

Thermal Vacuum Testing of ICPTA RCS at Plum Brook B-2

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Project Overview

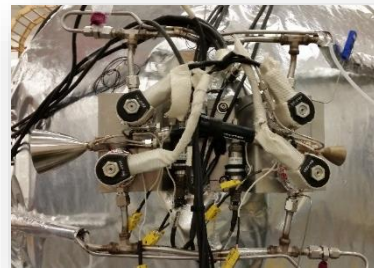
- Vacuum and thermal vacuum testing of the Integrated Cryogenic Propulsion Test Article (ICPTA) was performed at the Plum Brook B-2 facility as a part of a system checkout and facility characterization effort
- Multiple test objectives included: integrated Reaction Control System (RCS) characterization, cold helium pressurization system characterization, modal propellant gaging experiment (Orion), CFM propellant loading experiments, main engine characterization
- The ICPTA is a test bed for LOX/LCH₄ technologies built in 2016 using new components and hardware from the former Morpheus vehicle and other projects
 - Pressure-fed 2800 lbf main engine with ablative thrust chamber and 100:1 nozzle
 - Two 28 lbf RCS engines and two 7 lbf RCS engines with thermodynamic vent system (TVS) for manifold conditioning
 - Coil-on-plug ignition system for all engines
 - Cryogenic helium storage up to 4000 psi which is heated by main engine mounted heat exchanger for pressurization
 - Parallel tank architecture feeding both RCS and main engines

Test Objectives

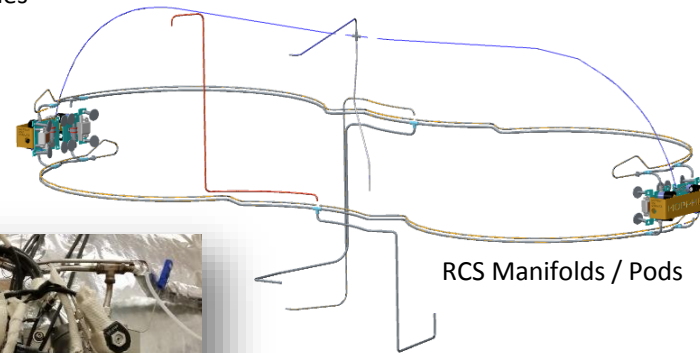
- Manifold priming dynamics
- Manifold thermal conditioning in various heat leak environments
- Fluid transient characterization (water hammer)
- Main engine/RCS system interaction
- Thermodynamic vent system characterization
- Engine performance in TVAC environment
- Coil-on-plug ignition system demonstration

Test Summary

- 40 RCS tests with 864 altitude ignitions
 - Transit phase MIB pulsing
 - Ascent/landing phase high duty cycle pulsing
 - Steady-state operation
- Gas-gas, gas-liquid, and liquid-liquid inlet conditions
- 7 ME+RCS simultaneous tests
- Altitude conditions ranging from 0.01 to 30 torr
- Temperature conditions ranging from ambient to -320 F cold wall
- RCS manifold and engine instrumentation: 4 submerged TCs, 12 welded-on TCs, 16 stick-on TCs, 4 static PTs, 6 dynamic PTs



RCS Pod 1
(1x 28lbf, 1x 7lbf per pod)

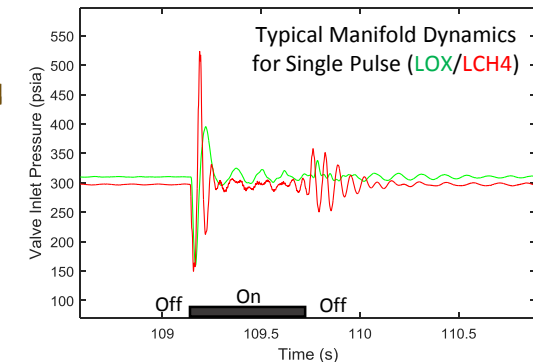


Test Outcomes

- First known demonstration of an integrated cryogenic RCS in a thermal vacuum environment
- Thermocouple and dynamic pressure data for a wide range of system operating conditions to anchor thermal and transient fluid models
- New information on RCS/ME interaction during simultaneous hotfire tests
- Ignition, TVS, and performance data for a range of external environments
- Observation of higher magnitude fluid transients on valve openings than closings, amplified significantly by cold soak environment
- Discovery of new ignition issues during cold soak testing due to thruster body temperatures that were not present in ambient testing



ICPTA Simultaneous Hotfire at NASA Plum Brook B2, 2/28/17



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