# Aviation Investigation Final Report

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| **Location:** | Apopka, Florida | **Accident Number:** | ERA14LA130 |
| **Date & Time:** | February 23, 2014, 13:35 Local | **Registration:** | N19VC |
| **Aircraft:** | VICTOR M CORDERO RV-9A | **Aircraft Damage:** | Substantial |
| **Defining Event:** | Powerplant sys/comp malf/fail | **Injuries:** | 1 Serious, 1 Minor |
| **Flight Conducted Under:** | Part 91: General aviation - Personal | | |

## Analysis

The pilot reported that, during the approach to landing, the airplane's propeller stopped spinning but that the engine continued functioning normally. He subsequently made a forced landing to a field. During the landing, the airplane flipped over and came to rest inverted, which resulted in substantial damage to the wings and vertical stabilizer.

Postaccident examination of the engine revealed that the spline shaft had uncoupled from the drive disk adapter. The splines of the spline shaft, the drive disk adapter, and the propeller speed reduction unit (PSRU) input spline exhibited signs of severe wear consistent with fretting corrosion. Research revealed that several spline shaft failures had occurred on other airplanes; some of the failures resulted in a loss of engine power and subsequent forced landings, whereas some of the failures were identified during inspection. The manufacturer issued guidance to users to apply a nickel or copper antiseize compound on the spline shaft during installation of the PSRU to decrease wear; however, the manufacturer did not provide users with any instructions or recommendations to routinely inspect and lubricate the spline components. The pilot/builder reported that the PSRU and spline shaft had not been removed, lubricated, or inspected since it had been installed about 325 hours before the accident.

## Probable Cause and Findings

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

The failure of the propeller spline shaft, the drive disk adapter, and the propeller speed reduction unit (PSRU) input spline due to a lack of inspection and lubrication, which resulted in a total loss of propeller drive and a subsequent forced landing. Contributing to the accident was the lack of manufacturer guidance for inspecting and lubricating the PSRU gearbox spline components.

## Findings

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| **Aircraft** | (general) - Fatigue/wear/corrosion |
| **Aircraft** | (general) - Not serviced/maintained |
| **Aircraft** | (general) - Related maintenance info |
| **Organizational issues** | Availability of policy/proc - Manufacturer |

# Factual Information

## History of Flight

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| **Prior to flight** | Aircraft maintenance event |
| **Enroute-descent** | Powerplant sys/comp malf/fail (Defining event) |
| **Enroute-descent** | Loss of engine power (total) |
| **Landing-landing roll** | Collision with terr/obj (non-CFIT) |
| **Landing-landing roll** | Nose over/nose down |

On February 23, 2014, about 1335 eastern standard time, an experimental amateur built Cordero RV-9A, N19VC, was substantially damaged during an emergency landing in Apopka, Florida. The private pilot received minor injuries and the passenger sustained serious injuries. Visual meteorological conditions prevailed for the personal flight conducted under Title 14 Code of Federal Regulations Part 91. The flight originated from Marsh Harbour International Airport (MYAM), Marsh Harbour, Bahamas at 1130 and was destined for Orlando Sanford International Airport (SFB), Sanford, Florida.

According to the pilot's written statement, the airplane was at an altitude of 3,000 ft and on approach for a landing on runway 9L, at SFB. Two minutes later, about 1330, the propeller stopped rotating, but the engine continued to function normally. There were no annunciations or warnings displayed on the engine monitoring unit. The pilot declared an emergency with Orlando approach who then issued a radar vector to the pilot for Orlando Apopka Airport (X04), Apopka, Florida, which was approximately 4 nautical miles away. The pilot subsequently determined the airplane would not glide to X04 and turned the airplane towards a dirt road. As the airplane approached the road, the pilot maneuvered the airplane to avoid some obstacles and then touched down. During the landing roll the nose-wheel made contact with the ground and the airplane nosed over and came to rest inverted.

## Pilot Information

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| **Certificate:** | Private | **Age:** | 68 |
| **Airplane Rating(s):** | Single-engine land | **Seat Occupied:** | Left |
| **Other Aircraft Rating(s):** | None | **Restraint Used:** | 4-point |
| **Instrument Rating(s):** | Airplane | **Second Pilot Present:** | No |
| **Instructor Rating(s):** | None | **Toxicology Performed:** | No |
| **Medical Certification:** | Class 3 Without waivers/limitations | **Last FAA Medical Exam:** | January 8, 2013 |
| **Occupational Pilot:** | No | **Last Flight Review or Equivalent:** | July 9, 2013 |
| **Flight Time:** | 1170 hours (Total, all aircraft), 344 hours (Total, this make and model), 1170 hours (Pilot In Command, all aircraft), 33 hours (Last 90 days, all aircraft), 15 hours (Last 30 days, all aircraft), 0 hours (Last 24 hours, all aircraft) | | |

The pilot held a private pilot certificate with ratings for single engine land and instrument airplane. He had accumulated about 1,170 hours total flight time, of which 324 hours were in the accident airplane make and model. His most recent third class Federal Aviation Administration medical certificate was issued on January 8, 2013.

## Aircraft and Owner/Operator Information

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| **Aircraft Make:** | VICTOR M CORDERO | **Registration:** | N19VC |
| **Model/Series:** | RV-9A | **Aircraft Category:** | Airplane |
| **Year of Manufacture:** | 2011 | **Amateur Built:** | Yes |
| **Airworthiness Certificate:** | Experimental (Special) | **Serial Number:** | 90319 |
| **Landing Gear Type:** | Tricycle | **Seats:** | 2 |
| **Date/Type of Last Inspection:** | September 12, 2013 Annual | **Certified Max Gross Wt.:** | 1800 lbs |
| **Time Since Last Inspection:** | | **Engines:** | 1 Reciprocating |
| **Airframe Total Time:** | 278 Hrs as of last inspection | **Engine Manufacturer:** | Subaru |
| **ELT:** | Not installed | **Engine Model/Series:** | EJ25 2.5L |
| **Registered Owner:** | On file | **Rated Power:** | 165 Horsepower |
| **Operator:** | On file | **Operating Certificate(s) Held:** | None |

According to Federal Aviation Administration (FAA) records, the RV-9A, a two-seat, all-metal, low-wing airplane with tricycle configured landing gear was issued an airworthiness certificate, in the experimental category, on July 18, 2011. It was built from a series of kits provided by Vans Aircraft and Eggenfellner Aircraft, Inc. The airplane was equipped with an Eggenfellner Subaru H4 modified automobile engine which included a Gen 3 V4 propeller speed reduction unit (PSRU) gearbox that was used to drive the propeller at a speed slower than the engine speed. The engine was equipped with an IVO propeller assembly that consisted of three electrically-controlled wooden propeller blades.

The engine kit was based on an EJ-25, 2.5L Subaru water cooled 4-cylinder engine and was rated at 160 HP at 5400 rpm.

The pilot/builder stated that he purchased the kit for the airplane in 2001 and began construction shortly after. He purchased the engine, which at the time, was equipped with a Gen 1 PSRU and solid flywheel, direct from Eggenfellner Aircraft, Inc. in 2002 and installed the engine about January 2008. In 2011, prior to receiving the airworthiness certificate, the pilot employed Eggenfellner Aircraft, Inc. to remove the original PSRU and replace it with a Gen 3 V4 PSRU.

During a telephone interview a representative of Eggenfellner Aircraft, Inc., now defunct, stated that the Eggenfellner Subaru H4 engine transfers power to the PSRU through a spline shaft. One end of the spline shaft is inserted into a splined drive disk adapter at the engine. The splined drive disk is bolted to the engine crankshaft through the flywheel. The other end is inserted into the PSRU input spline.

The spline shaft and PSRU input spline were taken from the transfer cases of Nissan Pathfinders. The machining of the drive disk adapter that affixes to the solid flywheel and crankshaft were outsourced to a separate facility and made from non-heat treated 4140 steel.

The engine information system (EIS) installed in the cockpit showed that the total time for the airframe and engine at the time of the accident was 324.5 hours

The last recorded annual inspection took place on September 13, 2013, at which time 278 hours were reported. A review of the maintenance records revealed no record that the PSRU had been removed or that the spline components had been inspected or lubricated since installation. In addition, the pilot/builder of the airplane stated that he had not inspected or lubricated the PSRU, the spline shaft, or drive disk adapter during the airplane's total time in service.

## Meteorological Information and Flight Plan

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| **Conditions at Accident Site:** | Visual (VMC) | **Condition of Light:** | Day |
| **Observation Facility, Elevation:** | SFB,55 ft msl | **Distance from Accident Site:** | 14 Nautical Miles |
| **Observation Time:** | 13:53 Local | **Direction from Accident Site:** | 90° |
| **Lowest Cloud Condition:** | Few / 2900 ft AGL | **Visibility** | 10 miles |
| **Lowest Ceiling:** | None | **Visibility (RVR):** | |
| **Wind Speed/Gusts:** | 7 knots / | **Turbulence Type Forecast/Actual:** | / None |
| **Wind Direction:** | 210° | **Turbulence Severity Forecast/Actual:** | / N/A |
| **Altimeter Setting:** | 30.02 inches Hg | **Temperature/Dew Point:** | 27°C / 19°C |
| **Precipitation and Obscuration:** | No Obscuration; No Precipitation | | |
| **Departure Point:** | Marsh Harbour (MYAM) | **Type of Flight Plan Filed:** | IFR |
| **Destination:** | Sanford, FL (SFB ) | **Type of Clearance:** | VFR |
| **Departure Time:** | 11:30 Local | **Type of Airspace:** | |

The 1353 automated weather observation at SFB included winds from 210 degrees at 7 knots; visibility 10 statute miles; few clouds at 2,900 feet; temperature 27 degrees Celsius (C); dew point 19 degrees C, and an altimeter setting of 30.02 inches of mercury.

## Airport Information

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| **Airport:** | ORLANDO Apopka Airport X04 | **Runway Surface Type:** | Grass/turf |
| **Airport Elevation:** | 142 ft msl | **Runway Surface Condition:** | Dry;Soft |
| **Runway Used:** | | **IFR Approach:** | None |
| **Runway Length/Width:** | | **VFR Approach/Landing:** | Forced landing |

## Wreckage and Impact Information

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| **Crew Injuries:** | 1 Minor | **Aircraft Damage:** | Substantial |
| **Passenger Injuries:** | 1 Serious | **Aircraft Fire:** | None |
| **Ground Injuries:** | N/A | **Aircraft Explosion:** | None |
| **Total Injuries:** | 1 Serious, 1 Minor | **Latitude, Longitude:** | 28.74908,-81.489341(est) |

According to information provided by the FAA, the airplane came to rest inverted in an area of vegetation. Photographs provided by the FAA showed the airplane remained mostly intact with fragments of the nose cone and wingtips distributed along the wreckage path. The forward wingtip sections of both wings and the vertical stabilizer were impact damaged. An outboard section of the left wing had been separated leaving the rib structure exposed. The nose landing gear was bent about 20 degrees inward. The engine remained attached to its mount at all attachment point, and the hub and PSRU remained attached to the engine. All three propeller blades remained attached to the hub and two of the blades exhibited both longitudinal and chordwise cracks. The inboard section of each blade was cracked about 1 foot from the hub and one blade was partially separated.

Additional examination of the engine was performed under the supervision of NTSB investigators. The propeller was rotated freely by hand with only slight resistance at some positions. The propeller hub was then removed and continuity was confirmed from the propeller through the PSRU to the engine.

Removal of the PSRU revealed that the spline shaft rotated freely within the drive disk adapter, which was attached to the engine solid flywheel. The PSRU input spline contained approximately one teaspoon of red dust (consistent with ferrous fretting-wear debris). The drive disk adapter and spline shaft were then removed from the flywheel and separated. The teeth of the spline shaft exhibited mechanical damage consistent with the wear on the drive disk adapter teeth.

Further examination at the NTSB Material's Laboratory revealed that the PSRU input spline, spline shaft, and drive disk adapter exhibited severe wear and were void of lubrication. Examination of the spline shaft and drive disk adapter using a 5X to 50X stereo zoom microscope revealed the flanks of the spline shaft teeth that mate with the drive disk adapter were worn by about 75%, with the tips of the teeth forming sharp cusps that had been bent over consistent with rotation of the spline shaft within the drive disk adapter. Wear surface features on the spline shaft teeth were consistent with fretting wear that had progressed to adhesive wear. [Additional information can be found in the Materials Laboratory Factual report located in the public docket.]

## Additional Information

Reported Spline Shaft Failures

The pilot/builder was also a member of the Subenews Yahoo! Group, which is a web group devoted to builders and maintainers of Eggenfellner Subaru aircraft engines. The Subenews group website contained historical reports of spline shaft failures in its group posts and newsletters. In September 2012, the Subenews group issued a bulletin titled "Safety Alert Bulletin: Spline Shaft Failures." The document provided several examples of spline shaft failures; some resulted in loss of engine power and subsequent forced landings while some failures were identified during inspection. In one example, the owner of an airplane equipped with an Eggenfellner Subaru H4 engine with a Gen 3 V4 PSRU encountered a loss of power at about 160 hours of operation and performed an emergency landing in a soccer field. A follow-up inspection of the engine revealed severe wear of the spline shaft and drive disk adapter. In addition the pilot shaft had broken from the spline shaft. In July 2012, another owner encountered a loss of power and completed an emergency landing. His subsequent examination of the engine revealed severe wear of the spline shaft and drive disk adapter. This engine, equipped with the Gen 3 gearbox, had a total time of 1,425 hours. After learning of these reported events, other owners conducted spline shaft inspections and discovered severe wear on their spline shafts and drive disk adapters.

Manufacturer Guidance – Spline Components and Lubrication

The Eggenfellner Aircraft Gen 3 V4 PSRU installation manual dated January 2008, instructed customers to "wipe a small amount of anti-seize compound on the new spline shaft." According to a statement by a company representative, the splined components incur constant metal to metal contact and will wear over time. As a result the factory would place a small portion of nickel or copper based anti-seize on the components during installation. He stated that it would make sense to remove the PSRU each year during annual inspection, but does not recall communicating this guidance to customers. When asked what the lubrication requirements were for the spline components, the representative stated they had previously seen only one other spline shaft failure. He added that due to the limited number of failures they had not issued any additional lubrication guidance to customers.

Active members of the Subenews group community reported that no spline shaft lubrication or inspection recommendations had been issued by any representative of Eggenfellner Aircraft, with the exception of the segment in the installation manual that instructs customers to apply anti-seize compound to the spline shaft during installation.

Owners are currently experimenting with various greases and combinations of greases in an attempt to better control the wear to the spline components.

Fretting Corrosion

According to Dow Corning, a lubricant/sealant manufacturer, fretting corrosion is defined as:

"Frictional wear which occurs at fits and seats due to oscillations with very low amplitude and high frequency. Usually, the very small iron wear particles react to rust in combination with oxygen, which finally results in seizing of the seats. Another disadvantage of fretting corrosion is the rapid material fatigue of the steel, a fact which can easily lead to breaking. (Fretting corrosion can be prevented most effectively by the separation of both metal partners, e.g. by means of solid lubricants.)"

## Administrative Information

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| **Investigator In Charge (IIC):** | Stein, Stephen |
| **Additional Participating Persons:** | Robert Haynes; FAA/FSDO; Orlando, FL |
| **Original Publish Date:** | November 3, 2014 |
| **Last Revision Date:** | |
| **Investigation Class:** | Class |
| **Note:** | |
| **Investigation Docket:** | https://data.ntsb.gov/Docket?ProjectID=88836 |