University of New Hampshire
Department of Mechanical Engineering
Department of Engineering Physics

THE LEE COMPANY

Quad-X Swarm A.S.T.R.A.

Aerial Satellite Testbed for Research Applications

ASTRA – Aerial Satellite Testbed for Research Applications – University of New Hampshire

beswick engineering – Excellence in Miniature

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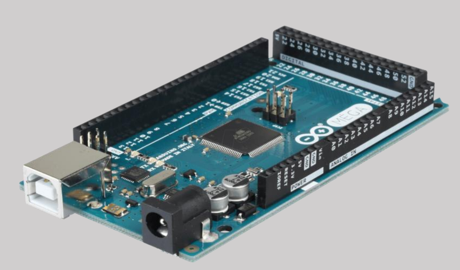
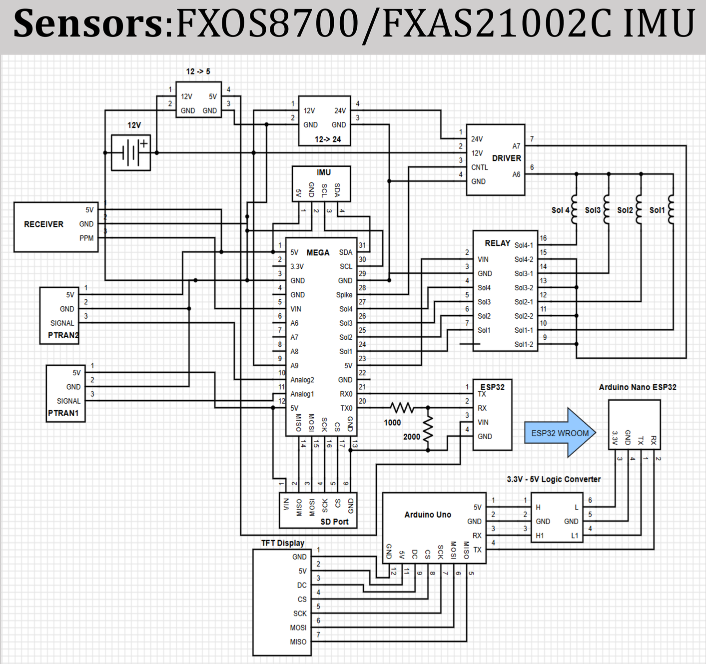
PROJECT OVERVIEW

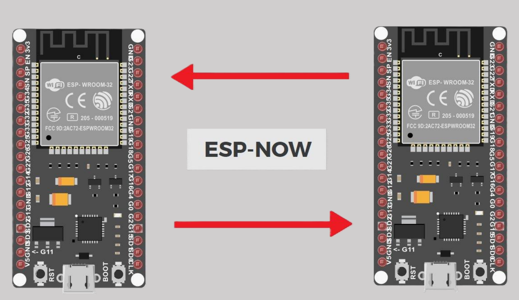
A.S.T.R.A. is a subsection of UNH's Quad-X Swarm team focusing on providing a scaled test platform for satellite control. It is an interdisciplinary team of Mechanical Engineering and Engineering Physics students working in the Kingsbury Design Lab. This year's focus is on translational movement, while future applications of our research would include a swarm of hexacopters that would provide an accurate representation of satellite configurations and attitude control.

CONTROL SYSTEM & DATA COMMUNICATION

Main Microcontroller: Arduino MEGA 2560
Feathering Control: PWM (5 Hz, 10 HZ)
Wireless Communication: ESP NOW
Display: 320 x 480 SPI TFT Screen
Sensors:FXOS8700/FXAS21002C IMU





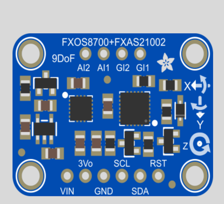


SENSOR CALIBRATION AND FILTERING

9-AXIS IMU: FXOS8700/FXAS21002C

50 Hz Opperating Frequency
Filters Applied:
Low-Pass: Smooth Data
High-Pass: Low Frequency Drift
Madgwick: quaternion calculation sensor orientation

Accuracy: ±0.005 m/s², ±0.1 m/s
Calibration Sequence: 1000 samples



150 PSI Pressure Transducer
Accuracy: 0.1% Full Scale Error

ATTITUDE CONTROL

Given by cold gas thrusters mounted below the frame.
Motion in x-y plane (perpendicular to the Earth)

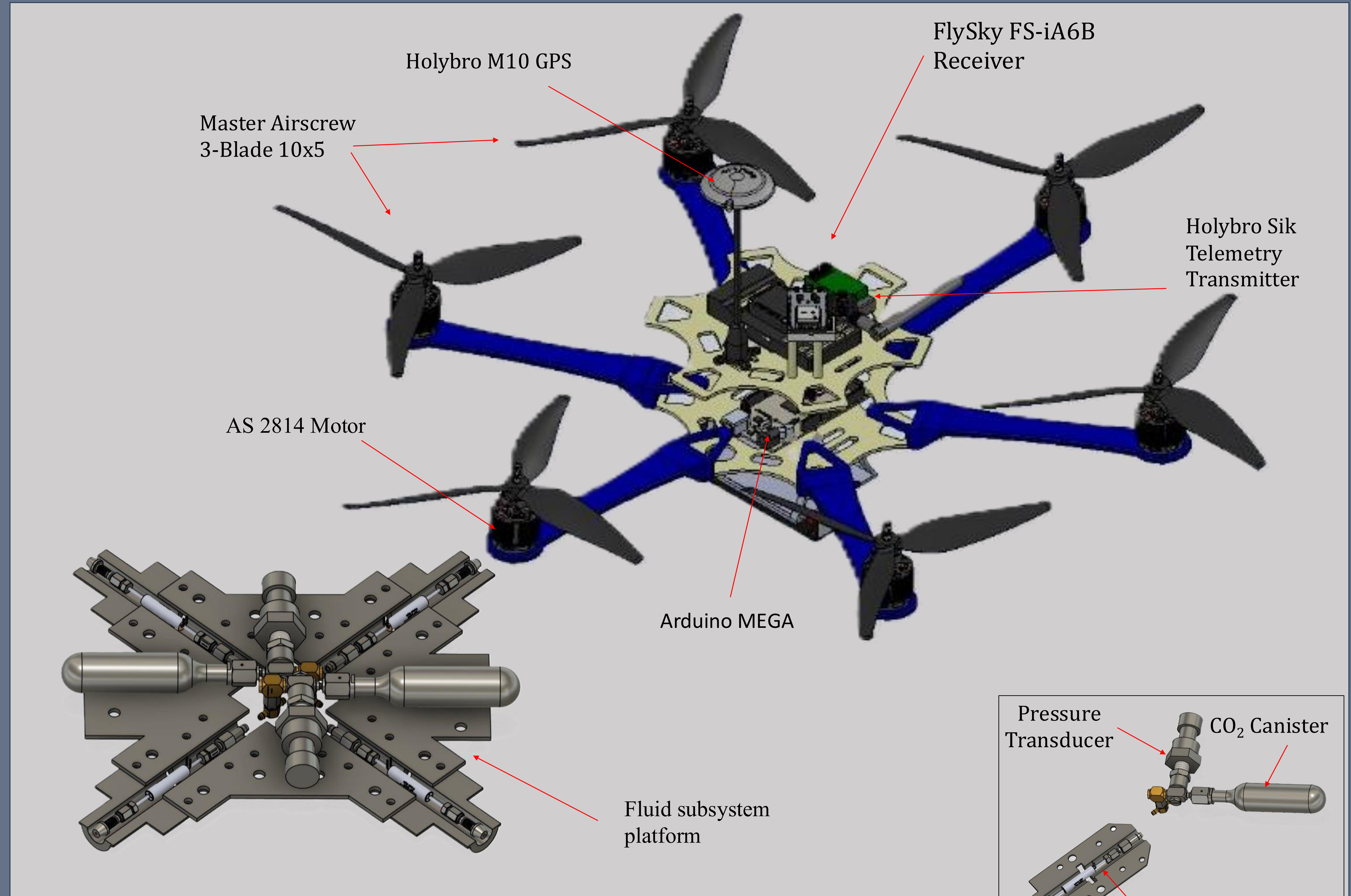
Future iterations:
- Z-axis movement
- Rotational control
- Swarm control

$$I_x = \frac{1}{5} m_s r_s^2 + m_r r_r^2$$

$$I_y = \frac{1}{5} m_s r_s^2 + m_r r_r^2$$

$$I_z = \frac{2}{5} m_s r_s^2 + 2 m_r r_r^2$$

S550 HEXACOPTER

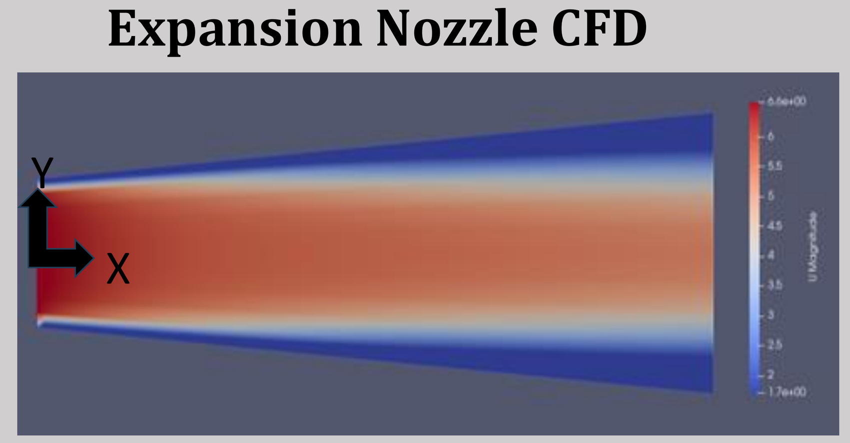


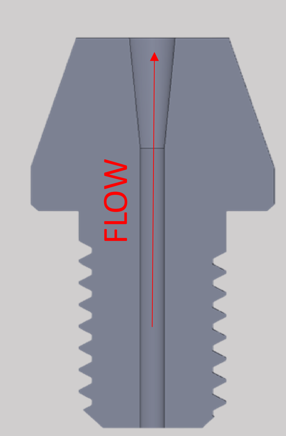
Total Assembly Weight: 3.5 kg

FLUID SUBSYSTEM

Nozzle Exit Diameter: 1.28 mm
Nozzle Exit Velocity (min, max): 1.7 m/s, 5.5 m/s
Thrust Generated (100 psi): 1.24 N

Expansion Nozzle CFD





Solenoid Valve Information
Type: Lee Company High Speed In-Line Valve
Response Time: < 1 ms
Weight: 4 g
Flow (100 psi): 0.2 L/m

Fittings & Tubing
Fittings: Beswick 303 SS, Brass
Tubing: 450 psi Nylon

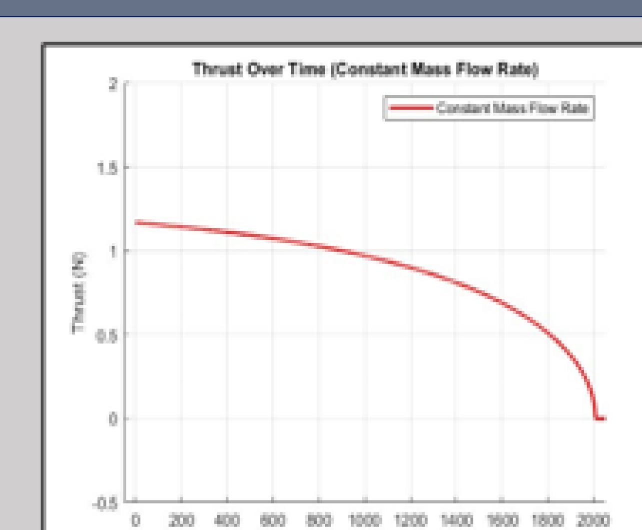
PRESSURE CONTROL

Governing Equations

$$PV = mR_{CO_2}T \qquad F_t = \dot{m}V_e + (P_e - P_0) * A_e \qquad V_e = \sqrt{\frac{2\gamma R_{CO_2} T_c}{\gamma - 1}\left(1 - \frac{P_e}{P_c(t)}\right)^{\frac{\gamma-1}{\gamma}}}$$

Pressure in Canister as a function of time:

$$P_c(t) = P_o e^{\left(\frac{-C_d A_{tc} R T t}{V}\sqrt{\frac{\gamma}{RT}\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}}\right)}$$



CURRENT TESTING

Current testing for satellite attitude control consists of floating a balloon in the air and performing dynamic testing upon it. A hexacopter-based aerial platform would allow for easier control, maneuverability, and real-time adjustments. While balloons are valuable for reaching very high altitudes and low-cost passive experiments, remote controlled vehicles are far better suited for precise, repeatable, and reactive dynamic testing that aligns more closely with real-world spaceflight scenarios.

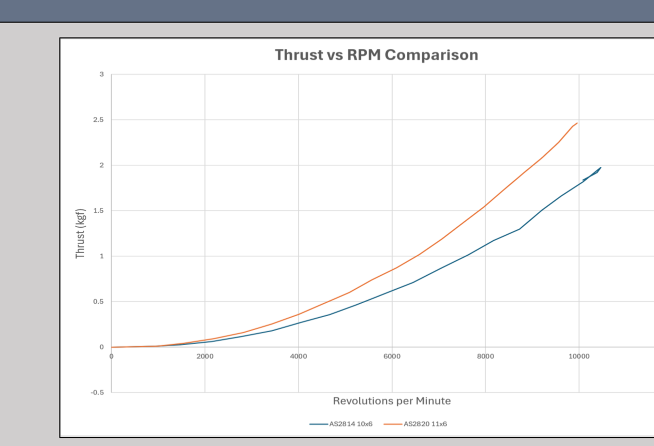
RC Vehicle	Data collection & real-time adjustments	Reusability & turnaround time	Altitude range & stability	Control & maneuverability
Balloon	Limit control during flight	Often single-use	Higher, but less stable altitudes	Follows atmospheric currents

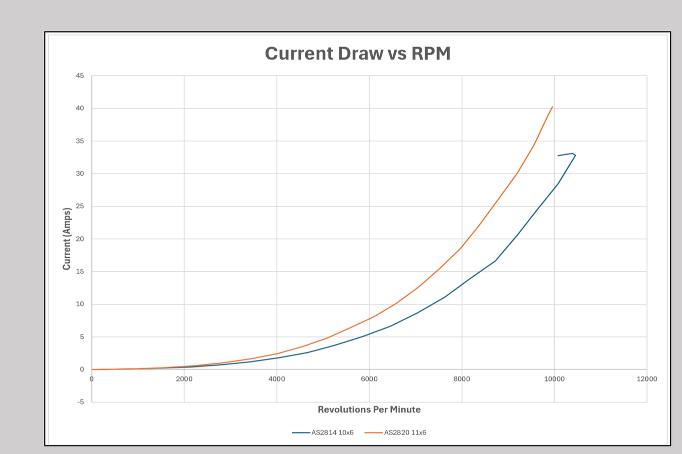
FLIGHT COMPONENT

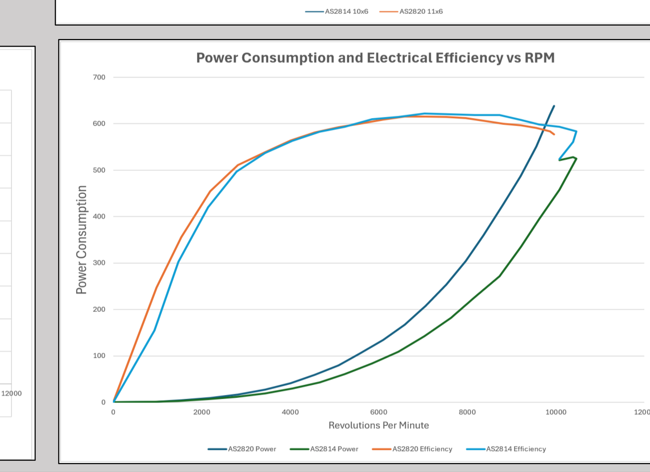
Flight Controller: Pixhawk 6X
GPS: Holybro M10
Receiver: FlySky FS-iA6B
Transmitter: Holybro Sik Telemetry
Frame: S550 Hexacopter
Battery: 11.1V 6000 mAh

UPGRADED FLIGHT COMPONENTS

Motor: AS2814 900 KV
Propeller: 3-Blade 10x5
ESC: 40 Amp ESC
Motor Output: >1.5 kgF
Operating RPM: 8000







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REFERENCES