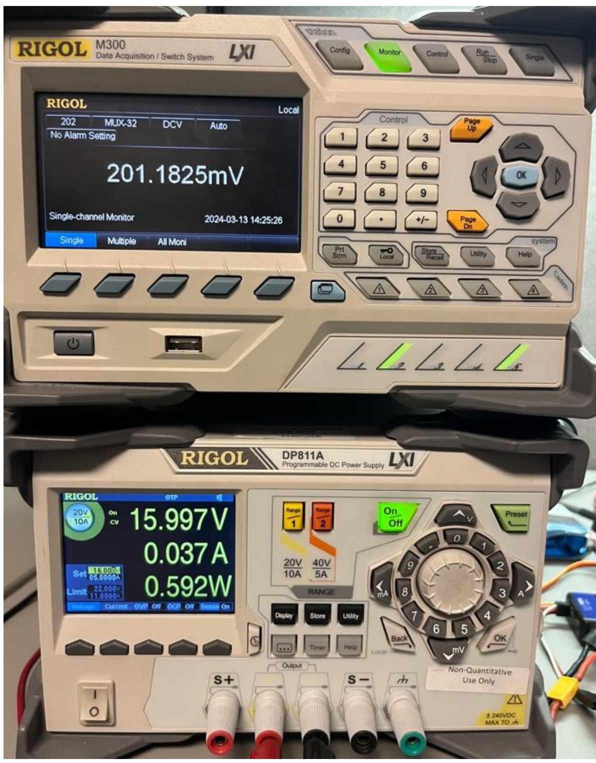
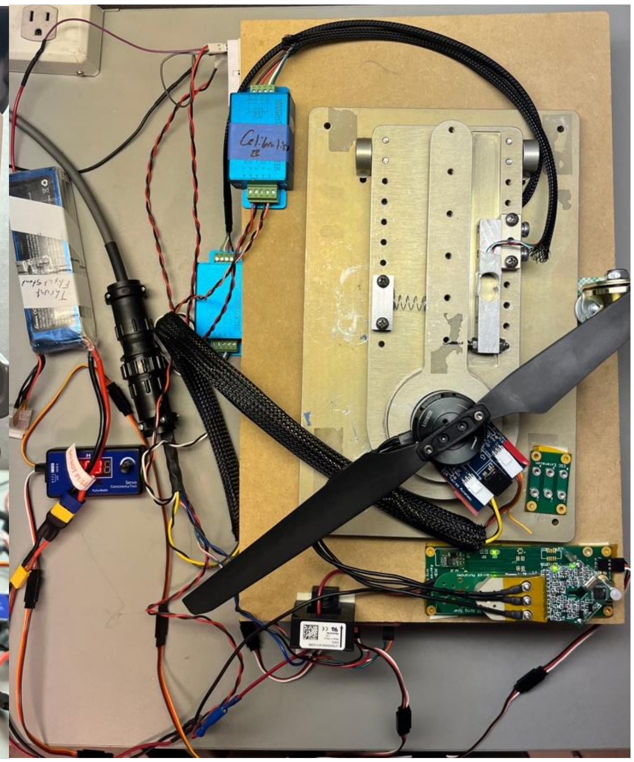
Drone Drivetrain Characterization Stand

Introduction:

The Kairos Autonomi Drone Drivetrain Characterization Stand (DCS) offers a comprehensive solution for evaluating various combinations of drone motors and propellers. By utilizing the DCS, Kairos can enhance the efficiency and effectiveness of its drones through rigorous testing. In addition to assessing motor and propeller configurations, the flight thrust test stand aids in comparing the performance of the Electronic Speed Controllers (ESCs) utilized in Kairos Autonomi drones. With the DCS, users can measure five key variables pertaining to flight efficiency across. Users control motor output through a servo controller, while data is collected via a robust Data Acquisition (DAQ) system before being processed and stored on a standard desktop computer.





Key Features:

- 5 Sensors set up to take measurements of the key variables
- Ability to quickly process raw analog data into readable graphs and values
- Works with most motor and propeller combinations

The Five Key Measurement Variables:

Current: Measurements are conducted using a Tamura closed circuit current sensor, which employs magnetic induction to measure the current flowing through the wire.
Voltage: Measurements are obtained directly through the voltameter of the data acquisition system.

RPM: Measurement of RPM is achieved by detecting the frequency of voltage change using an IR and phototransistor sensor. This process is managed by the DAQ system.

Thrust: Measurement of thrust is executed by a strain gauge, powered independently and positioned vertically. The obtained data undergoes amplification and filtration by a weight transmitter before being collected by the DAQ.

Torque: Torque is indirectly measured through a horizontally positioned strain gauge designed for force sensing. This gauge is preloaded with a spring to enhance its signal. Like the thrust measurement, the data is amplified and filtered by a weight transmitter before being processed by the DAQ. Both the thrust and torque sensors share the same power supply. The proxy torque measurement is then converted into actual torque measurements using physical equations.

Table 1: The range of calibration of each sensor.

Measuring	Low	High	Units
Current	-50	50	A
Voltage	0.000	300.000	V
RPM	3	300k	Hz
Thrust	0.3	5.0	kg
Torque	0.025	1.000	kg

Signal Collection:

All signals are routed through the reliable Data Acquisition (DAQ) system. Kairos employs a Rigol M300 Data Acquisition and Switch System to capture analog data from the sensors. This versatile system not only processes and stores the collected data but also has the capability to store procedures, facilitating automated data collection during tests.

Data Processing:

The data retrieved from the DAQ is subsequently processed using a Python program tailored for converting analog data into meaningful measurements. Additionally, this program generates graphical representations of the data for enhanced visualization. The raw data is meticulously organized by the program and, along with the generated graphs, is stored in a dedicated folder within the database.

In tandem with this process, the data obtained from the DCSis compiled into a PDF format. This format ensures easy sharing and readability, facilitating future comparison of data from various drivetrain systems.

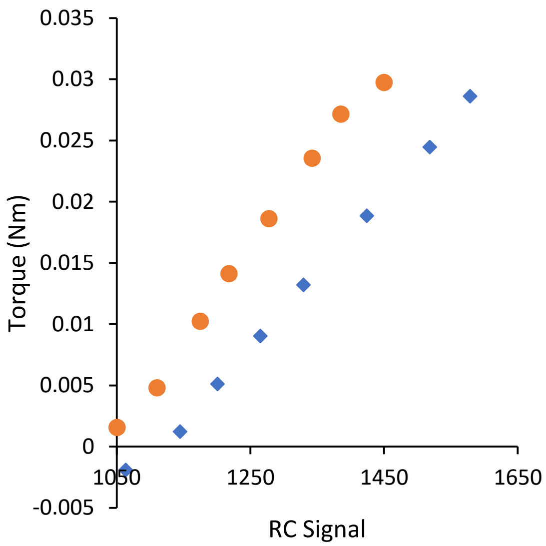
Collected Data:

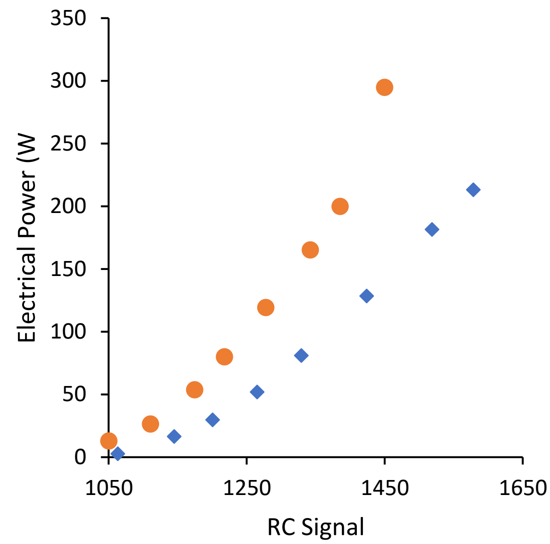
It's worth noting that the method employed for measuring RPM encountered an issue during a control test. RPM was initially measured by applying paint directly onto the motor. However, it was discovered that this paint acted as an insulator, causing the motors to heat up significantly. As a result, there was a notable loss of power due to heating rather than efficient conversion into mechanical power.

A Comparison of Unpainted Motors vs. Painted Motors

Testing was carried out using the 1408 Arthur Motor 2800KV and 5.1*3 2-Blade Propeller

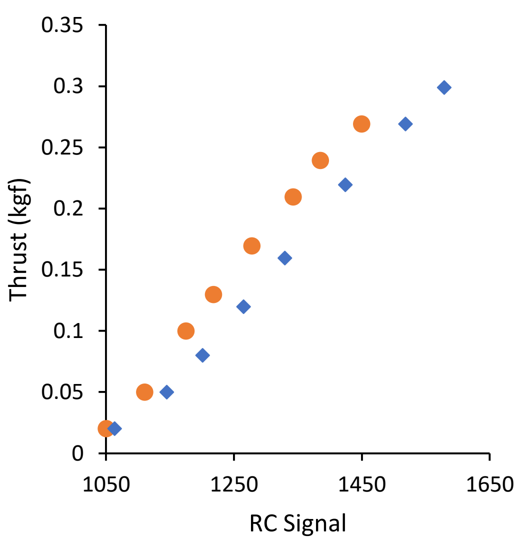
- Orange is Painted
- Blue is Unpainted

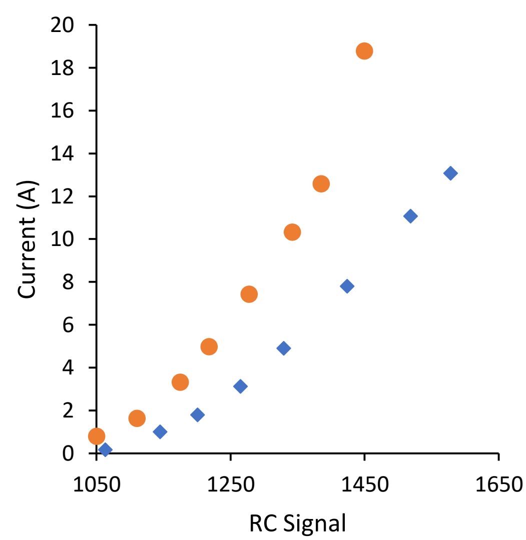




Torque: Related to how much mechanical power is needed to cause rotation in the propeller blades and provide lift.

Electrical Power: Is the power output from the battery. Ideally most of it is converted to mechanical power which is used to lift the drone.





Thrust: The force the drivetrain can provide to lift the drone. The greater amount of force possible the heavier the drone can be.	Current: The electrical current needed at the specified conditions to operate the drone.

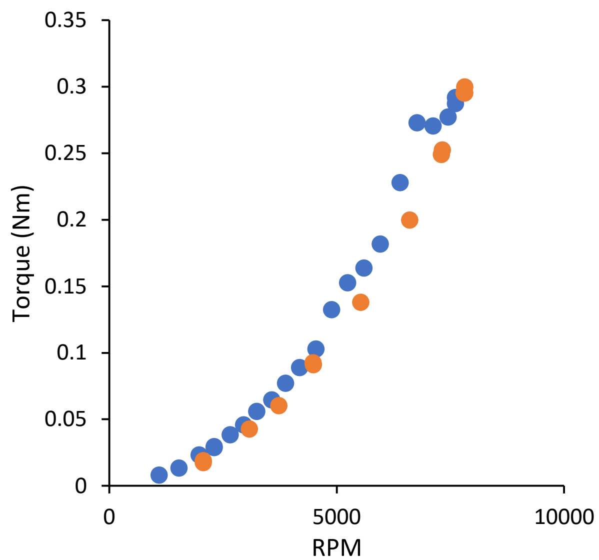
Furthermore, temperature measurements revealed that the painted motors would quickly exceed the measurable range before the test was completed, while the unpainted motor remained within a measurable range. Subsequently, a new methodology for testing RPM has been devised and is presently undergoing testing to ensure accuracy and functionality.

Below are graphical representations of the data collected from the Lumenier LU3 700KV motor, showcasing a side-by-side comparison of two propellers utilized on the Sturnus Drone.

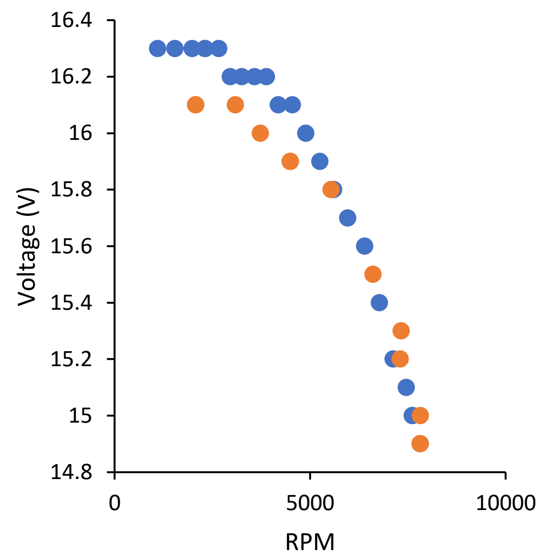
A Comparison of Different Propellers with the Lumenier LU3 700KV Motor

A motor used on the Sturnus drone

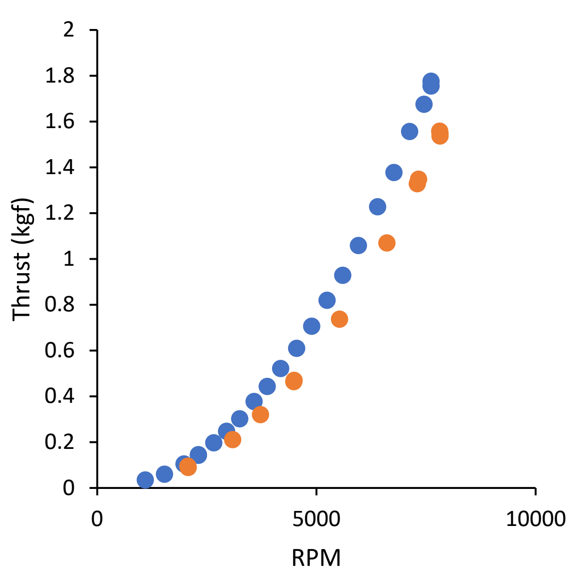
- Orange is the 12*4.5 APC 2 Blade Propeller
- Blue is the 13*4.8 T-Motor Foldable 2 Blade Propeller

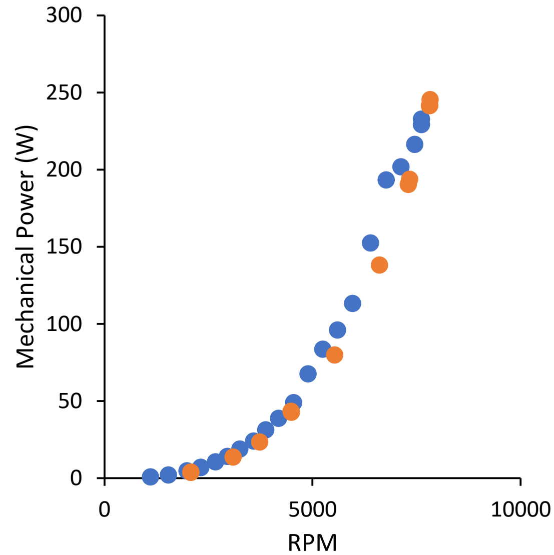


Torque: Related to how much power is used to cause rotation in the propeller blades.

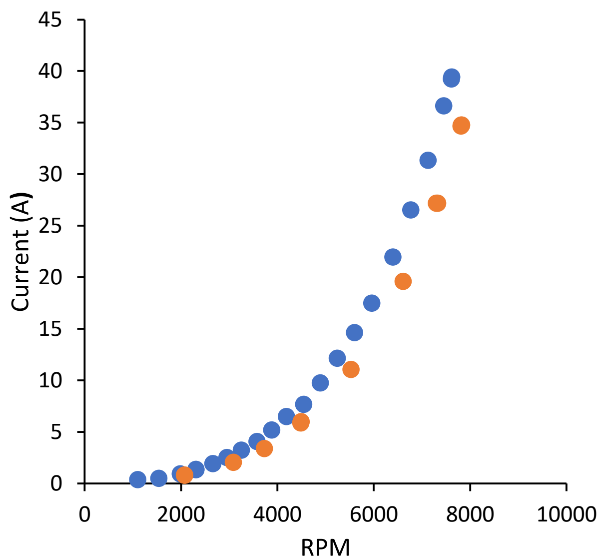


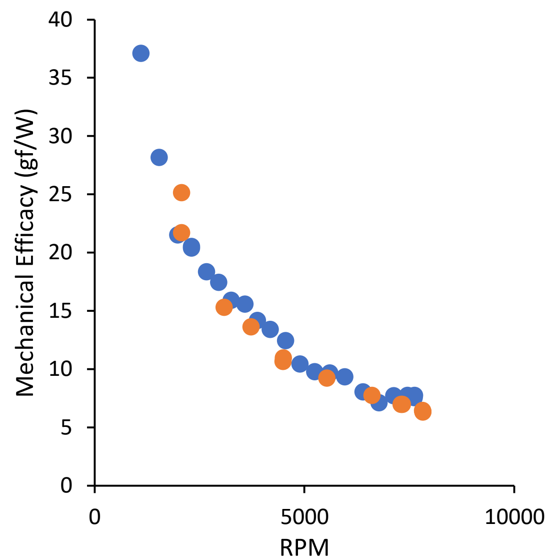
Voltage: The energy provided by a battery to the drone.





Thrust: The force the drivetrain can provide to lift the drone. The greater amount of force possible the heavier the drone can be.	Mechanical Power: Gives an idea of what electrical power the drivetrain combination will require.





Current: The electrical current needed at the specified conditions to operate the drone.	Mechanical Efficacy: Grams of Thrust per Mechanical Power Watt.

While this set of data does have significant inaccuracies, it still provides valuable insight into the mechanical performance of the motors. Additionally, the data indicates that the two propeller blades perform very similarly, with the most significant difference observed in the thrust output.

Next Steps:

- Ensuring accuracy of RPM sensor
- Automation of DCS test
- Testing of motors and propellers used here at Kairos