SPACE VEHICLE FUEL GAUGE

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Mission

- Sierra Space is developing a fuel gauge capable of measuring remaining fuel to an accuracy of ≤1% of actual in microgravity conditions
- Designed for Sierra Space's ECLIPSE satellite line, the system supports on-orbit refueling operations with precise fuel tracking
- This concept reduces mission costs and extends spacecraft lifetimes

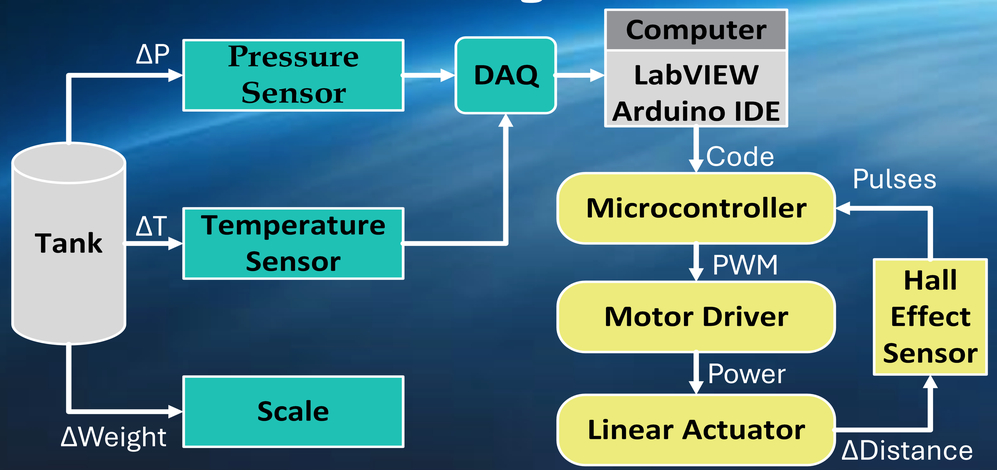
Requirements	Specifications
☑ Safe to use	• System Leakage ≤ 0.7 psi/hr
☑ Gauge external to tank	• 5.6-gallon tank
☑ Budget: $2000	• ¼ " NPT piping junction
☒ Accuracy: ≤ 1% of actual	• 500-lbf linear actuator
☑ Working Pressure: 0-50psi	• Pressure Sensor Accuracy: ± 0.02psi
☑ Working Temperature: 0-40°C	• 120W power limit
☑ Applicable in Microgravity	• Thermistor Accuracy: ± 0.2 °C

Theory

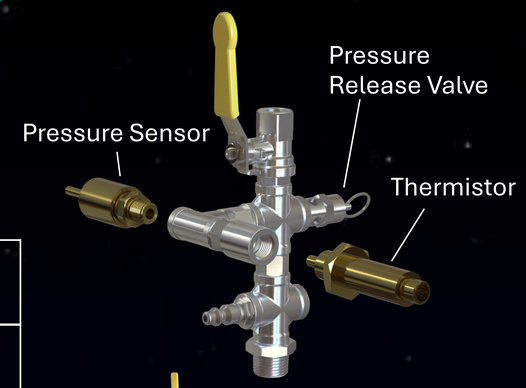
- The fuel gauge uses a method called *Compression Mass Gauging (CMG)*
- The system compresses a known volume (ΔVol) using the linear actuator to compress the piston cylinder
- The change in volume is correlated to a change in pressure (ΔP) measured by the pressure sensor
- Testing proved the gas in our system behaves ideally and isothermally
- Ideal gas behavior allows us to correlate ΔVol and ΔP using a modified Boyle's Law (Eq. 1)
- The volume of gas is used to determine the volume of fuel in (Eq. 2)

$$(1)\ V_{gas} = P_{max}\left(\frac{\Delta Vol}{\Delta P}\right) \qquad (2)\ V_{fuel} = V_{system} - V_{gas}$$

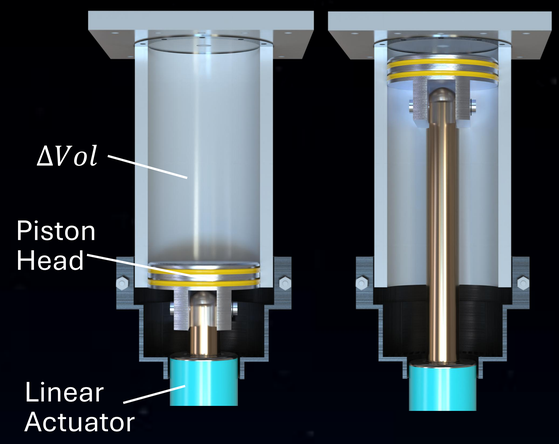
Electronics Control Diagram



1 Piping Junction

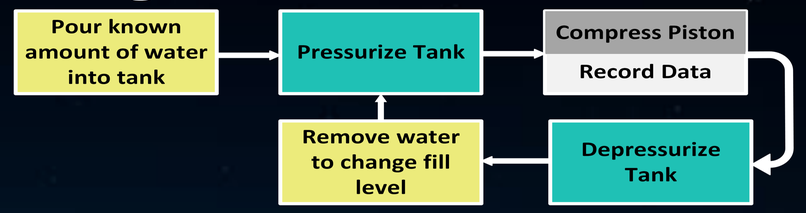


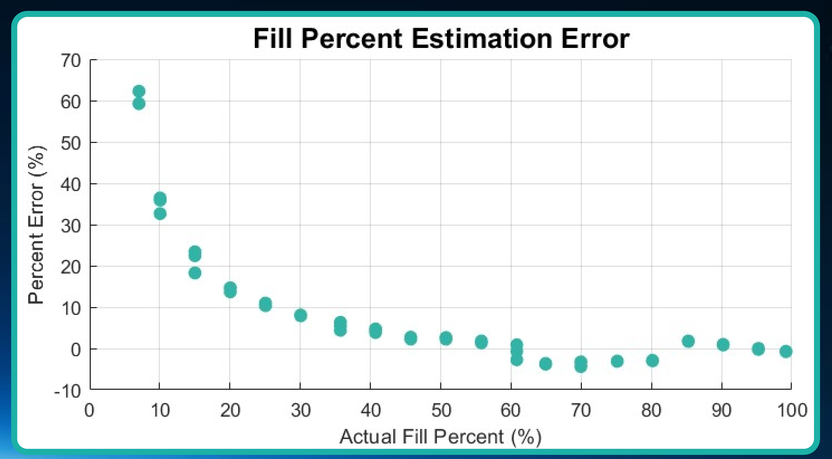
2 Piston & Linear Actuator

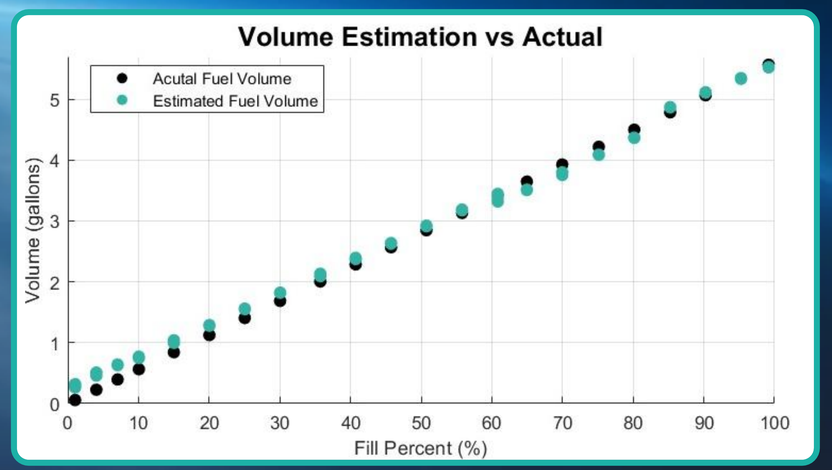


- Fine tolerancing for an exact volume and minimized leakage
- Maximum piston ΔVolume designed to induce smallest measurable ΔPressure
- Actuator can push 500lbf (415lbf calculated during testing)
- Subsystem factor of safety of 4

Testing & Results







Future Work

- Further thermal testing
- Drastically reduce piston size with higher accuracy pressure sensor
- Test in microgravity environment to confirm functionality

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