Kristopher Lemieux,
Spring Semester, 2024

University of Victoria

Engine Monitoring System

Department of Electrical and Computer Engineering

R & D Roadmap for the Instrumentation and Controls Platform for Engine development

BACKGROUND

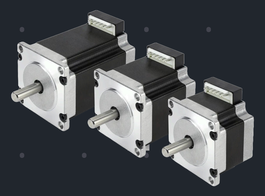
The engine monitoring platform is a combination of systems designed for testing and developing hybrid rocket engines. This system's primary goal is to actuate valves at specific times, feeding liquid oxidizer into a combustion chamber where it contacts solid fuel, causing a reaction that initiates rocket propulsion.

As of January 2024, a rudimentary system was in place capable of independently completing all tasks. However, poor reliability and lack of user-friendliness made the system difficult to operate. By January 2025, the system operates reliably and has successfully completed 7 safety-critical tests.

CONTROLS

- Stepper motor and solenoid driven valves control flow of pressure.
- Valve state feedback determined by limit switches.

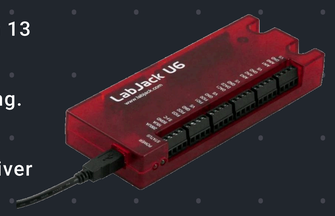
UPDATES
- Firmware architecture refactored from polling loop to FreeRTOS interrupt-based scheduling.



INSTRUMENTATION

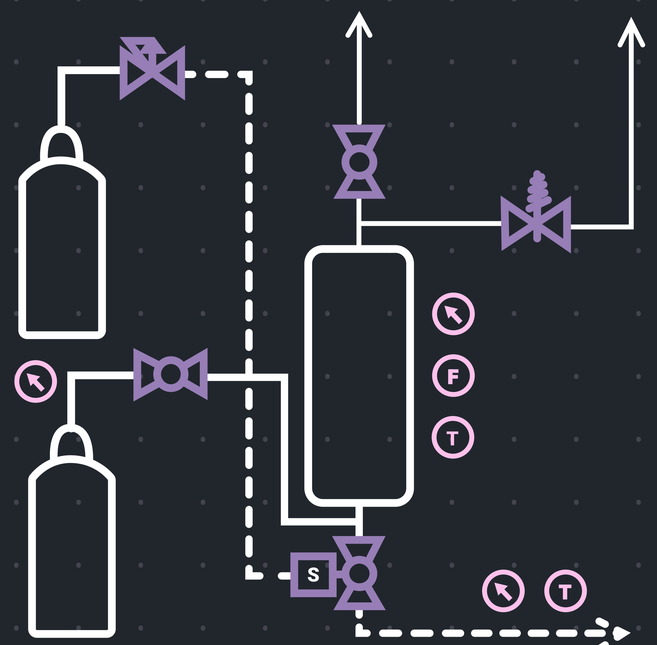
- LabJack U6 data acquisition unit with 13 sensors connected.
- Sensor suite includes: Temperature, pressure, force, and current monitoring.

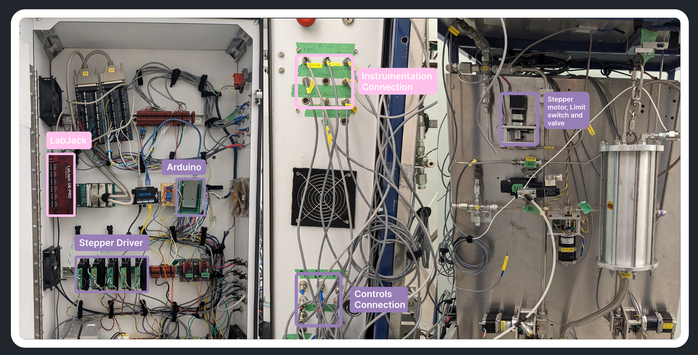
UPDATES
- Switched from LabVIEW to custom driver and UI.



R&D 2024 - 2025

Design philosophy: simplicity, reliable, maintainable





COMMUNICATION INFRASTRUCTURE

- TP-Link WiFi antennas for a wireless connection from mission control to the valve cart.
- WebSocket communication between valve cart and mission control.

UPDATES
- Switched from USB-over-Ethernet to TP-LINK WiFi.
- Standardized API across all interfaces.

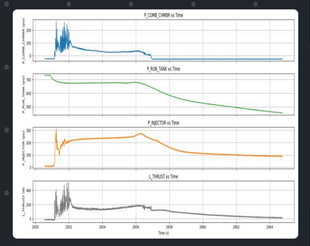
MISSION CONTROL

- Piping and Instrumentation (P&ID) diagram visualizer.
- Real-time instrumentation graphical visualization at a 1 kHz sampling rate.

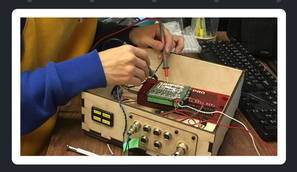
UPDATES
- Built from scratch.
- Integrated visualization into one UI for instrumentation and controls.

TEST RESULTS

"The thrust for Mule-1 was approximately 25% lower than expected. The cause remains unclear, with multiple possible explanations:
- The injector was improperly characterized or contaminated, lowering its discharge coefficient.
- The nitrogen supply regulator had an insufficient flow rate to maintain constant pressure during the test, resulting in lower overall system pressure.



2018
- Initial static hot fire test stand developed
- Mule-1 test engine created



2019
- Labjack instrumentation acquisition unit
- Creation of valve cart

2021
- Electrical cabinet addition to back of valve cart.
- Frist successful instrumentation readings

2022
- Travelled across Canada for attempted cold flow test
- instrumentation successfully operating Labview over wired connection.

2024
- Secured test site
- Established a reliable testing platform.
- Performed first cold-flow test of Mule-1 engine.

2025
- First successful hot fire test of Mule-1 engine.
- Began development of new flight engine, Mule-2.

This research was supported by the Jamie Cassels Undergraduate Research Awards, University of Victoria, and supervised by Dr. Navneet Kaur Popli