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INVESTIGATION REPORT

ACCIDENT INFORMATION

Date of accident:	12/28/2017	NTSB file number:	CEN18LA064
Location of accident:	Paulding OH	FAA Inspector:	Paul Gillenwater
Location of Investigation:	Owner's Hanger in Paulding OH, USA & Rotech Flight Safety in Vernon BC, Canada	Law Enforcement:	None
Investigator In charge:	Ed Malinowski	Corner/Medical Examiner	None

AIRCRAFT INFORMATION

Aircraft Make:	Pipistrel	Aircraft registration:	N4JW
Aircraft Model:	Virus SW	Aircraft S/N	877 SWN 100 iS
Propeller make, model & S/N	MT-Propeller MTV-33-1-A/170-2		

ENGINE INFORMATION

Engine Type:	Rotax 912 iS 3 Sport	Engine TTSN	54
Engine Serial Number:	7703726	Engine TTSOH	None
Engine Manufacture date:	2016 / 07 /08	Engine position:	Tractor

ADDITIONAL INFORMATION

Persons in attendance:	NTSB Air Safety Investigator – Ed Malinowski – Chicago IL
	FAA Aviation Safety Inspector – Paul Gillenwater – Columbus FSDO
	NTSB Air Safety Investigator – Michael Hicks – Los Angeles CA
	Jordan Paskevich – Rotech Flight Safety – Rotax Aircraft Engines
Date of Report:	September 14 2018
RFS File number:	2018-001

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12/28/2017	Rotax 912iS 3 Sport	7703726	N4JW	2018-001

NTSB Preliminary

On December 28, 2017, about 1630 eastern standard time, a Pipistrel Doo Ajdovscina Virus SW airplane, N4JW, impacted terrain during a forced landing on a road following an inflight loss of engine power near Paulding, Ohio. The pilot, who was the sole occupant, was uninjured. The airplane sustained substantial wing damage when it exited the road and impacted vegetation and rough terrain. The airplane was registered to and operated by the pilot as a 14 Code of Federal Regulations Part 91 personal flight. Day visual meteorological conditions prevailed in the area about the time of the accident, and the flight was not operated on a flight plan. The local flight originated from a private airport near Paulding, Ohio.

According to an initial statement from the pilot, he was conducting slow flight about 80 kts when the engine began to lose power. He switched ignition systems and engine performance did not improve. The pilot switched fuel tanks and no improvement in engine performance was noted. Changing power appeared to improve engine operation. However, engine performance got worse again.

The pilot tried to reach a private airstrip about 3 miles east of his location. He was not able to reach the airstrip, given the local wind and airplane altitude, so he selected a nearby road for a forced landing. The road was ice covered and provided very little braking. During rollout, the pilot was concerned about approaching railroad crossing signs and a tall bush. The airplane's left wing impacted the bush just before the airplane crossed the railroad. The airplane subsequently swerved to the left and the nose wheel broke off when the airplane impacted the ditch on the northwest side of the railroad. The airplane stopped on the north side of the railroad about 30 ft off the road.



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Initial Inspection

The on-site investigation took place on February 14, 2018 under the supervision of NTSB Air Safety Investigator, Ed Malinowski. The aircraft wreckage was located in the pilot/owner's hanger just outside of Pauling OH where it had been secured since the accident occurred.

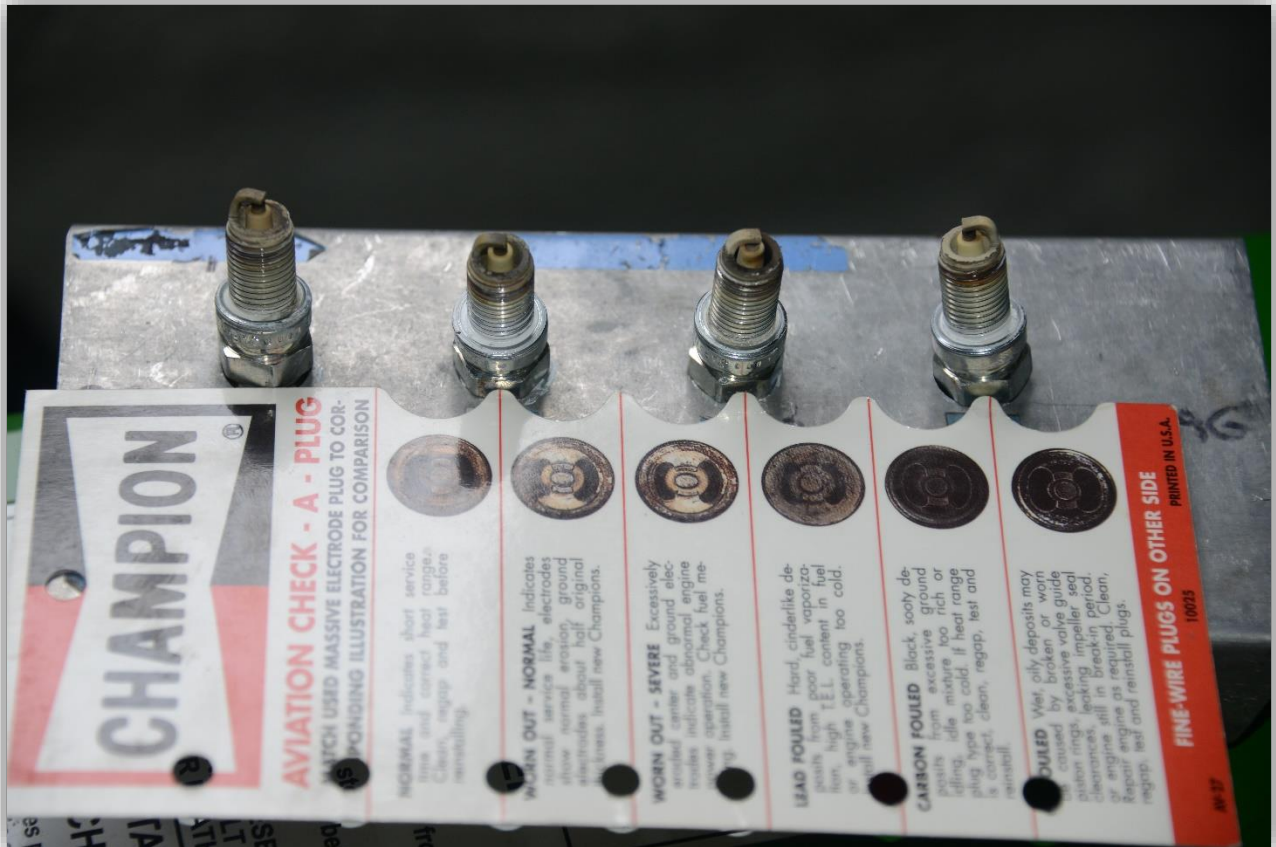
The aircraft sustained frontal impact damage to the engine cowling, propeller spinner, nose landing gear and the left hand wing. One of the two propeller blades was broken off at the hub. Both wings had been removed by the owner and placed on the hanger floor behind the aircraft.



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Detailed Inspection

Spark Plugs: The top spark plugs were removed from engine and inspected for condition and conformity. The lead build up on the spark plug electrodes indicated the engine had previously operated AV-GAS. No anomalies were found with the top spark plugs of the engine.



Continuity check & Thumb Compression: With the top spark plugs removed, a continuity and thumb compression check was done. During rotation of the engine by the propeller hub, continuity and thumb compression was established. No anomalies were found during the continuity and thumb compression check.

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Detailed Inspection

Ignition System: The ignition system was physically examined for condition (not tested at this time). No anomalies were found.

Fuel system: The Rotax 912iS Installation manual states the following: **NOTICE** - The design of the fuel system is the responsibility of the aircraft manufacturer, who has to make sure that the applicable building regulations are complied with and the technical implementation on the aircraft side is ensured. The fuel system must be designed to ensure that the engine is supplied with sufficient fuel at the correct pressure in every operational situation. Operating limits must be adhered to!

The fuel delivery is provided by two electric pumps connected in series with bypass valves and engine will operate with either one or both pumps running. The system has to allow both fuel pumps to be tested separately. There are 2 injectors per cylinder (8 in total). During engine run both injectors per cylinder are in operation. If a failure is detected in any one injector the injection period of the other one on the same cylinder is adjusted to compensate this failure. The ECU controls all fuel injectors. A single blocked injector will be compensated automatically. If a failure in a fuel injector occurs, this will be reported to the ECU and the pilot will be informed via the instrument panel. The representation of components that are not included in the scope of engine delivery is purely symbolic. It does not constitute a specification of the version and shall therefore only be seen functionally. The actual interpretation / selection of the corresponding regulations and characteristics is the task of the aircraft manufacturer.

NOTE: The switching between several fuel tanks at power loss due to fuel shortage must be given within a defined period of time and without falling below the minimum performance limit and must be ensured by the aircraft manufacturer. Refer to the latest requirements such as FAR or EASA.

The aircraft's fuel system was examined for any anomalies. The aircraft's fuel tanks are built into the LH and RH wings. Since the aircraft's wings were previously removed by the owner, the fuel system was not completely intact. The fuel lines that connected to the wing tanks were transparent and 6.5x11 mm in size with quick disconnect couplers attached. The aircraft's fuel system incorporated two small header tanks that were located behind the pilot and passenger (L/H & R/H) seat in the fuselage. Below each header tank was a paper style fuel filter in a transparent casing. Both fuel filters were examined and found to be clear of any obstruction.

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Detailed Inspection

Fuel system Continued:



The fuel system was examined for any obstruction by blowing air through the fuel lines. No obstructions were noted. A small fuel sample was collected from each wing and tested for water with the use of water finding paste. No evidence of water was found within the fuel contained in the sample bottles. The gascolator bowl had been previously removed by the FAA inspector. Fuel was still contained within the gascolator bowl and it was tested for water with water finding paste. No evidence of water was found in the fuel that was contained within the gascolator bowl.

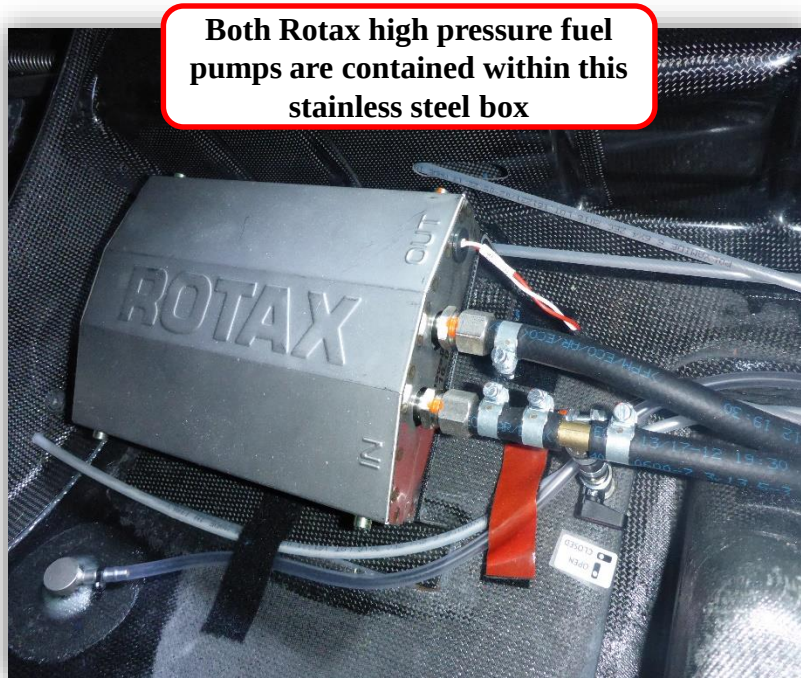


The wing tank fuel venting caps were examined and tested for any obstruction. The fuel tank vent caps were free of obstruction and no anomalies found.

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Fuel system continued: The Rotax 912iS comes from the Rotax factory with two high constant pressure, electronic fuel pumps that are connected in series with bypass valves. The engine will operate with either one or both pumps running simultaneously. The fuel pressure of the engine is adjusted by a mechanical pressure regulator. The pressure regulator is installed in the fuel line after Cyl. 4. The reference pressure of the fuel system is the airbox pressure. The operating limit of the fuel pressure must be maintained at the inlet of the fuel pressure regulator. The fuel pumps were tested by turning them both on and by pumping fuel through them. Both fuel pumps operated normally and no anomalies were noted.



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Lubrication System: The Rotax 912iS is equipped with a dry sump, forced flow lubrication system. The standard Rotax oil system consists of the following components:

- Dry sump oil Tank
- Trochoid oil pump
- Oil Cooler
- Fire sleeved oil lines
- Oil filter

The lubrication system was examined for condition, conformity and modifications. The oil was returned from the engine to the oil tank by rotating the engine by the propeller. The oil level was checked and found to be slightly over filled. The oil system incorporated an aftermarket oil thermostat that is commonly found with aircraft that are operating in colder climates and temperatures. The oil cooler was found to be undamaged and the entire lubrication system was in good condition with no anomalies found.

Rotax Oil tank



Aftermarket Oil thermostat



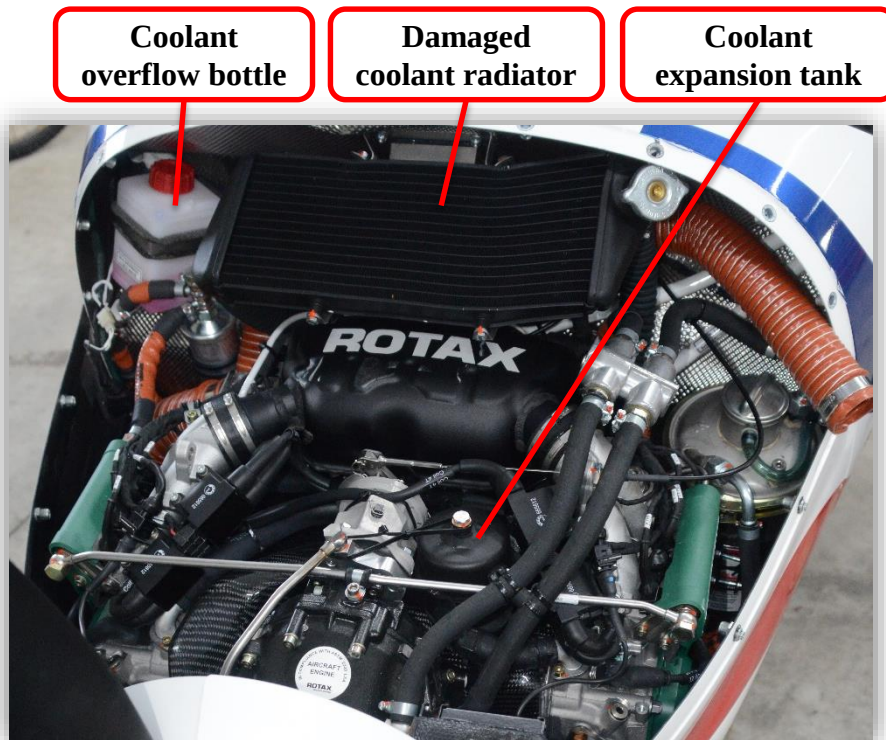
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Detailed Inspection

Cooling system: The Rotax 912iS cylinder heads are liquid-cooled. The coolant is pumped through the system by the water pump that is driven by the camshaft from the radiator to the cylinder heads. The Rotax 912iS cooling system normally consists of the following:

- Expansion tank
- Overflow bottle
- Radiator
- Water pump
- Rubber Coolant lines

The coolant system was examined for condition, modifications and conformity. The only damage found to the coolant system was on the coolant radiator located on top of the engine. This damage was caused from impact, however the system was not breached and no loss of coolant was noted. No anomalies were found with the coolant system.



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Extraction of ECU and Dynon data

The Rotax 912iS engine comes equipped with an engine control unit (ECU) that captured and recorded engine parameters at the time of the loss of engine power and forced landing . The ECU data was downloaded and saved for future analyses.



The aircraft is equipped with a Dynon flight instrument that also captured and recorded engine parameters at the time of the loss of engine power and forced landing. The Dynon unit was removed from aircraft and sent to the NTSB lab for data extraction.



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Preparing the engine for removal

Due to the damage the aircraft sustained during the forced landing, an engine test run could not be accomplished during the on-site investigation. The wreckage was then relocated to an aircraft repair station to have the engine and its components removed and shipped to a Rotax test facility in Vernon B.C. Canada.

The list of components shipped to the Rotax test facility are as follows:

- Rotax 912iS Fuse Box
- Rotax 912iS ECU
- Rotax fuel pumps
- Rotax oil tank
- Oil coolers and oil lines
- Pipistrel engine ring mount
- Pipistrel exhaust system



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Engine test run

The Rotax 912iS engine was received by the Rotax test facility in Vernon B.C. Canada and placed in quarantine until NTSB oversight could be arranged. NTSB Air Safety Investigator Michael A. V. Hicks provided oversight of the engine test run and data analysis on July 31st 2018. The Rotax 912iS was removed from the shipping box and configured for the Rotax engine test stand.



Fuel injection rail housings



This configuration consisted of changing fuel injection rail housing, water pump housing, propeller governor and engine mount. The ignition wiring harness was not shipped with the engine, therefore a new 912iS ignition wiring harness was installed.

One of the two oil coolers was damaged from impact and was required to be removed from the engine for test run purposes. The top spark plugs were removed and the engine was rotated by hand to return all the oil contained within the engine case back to the oil tank. The oil and Rotax oil tank was inspected and found to be clean and clear of debris.

Damaged oil cooler



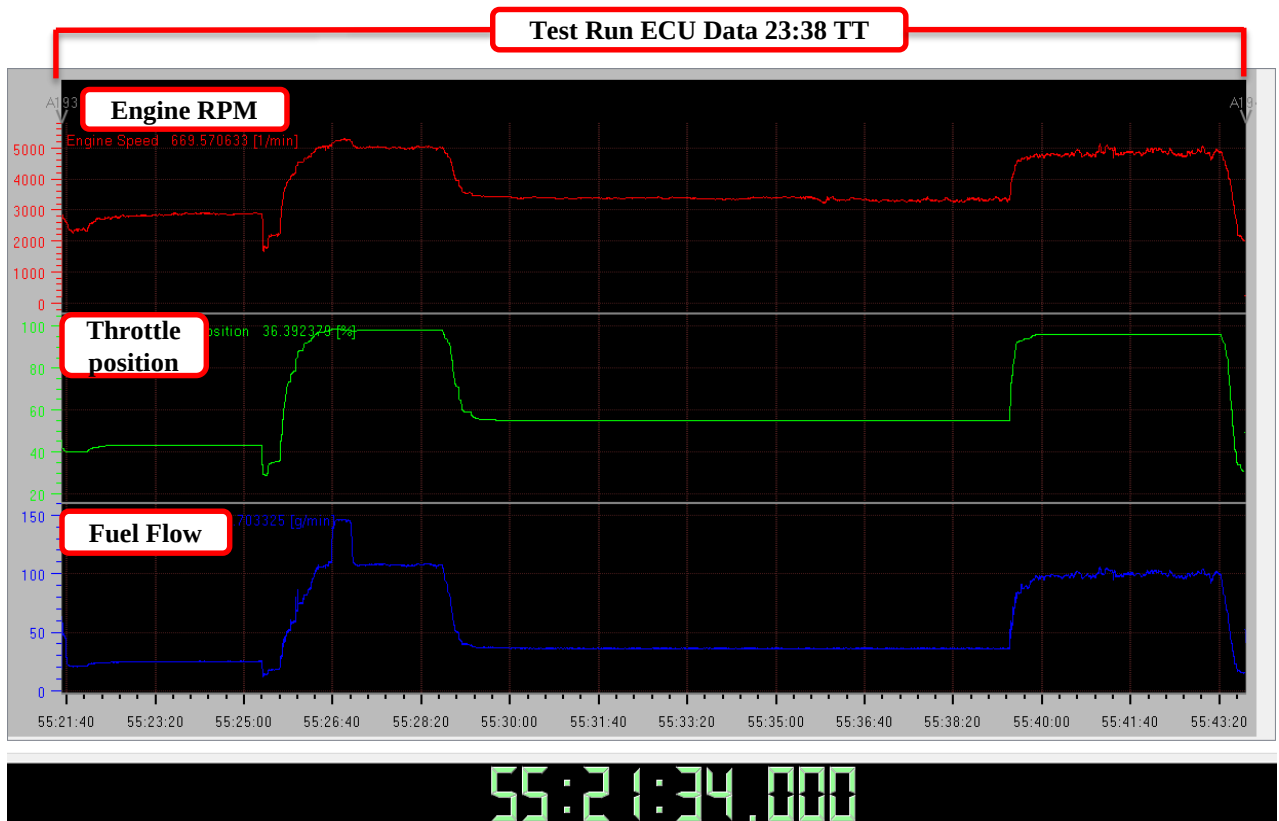
Oil tank



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Engine test run data (1st test run)

A calibrated test propeller was installed on the 912iS accident engine for the test run. The coolant system, oil system, fuel system, ignition systems and wiring harness were connected to the Rotax 912iS engine and test stand. The engine was then started and ran at idle for several minutes until the operating temperatures were within normal operational range. The first engine test run lasted approximately 23 min and 38 seconds. Below is the engine parameters graph that was captured by the accident engine ECU. This graph shows engine RPM, Throttle Position and Fuel Flow for the duration of the engine test run.



The engine was ran at various RPM settings:

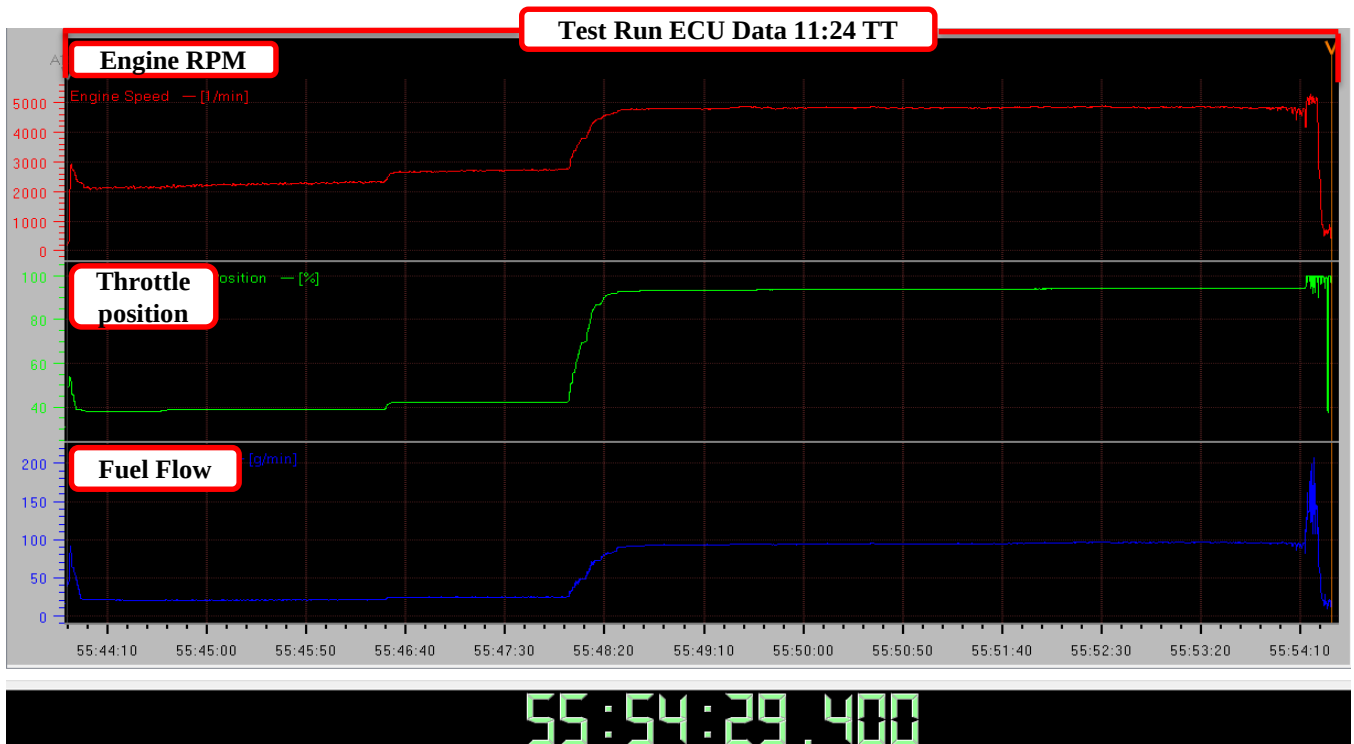
- Idle Throttle – Approx. 2500 RPM for 4 min
- Advanced Throttle – Approx. 5000 RPM for 4 min
- Reduced Throttle – Approx. 3300 RPM for 10 min
- Advanced Throttle – Approx. 4800 RPM for 4 min
- Shut down.

During the first test run, no anomalies were noted and all engine parameters were normal.

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Engine test run data (2nd test run)

A second engine test run was conducted with reduced amount of fuel in fuel tank. The purpose of this second test run was to see how the 912iS would react when it was ran out of fuel and to see what the ECU data would indicate. The second engine test run lasted for approximately 11 minuets and 24 seconds.



The engine was ran at various RPM settings:

- Idle Throttle— Approx. 2200 RPM for 3 min 30 seconds
- Advanced Throttle – Approx. 2800 RPM for 1min 30 seconds
- Advanced Throttle – Approx. 4800 RPM for 6 min 25 seconds
- Engine Shut down due to fuel starvation.

During this second test run, no anomalies were noted and all engine parameters were normal until engine began to run rough due to running out of fuel. A video recording was done during this second test run.

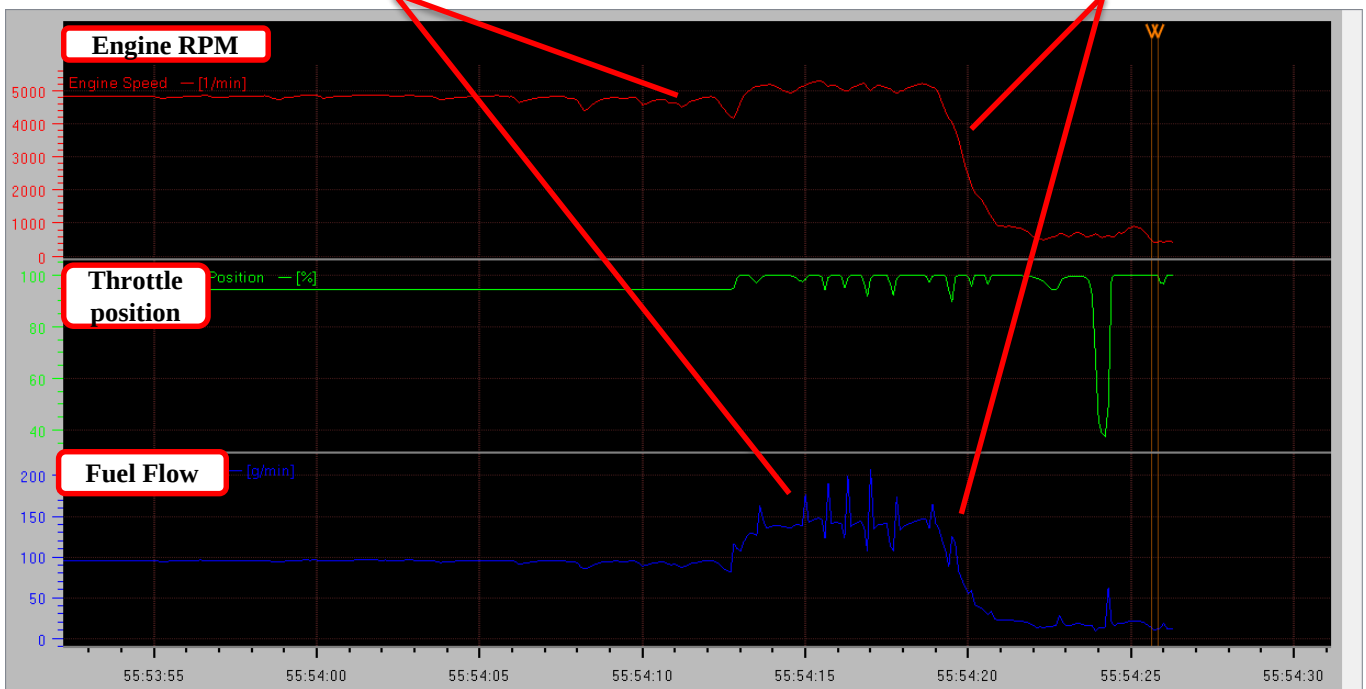
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Engine test run data (2nd test run)

Approximately 10 min and 44 seconds into the second engine test run, the ECU data shows the engine begin to run rough as the RPM and fuel flow begin to fluctuate for approximately 19 seconds until a reduction of RPM and fuel flow is seen. The RPM begins to drop from 5206 RPM to 515 RPM over a 7 second time span. The throttle position remained fairly consistent between 94% and 100% throughout this loss of power sequence, until it was manually manipulated following the drop in RPM. Manipulation of the throttle lever did not make any changes to engine parameters.

Fluctuation in Engine RPM (Engine begins to run rough) and fluctuations and spikes in fuel flow

Drop in RPM and fuel flow

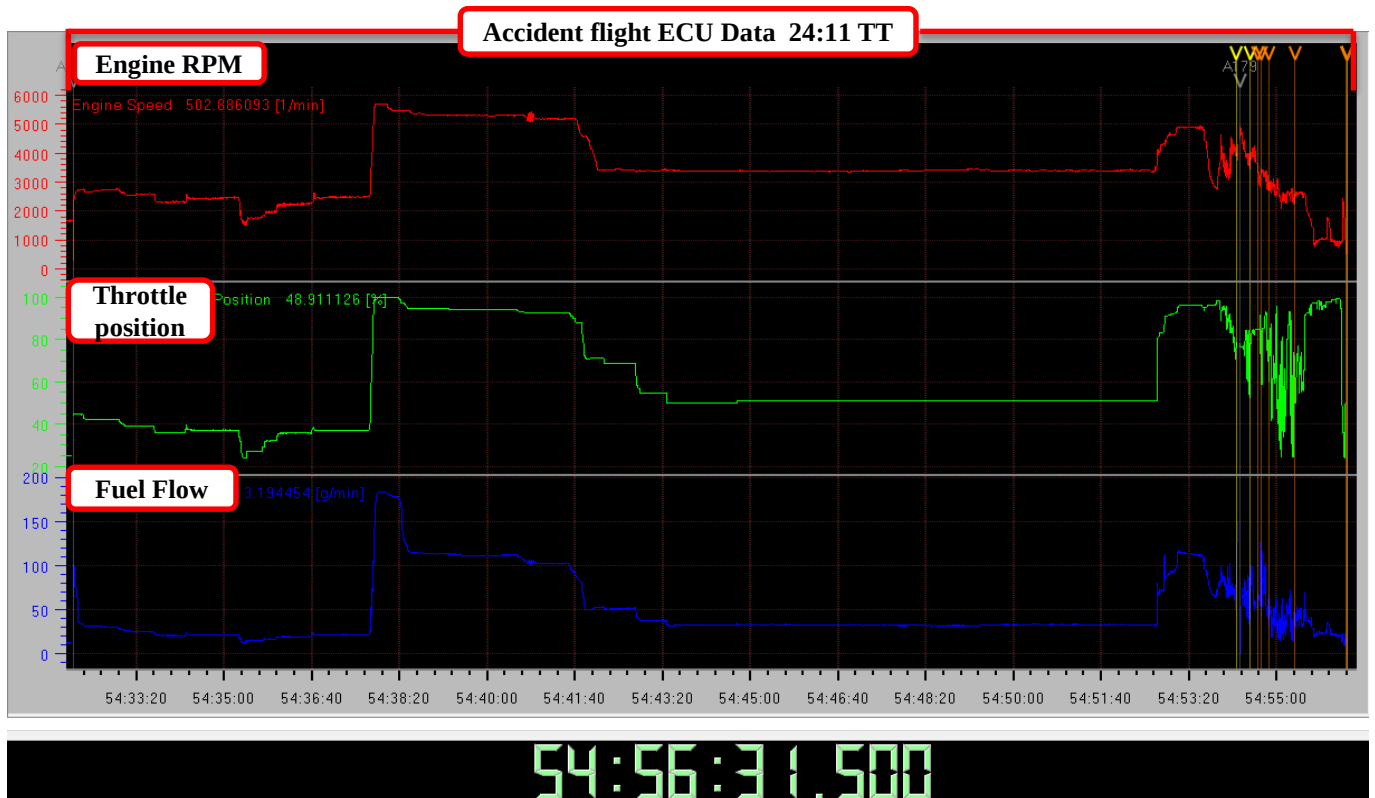


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Analyzing Accident ECU Data

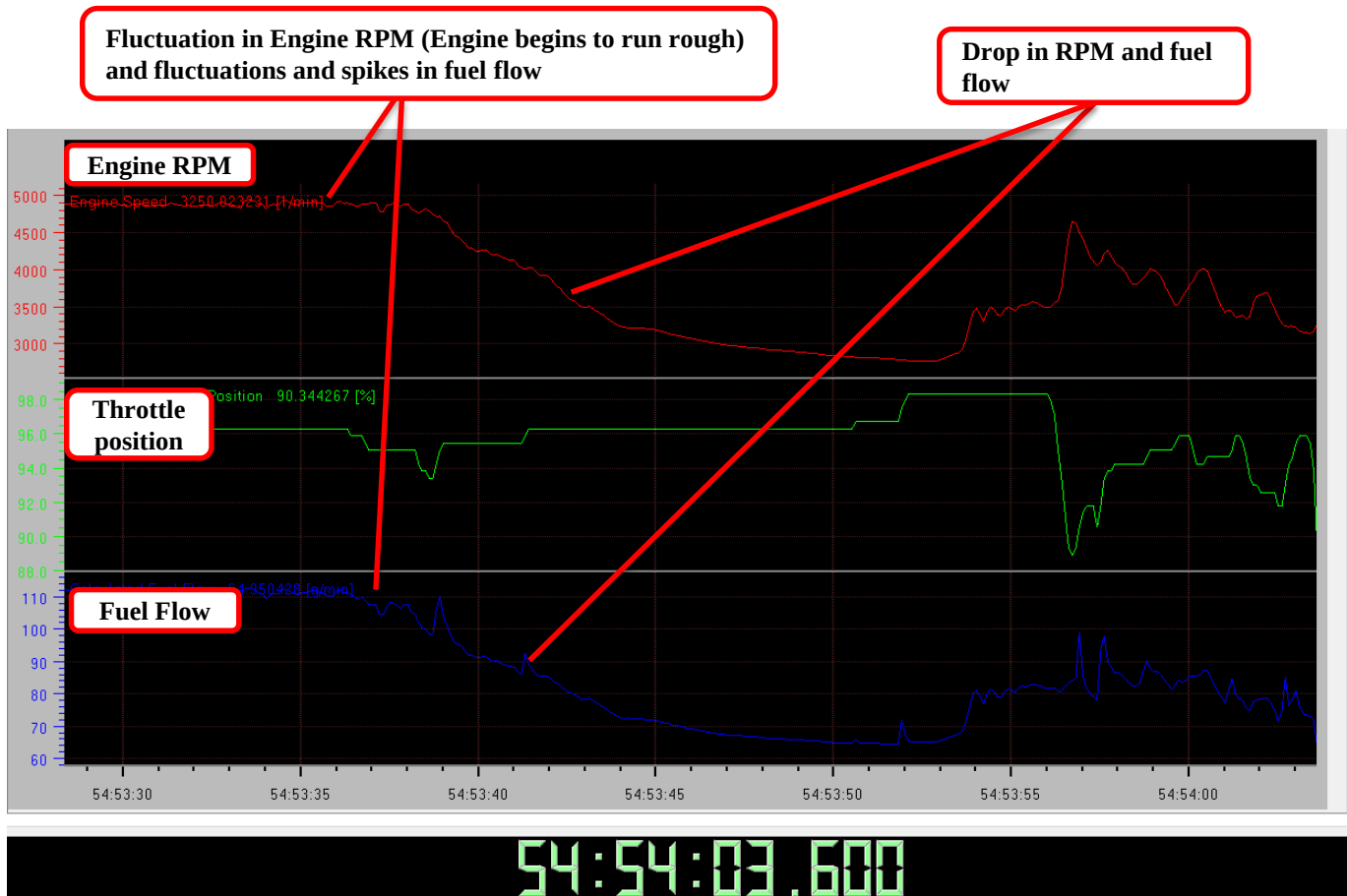
Based off the accident ECU data, it was determined the Rotax 912iS engine ran for approximately 24 min and 11 seconds during the accident flight.



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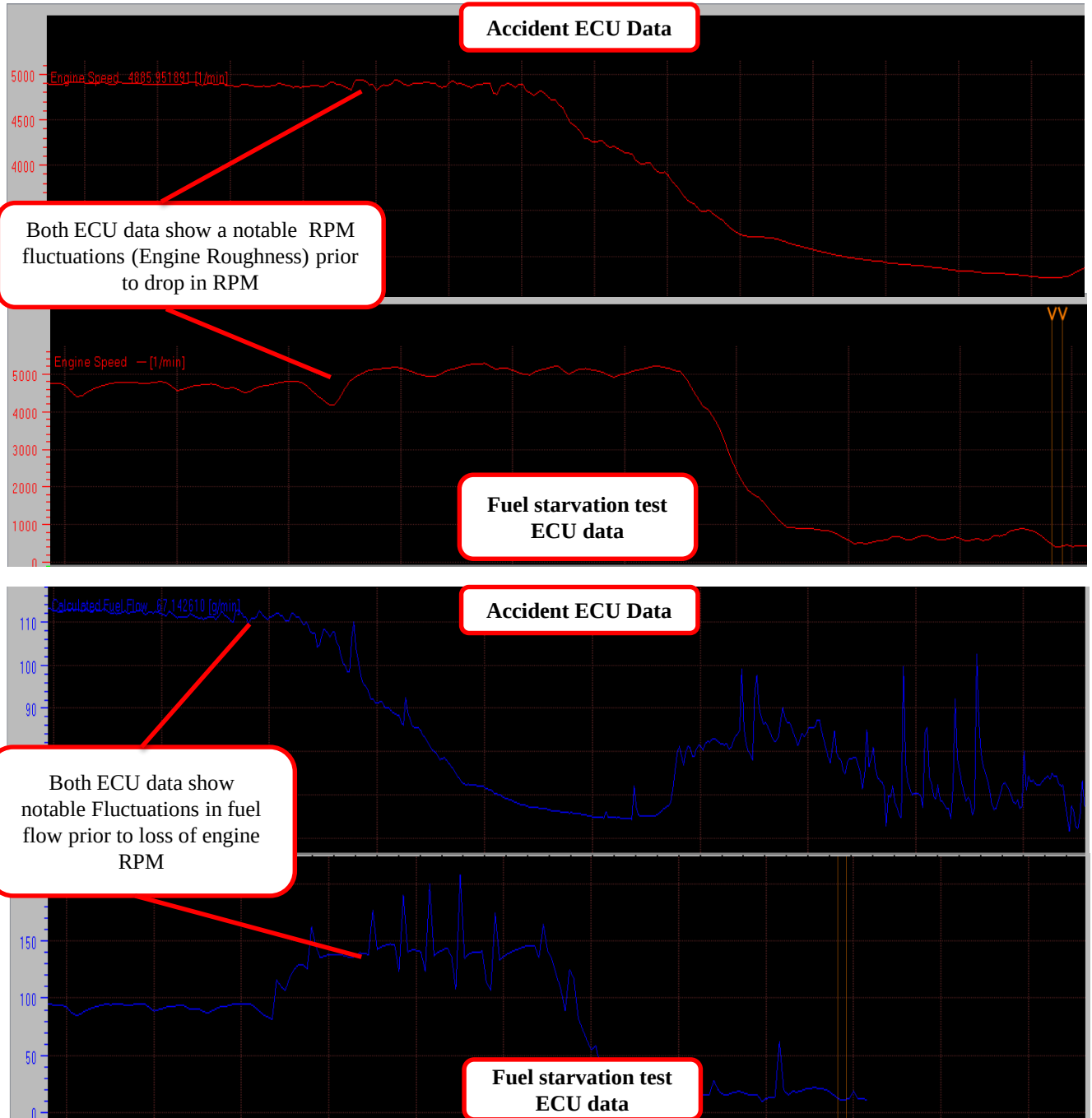
Approximately 21 minutes into the accident flight, the ECU data shows the engine begin to run rough as the RPM and fuel flow begin to fluctuate for approximately 6 seconds until a reduction of RPM is seen. The RPM and fuel flow begin to drop from 4892 RPM to 2766 RPM over a 15 second time span and the throttle position remained fairly consistent between 93% and 96% throughout this loss of power sequence.



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Comparing ECU data

Both the accident ECU data and the fuel starvation test ECU data were compared to each other. Similarities can be seen with the data as RPM show notable fluctuations in engine RPM and fuel flow just prior to drop in RPM.



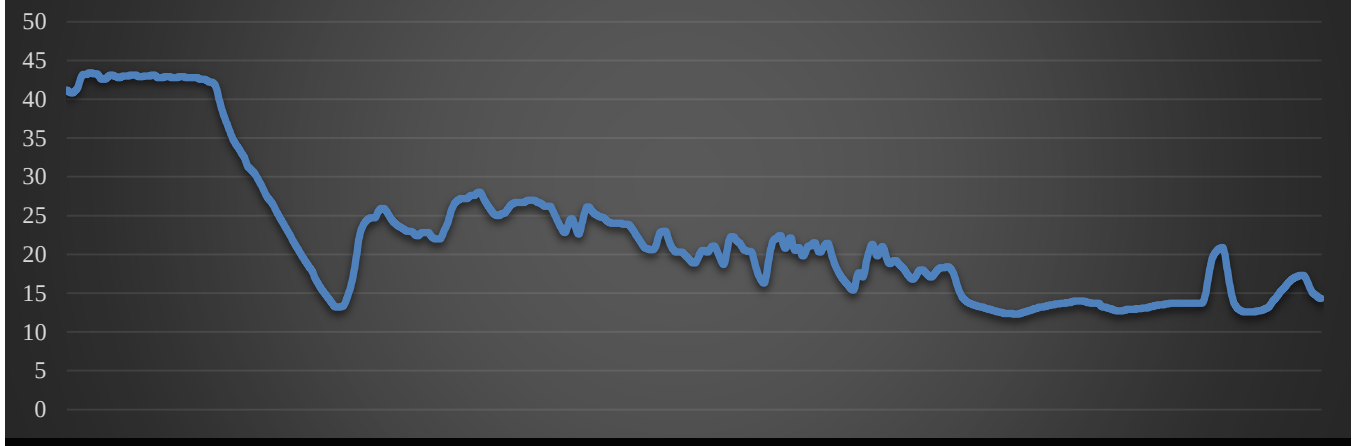
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Comparing Dynon fuel pressure data

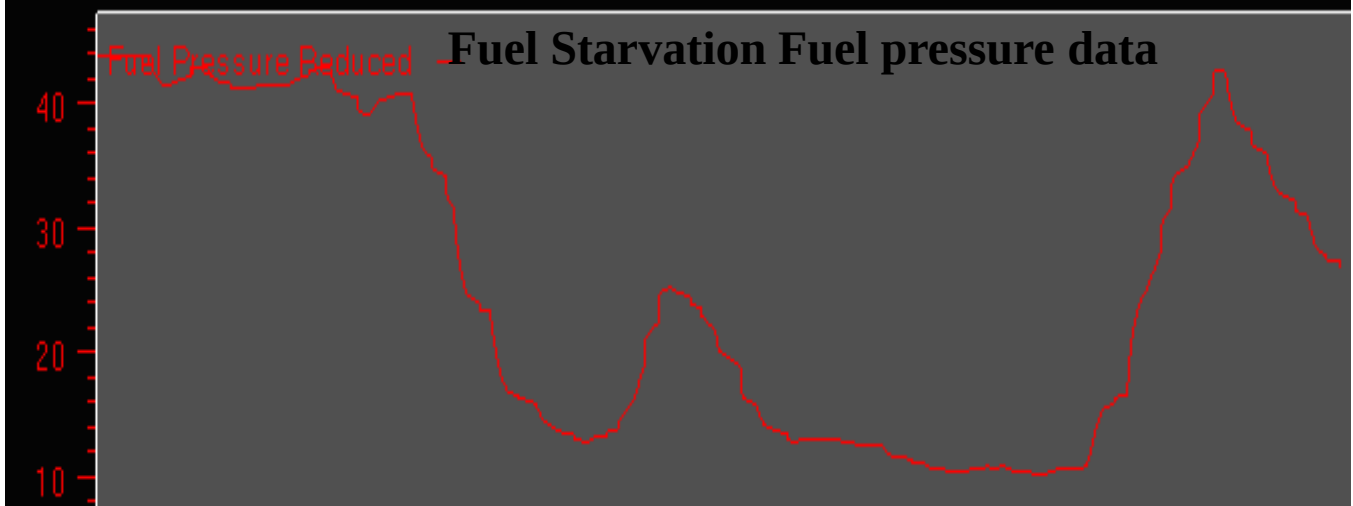
Monitoring and recording of the fuel pressures is done through the Dynon instrument that was installed in the accident aircraft. The accident flight fuel pressure data was analyzed and compared with the fuel pressures taken during the fuel starvation engine test run.

As shown below, there is a notable drop in fuel pressures on both the accident flight data and the fuel starvation test run data. Both the accident flight data and fuel starvation test run data have similar indications and pressure drop following a rise.

Accident Aircraft Fuel Pressure



Fuel Starvation Fuel pressure data

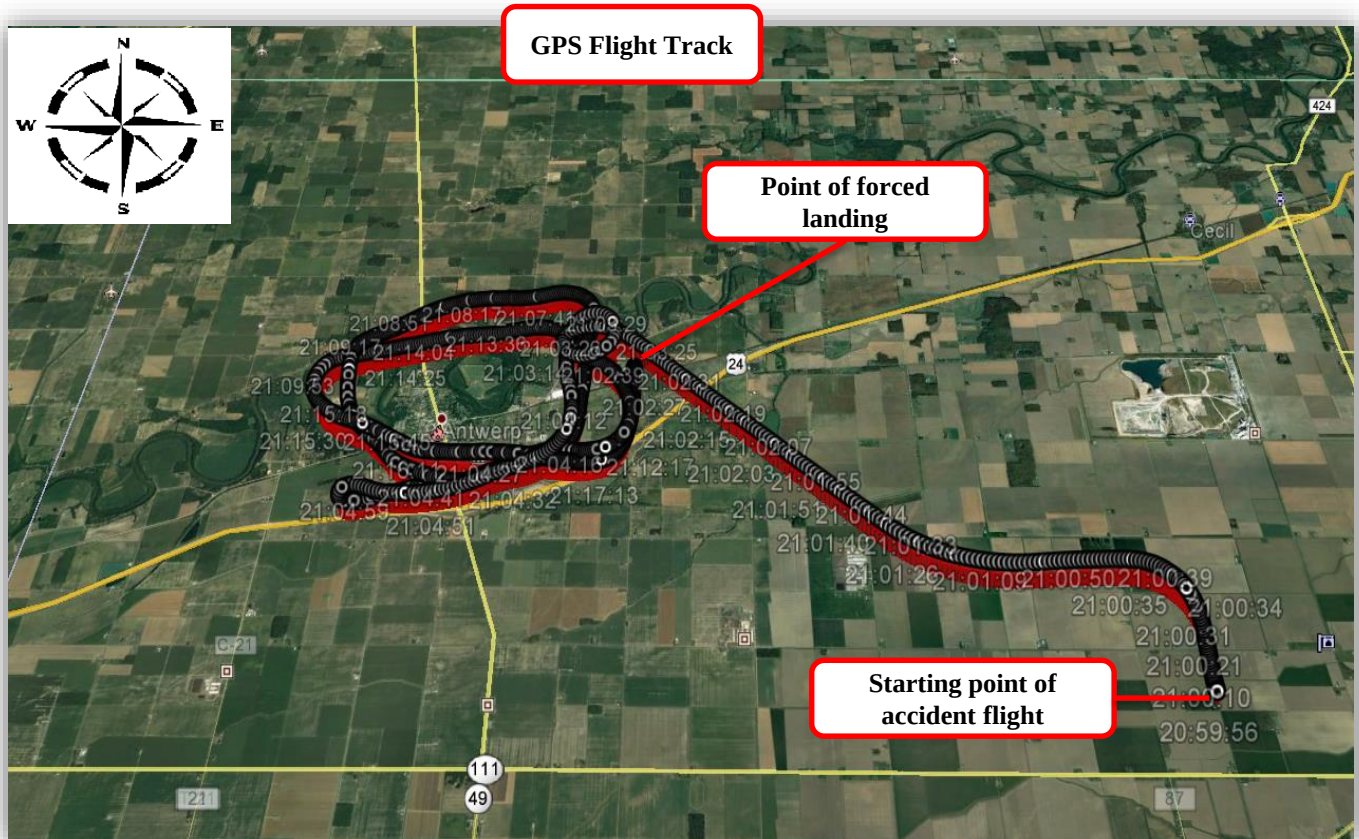


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Analyzing GPS Data of accident flight

The aircraft's GPS was able to track the accident flight from the point of take-off to the point of the forced landing. This GPS data was used in conjunction with the engine ECU data to determine the point of fluctuating engine RPM (Engine roughness) and loss of engine RPM/power.

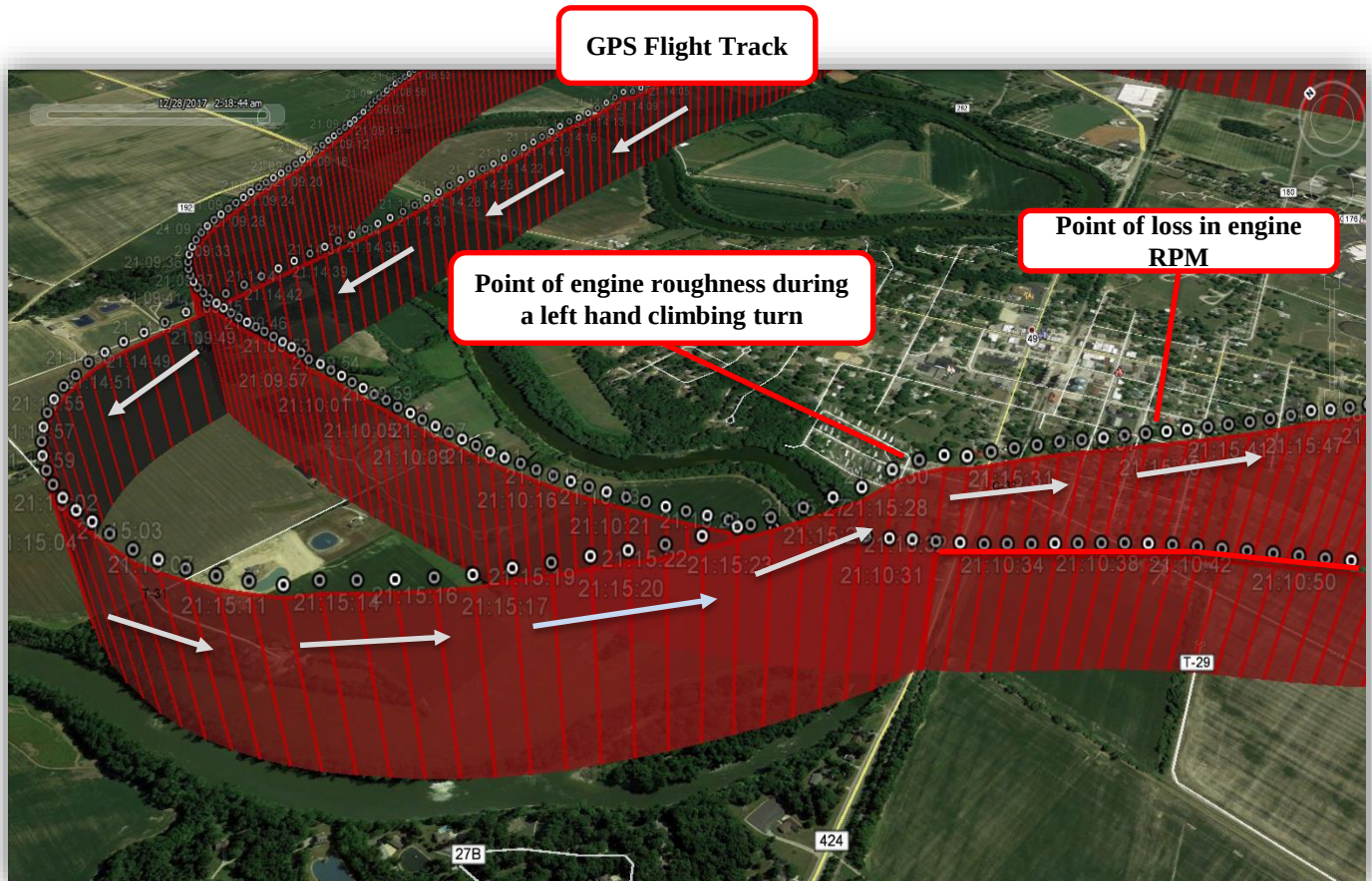
Following the point of take-off the aircraft ascended and made multiple left hand turns with multiple altitude changes. From the point of take-off to the forced landing was approximately 19 minutes.



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Analyzing GPS Data of accident flight

The aircraft was heading South East in a left hand climbing turn when the engine began to loose power following fluctuations in engine RPM (Engine running rough).



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Summary

- No anomalies were found during the initial investigation of the aircraft and Rotax 912iS engine in the owner's hanger on February 14, 2018.
- No anomalies were found during the initial 912iS engine test run at the Rotax testing facility in Vernon B.C. Canada that took place on July 31st 2018. The initial test run time was approximately 23 min and 38 seconds long. All engine parameters were normal during this test run until it was manually shut down.
- No anomalies were found during the 2nd 912iS engine test run (Fuel starvation test) at the Rotax testing facility in Vernon B.C. Canada, that took place on August 1st 2018. The 2nd 912iS engine test run time was approximately 10 min and 44 seconds long until the Rotax test stand exhausted all its fuel. All engine parameters were normal during this test run and the engine acted accordingly once the fuel in the test stand was exhausted (Ran rough, fluctuating RPM, fluctuating fuel flow, loss in RPM).
- Accident engine parameter data (RPM, Fuel Flow, Fuel Pressure) captured from the accident aircraft showed similarities with the fuel starvation test data. These similarities indicate a possible fuel flow interruption or fuel exhaustion to the 912iS accident engine during the L/H climbing turn.
- Statements made by the pilot following the accident indicate he was unsure about the amount fuel onboard the accident aircraft during the time of the accident. The pilot stated to the NTSB in an e-mail: **“After a great deal of thought, I am very upset about the time wasted trying to read the fuel gauges (sight tubes for fuel overhead in the Virus airplane). Years of flying would say to check the fuel quantity at a loss of power with no other indication is the lack of fuel. In-flight with the engine running rough, it is virtually impossible to read the site gauges late in the day with us unload in the west. Neither the left nor the right sight gauge was readable.”** Having flown the BD/Grumand single engine aircraft for many hours their site gauge with the contrasting color little bead in the sight tube is a huge improvement compared to looking for the meniscus of the fuel. From the Dictionary is the definition of meniscus ((physics) the curved upper surface of a non-turbulent liquid in a vertical tube). The keyword here I feel is non-turbulent.”
Jack (J. H. Webb)”