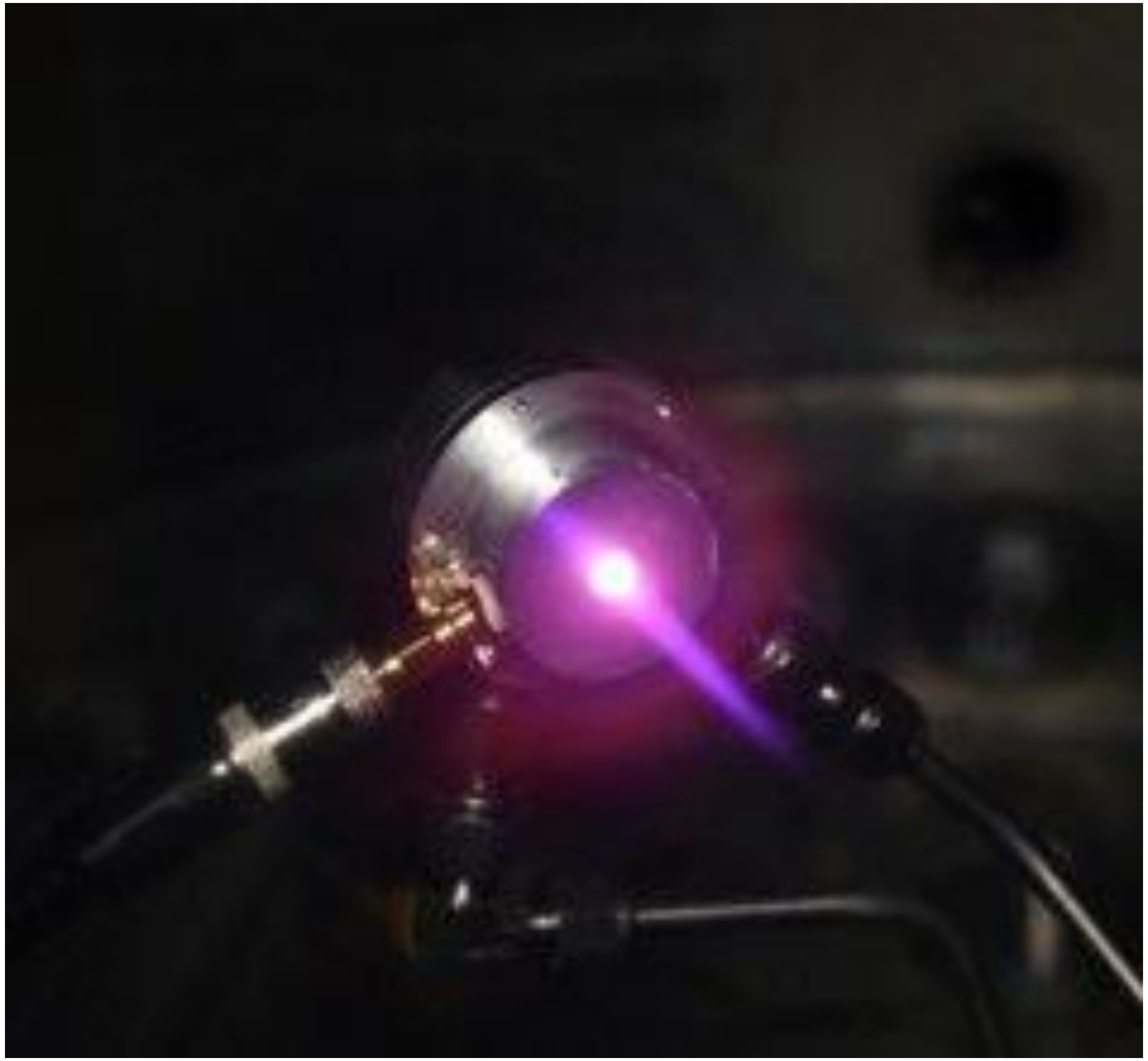
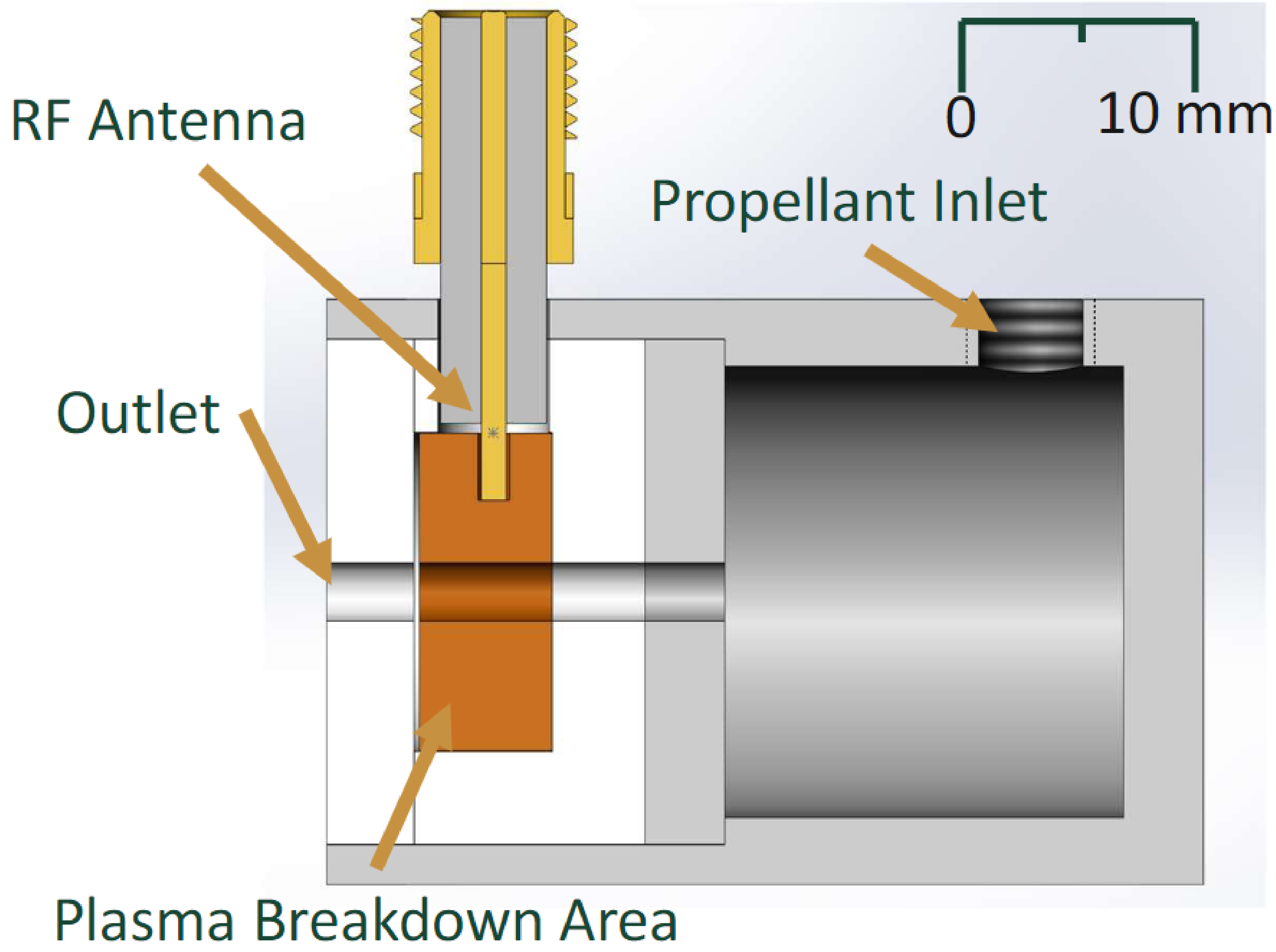


SPRIET-Jet

SMALL PLASMA RF INTEGRATED ELECTROTHERMAL THRUSTER

CSDW 2023

PROJECT LEADS: NEIL BEDAGKAR, MONT MURAD



What is SPRIET-Jet?

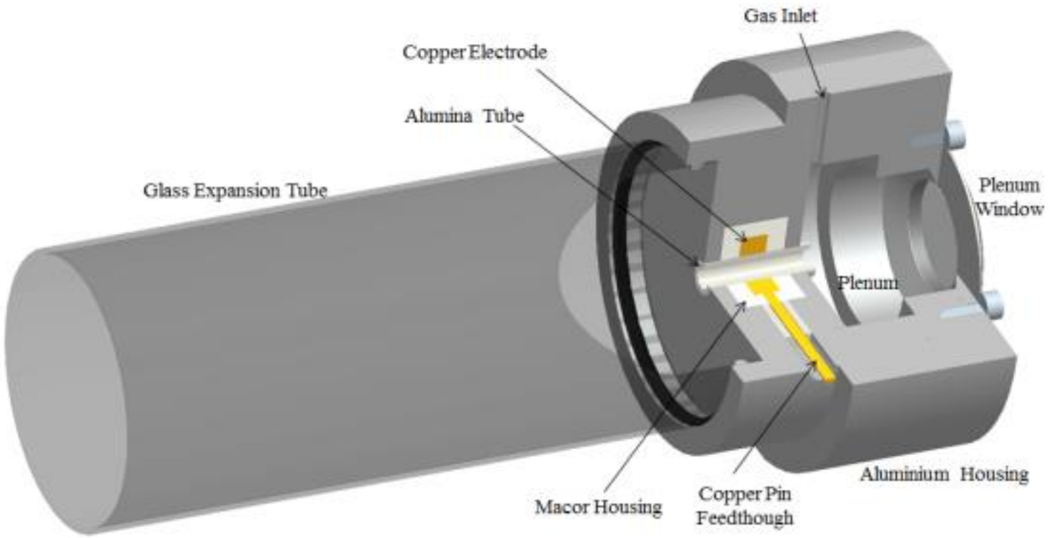
- A 1U (+ tuna can!) system that can be mounted to 2U+ CubeSats
- Utilizes an RF powered micro-propulsion system

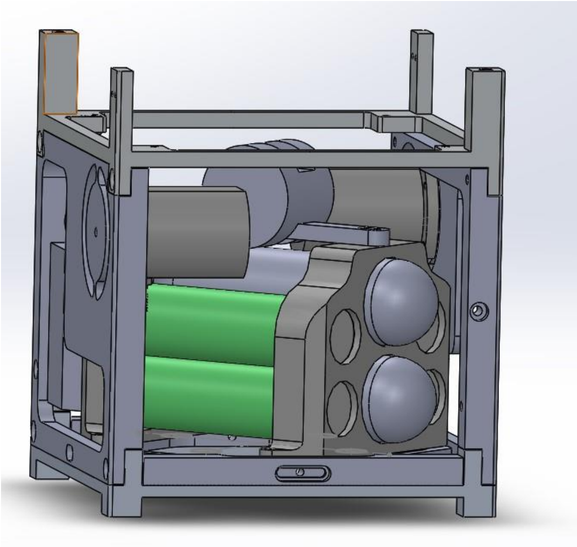
How does SPRIET-Jet work? (Currently)

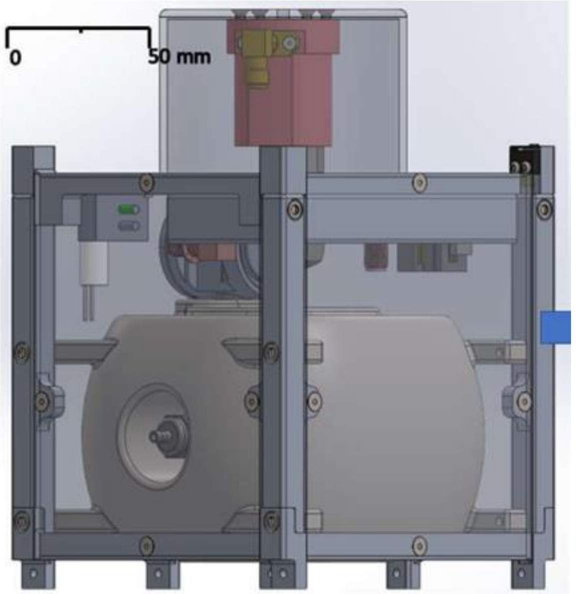
- DC to RF converter, draws from batteries
- RF energy is delivered into a copper electrode at a minimum breakdown voltage
- Electrode couples the RF energy into the gas, initiating plasma breakdown
- Thrust occurs due to pressure differential (higher pressure in the pressure vessel from plasma breakdown than in orbit)

Phase 1 – Dr. Amelia Greig's Thesis

- The first design iteration of SPRIET (Pocket Rocket) at the time
- Underlying system design is the same, but this iteration focused a lot on the plasma physics and designing around those
  - Lot of testing involved with spectroscopy to analyze the plasma thrust generated
- Base system knowledge & design comes from here





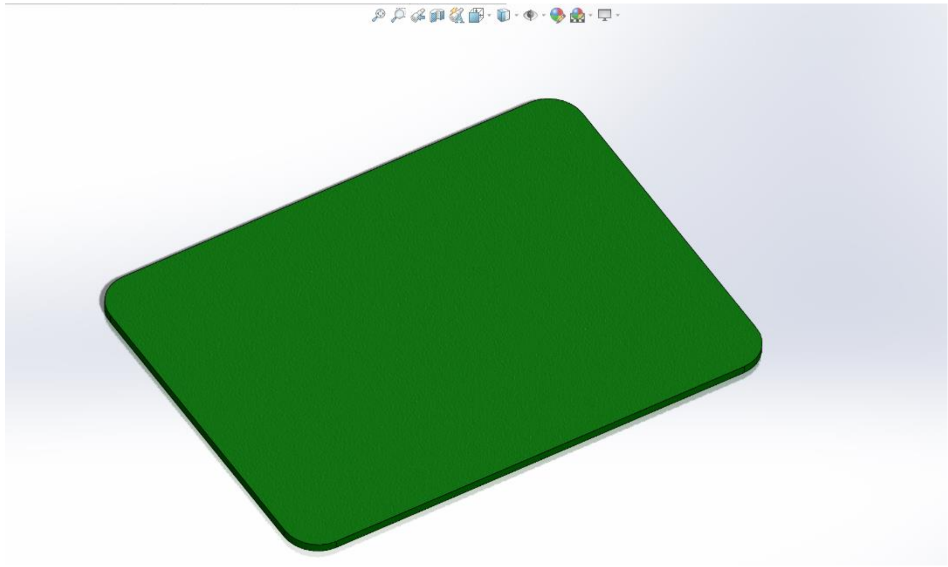


Phase 2 – James Harper's Thesis

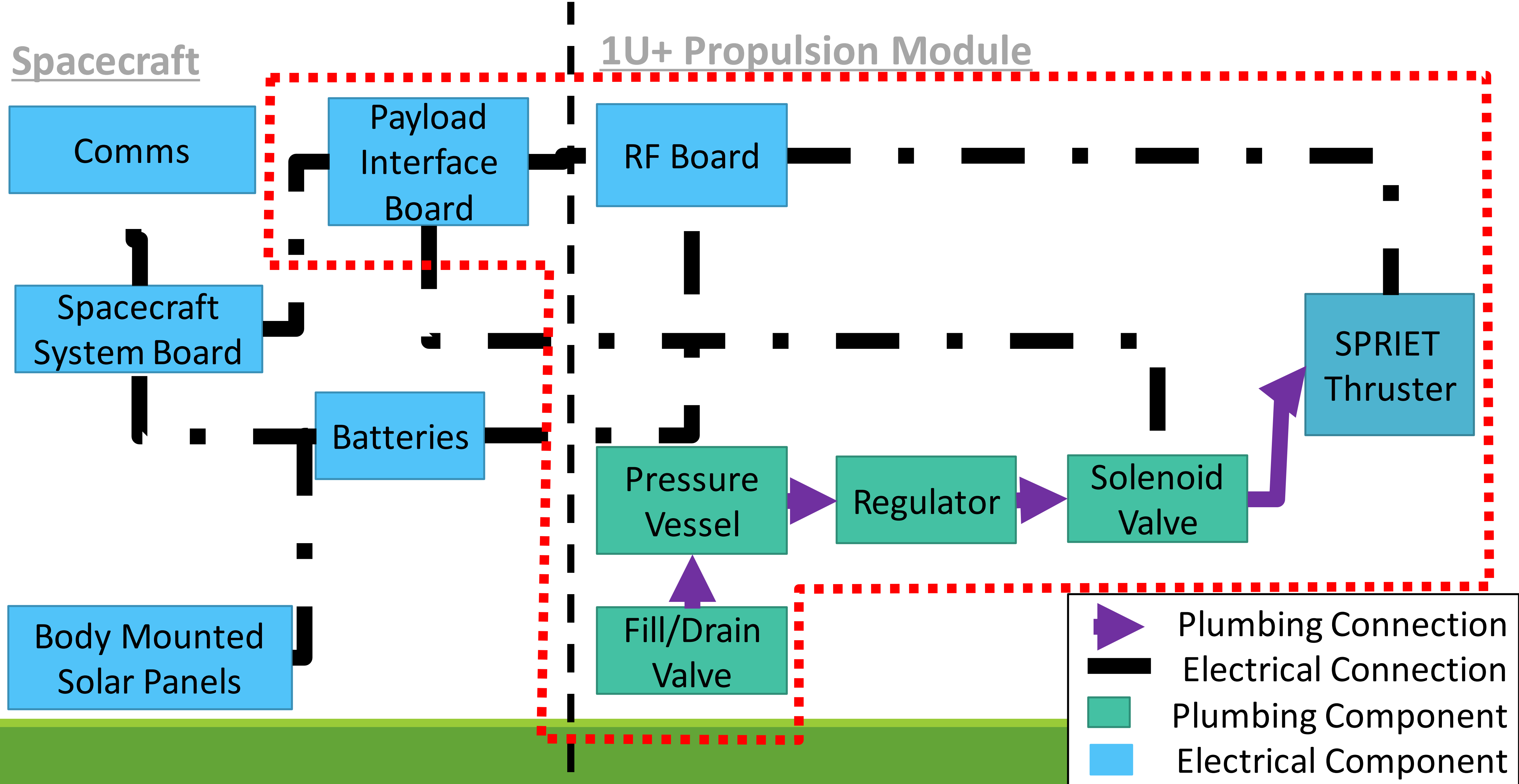
- Change to a Tuna can design for a 1U
- Redesign pressure vessel (validated in FEA for 20.7 MPa)
- In theory, has a Delta-V of 20 ± 3m/s
- Harper's thesis had the following plan
  - Phase 1: Early communications
  - Phase 2: Thruster check out for 10 min
  - Phase 3: Nominal
  - Phase 4: Module remains idle (Mission Accomplished)
- Life span of about a week
- The thesis also picked Argon as the propellant
  - However, this might change for our design

Phase 3 – Electronics (Mainly)

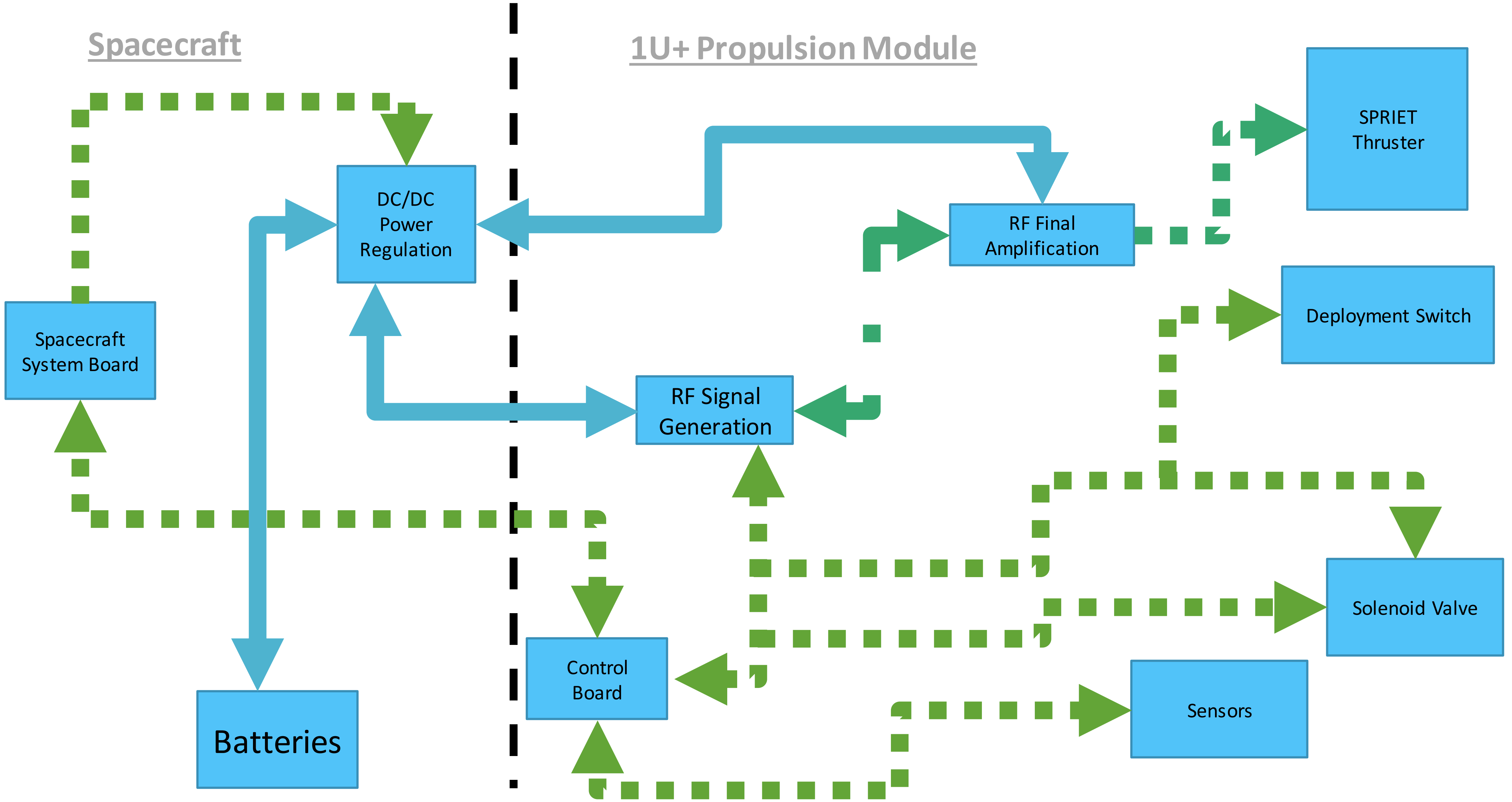
- This will be our current design, and everything related to it
- Two over all goals
  - Design/Plan out the electronics [There are NO electronics]
    - Including a supply of 5W in RF and a 10W DC nominal input at “13.56” MHz
  - Re-design the pressure vessel for manufacturability, and not $7,000+



System Electrical and Plumbing Routing Overview



System Electrical Overview



Phase 3 Con't – Pressure Vessel

- Mechanically, JHT pressure vessel is too complicated to be machined in a CNC
  - 3D metallic printing is very expensive out of pocket , would have to be printed in two parts
  - If we can get it printed without spending too much it would be worthwhile welding it and testing it for structural strength
  - Welding has little flight heritage & standards on pressure vessels
- Exploring COPV's
  - Pros: Strong pressure vessel, would be more feasible to manufacture
  - Cons: Would have to control manufacturing process heavily to ensure reliability, failure analysis is difficult
    - LBB, Stress rupture

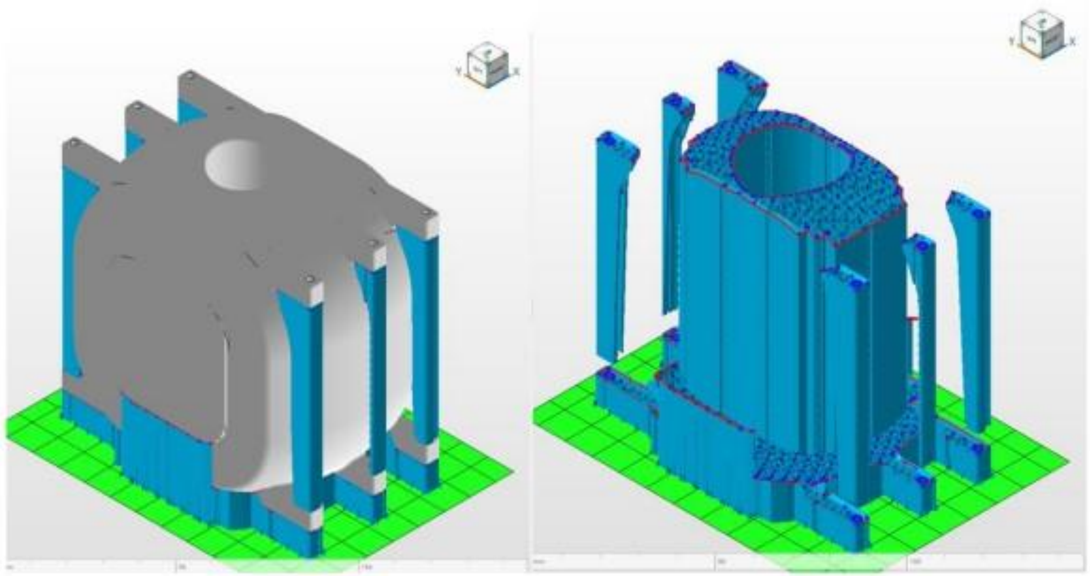


Figure 3.30: a) Example of thermal support structures in 3D printed SS316L part with part included and b) Example of thermal support structures in 3D printed SS316L part without part included

Phase 3 Con't – Testing

- Replicating a fire test that was done with the thruster prototypes we have in lab
- This will prove very useful for understanding the plumbing, propulsion mechanisms, and power draw of the overall system
- Want to test different propellants and frequencies to validate thrust values
  - Argon, Xenon, Krypton mainly
  - Haven't decided frequencies

Where do we go from here?

- Electronics / Software:
  - Electrically Characterize the thruster
  - Work backwards to re-build an electrical system
  - Components Trade studies
  - PCB design / Testing
- Structures:
  - Continue exploring different pressure vessel designs and begin iterating on a COPV
  - Figure out thermal insulation for pressure vessel & RF insulation from thruster to rest of the module
- Testing
  - Test the current modules and different propellants to validate thrust calculations

Goals for SPRIET-Jet

- Design and analytical verification of an AFFORDABLE 1U+ electrothermal micro-propulsion system adaptable on 2U+ CubeSats for drag and orbital correction applications.
- Long-Term: Market and sell as an affordable and relevant ADCS integration option

Questions?

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