Test&Measurement

YOKOGAWA

Case Study

How a sophisticated power analyser helped drone maker Atmos UAV accelerate motor system testing

Precision Making

ATMOS UAV

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Founded in 2013, Atmos is the manufacturer of Marlyn, the world's first drone to combine Vertical Take Off and Landing (VTOL) and forward flight in a fully autonomous flight. Marlyn combines the flexibility of a multirotor 'quadcopter' style drone with the efficiency and speed of a fixed-wing drone.

Benefiting from patented technology developed by Atmos and featuring a unique hybrid design, Marlyn safely performs airborne surveying and mapping projects in any terrain and in almost any weather. In particular, Marlyn is capable of operating safely and reliably in wind speeds up to 45km/h (6 Bft).

The hybrid rotor/fixed-wing design means that, once airborne, Marlyn can fly efficiently at high speed like a conventional fixed-wing drone. This means that, in a single flight, Marlyn can typically scan an area of 12km^2 before its batteries are discharged. By comparison, a conventional quadcopter-style drone can only scan an area of 0.5km^2 per flight.

Unlike a conventional fixed-wing drone, however, Marlyn can take off vertically and land vertically on the same spot. Conventional fixed-wing drones require a runway for take-off and landing, or inconvenient auxiliary devices such as catapults, landing pads or nets.

The VTOL capability of Marlyn means that it offers much greater flexibility when used in the field. It may be launched from almost anywhere, and all the equipment needed for a flight can be carried by a single operator in its dedicated backpack.

This superior flying performance means that surveyors can dramatically reduce flying time per square kilometer surveyed, and thus achieve higher productivity and a lower cost of operations.

Marlyn is in use worldwide today in numerous surveying, mapping and geospatial data-gathering operations by organizations in the mining, agriculture, forestry and construction industries, and by government agencies.

The Challenge

Background

In designing a high-speed fixed-wing aircraft with VTOL capability, Atmos' design engineers had to find a way to safely and reliably channel large electrical energy and mechanical force through Marlyn's rotors. As in a conventional drone, the Marlyn design is based on the use of off-the-shelf motors and motor drive circuits. But in Marlyn, these components are driven in a larger range of operating conditions than in other drones.

When motor systems do more work, they can get hotter. If the motor's or drive's operating temperature were to exceed its safety threshold, the drivetrain would be at risk of damage, shortening the drone's operating lifetime and increasing the frequency of maintenance operations.

The Atmos engineers addressed this problem in the mechanical design of Marlyn's chassis, which channels a cooling airflow over its motors and drives when airborne. This provided a known thermal dissipation capability, allowing the Atmos engineers to set a safe maximum threshold for the heat generated by power dissipation in the drone's drivetrain.

The Atmos design team then needed to select a combination of motor system and propeller that could:

- provide the required thrust in all flight modes, including take-off, cruising and landing
- and maintain a flat and safe power dissipation profile across the range of loads

To select the best combination of motors and propellers, Atmos performed detailed and exhaustive testing and modelling of hundreds of motor/propeller combinations, to measure the power dissipation in the drivetrain across all possible operating conditions and loads.

The Challenge

The professional drone market is extremely competitive, and hundreds of innovative manufacturers are continually developing and refining new products. Time to market and performance were key determinants of Atmos' success with the Marlyn product.

This meant that the set-up for motor/propeller testing had to meet the twin conditions of **speed** and **accuracy**. The engineering requirement was to measure power dissipation in the drivetrain given a known power input and a known rotor speed (rpm) measurement. The challenge for the Atmos engineers was to achieve highly accurate measurement results while keeping the test time for each motor/propeller combination as short as possible.

The Solution

Application requirements

Atmos' early attempts to perform measurements of motor/propeller combinations used readings from a temperature sensor as the basis for calculated power dissipation measurements, but this test method was slow because of the need for a temperature settling time at each new load step. Comparison of results from different motor/propeller combinations was also difficult.

Atmos required a faster test method that would provide for easier comparison of the results from different motor/propeller combinations. Evaluation of the WT1800E, a six-channel high-performance power analyser from Yokogawa, suggested that the test routine could be completed much faster while providing more accurate measurement of power dissipation in the drivetrain.

Dirk Dokter, Technical Director & Founding Partner of Atmos says:

'We performed our first tests without using a power analyser: it took over four hours to do a test for each single motor drive combination. With a power analyser, the test time fell dramatically. After fine-tuning the power analyser test set-up, the time to test a single motor fell to just 30 minutes.'

Measurement solution

Atmos used a WT1800E power analyser to take simultaneous current and voltage measurements at the motor's power supply, at the motor drive circuit and at the motor. These measurements were used to calculate power dissipation in the motor drive and the motor.

For each motor, the test routine applied simulated loads to the motor to mirror the operation of a propeller on a drone in real-world conditions, such as:

- Take-off
- Rotation from vertical to horizontal attitude, and from horizontal to vertical
- Acceleration to cruising velocity
- Cruising
- Landing

The load simulations were generated in the form of an electric brake applied to the motor. These simulations were based on the results from earlier wind-tunnel testing of all the propellers under consideration for use in the Marlyn prototypes.

Dirk Dokter of Atmos says:

'The most important question with measurement equipment is, can you trust the results it produces?
I did not have to worry about the WT1800E on this score – I had total confidence in the values displayed on screen. I know that the WT1800E was telling me the actual power dissipated.'

Results

The ideal combination of propeller and motor

Exhaustive testing of hundreds of motor/propeller combinations enabled Atmos to find the ideal design configuration for the unique range of operating conditions to which the Marlyn hybrid fixed-wing drone is subject.

The basis for Atmos' evaluation of these combinations was the accurate measurements of power dissipation provided by the WT1800E, which offers guaranteed power accuracy of 0.05% reading and 0.05% range at 50/60 Hz.

Test flights have verified the results of Atmos' simulations: the Marlyn drone's drivetrain remains within a tightly defined range of power dissipation values under all rated operating conditions, ensuring that the temperature of the key motor and motor drive components stays safely below the maximum threshold value at which they are at risk of damage.

Dirk Dokter of Atmos says:

'The Marlyn design has exceeded our expectations in terms of reliability. That's not just in normal operation – because of the results from our power dissipation testing, we know that we can produce more thrust without risk of the drive overheating. We have a safety margin over and above what's required in normal operation. That's very important for us, because our name is on the aircraft, and the Atmos brand stands for reliability and performance.'

WT1800E High-performance power analyser

The WT1800E is a high-performance power analyser which guarantees power accuracy of 0.05% of reading plus 0.05% of range. It is capable of performing harmonics analysis up to the 500th order of a 50/60 Hz fundamental frequency.

It provides up to six measurement channels to enable simultaneous electrical power measurements of up to six voltages and six currents at a sampling of rate of 2MS/s. Users may view the inputs and compare them in split-screen mode on the unit's high-resolution, 8.4" XGA display. A fast 5ms response time allows for rapid execution of complex power test routines.

Providing GP-IB, USB and Ethernet Modbus/TCP connections and a web server, the WT1800E gives engineers a comprehensive tool for power analysis which may easily be integrated with design or production software tool suites.

For more information on the WT1800E, visit **tmi.yokogawa.com**.

For more information on Marlyn and Atmos UAV, visit **www.atmosuav.com**.

About Yokogawa Test & Measurement

Yokogawa has been developing measurement solutions for 100 years, consistently finding new ways to give R&D teams the tools they need to gain the best insights from their measurement strategies. The company has pioneered accurate power measurement throughout its history, and is the market leader in digital power analyzers.

Yokogawa instruments are renowned for maintaining high levels of precision and for continuing to deliver value for far longer than the typical shelf-life of such equipment. Yokogawa believes that precise and effective measurement lies at the heart of successful innovation - and has focused its own R&D on providing the tools that researchers and engineers need to address challenges great and small.

Yokogawa takes pride in its reputation for quality, both in the products it delivers – often adding new features in response to specific client requests – and the level of service and advice provided to clients, helping to devise measurement strategies for even the most challenging environments.

The guaranteed accuracy and precision of Yokogawa's instruments results from the fact that Yokogawa has its own European standards laboratory at its European headquarters in The Netherlands.

This facility is the only industrial (i.e. non-government or national) organization in the world to offer accredited power calibration, at frequencies up to 100 kHz. ISO 17025 accreditation demonstrates the international competence of the laboratory.

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