# REcuperating Advanced Propulsion Engine Redesign


**Customer**: Air Force Research Lab **Advisor**: Dr. Ryan Starkey

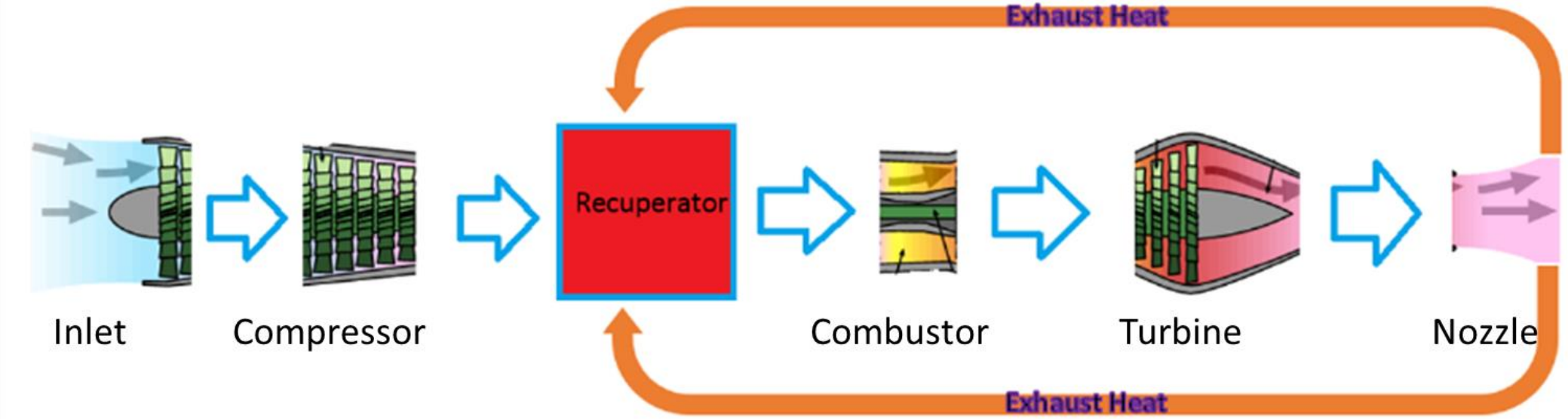
**Team:** Kevin Bieri, David Bright , Kevin Gomez, Kevin Horn, Becca Lidvall, Carolyn Mason, Andrew Marshall, Peter Merrick, and Jacob Nickless

# Presentation Agenda

- Project Overview
- Concept of Operations
- Mechanical Alterations
- Electronic Alterations
- Testing Results

# Overview

Model, build, implement, and verify an integrated recuperative system into a JetCat P90-RXi miniature turbojet engine for increased fuel efficiency from its stock configuration.




$$TSFC = \frac{Weight\ Flow\ Rate\ of\ Fuel}{Net\ Thrust}$$

# What is a Recuperator?

- A recuperator is a form of energy recovery heat exchanger designed to recover waste heat from a system

$$Q_{required} = Q_{fuel\ burn} + Q_{heat\ transfer}$$

- Most existing systems are ground based
- Recuperators have not been used on turbojets of any size
  - This project is a proof of concept

# Engine: JetCat P90-RXi

- Hobbyist miniature jet engine
- Fuel: 19:1 Kerosene/Oil Mixture
- Specifications:
  - Max thrust: 105 N @ 130,000 RPM
  - Exhaust: 490-690 °C
  - Diameter: 112 mm (4.41 in)
  - Mass: 1.435 kg

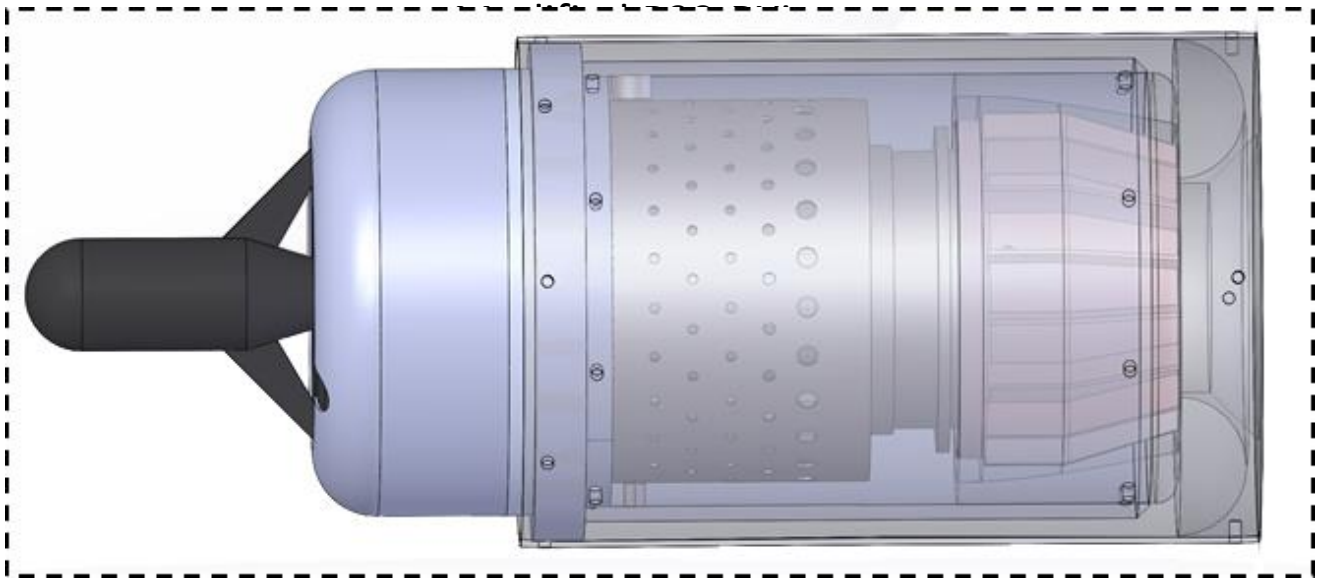


# Concept of Operations

Kerosene Fuel

Fuel Flow Sensor

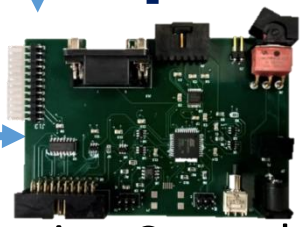
Transmitter

Load Cell, Thermocouples


SD Card

Receiver



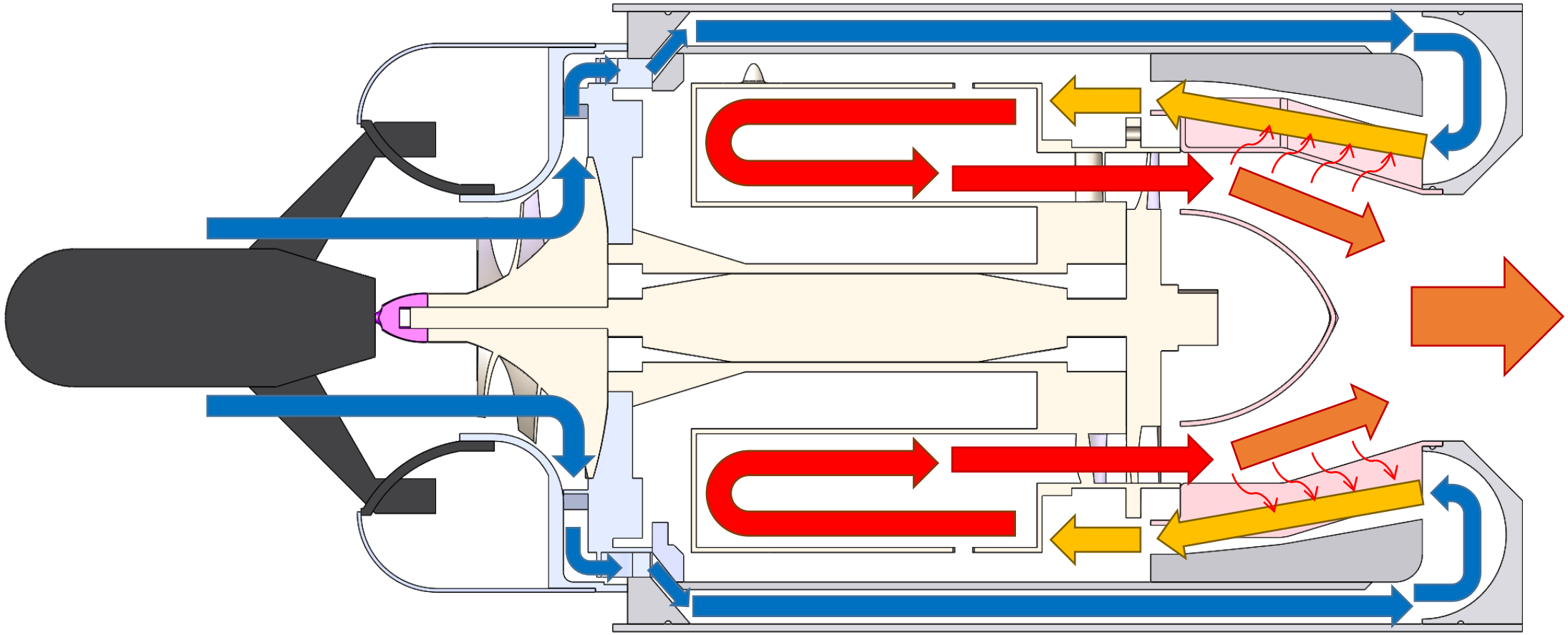
Engine Control Unit

Computer

NI DAQ Chassis

# Baseline Design: Flow Path

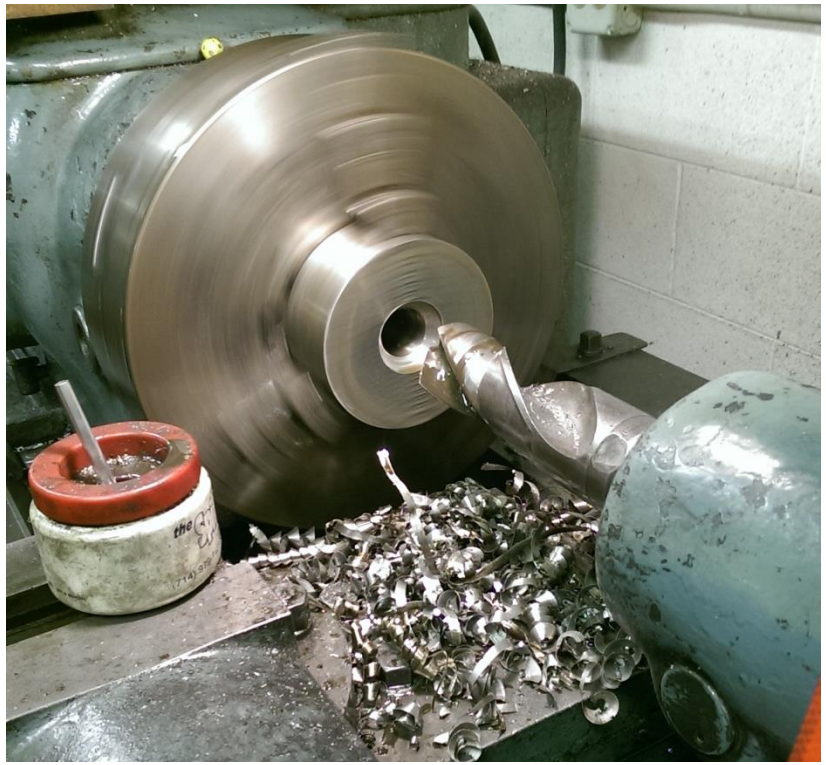
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| Engine Starts Up | Air Enters Compressor | Air Passes Along Outside of Casing | Air Enters Recuperator | Recuperator Heats Passing Air | Air Enters Combustor | Exhaust Passes through Turbine | Exhaust heats Recuperator Manifold |



# Focus Areas

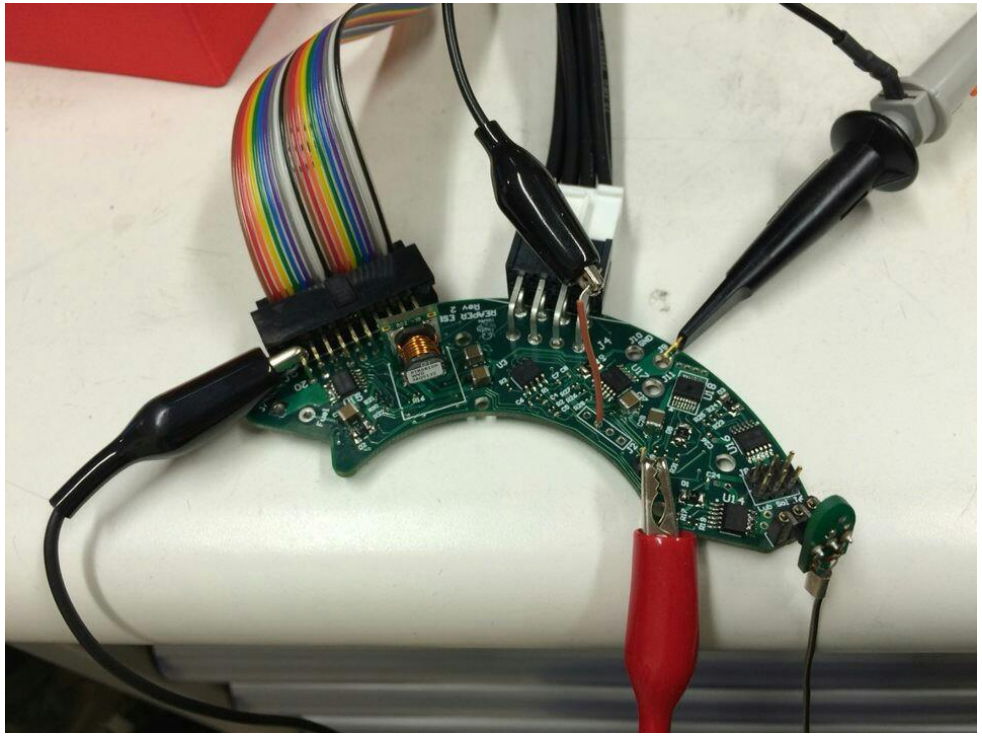
## Mechanical Alterations

- Reroute airflow to recuperate heat



## Electronic Alterations

- Gain better control and understanding of the engine

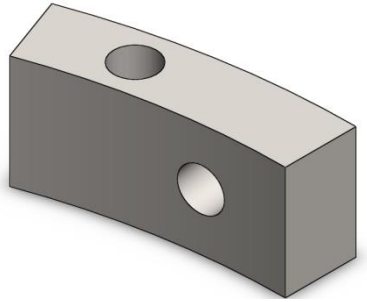


# Mechanical Alterations

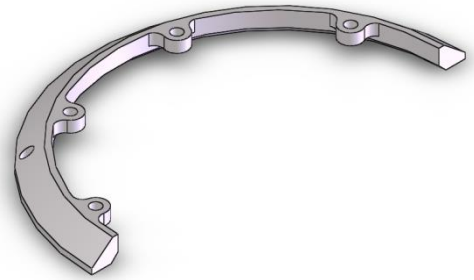
# Heat Exchanger Nozzle

- Most crucial component
- Titanium
- Direct Metal Laser Sintered by ProtoLabs

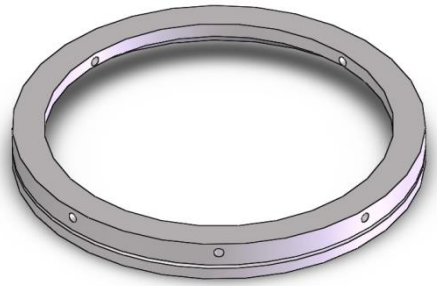
# Other Mechanical Components



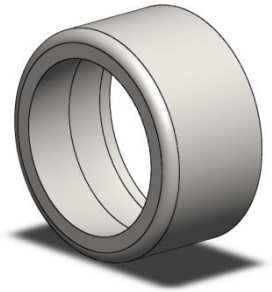
Mounting Blocks (x4)



Mount Brackets (x2)



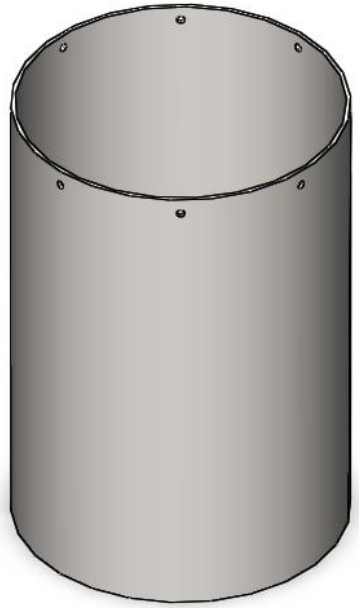
Forward Ring



Nozzle Shroud

End Cap

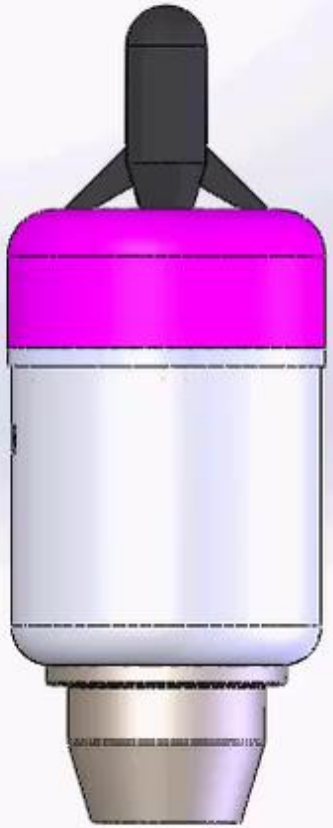
Inner Casing



Outer Casing

# Manufacturing: Parts Video

Forward Ring

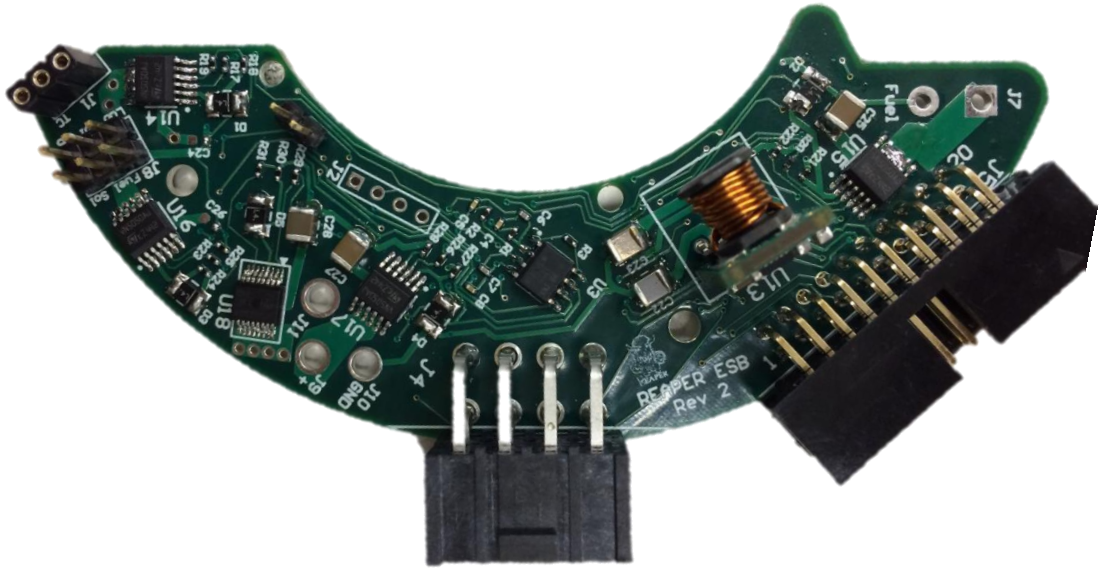


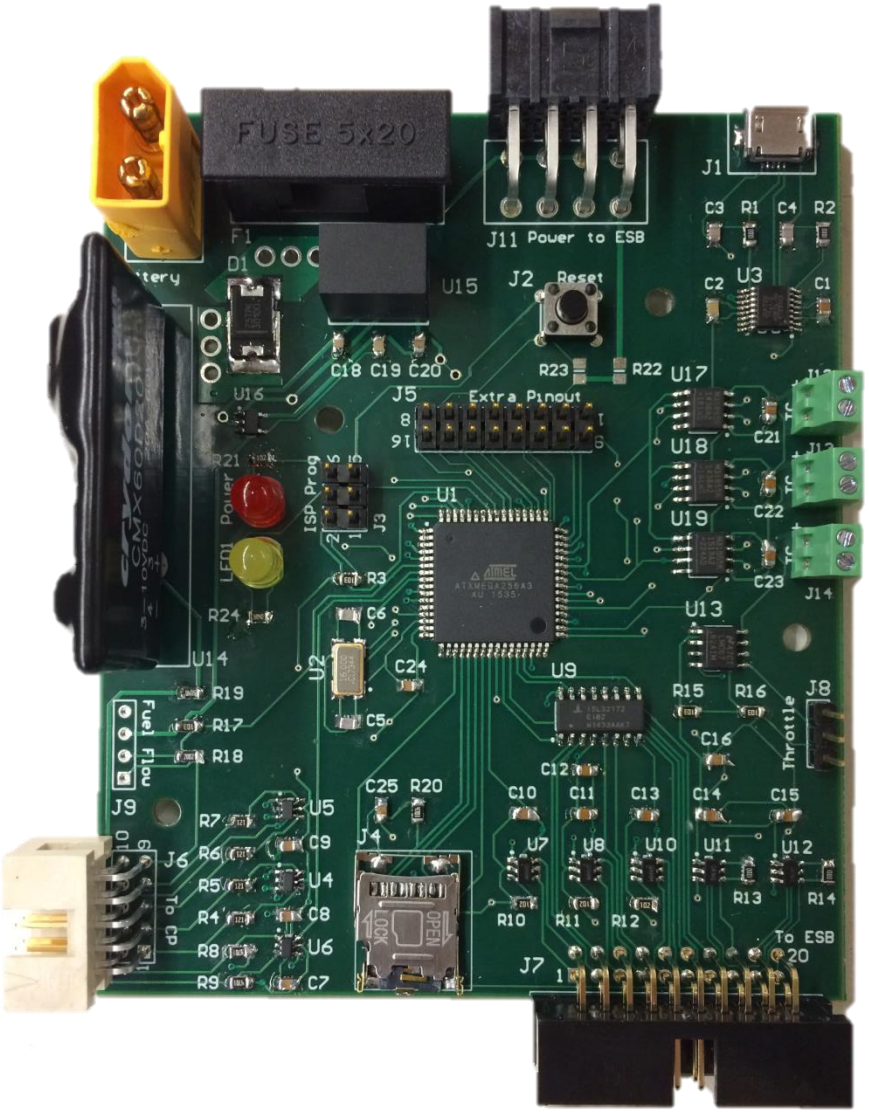
# Electronic Alterations

# Engine Electronics

- 2 custom Printed Circuit Boards (PCBs)
- Designed in Altium
- Manufactured by Advanced Circuits

Engine Sensor Board (ESB)

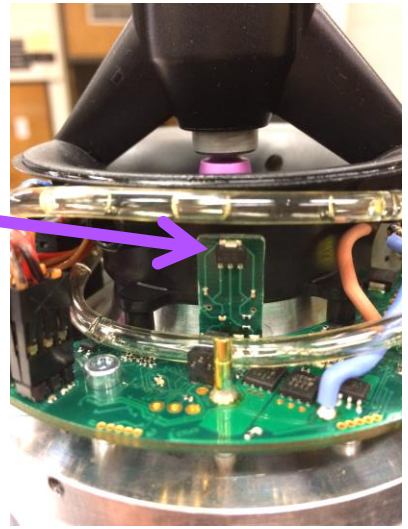



Engine Control Unit (ECU)

# Major Sensors

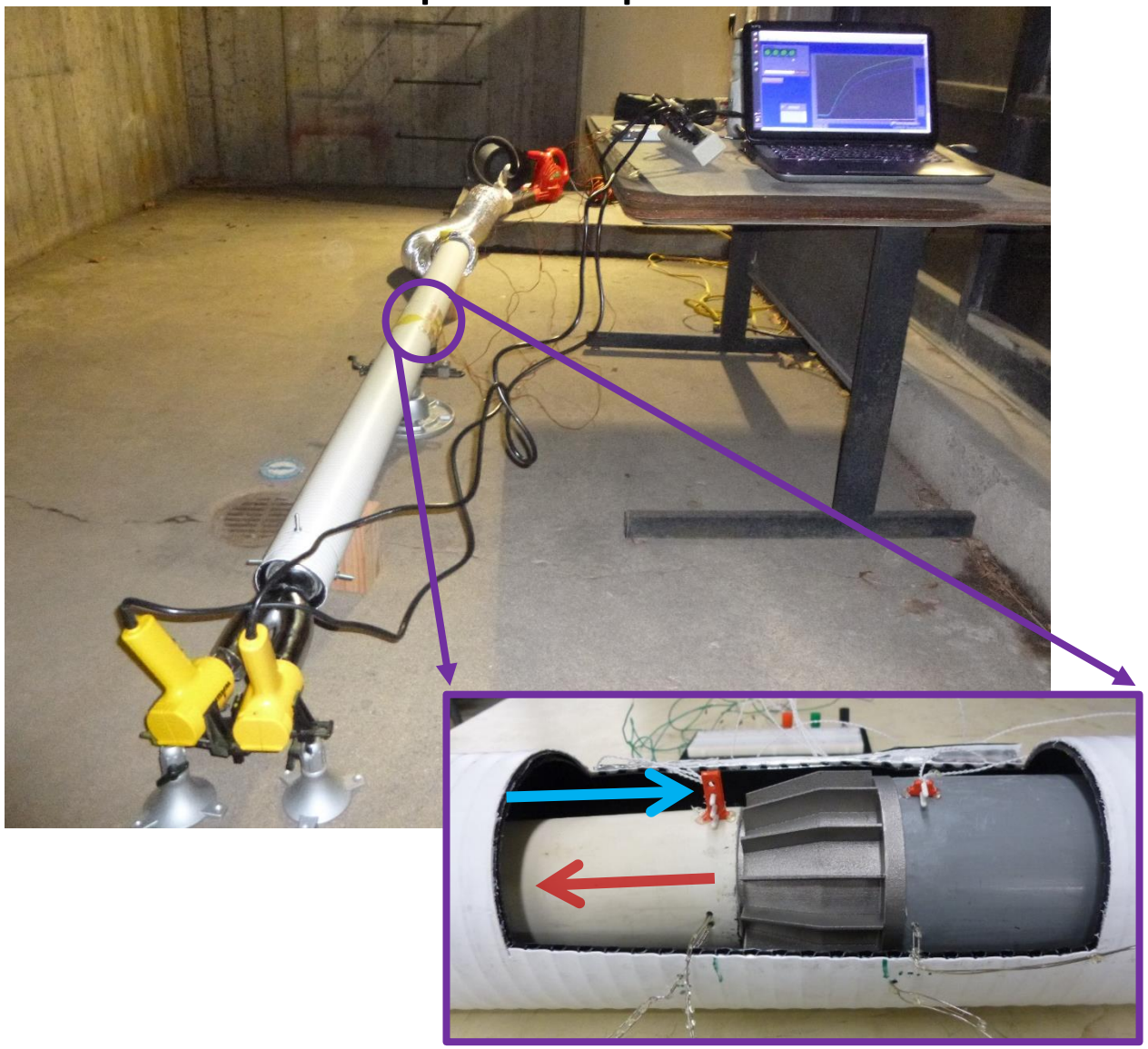
- Thermocouple
  - Measure exhaust temperature
- Hall Effect
  - Measure shaft RPM
  - Uses changing magnetic field to detect one turn
- Load cell
  - Measure engine thrust
  - Connected to the test stand
- Fuel Flow
  - Measure fuel flow for efficiency calculations

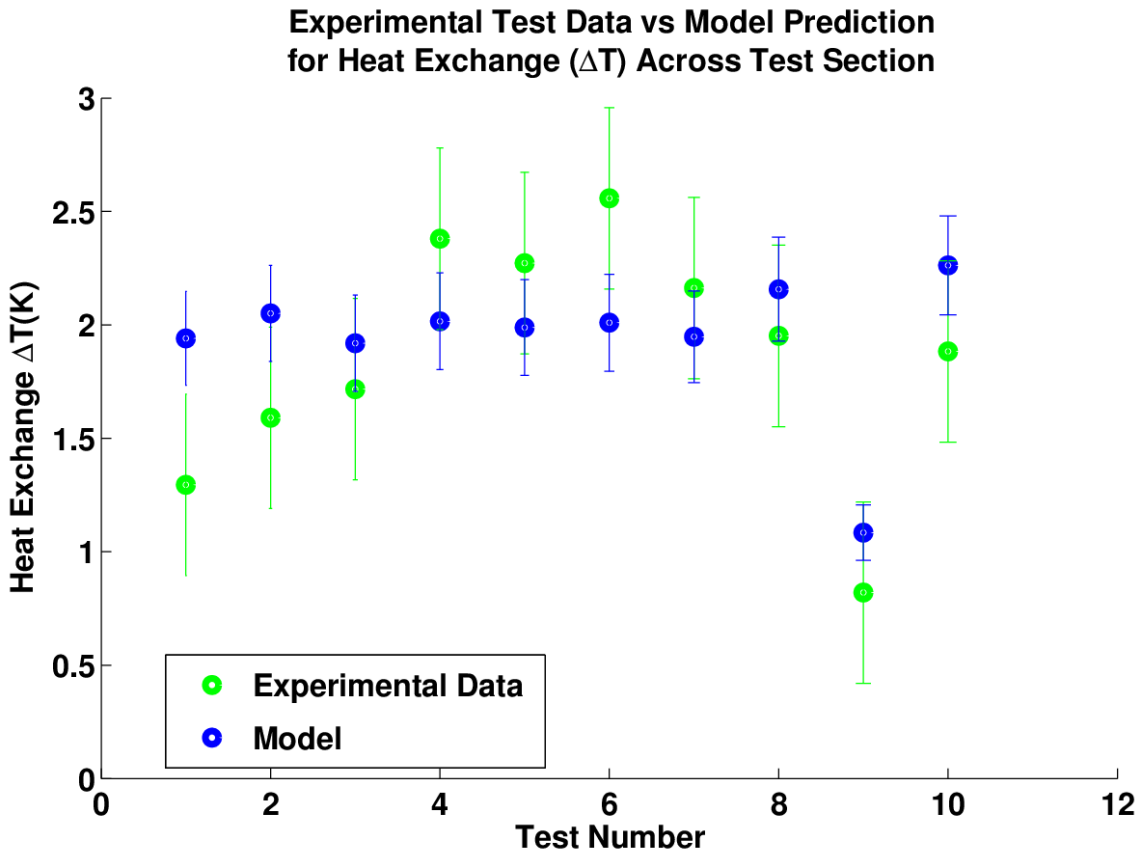


# Testing Results

# Heat Exchanger Test

Goal: Compare expected heat transfer with experimental results





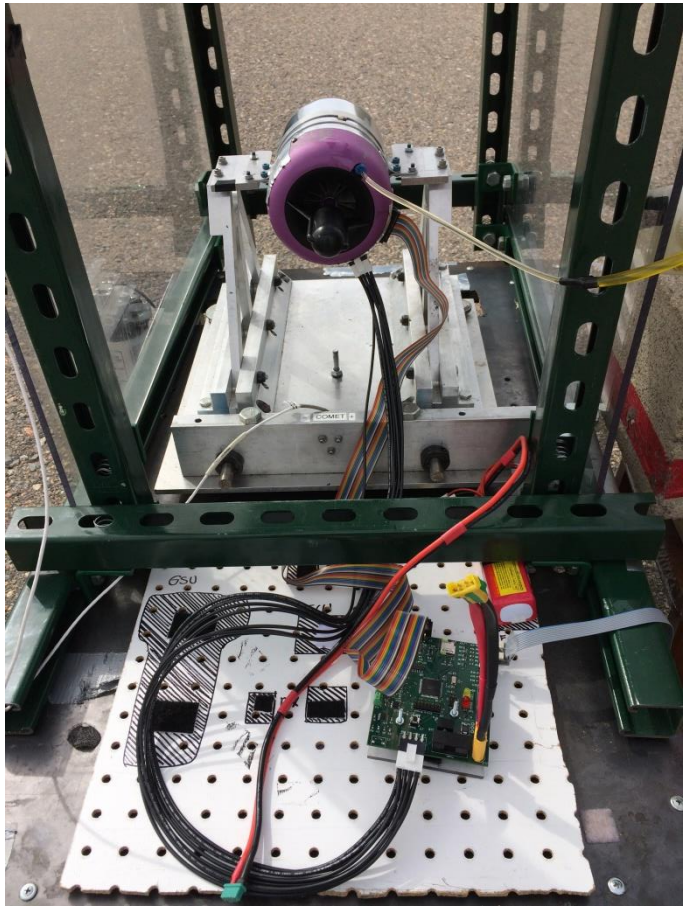

90% of tests match within error bounds

Success!

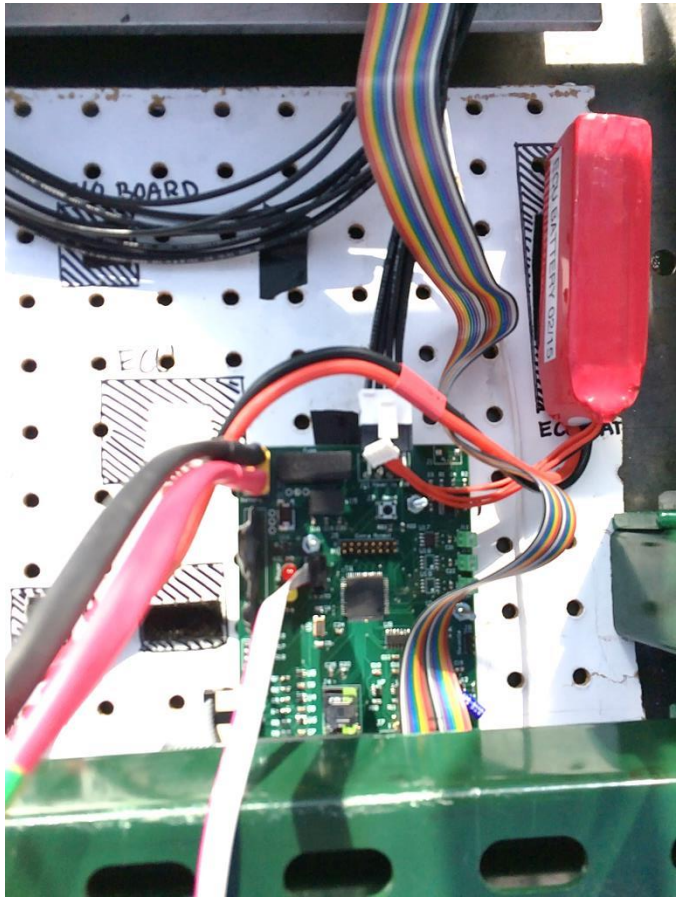
# Engine Testing

- Goal: Prove electronics are functional and test recuperating engine

Engine Test at Boulder Airport



Engine Control Unit



Control Box


In Progress

# Acknowledgements

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- Boulder Municipal Airport
- and Air Force Research Lab

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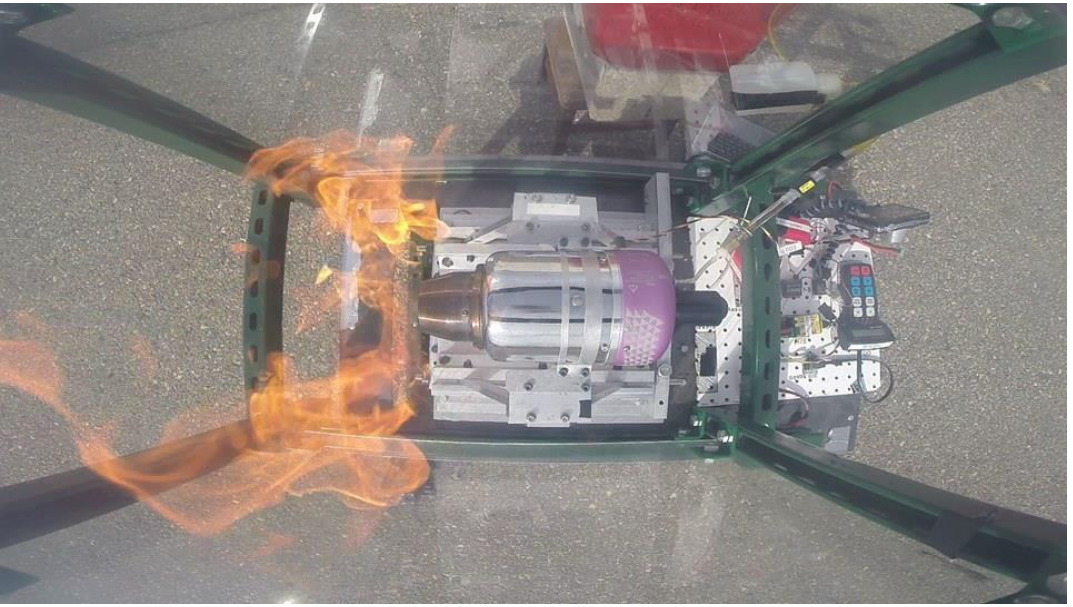
# Thank You!



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