Development of ASCENT Propellant Thrusters and Propulsion Systems

August 10th, 2022

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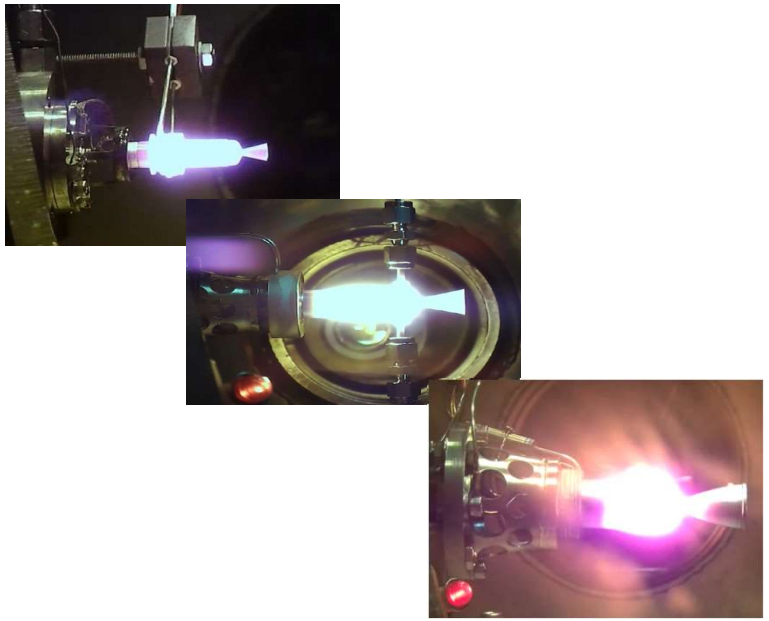
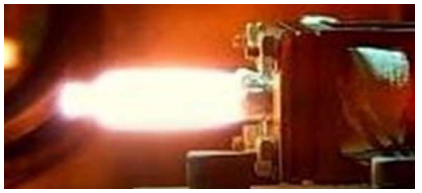
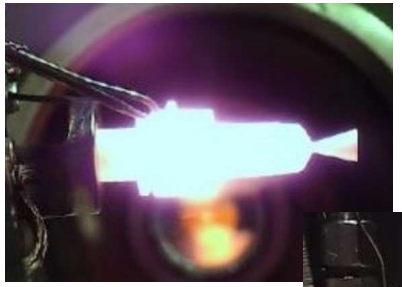


100 mN Thruster Development

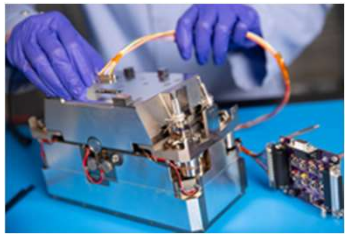
- Flight qualified for Lunar Flashlight (NASA)
  - Lunar Flashlight will survey the moon's south pole for water ice
  - The Lunar Flashlight Propulsion System provides 250 m/s delta-V using four Plasma Processes 100 mN thrusters
- Developed from 2016-2021
  - Selected for LFPS in 2019
- 20 thrusters produced
  - Four thrusters are expected to fly in late 2022
  - Remaining thrusters may fly on additional missions



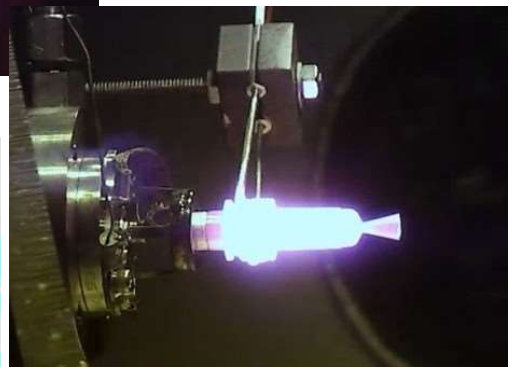
Early development 100 mN thruster



Mid-development 100 mN thruster



100 mN thrusters on Lunar Flashlight Propulsion System



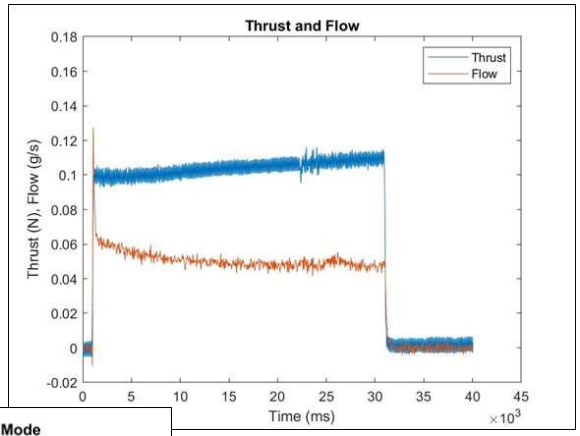
Flight qualification of 100 mN thruster

PLASMA PROCESSES

100 mN Thruster Development

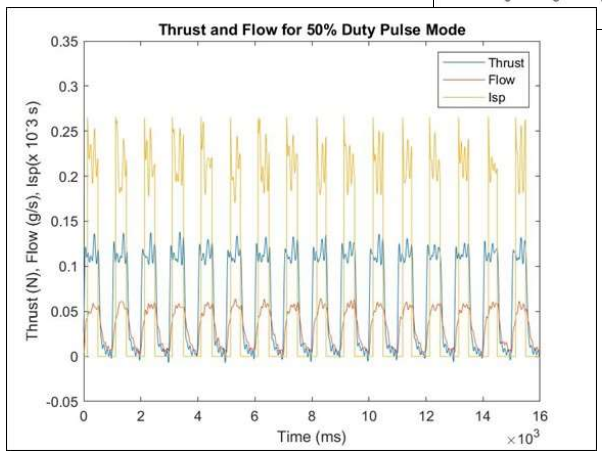
U.S. AIR FORCE

- *Thrust range*: 30-280 mN
- *Isp*: 214 sec (steady state), 235 sec (pulse mode)
- *Minimum Impulse Bit*: 3.6 mNs
- *Response Time*: 70 ms
- *Decay Time*: 100 ms
- *Throughput*: 1250 g
- *Accumulated Burn Time*: 6.15 hrs
- *Longest Burn*: 101 min
- *Heater Power*: 7-9 W



Thrust and flow of 100 mN thruster during steady state

Thrust and flow of 100 mN thruster during pulse mode

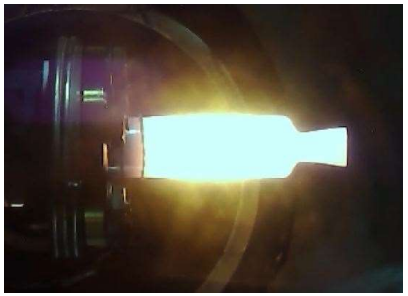


PLASMA PROCESSES

1N Thruster

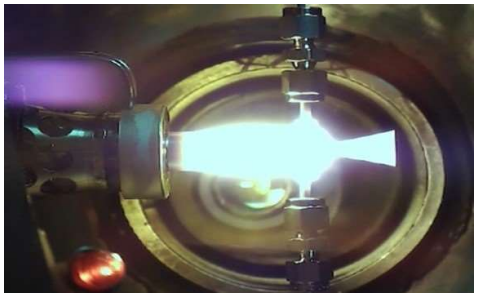
U.S. AIR FORCE

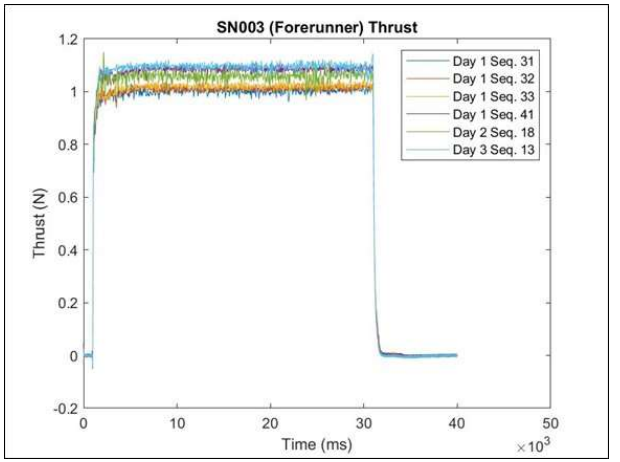
- Early prototype developed under IR&D
- Instrumented design developed under Air Force Sprint BAA
- Flight 1N thruster is being developed under Sprint BAA continuation
- Qualification of this flight thruster project to conclude near the end of 2023
- Performance attributes:
  - *Thrust range*: 0.2-1.1 N
  - *Isp*: 250 sec (steady state), 236 sec (pulse mode)
  - *Minimum Impulse Bit*: 0.05 Ns
  - *Throughput*: 2350 g
  - *Longest Burn*: 240 sec
  - *Heater Power*: 20 W



Prototype 1N thruster

Instrumented 1N thruster

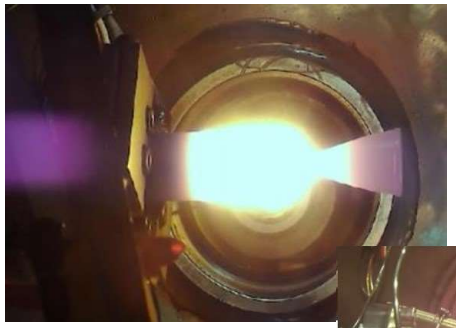




Thrust of 1N instrumented thruster

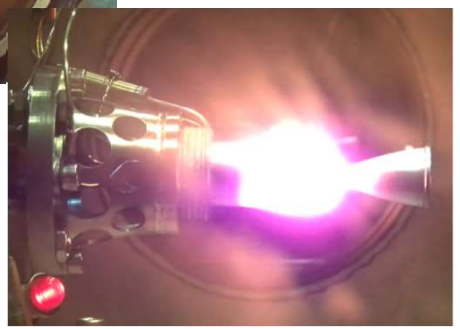
5N Thruster

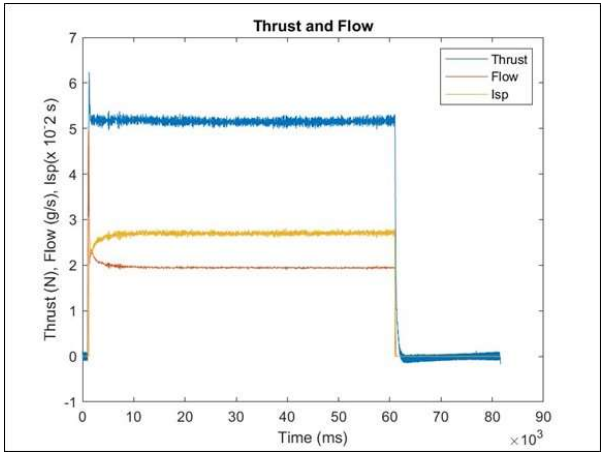
- Prototype 5N thruster developed under NASA SBIR contract
- Low and high throughput versions of 5N thruster are being developed
- Expected flight versions to be available in early 2023
- Performance attributes:
  - *Thrust range*: 1-5.6 N
  - *Isp*: 261 sec (steady state), 221 sec (pulse mode)
  - *Minimum Impulse Bit*: 0.7 Ns
  - *Throughput*: 3.01 kg
  - *Longest Burn*: 384 sec
  - *Heater Power*: 20 W



Prototype 5N thruster

Late development 5N thruster

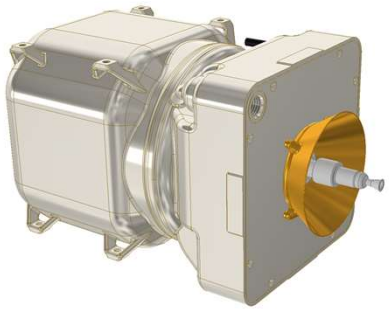




Thrust and flow of 5N thruster

Sprite Propulsion System

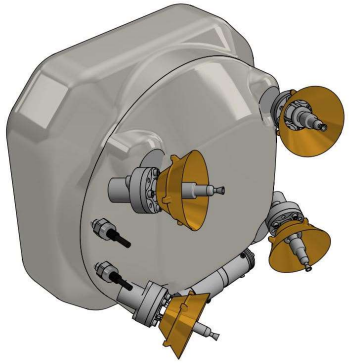
- Mission and Development Overview
  - The Sprite Propulsion System will provide small satellite propulsion via previously demonstrated hardware in a standard form factor.
  - This 1.5U propulsion system allows plug-and-play green propulsion to CubeSat and other nanosatellite systems.
- Capability
  - The CubeSat is adorned with one, 100 mN ASCENT thruster from Plasma Processes.
  - Sprite will produce over 100 m/s in delta V.
- Expected Launch
  - This propulsion system is to be completed no earlier than FY 2023.



Sprite Propulsion System

Phantom Propulsion System

- Mission and Development Overview
  - The Phantom Propulsion System is being designed as a successor to the Lunar Flashlight Propulsion System in conjunction with NASA and Georgia Tech.
  - This 12U variant (double the size of LFPS) allows for a larger payload and wet mass, which extends mission parameters this module could be applied for.
- Capability
  - The CubeSat is adorned with four, 100 mN ASCENT thrusters from Plasma Processes.
  - Phantom will produce over 500 m/s in delta V.
- Expected Launch
  - This propulsion system is to be completed no earlier than FY 2023.



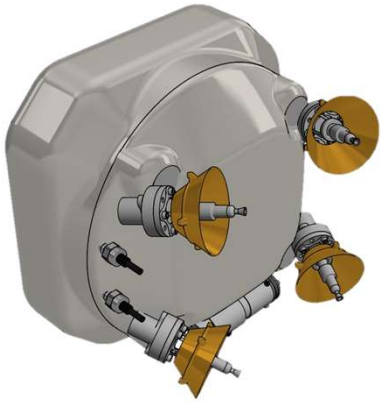
Phantom Propulsion System

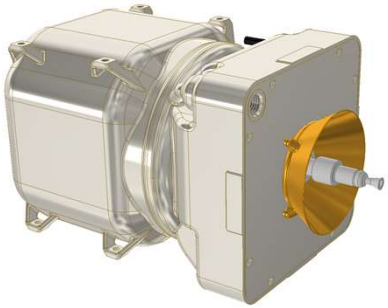
PLASMA PROCESSES

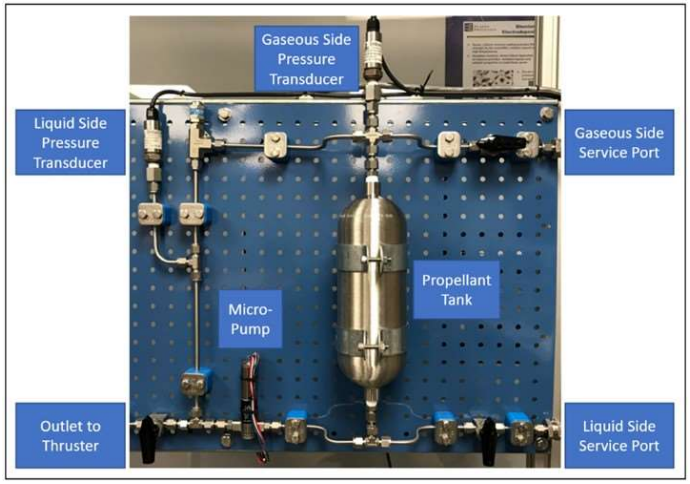
Propulsion Systems

U.S. AIR FORCE

- Micro-Pump CubeSat Propellant System
- Phantom (12U)
  - Over 500 m/s delta-V capability using 100mN, 1N, or 5N thrusters
  - Custom controller, propellant tank, and manifold
  - ETC 2023
- Sprite (1.5U)
  - Demonstration mission using Phantom and Lunar Flashlight related hardware, launching in 2023
  - Provides 100 m/s delta-V with a single thruster







PLASMA PROCESSES

Capabilities

U.S. AIR FORCE

- Manufacturing
  - EL-Form® deposition
  - EDM
  - Vacuum induction brazing
  - ISO 8 Cleanroom
- Testing
  - Hot fire test capacity for up to 22N to steady state

Acknowledgements

Thank you to the AFRL and NASA MSFC for their critical support in multiple thruster programs and other development efforts.