Rotax® 912 iS Single Lever Propeller Governor System

Would you drive your car in first gear on the highway?

If you fly a fixed pitch propeller, that is exactly what you are doing in cruise flight.

Would you like to change that?

We have a solution by reducing complexity.
In-Flight Adjustable Variable Pitch Propeller – Why?

- A fixed pitch propeller may not work well on a particular airplane - varying the blade pitch requires propeller exchange.

- Ground adjustable propellers are more flexible and allow a certain degree of optimization by changing the blade pitch based on flight test results.

- In general, all propellers which are not in-flight adjustable are a compromise between take-off and climb performance (power) and cruise flight (speed, endurance). They cannot work at maximum efficiency in both flight regimes.

- Propeller thrust for take-off and climb can be up to 30% higher if the propeller blade angle is perfectly adjusted at all times.

- Only in-flight adjustable propellers allow to optimize power, speed and economy at the same time.

- An in-flight adjustable propeller for LSA should be controlled automatically and not require operation by the pilot.

- An automated blade pitch control system for LSA must provide a 100% fail-safe behavior at all times.
From 3-Lever Engine Control to Single Lever Engine Control

- Traditional engine cockpit controls for aircraft equipped with constant speed propellers consist of power, propeller and mixture levers (3-lever control).

- The Rotax® 912 iS engine eliminates the need for manual mixture control, which is automatically done by the Engine Control Unit (ECU).

- The fully automatic governor control system as discussed here also eliminates the need for manual RPM control. The result is a true single lever control for the aircraft power plant, reducing the pilot's workload during all phases of flight, and optimizing the engine fuel consumption.
System Overview
Rotax® 912 iS Aero Engine

- Fuel injection and ignition of the 912 iS is controlled by a duplex redundant Engine Control Unit (ECU) that uses two individual sets of injectors/sparc plugs per cylinder.
- The ECU controls the fuel/air mixture and the ignition timing electronically to optimize fuel consumption and engine performance. The ECU also monitors all engine parameters continuously.
- The 912 iS engine is accompanied by secondary systems:
  - Engine Control Unit (ECU)
  - Fuel Pump Module
  - Fuse Box (electric energy management)
Rotax® 912 iS System

- There is no access to individual 912 iS engine sensors for the cockpit.

- A dual redundant CANaerospace data bus provides a large amount of information for the cockpit instrumentation, which exceeds that of the original 912 (S) engine by far.

- The only way to provide the pilot with the 912 iS engine parameters is an electronic cockpit display unit, which interfaces to the redundant CAN data bus system using the CANaerospace data protocol.
EMU 912 iS evo Overview

- The Engine Management Unit (EMU 912 iS evo) has been designed along with the Rotax® 912 iS engine and test flown in many airplanes and gyrocopters.

- It makes full use of all resources available with the dual redundant CANaerospace data buses and provides the pilot with an unprecedented level of awareness about engine status and performance.

- The EMU 912 iS evo Start Power function provides “912 S style” engine start and handling.

- Flight tests included operation at temperatures as low as -18 deg. C and altitudes as high as 18,000 ft.

- Integrated data recording and computer tools support post-flight data analysis.
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EMU 912 iS evo Advanced Display Functions

- The EMU 912 iS Main Display Page provides the 912 iS pilot with advanced 21st century features:
  - Quick information at a glance: All green means “don't care”.
  - Assistance for cold start throttle settings.
  - Immediate information about fuel economy (ECO = lean, POWER = rich).
  - Realtime information about the computed fuel flow.
  - Information about the status of the redundant ECU lanes (lane in control, lane with detected warnings/failures).
  - Manifold pressure or Power Margin Indicator as second instrument, complementing engine RPM.
  - External interface to control electrically operated constant speed propeller governors.
  - The EMU 912 iS evo is the LSA pilot's friend!
Rotax® 912 iS MT Propellers

- 2-blade (MTV-33-1-A/175-200) and 3-blade (MTV-34-1-A/175-200) composite propellers with a rated power of 115 HP.

- Scimitar blade shape for high performance and noise reduction, stainless steel leading edge for all weather operation.

- Same technology as used on regional airliners and unlimited aerobatic aircraft.

- 69” diameter, 912iS vibration approved.

- Total weight 14.3 lbs (2-blade) or 19.8 lbs (3-blade).

- EASA certified, FAA certification pending.

- Ground adjustable; alternatively driven by MT Propellers P-853-12R hydraulic constant speed governor (weight 2.2 lbs).
Electrically Driven Hydraulic MT Propeller Governor

- The P-853-12R hydraulic constant speed propeller governor has been specifically designed for the Rotax 912iS engine.

- RPM control of the P-853-12R is accomplished through an electric DC motor which can be driven by the EMU 912iS evo.

- The combination of the MT governor and the EMU 912 iS evo allows to provide true single lever operation for Rotax® 912 iS equipped airplanes.

- MT Propeller and Stock Flight Systems teamed up in January 2013 to develop the single lever control system.

- The entire system (engine, propeller, governor, EMU 912 iS evo) presently undergoes a flight test program and will be available in Q4/2013.
Increasing Flight Safety for Rotax® 912 iS equipped LSA

The advanced technology offered by the Rotax® 912 iS engine, the MT Propeller with hydraulic governor and the EMU 912 iS constitute an excellent basis for the development of new features to increase flight safety:

- Think about an instrument informing the pilot in real time about the actual and available engine power;
- Then, consider to use this information to automatically adjust the propeller blades, so that the optimum thrust is available for takeoff and climb, while speed and fuel consumption is optimized during cruise.

With the Rotax® 912 iS being a normally aspirated engine, the available power can easily be reduced by 30 - 50% under unfavorable environmental conditions (low ambient pressure, high ambient air temperature).

- The only way to compensate for this natural problem (without installing a turbo charger) is an inflight adjustable, variable pitch propeller.
- The difference is significant; it is similar to comparing the Piper PA 28-140 (140 HP) to the Piper PA 28-200 (200 HP).
Governor Control System

- The P-853-12R hydraulic governor is controlled through the EMU 912 iS which employs the engine data delivered by the ECU via the CANaerospace data buses.
- The throttle lever still has a mechanical link to the butterfly valve; No change here!
- The system is powered through the aircraft electric DC bus, but uses a backup power source to avoid a loss of RPM control the effect of electrical system malfunction.
- Under no circumstances will the RPM be outside the aircraft specific safe range due to the adjustable internal mechanical limits of the governor.
Closed Loop RPM Control

- Engine/Propeller RPM is precisely adjusted through the closed-loop control algorithm.
- The actual RPM is delivered by the ECU, while the desired RPM is computed within the EMU 912 iS evo using a complex control law.
RPM Control Law

- Throttle Position, Engine Power State
- Manifold Pressure and Temperature
- Ambient Pressure and Temperature
- Actual RPM, Fuel Flow
- .......

- The Control Law uses several multi-dimensional fields to compute the desired RPM from many engine parameters.

- The data to design the control law transfer functions stem from engine/propeller test stand and flight test data.

- The control law does not only compute the desired RPM, but also actual and maximum engine power.
Rotax® 912 iS Single Lever Propeller Governor System

Tips & Tricks:

- The power margin may be displayed together with engine or propeller RPM instead of Manifold Pressure.

- The Power Margin Indicator (PMI) informs the pilot about the difference between maximum available engine power and the actual power at any given time.

- The PMI display makes use of the computation results from the governor control law.
Power Margin Indicator Display

- **Pointer**: actual engine power in per cent
- **Green arc**: maximum available engine power
Power Margin Indication Examples

- Cold & Low: Large spread between actual and maximum power (here: 92.0 % - 67.0 % = 25 %)

- Hot & High: Small spread between actual and maximum power (here: 73.4 % - 65.4 % = 8 %)

- The PMI provides enhanced situational awareness for the pilot with respect to the available engine power under the naturally varying environmental conditions (think hot & high)

- The PMI is a safety feature!
Governor Test Stand

- The proper function of the governor closed loop RPM control was verified on the propeller governor test stand of MT Propeller in Straubing/Germany.

- The mechanical control limits of the governor were set to the minimum and maximum safe values for the selected test aircraft (4300 RPM and 5800 RPM, respectively).

- For the selected test airplane, these values are equivalent to a minimum propeller RPM of 1770/min and a maximum propeller RPM of 2387/min (The Rotax® 912 iS has a 1 : 2.43 reduction gear).
The installation of the P-853-12R governor is very similar to its standard (mechanically operated) equivalent.

Instead of the traditional pushrod, an electrical cable is routed from the governor to the cockpit (that is, to the EMU 912 iS evo).

No other installation is required firewall forward for the P-853-12R governor.
Tecnam P92 Flight Test Aircraft

- Flight Test Aircraft equipped with Rotax® 912iS and EMU 912 iS evo.
- P-531-12R governor and MTV-34-1-A/175-200 propeller installed.
- Flight test in progress, to be continued until Q4/2013.
The combination of the Rotax® 912 iS engine, electrically controlled MT propeller and EMU 912 iS evo brings enhanced flight safety and 21st century engine management technology to the world of Light Sport Aircraft:

- Single lever control of engine power and thrust;
- 100% fail-safe behavior through mechanical limitations;
- Real time adjustment of engine and propeller parameters:
  - maximum thrust during take-off and climb and
  - maximum efficiency and endurance during cruise flight;
- Up to 30% more thrust compared to fixed-pitch propeller;
- Fuel savings in cruise flight (environmentally friendly, spend even more time in the air!)
- Improved situational awareness through revolutionary Power Margin Indicator instrument;
- Simple installation, seamless integration into the Rotax® 912 iS engine system.
In contrary to the Light Sport Aircraft (LSA) regulations in Europe, the FAA allows only fixed-pitch or ground adjustable propellers for this class of aircraft.

The reason for this rule is to limit complexity and avoid higher pilot's workload, caused by the need to manually control propeller RPM in addition to power (and mixture).

The single lever engine/propeller control system discussed here does not increase pilot's workload, however. It works without any pilot's interaction.

In contrary, the single lever control system provides optimum engine power at all times, which has a positive effect on flight safety.

At the same time, the efficiency of the airplane is greatly improved, leading to less fuel consumption and increased endurance.

Fault tolerance ensures manageable failure behavior (mechanically limited RPM range).

With the new ASTM standard for in-flight adjustable variable pitch propellers, MT Propeller and Stock Flight System actively support activities to modify the FAA LSA rules in order to embrace single lever controlled, in-flight adjustable variable pitch propellers.
Questions & Answers

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