



**WATERLOO
ROCKETRY**

**REMOTE LAUNCH CONTROL SYSTEM
FOR HYBRID ROCKETS**

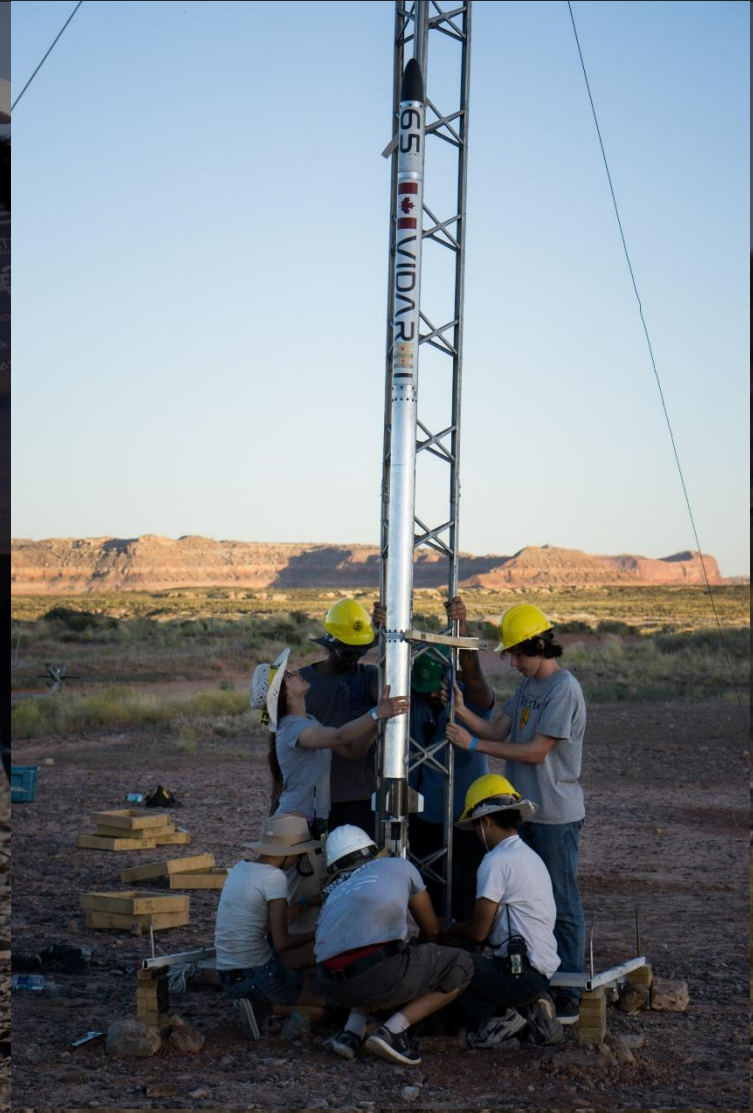
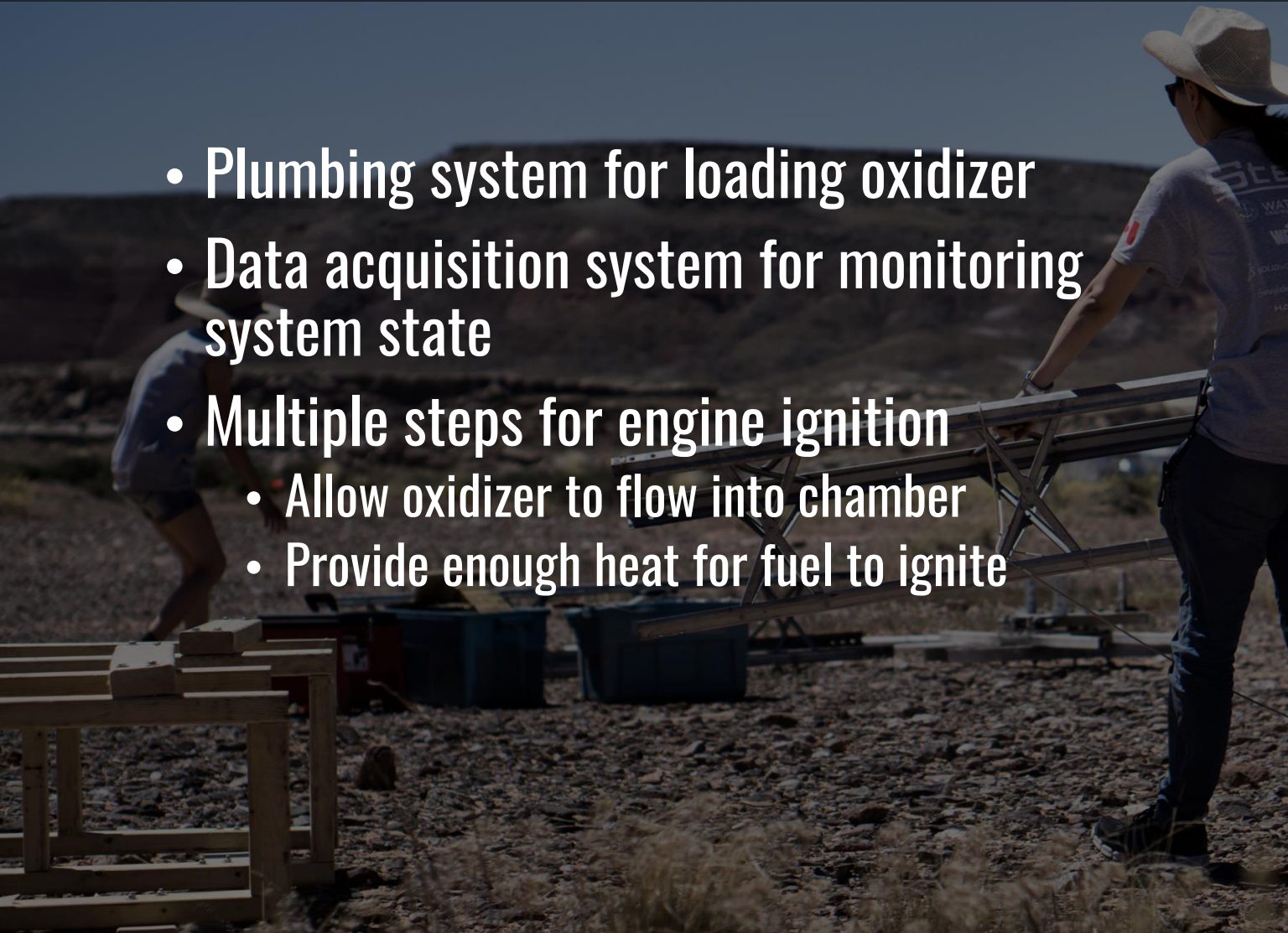
ABOUT US

- University of Waterloo in Ontario, Canada
- 20 undergraduate engineering students
- 8th year at IREC
- 2017 (Vidar III)
 - 1st place: 10K SRAD Hybrid/Liquid
 - Jim Furfaro Award for Technical Excellence



HYBRID REQUIREMENTS

- Plumbing system for loading oxidizer
- Data acquisition system for monitoring system state
- Multiple steps for engine ignition
 - Allow oxidizer to flow into chamber
 - Provide enough heat for fuel to ignite



PRE-LAUNCH OBJECTIVES

- Fill oxidizer tank with NOS from supply cylinder
- Disconnect fill line from oxidizer tank
- Perform ignition procedure

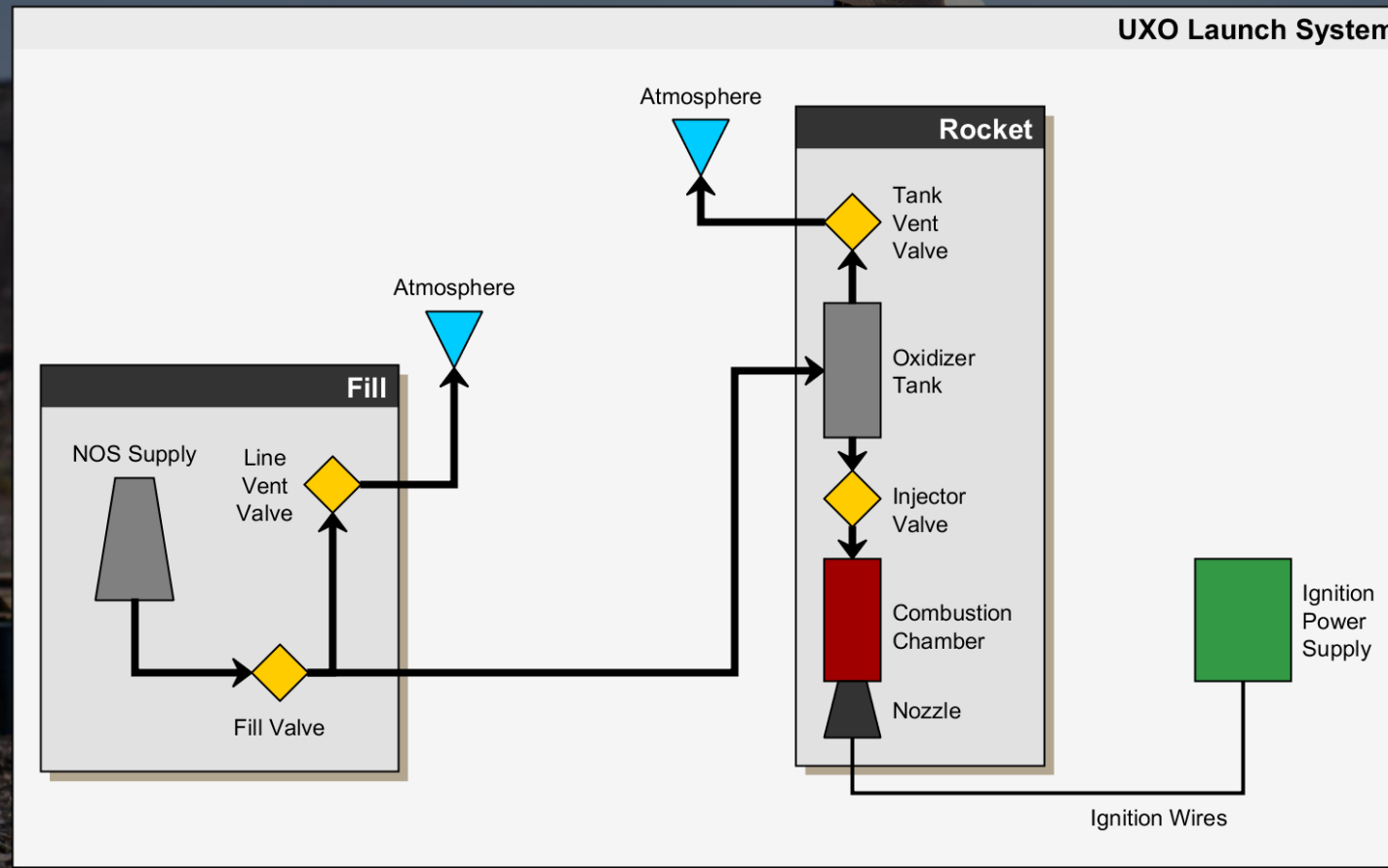


CONSIDERATIONS

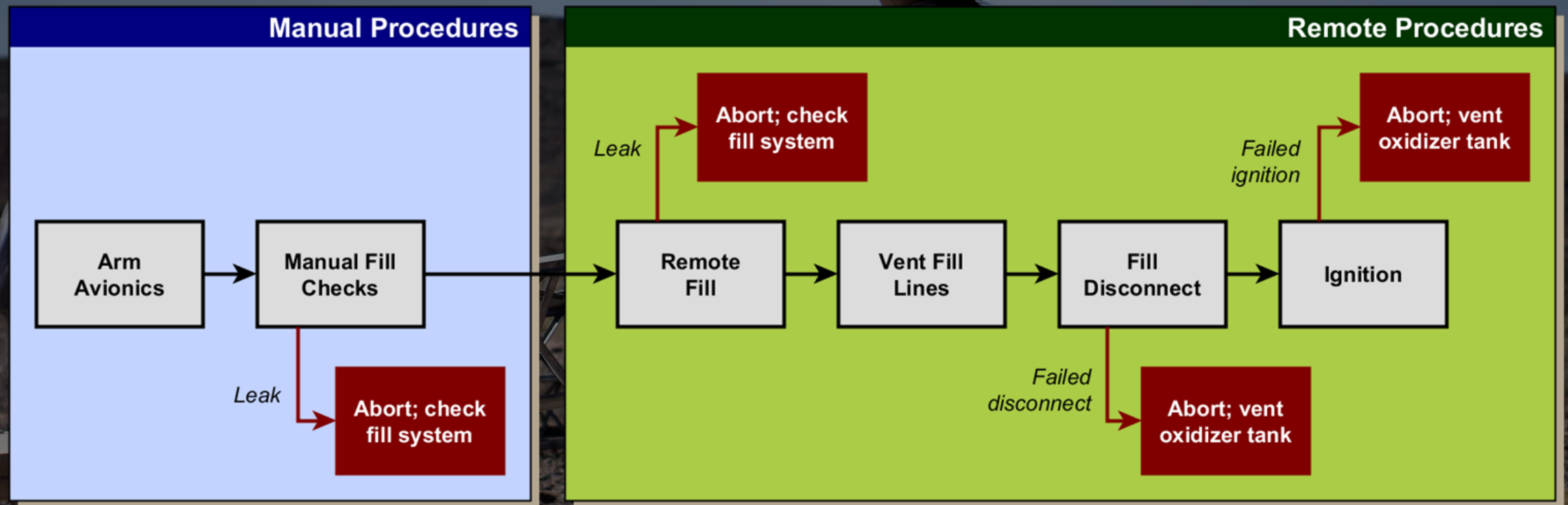
- Safety
 - Operator proximity to rocket
 - Fail-safe
- Efficiency
 - Speed of fill
 - Ease of setup
- Reliability
 - Well-defined and understood failure modes
- Modularity
 - Extension for future rocket capabilities
 - Replaceable components



SYSTEM OVERVIEW



LAUNCH OPERATIONS



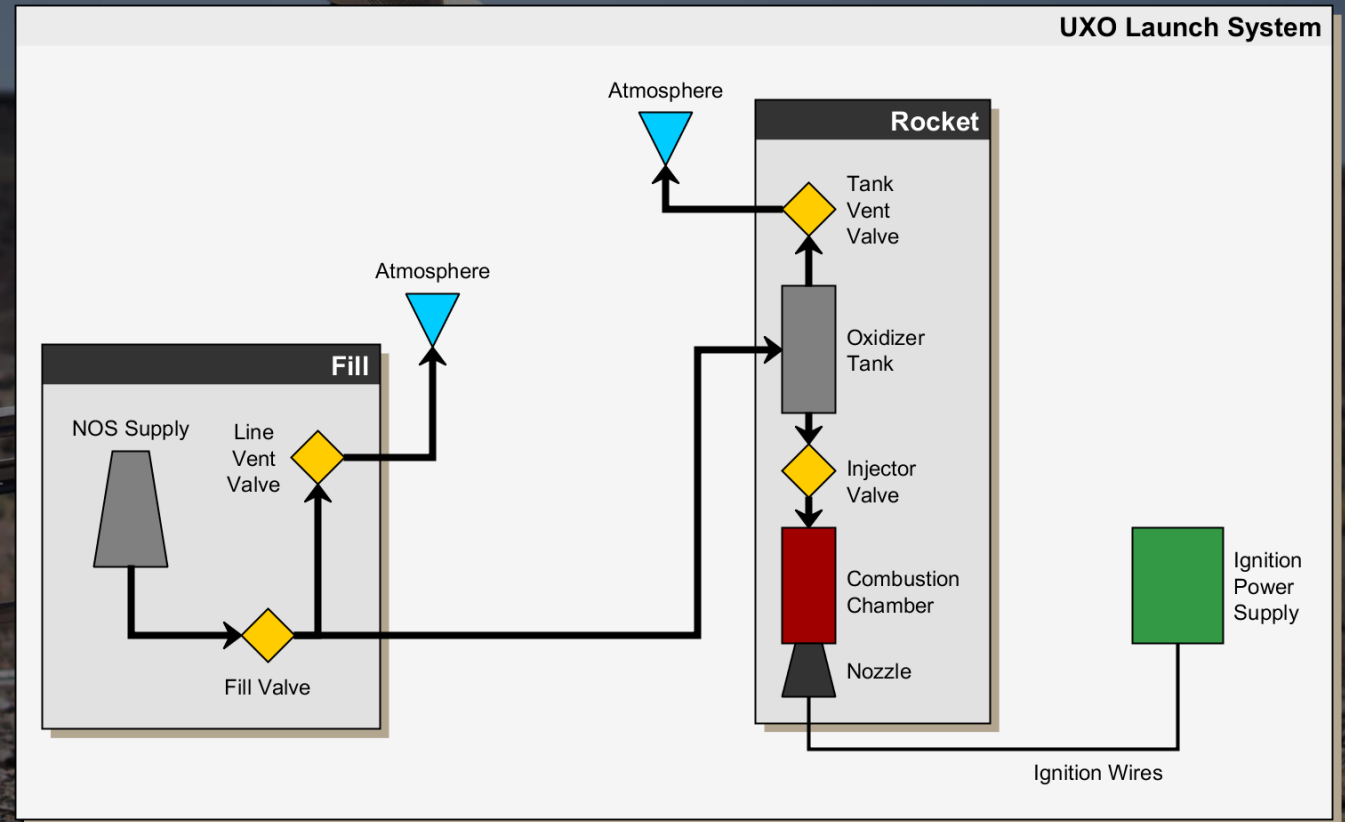
SYSTEM BREAKDOWN

- Sensors
 - Pressure
 - Mass
 - Current
 - Limit switches
- Actuators
 - Valves
 - Fill disconnect
 - Ignition



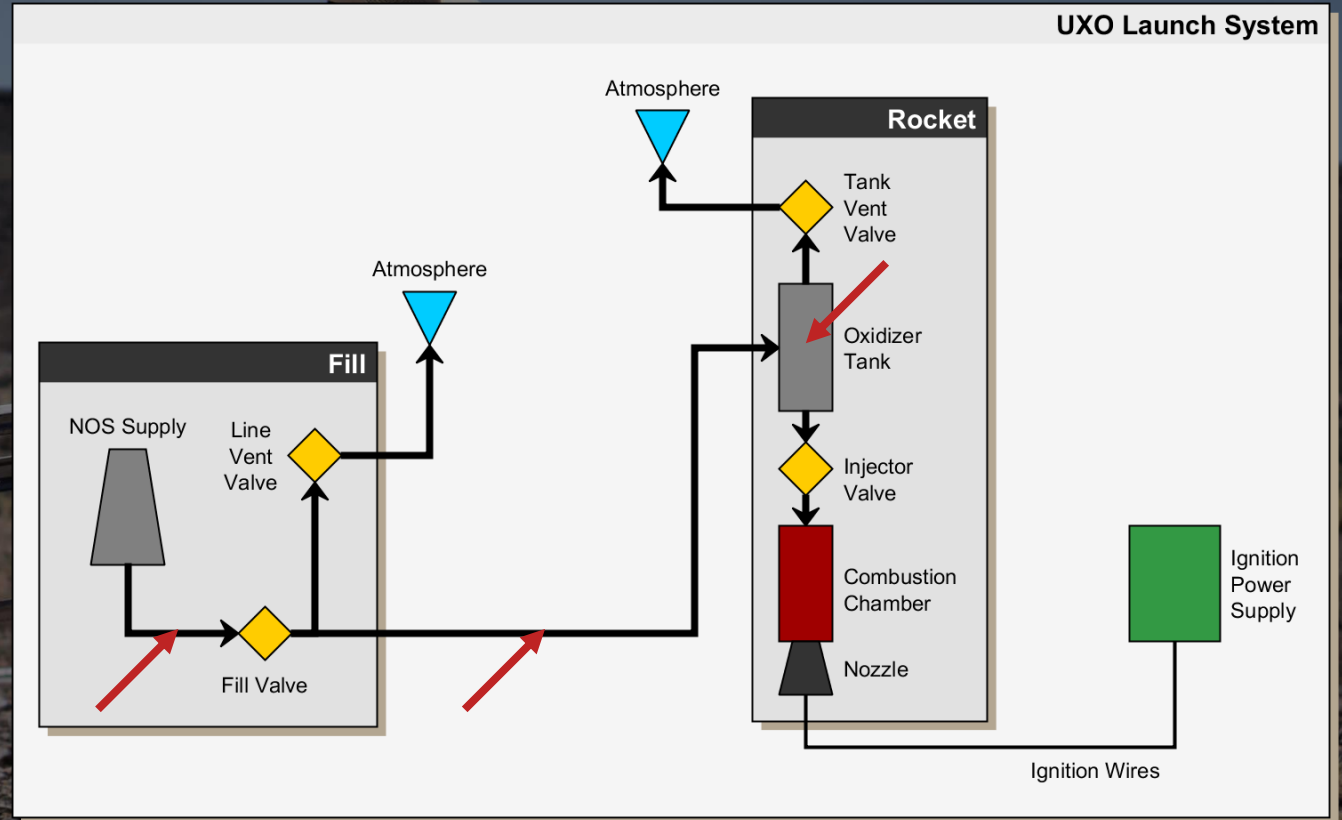
SENSORS

- Obtain full system state



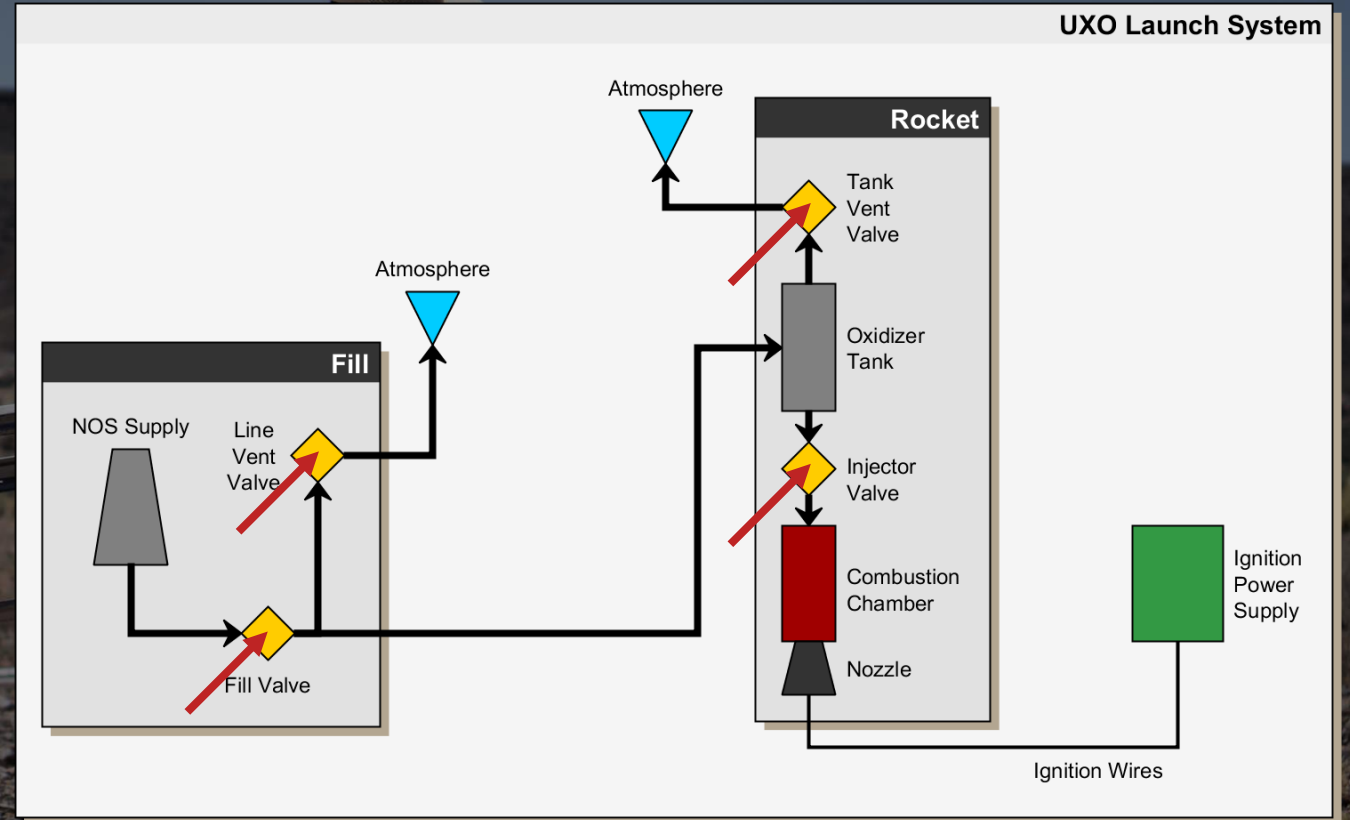
SENSORS

- Pressure in three sections:
 - Supply cylinder
 - Fill lines
 - Oxidizer tank



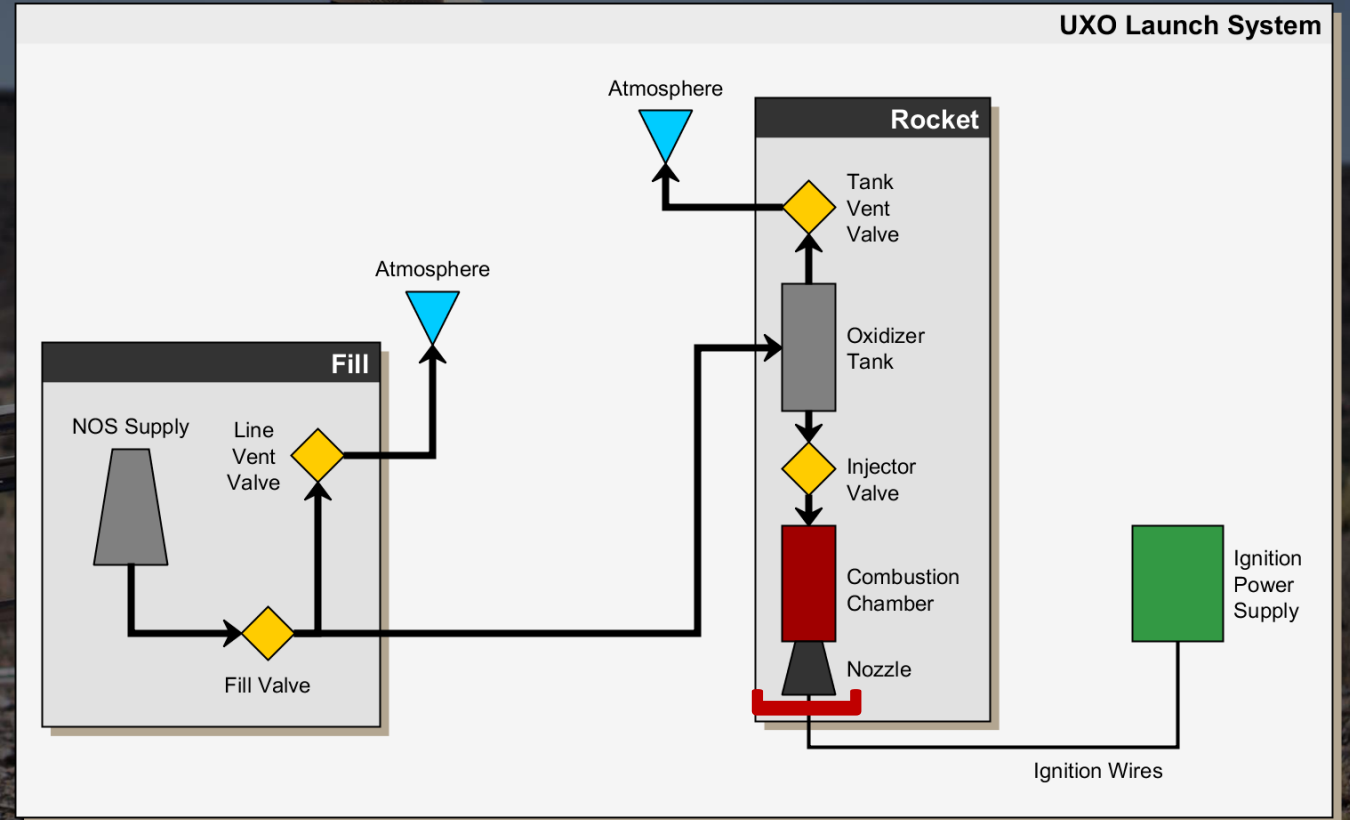
SENSORS

- Line pressure indicates valve state once fill begins
- Limit switches on motorized valves confirm actuation



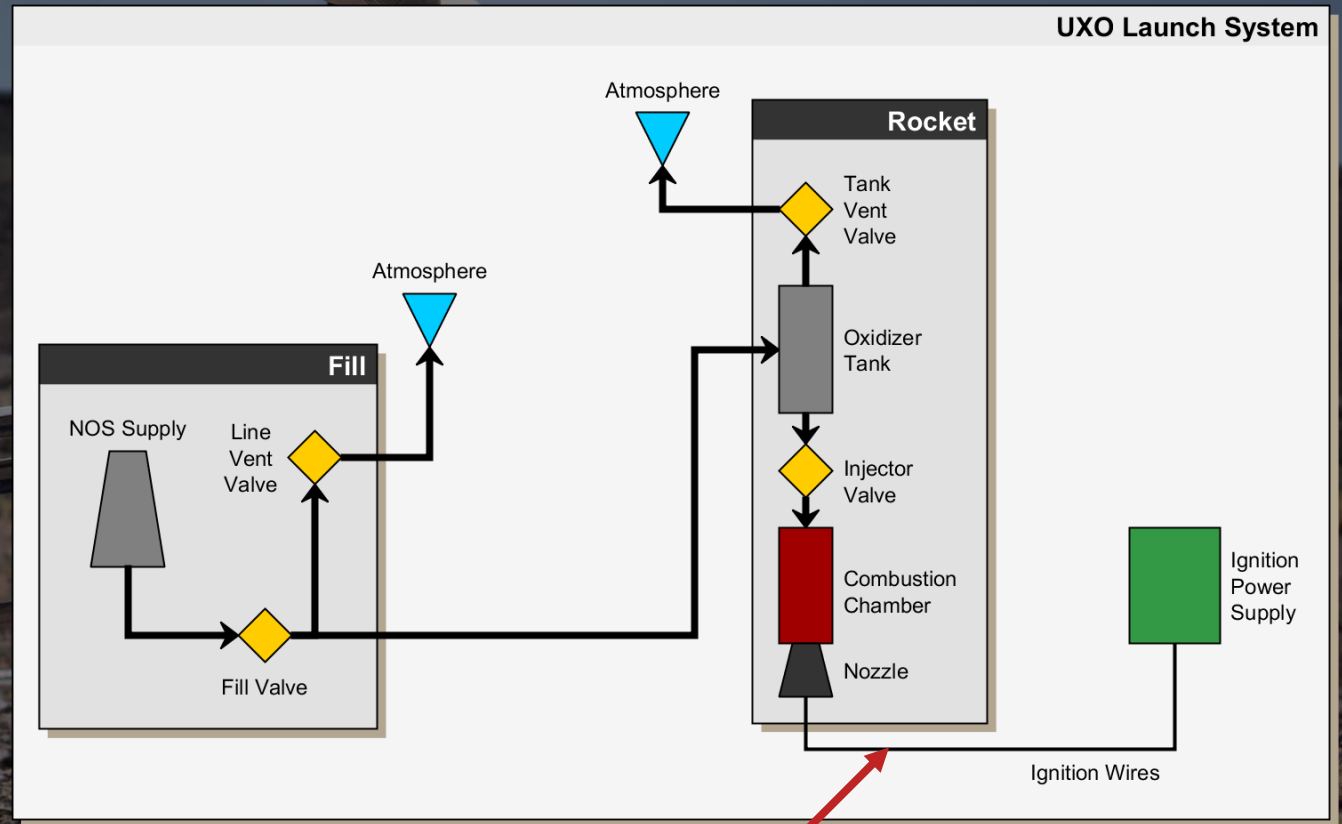
SENSORS

- Pressure measurements are insufficient for confirmation of full oxidizer tank
- Rocket mass provides confirmation

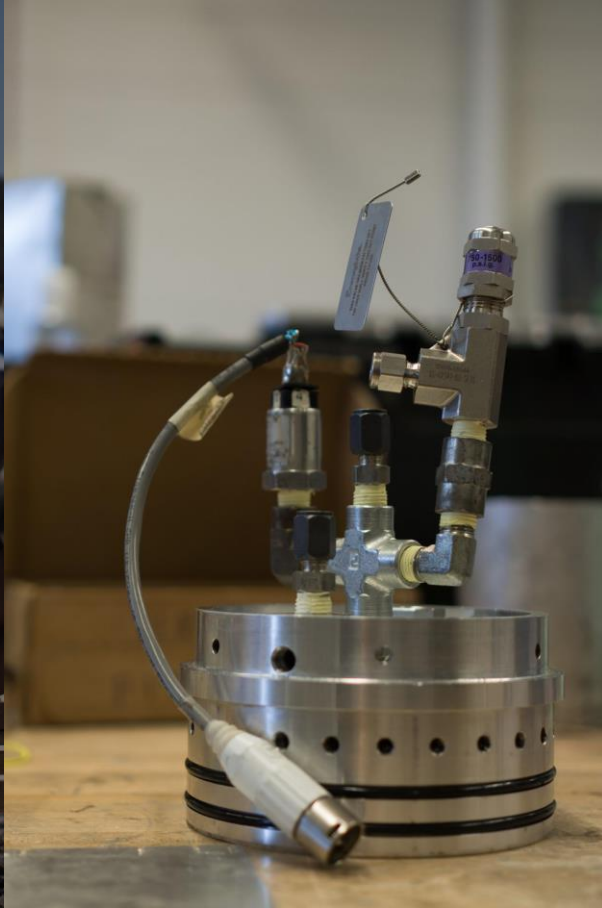


SENSORS

- Current through nichrome coils indicates active state



SENSORS - PRESSURE



SENSORS - MASS

- Allows precise, real-time measurement of amount of oxidizer loaded



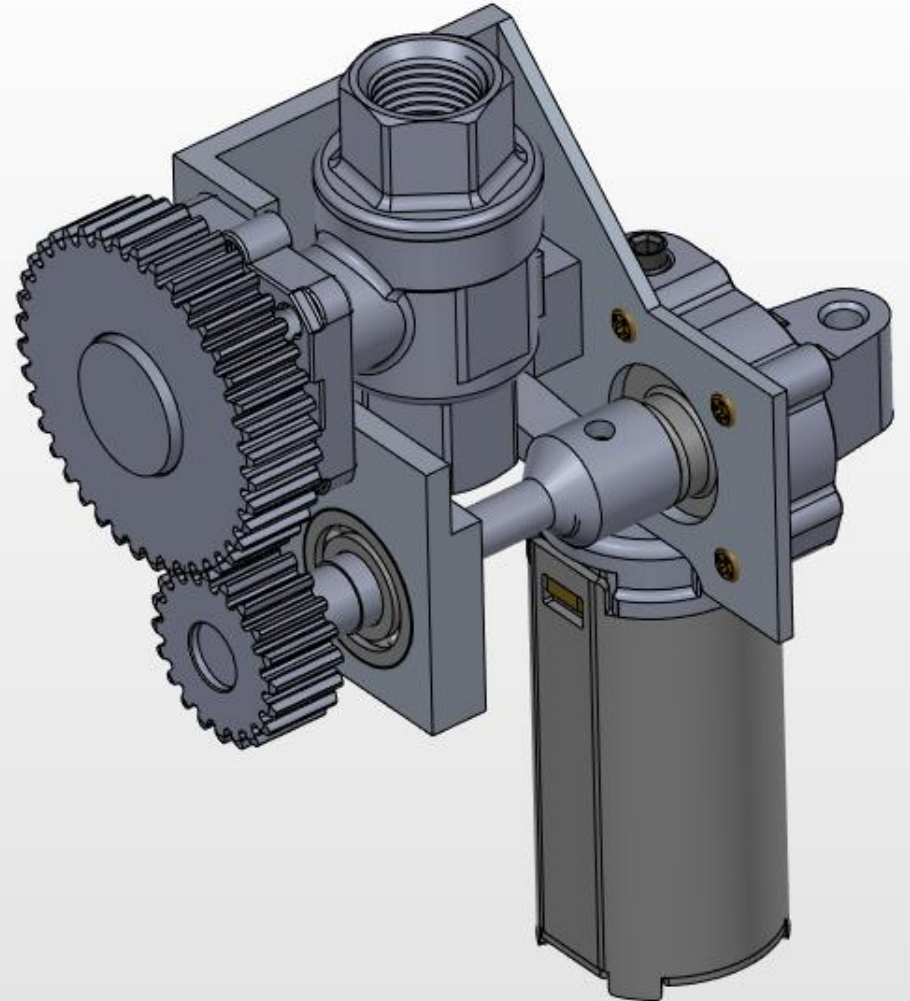
ACTUATORS - VALVES

- Fill system uses industrial electrically actuated ball valves
- Large flow rate, high reliability
- Very slow opening and closing times



ACTUATORS - VALVES

- Engine uses two custom motorized ball valves
- Torque of 10 N m
- Actuation time of 0.3 s
- Limit switches necessary



ACTUATORS - DISCONNECT

- Disconnects fill hose from oxidizer tank
- Tension springs secured with modified three-ring release
- Linear actuator used to pull release pin



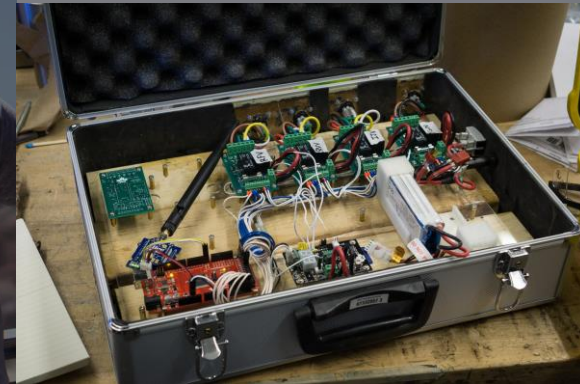
ACTUATORS - IGNITION

- Two stage ignition process
- Nichrome coil embedded in solid fuel puck
- 30 second window to open valve from oxidizer tank to combustion chamber after igniting puck



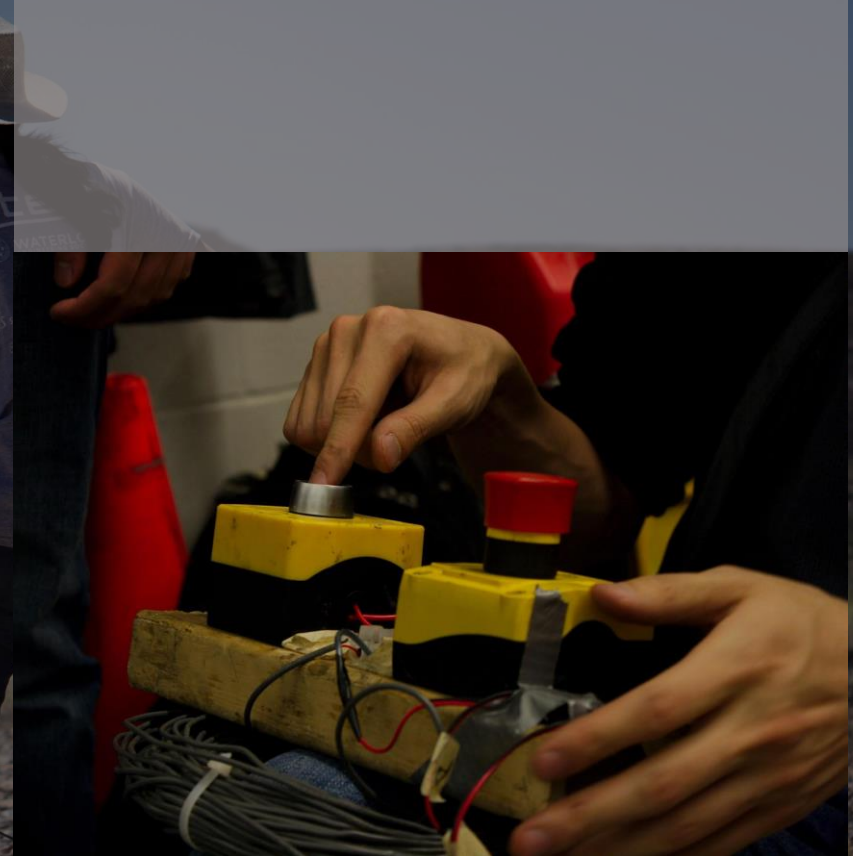
CONTROL AND COMMUNICATION

- Major components:
 - 2x ATmega 2560
 - 2x 900 MHz XBee S3B Pro
 - Custom PCBs for actuation and power management



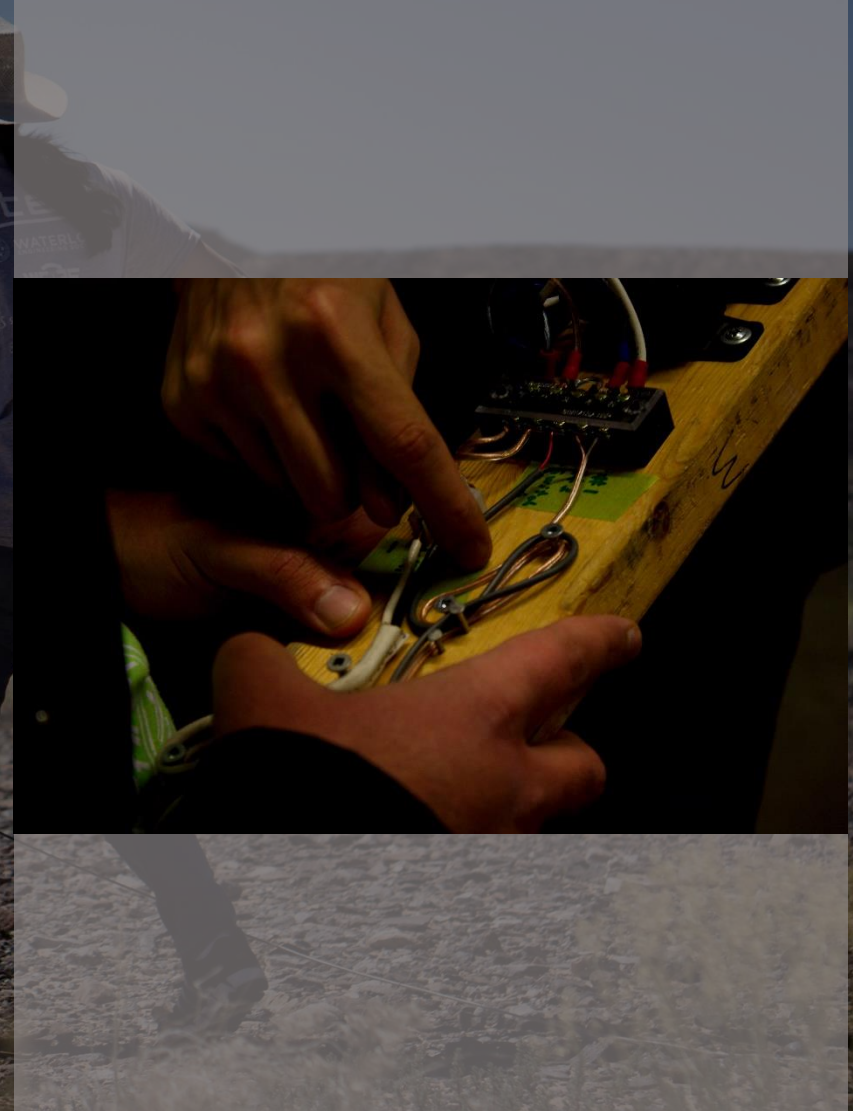
NEXT STEPS

- Improvements for reliability
 - Connectors → common failure point
- Improvements for future capabilities
 - Additional sensors
 - Additional valves for additional propellants



LESSONS LEARNED

- The best PPE is distance
- Lack of data can compromise launch operations
 - Conversely, more data improves confidence in status of system
- Modularity should be considered early in development



THANK YOU



Stein Industries Inc. 
Engineered Electrical Apparatus & Systems



UNIVERSITY OF WATERLOO
FACULTY OF ENGINEERING



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