They then removed the balancing equipment. In the paperwork from the previous owner, the pilot found a weight and balance sheet that showed the helicopter was balanced for a 200-pound (lbs) pilot. Because there was a difference between the check pilot's weight (180 lbs) and the pilot's stated weight of 200 lbs, they added 10 lbs of ballast weight on the floor of the helicopter.

Next, they rolled the helicopter out to the taxiway. The check pilot then started the helicopter and began to do some hover testing, vibration level testing, and handling tests. He hovered for about 10 minutes and then began hover taxiing, followed by forward take offs and landings, with several runs up to a cruise speed of 90 to 100 mph, then more hovering and hover taxiing.

After landing, he spoke to the pilot about him flying the helicopter. The pilot said that because of his lack of sleep and nervousness, he did not feel safe to fly the helicopter that day, so they rolled the helicopter back into the hanger. The check pilot explained that because the pilot was not able to fly the helicopter that day, the pilot would later need to check the weight and balance of the helicopter. He explained to the pilot that he would need to pull into a hover and check the position of the cyclic stick. Ideal position was 1- to 1 ½-inches rearward and no more than 2 inches. If the stick was close to 2 inches, he would need to move the battery to the rear or add a counterbalance weight to the tail boom. The pilot said that he thought it would be easier to add a weight than move the battery. The check pilot then explained to him that if weight was needed, he should start out with a 2 to 3 lbs, round bar of steel or lead fastened to the center of the tail boom with Adel clamps. The pilot should hover, then check the cyclic stick position, and then move the weight fore or aft depending on the cyclic stick position.

The check pilot also explained to the pilot that if the cyclic was too far back, the helicopter was nose heavy and needed more weight to the rear. If the cyclic was too far forward, then it was tail heavy, and he would need to decrease the amount of weight or move the weight forward.

They discussed what the pilot's next steps should be. The check pilot suggested that the pilot get more training before he flew his helicopter, and, when he was more confident flying, he should start out with hover practicing for at least 5 hours before flying the helicopter to altitude and to stay at the airport. He also suggested that the pilot keep his speed down to 70 to 80 mph for practice takeoffs and landings.

Helicopter Flying Handbook

According to the FAA's Helicopter Flying Handbook (FAA-H-8083-21A), it is vital to comply with weight and balance limits established for helicopters. Operating above the maximum weight limitation compromises the structural integrity of the helicopter and adversely affects performance. Balance is also critical because, on some fully loaded helicopters, center of gravity (CG) deviations as small as 3 inches

can dramatically change a helicopter's handling characteristics.

Ideally, a pilot should try to balance a helicopter perfectly so that the fuselage remains horizontal in hovering flight, with no cyclic pitch control needed except for wind correction. Since the fuselage acts as a pendulum suspended from the rotor, changing the CG changes the angle at which the aircraft hangs from the rotor. When the CG is directly under the rotor mast, the helicopter hangs horizontally; if the CG is too far forward of the mast, the helicopter hangs with its nose tilted down; if the CG is too far aft of the mast, the nose tilts up.

A forward CG may occur when a heavy pilot and passenger take off "without baggage or proper ballast located aft of the rotor mast." This situation becomes worse if the fuel tanks are located aft of the rotor mast because as fuel burns the CG continues to shift forward.

Review of Weight and Balance Data

Review of weight and balance data supplied by the kit manufacturer indicated that the center of gravity of the Helicycle was dependent on the pilot's weight, installed position of the battery, and position and weight of any ballast installed. According to the manufacturer-supplied operator manual for the Helicycle, the "safe flight CG window" was 99 1/4 inches to 99 3/4 inches and "must be substantiated by a hang test." The operator manual included a note that stated, "the relative narrowness of the Helicycle fore and aft CG limit is extremely difficult to arrive at by calculation and must be substantiated by a hang test and later by an in-flight cyclic stick position measurement."

Calculations based on the manufacturer-supplied weight and balance data, weight and balance sheet from the previous owner, weight of the pilot, weight of the angle iron (about 1 lb), and location of the angle iron on the Helicycle's tailboom, which was determined from the videos taken of the accident flight, revealed that:

- The Helicycle's center of gravity was outside of the forward edge of the kit manufacturer's approved envelope.

- The imbalance was the result of the pilot's actual weight (211 lbs) being 11 lbs more than the weight of the previous owner (200 lbs) and 21 lbs more than the weight of the check pilot.

- The angle iron attached to the tailboom of the Helicycle by the pilot only accounted for 46% of the imbalance.

- A weight of about 2 lbs (about twice the weight of the angle iron), would have been required to balance the Helicycle.

The kit manufacturer advised that the starting point of achieving a finely balanced Helicycle was to start with a "hang test." During the test, the balance would be adjusted until a 3.25-degree forward tilt of the main rotor was achieved. This adjustment did not represent the end of the balancing process. The final step required in fine tuning the balance was to analyze and adjust the cyclic position in hover until the proper cyclic position was achieved. This final step however was not accomplished by the pilot prior to the accident flight.

Administrative Information

Investigator In Charge (IIC):	Gunther, Todd
Additional Participating Persons:	David Alderman; FAA FSDO; Nashville, TN Blake Estes; Eagle R & D; Nampa, ID
Original Publish Date:	March 29, 2017
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=90168