Aviation Investigation Final Report

Location:	Goodyear, Arizona	**Accident Number:**	WPR17LA121
Date & Time:	June 4, 2017, 09:17 Local	**Registration:**	N51FB
Aircraft:	Bob Frederick Titan T-51	**Aircraft Damage:**	Substantial
Defining Event:	Powerplant sys/comp malf/fail	**Injuries:**	1 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The airline transport pilot indicated that, immediately after takeoff for the local flight, the experimental, amateur-built airplane began to vibrate. As he transitioned the airplane to the downwind leg, the vibration increased, and the engine then experienced an overspeed and lost all power. The cockpit filled with smoke and the pilot subsequently performed a forced off-airport landing, which resulted in substantial damage to the left wing and aft fuselage.

The airplane had accrued about 43 flight hours since its construction, which was completed about 2 years before the accident.

Examination of the propeller speed reduction gearbox revealed that the teeth of the input drive gear had separated, which caused a loss of drive continuity to the propeller. The drive and idler gears did not appear to meet the manufacturer's case hardness requirements; however, evidence suggests that the gearbox had undergone severe heat buildup during the failure sequence, which may have subsequently altered the hardness. Oil starvation or exhaustion likely did not occur, as the gearbox bearings were intact and largely undamaged. Due to damage sustained to the gears, an accurate assessment of the initial failure mode could not be determined. Thus, the investigation could not determine the reason for the failure of the propeller speed reduction gearbox input drive gear.

Probable Cause and Findings

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

Failure of the propeller speed reduction gearbox input drive gear during the airplane's initial climb for reasons that could not be determined due to extensive damage.

Findings

Aircraft	(general) - Failure

Factual Information

History of Flight

Initial climb	Sys/Comp malf/fail (non-power)
Initial climb	Powerplant sys/comp malf/fail (Defining event)
Initial climb	Loss of engine power (total)
Initial climb	Fire/smoke (non-impact)
Emergency descent	Off-field or emergency landing

On June 4, 2017, at 0917 mountain standard time, an experimental amateur-built Titan T-51 Mustang, N51FB, lost thrust to the propeller during the initial takeoff climb from Phoenix Goodyear Airport, Goodyear, Arizona. The pilot was not injured, and the airplane sustained substantial damage to the left wing and aft fuselage during the forced landing. The airplane was registered to a private individual and the pilot was operating the airplane as a Title 14 *Code of Federal Regulations* Part 91 personal flight. Visual meteorological conditions prevailed for the local flight, and no flight plan had been filed.

The pilot reported that immediately after takeoff, the airplane began to vibrate. He stated that it felt like one of the wheels was still spinning, so he applied the brakes, but the vibration continued. As he transitioned the airplane to the downwind leg, the vibration increased, and the engine then experienced an overspeed and lost all power. As the pilot initiated a return to runway 21, the cockpit filled with smoke, and unable to reach the runway, the airplane landed short in a dirt area, where the landing gear collapsed (See Figure 1).

Figure 1 – Airplane at the Accident Site

Pilot Information

Certificate:	Airline transport; Flight instructor	**Age:**	67,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Front
Other Aircraft Rating(s):	None	**Restraint Used:**	4-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine	**Toxicology Performed:**	No
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	March 16, 2017
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 4, 2016
Flight Time:	10377 hours (Total, all aircraft), 183 hours (Total, this make and model), 8823 hours (Pilot In Command, all aircraft), 6 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Bob Frederick	**Registration:**	N51FB
Model/Series:	Titan T-51	**Aircraft Category:**	Airplane
Year of Manufacture:	2015	**Amateur Built:**	Yes
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	MO4XXXS0HK0052
Landing Gear Type:	Retractable - Tailwheel	**Seats:**	2
Date/Type of Last Inspection:	October 26, 2016 Condition	**Certified Max Gross Wt.:**	1850 lbs
Time Since Last Inspection:	20 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	43.4 Hrs at time of accident	**Engine Manufacturer:**	Suzuki
ELT:	C91A installed, not activated	**Engine Model/Series:**	H27A
Registered Owner:		**Rated Power:**	183 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

The airplane kit was manufactured by Titan Aircraft in the United States, and the kit was assembled by the owner, who completed construction in July 2015.

The most recent conditional inspection was completed on October 26, 2016, and at the time of the accident the airplane and engine had accrued 43.4 hours of total flight time.

The airplane was equipped with a Suzuki H27A six-cylinder, 2.7-liter automobile engine. The engine was one of the types recommended by Titan Aircraft for installation in the T51. The pilot purchased the engine used, and reported that it had accrued about 2,000 miles of use in its donor automobile prior to installation.

A Whirl Wind four-blade 100-4-84D hydraulically-controlled constant-speed composite propeller was driven by a reduction gearbox manufactured in New Zealand by Autoflight Ltd. The propeller was supplied to the owner by Titan Aircraft, and was the type recommended by Titan Aircraft and Autoflight for the airframe, engine, and gearbox combination.

Representatives from Titan Aircraft did not respond to multiple requests for technical support by NTSB investigators, and did not provide any information or assistance during the investigation. Autoflight provided summary information regarding basic gearbox specifications.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KGYR,968 ft msl	**Distance from Accident Site:**	1 Nautical Miles
Observation Time:	16:20 Local	**Direction from Accident Site:**	218°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.84 inches Hg	**Temperature/Dew Point:**	33°C / 5°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	GOODYEAR, AZ (GYR)	**Type of Flight Plan Filed:**	None
Destination:	GOODYEAR, AZ (GYR)	**Type of Clearance:**	VFR
Departure Time:	09:15 Local	**Type of Airspace:**	Class D

Airport Information

Airport:	PHOENIX GOODYEAR GYR	**Runway Surface Type:**	Asphalt
Airport Elevation:	968 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	21	**IFR Approach:**	None
Runway Length/Width:	8500 ft / 150 ft	**VFR Approach/Landing:**	Forced landing

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	In-flight
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 None	**Latitude, Longitude:**	33.433887,-112.366943(est)

Engine

Post-accident examination revealed two holes in the lower left side of the engine crankcase, adjacent to the cylinder number 4 crankshaft journal. The oil sump was removed, and contained dark colored oil. The oil level was above the oil pickup tube inlet, and the sump contained significant quantities of metallic shards and remnants of connecting rod components. The engine exhibited evidence of a catastrophic internal failure, with the connecting rods of cylinders number 1 and 4 separating from the

crankshaft, and extensive peening and gouging of the internal surfaces of the crankcase.

The oil cooler contained oil, and the internal gear and cavity of the oil pump was intact and free of damage.

Propeller Speed Reduction Gearbox

The propeller speed reduction gearbox was composed of a two-piece cast aluminum case, mounted directly to the engine flywheel bell housing, and oriented with the input shaft at the bottom. The input shaft was connected to the engine crankshaft via a "CENTAFLEX" flexible rubber coupling, manufactured by CENTA Antriebe Kirschey GmbH. The gearbox drivetrain consisted of the input drive gear and shaft, an idler gear, and an output drive gear fitted to the propeller flange.

According to the gearbox manufacturer, the gear ratios were designed as a "hunting tooth set", to minimize gear tooth wear, and distribute propeller blade passage across different engine strokes. Lubricant was shared with the propeller governor via an external oil sump mounted on the right side of the gearbox. The recommended lubricant was Synthetic 75W-90 gear oil, and the airplane builder reported that this was the oil he used.

Gearbox Examination

Initial gearbox disassembly was performed by the builder after he drained the oil from the sump and gearbox. He reported that the oil in the gearbox appeared dark in color, and full of black fragments.

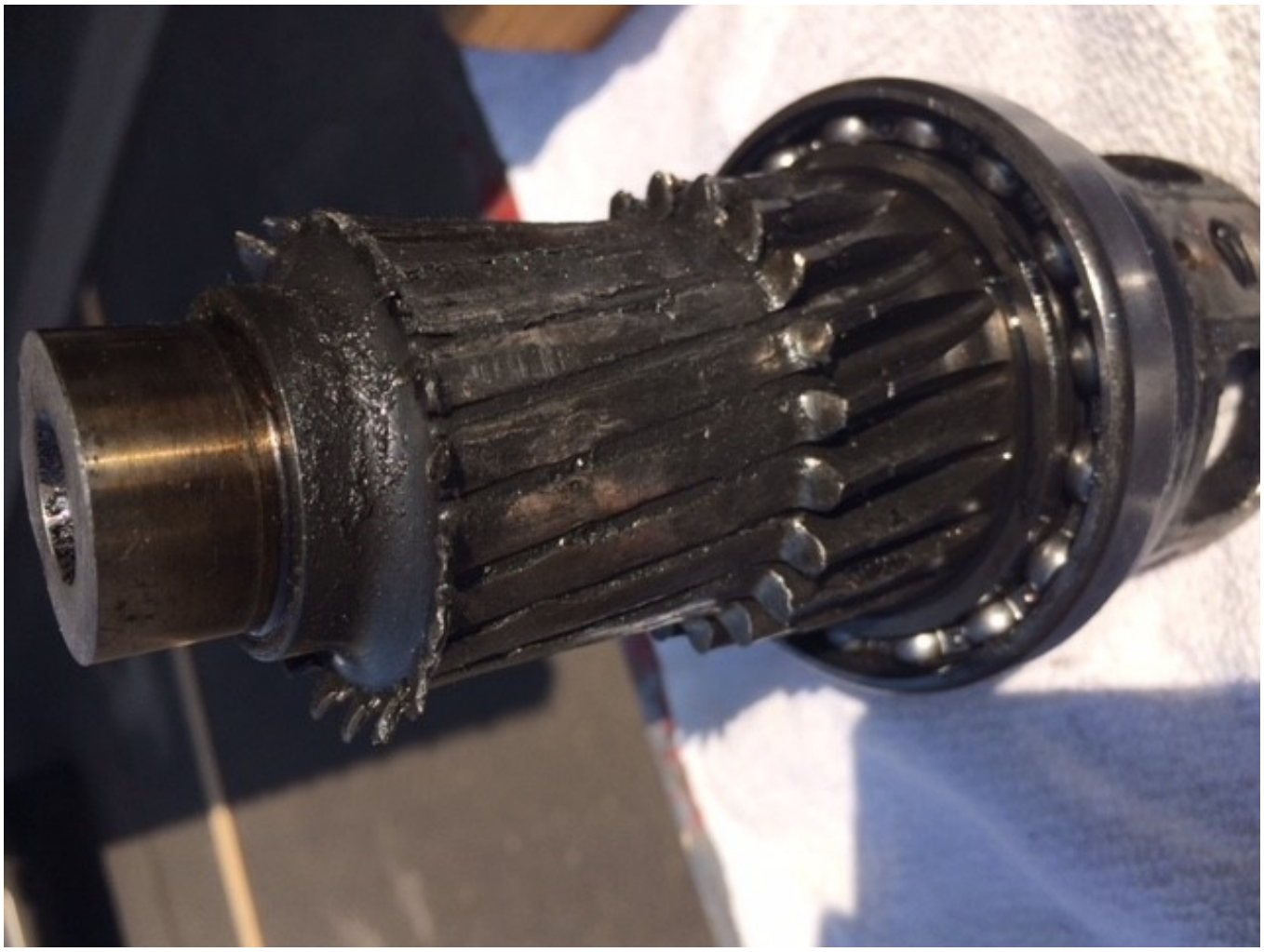

Figure 2 – Input Drive Gear

Figure 3 – Idler Gear

Follow-up NTSB examination of the gearbox components revealed that the input drive gear had shed all of its teeth at its contact area with the idler gear (See Figure 2). The idler gear teeth were all deformed and rounded, with numerous sections of their tips and faces missing (See Figure 3). Both damaged gears exhibited a dark surface tint. The inner and outer rings of the input drive gear bearing on the forward side were intact, but its polymer cage had disintegrated and/or melted. The balls were round and intact, and remained within the bearing, and the ring-to-ball contact faces were free of damage. All remaining drive gear bearings were intact and were free of damage.

The bottom of the gearbox case contained crushed slivers of gear teeth coated in oil. The failure surfaces of the input drive gear teeth were obliterated and smeared, preventing a detailed examination of their fracture surfaces.

The input and idler gears were sent to the NTSB Materials Laboratory for hardness and microstructure

evaluation. A complete report is contained within the public docket.

As part of the Materials Laboratory evaluation, the drive gear was cross-sectioned at an undamaged location adjacent to the damaged teeth. Because all teeth of the idler gear were damaged, a cross-section could only be taken at a damaged location. Hardness testing of each gear was performed at a tooth face, tooth root, and the inside diameter of the gear case. Micrographs for 100X, 200X and 500X magnification were also taken at a tooth face, tooth core, and inside diameter of the gear case.

The results for the drive gear indicated maximum hardness values of between 49.3, and 49.7 Rockwell C (HRC), with case depths of between 0.029in and 0.034in.

The results for the idler gear indicated maximum hardness values of between 42.5 and 54.6 HRC, with a case depth of 0.025in for the inside diameter edge (case depth is typically defined as the depth of hardness where the hardened layer reaches the same hardness and properties as the base or core material). Damage prevented an accurate assessment of the case depth at the other locations.

The effective case depth for both gears (the depth where a hardness measurement drops below a specified point - such as 50 HRC for high carbon steel) could not be determined because almost all the hardness values were below 50 HRC.

According to the gearbox manufacturer, the gears were made of EN39B steel, case hardened to 58/60 Rockwell.

Other T-51 Accident

Another accident involving a Titan T-51 Mustang equipped with the same speed reduction gearbox occurred in New Zealand on August 23, 2010. A Safety investigation report provided by the Transport Accident Investigation Commission of New Zealand revealed that the input, idler, and output gears had suffered complete gear tooth failure and severe overheating damage. The idler gear had experienced heavy wear on the teeth to such an extent that they had worn to a knife edge, and the drive gear had shed all of its teeth in a similar manner to that observed in the gearbox of N51FB. The investigation determined that the builder had been using an oversized propeller, and that while other failure modes could not be definitively ruled out, it was likely that the failure was caused by harmonics associated with the untested propeller, gearbox, and engine combination.

Administrative Information

Investigator In Charge (IIC):	Simpson, Eliott
Additional Participating Persons:	Charles E Baxter; Federal Aviation Administration FSDO; Scottsdale, AZ Steven Walker ; Transport Accident Investigation Commission; Wellington
Original Publish Date:	November 19, 2019
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=95301

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.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report. A factual report that may be admissible under 49 U.S.C. § 1154(b) is available here.