

A Summary of Ad Astra Rocket Company's Microgravity Flight Campaigns Related to the Testing of the VF-200 Cooling System.

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VASIMR & VF-200

• VASIMR

- High power electric propulsion system.
- Variable specific impulse.

• VF-200

- 200 kW flight model.
- Includes set of High Temperature Superconducting Magnets.
- Conduction cooled by cryocoolers and heat pipes.





NASA's Flight Opportunities Program

- Objective
 - Technology demonstration of VF-200 cooling system.
- Three flight campaigns
 - FOP2010
 - FOP2011
 - FOP2012
- Team of three engineers/scientists per flight.
 - PI: Ben Longmier Ph.D.





FOP2010: Objectives and Experimental Setup

- Objectives:
 - Demonstrate magnetic field tolerance of cryocooler.
 - Operating below 50 K.
 - In microgravity environment.
 - Characterize cryocooler performance in different acceleration levels (µg-1.0g).
- Flight hardware.
 - Crycooler, vacuum system, magnets and DAQ.









FOP2010: Results



FOP2011: Objectives and Experimental Setup

• Objectives.

- Characterize vibrational modes of cryocooler.
 - Power levels.
- Test dampening configurations.
- Flight hardware.
 - Similar to FOP2010.
 - Accelerometers.
 - Three dampening configurations tested.



FOP2011: Results, Dampening #1



Frequency (Hz)

FOP2011: Results, Dampening #2



FOP2011: Results, Dampening #3



Frequency (Hz)

FOP2012: Objectives and Experimental Setup

- Objectives
 - Test different heat pipe configurations at different power levels.
 - Test tethered system to avoid vibrations while testing.
- Flight hardware
 - Structure from FOP2010/FOP2011.
 - 200 W heater.
 - Four heat pipe configurations.
 - Tethered system/accelerometers.







Heat Pipe



• Thermal resistance

- Temperature difference when unit energy flows through it in unit time.
- Greater resistance = lower conductivity

- Capillary limit:
 - Rise in thermal resistance of heat pipe.

FOP2012: Results, Flight #3



Flight 3 Heat Pipe Thermal Resistance (Sintered Wick, Nickel Plated Copper/Water)

FOP2012: Results, Flight #4



Flight 4 Heat Pipe Thermal Resistance (Sintered Wick, Copper/Water)

Conclusions

- Flight campaigns allowed Ad Astra to make considerable progress in design/verification of the VF-200 cooling system.
 - From TRL 4 to 5.
- Different components were tested:
 - Cryocooler performance was characterized.
 - Dampening system was implemented.
 - Optimal heat pipes were selected.



Thank you. Questions?



