NEXT Single String Integration Tests in Support of the Double Asteroid Redirection Test Mission

Robert Thomas and Michael Aulisio
NASA Glenn Research Center, Cleveland, OH

Andrew R. Badger, Christopher C. Heistand, Derik S. Thompson, Raymond Liang, and Jeremy John
Johns Hopkins University Applied Physics Laboratory, Laurel, MD

Keith Goodfellow
Aerojet Rocketdyne, Redmond, WA

James Bontempo
Zin Technologies, Cleveland, OH

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DART Mission

- Demonstrate kinetic impactor deflection of a representative threat asteroid
- A controlled impact experiment to increase confidence of kinetic impact predictions and improve understanding of asteroid physical properties and high speed collisions
- Binary target allows measurement of deflection by ground-based observatories
- The primary launch period extends from 22 July to 11 August 2021
- DART will launch on a SpaceX Falcon 9 from Vandenberg Air Force Base
- The arrival dates vary from 30 September to 02 October 2022, optimized to achieve the impact geometry requirements

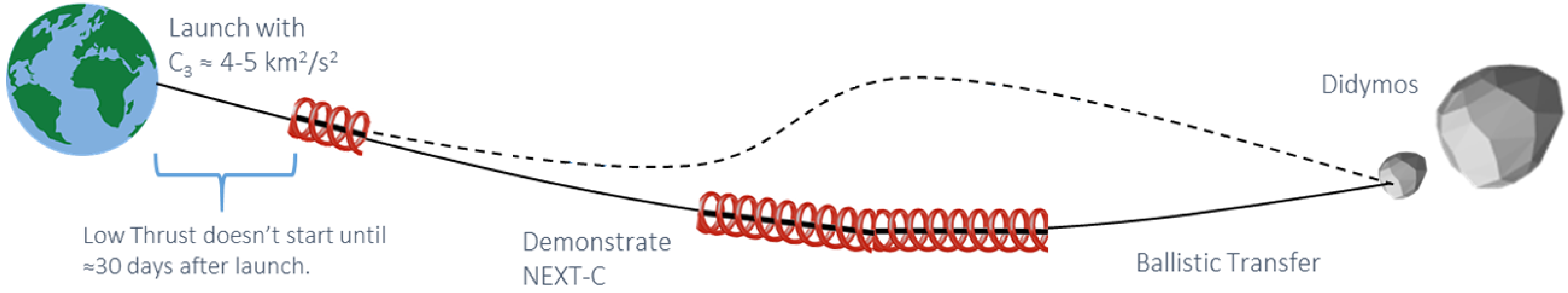
The DART target (the moon of 65803 Didymos) is a realistic-sized asteroid of the most common NEO composition

NEXT Use on DART Mission

- Once the NEXT system has been checked-out, the DART mission will use it for TCMs and then exercise it using several "neutral burns"
  - the burn has the objective of demonstrating NEXT-C without risking the ballistic impact
  - NEXT will be operated for a total of ~ 1400 hours

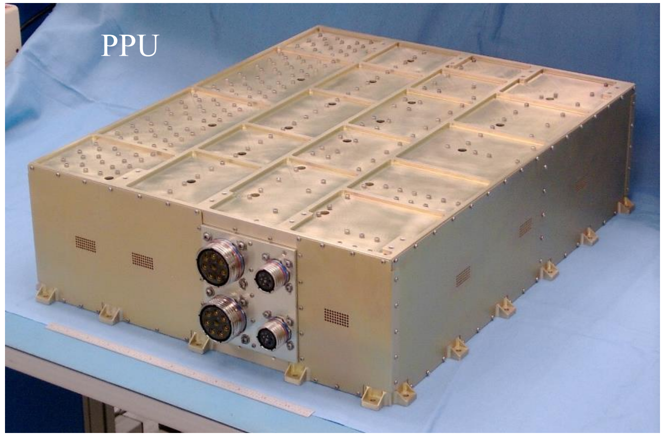
- The neutral burns are achieved by pointing DART's +X axis to the Sun and rotating about the Sun-line with a 12 hour period
  - Over the full period, the induced orbit change integrates to nearly zero change in velocity
  - Fixes spacecraft geometry (solar arrays locked)
  - Gives consistent low-gain-antenna gain to Earth
  - Given its constant attitude state, it requires little propellant for attitude control

- At any point, if NEXT-C thruster is turned off, the original impact conditions can be recovered for < 3.5 m/s with a TCM

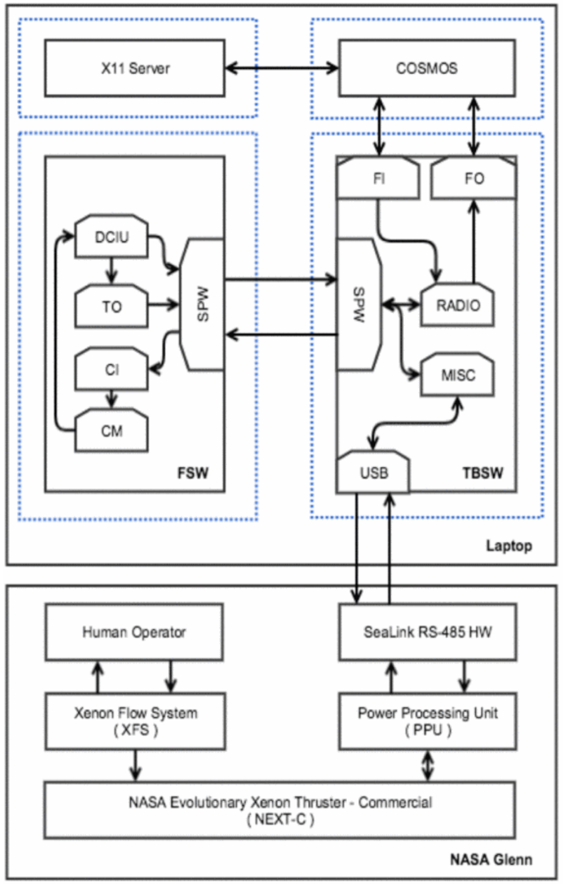


Test Objectives

- Evaluate system performance across anticipated DART flight conditions
- Characterize drift in thrust vector across Xe flow envelope
- Demonstrate functionality and fault detection of command and data handling system
- Provide baseline PPU/thruster for flight hardware tests (fall 2019)



Software in the Loop Simulator



Test Matrix

- Tests conducted at a beam current of 2.70 A , at three different voltage levels

Test Parameter	Range
PPU Baseplate Temperatures	-24 °C, 40 °C, 55 °C
Propellant Flow Rates	Main: +7% and -5% of nominal flow value Disch. Cathode: +/- 6% of nominal flow value Neut. Cathode: +21% and -6% of nominal flow value
PPU High Power Bus Input Voltages	80 V, 100 V, 125 V
PPU Low Power Bus Input Voltage	28 V
Throttle Levels	DETL2.7A, DTL28, DTL29

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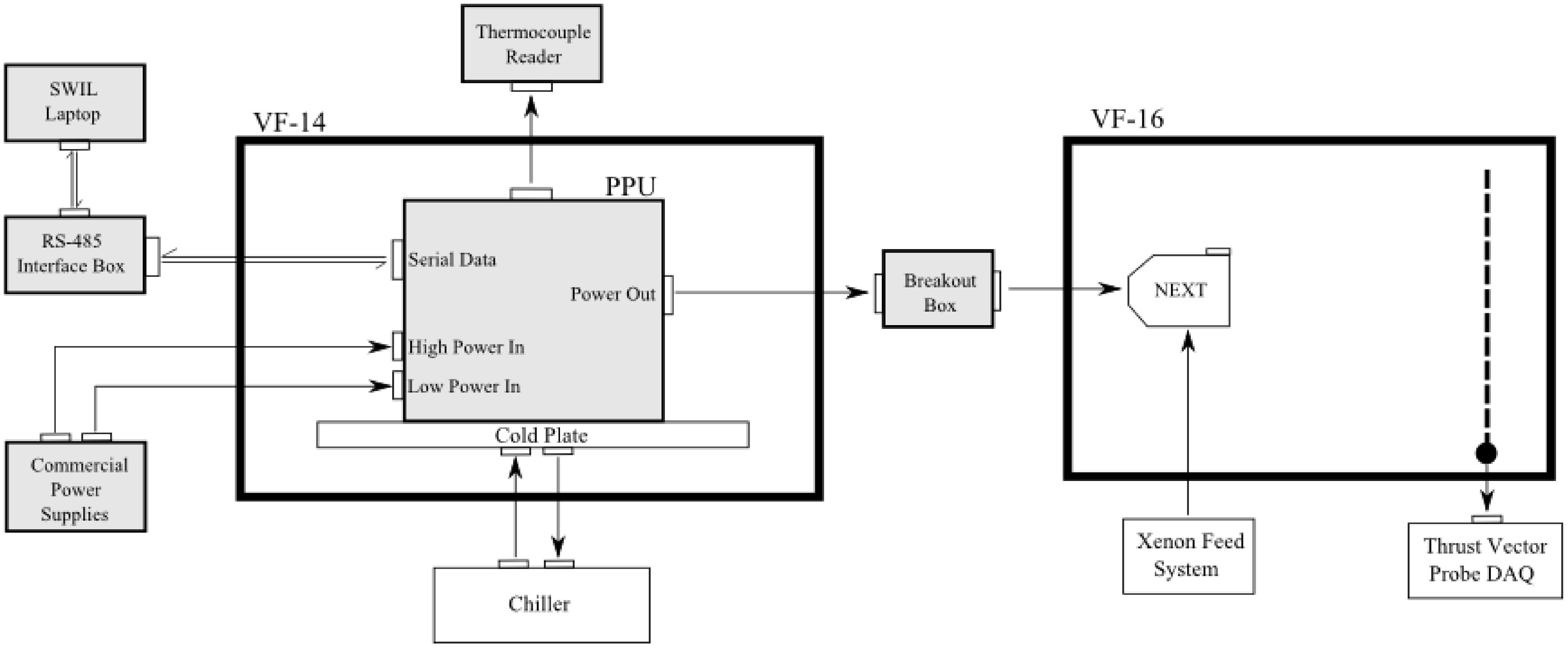
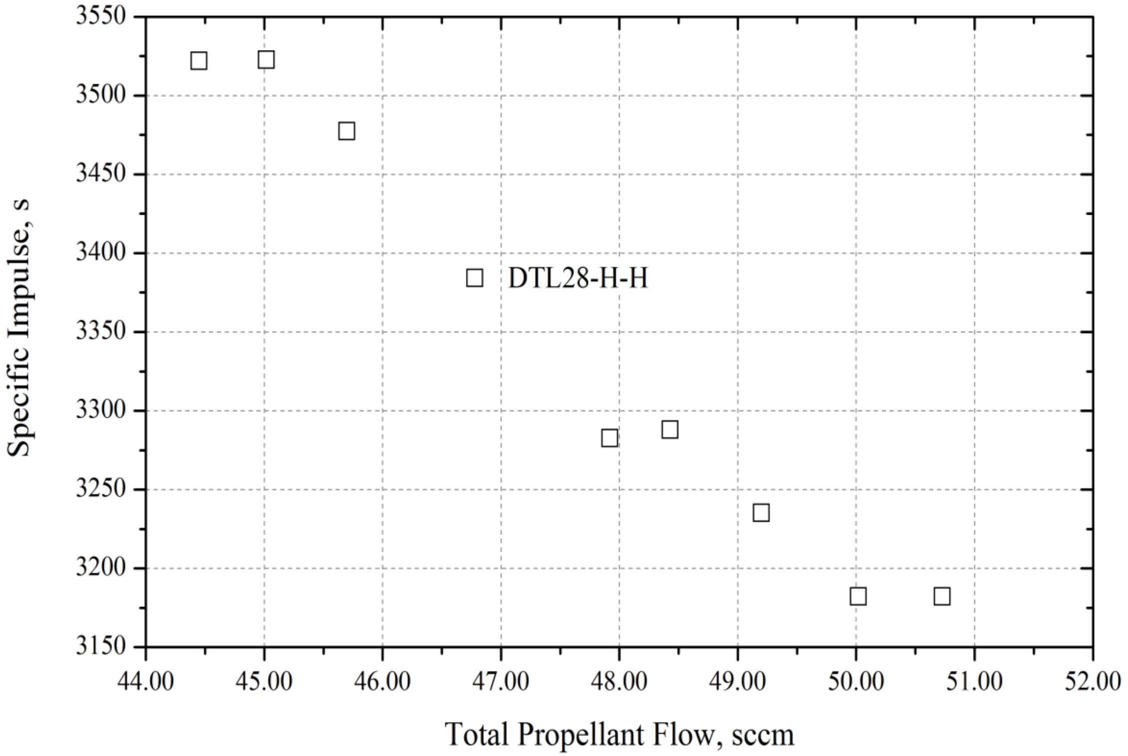
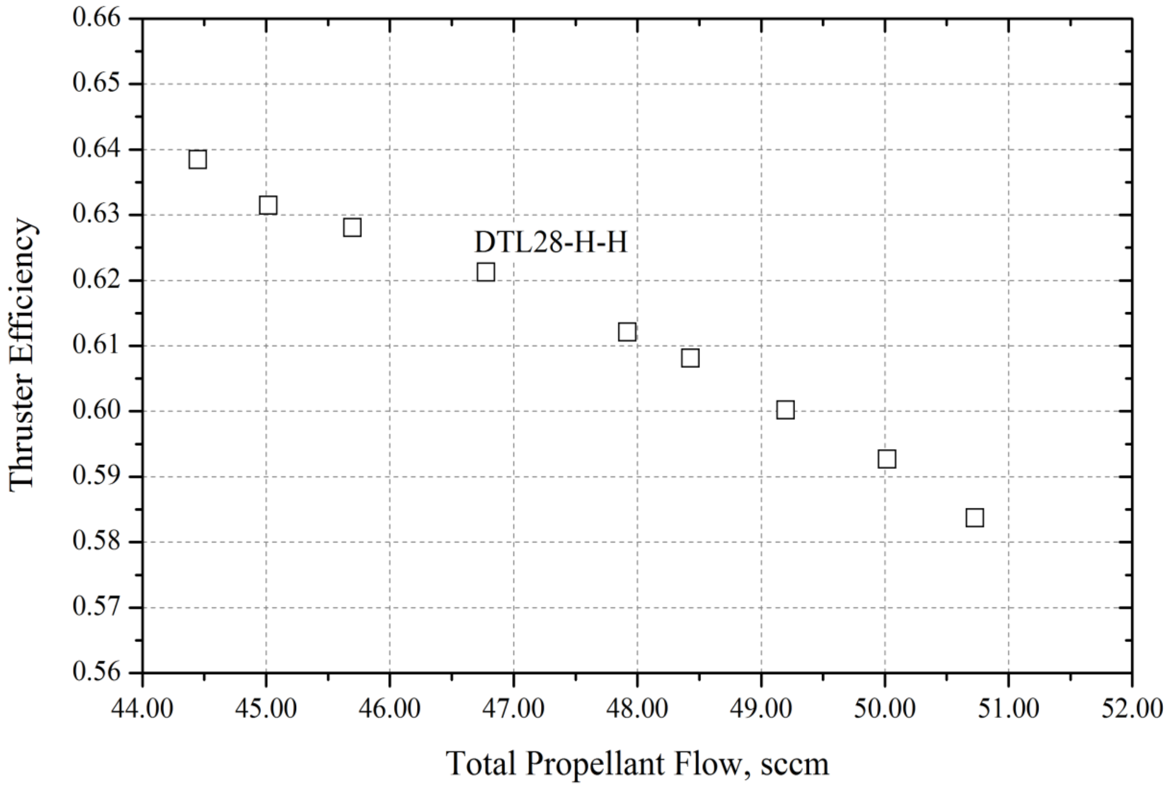
Test Setup



Thruster Performance

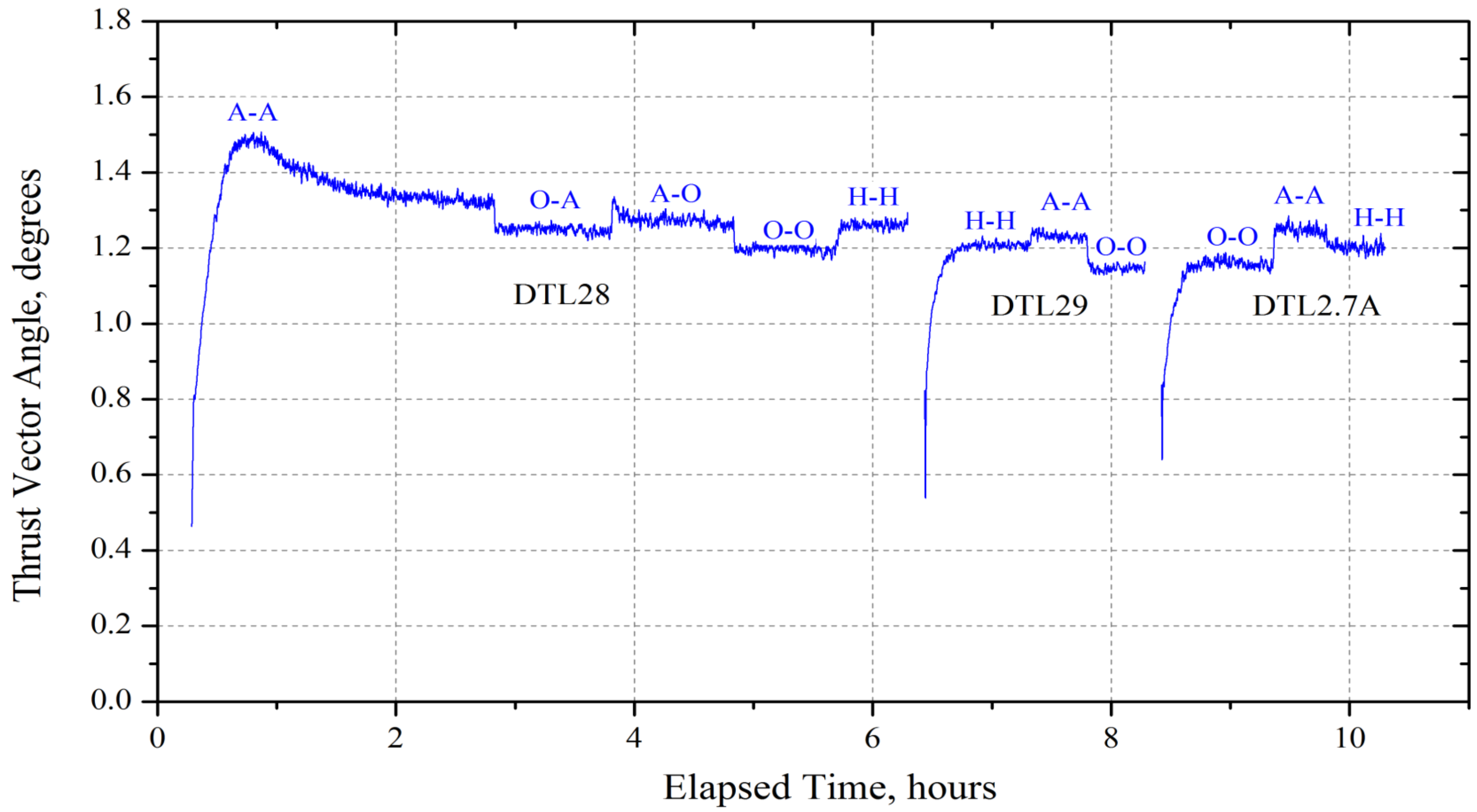
- Thruster performance invariant with high/low input power bus PPU voltages, PPU baseplate temp.
- Performance in-family with risk reduction data obtained with EM4 engine and commercial power supplies





Thrust Vector Behavior at Various Throttle Levels

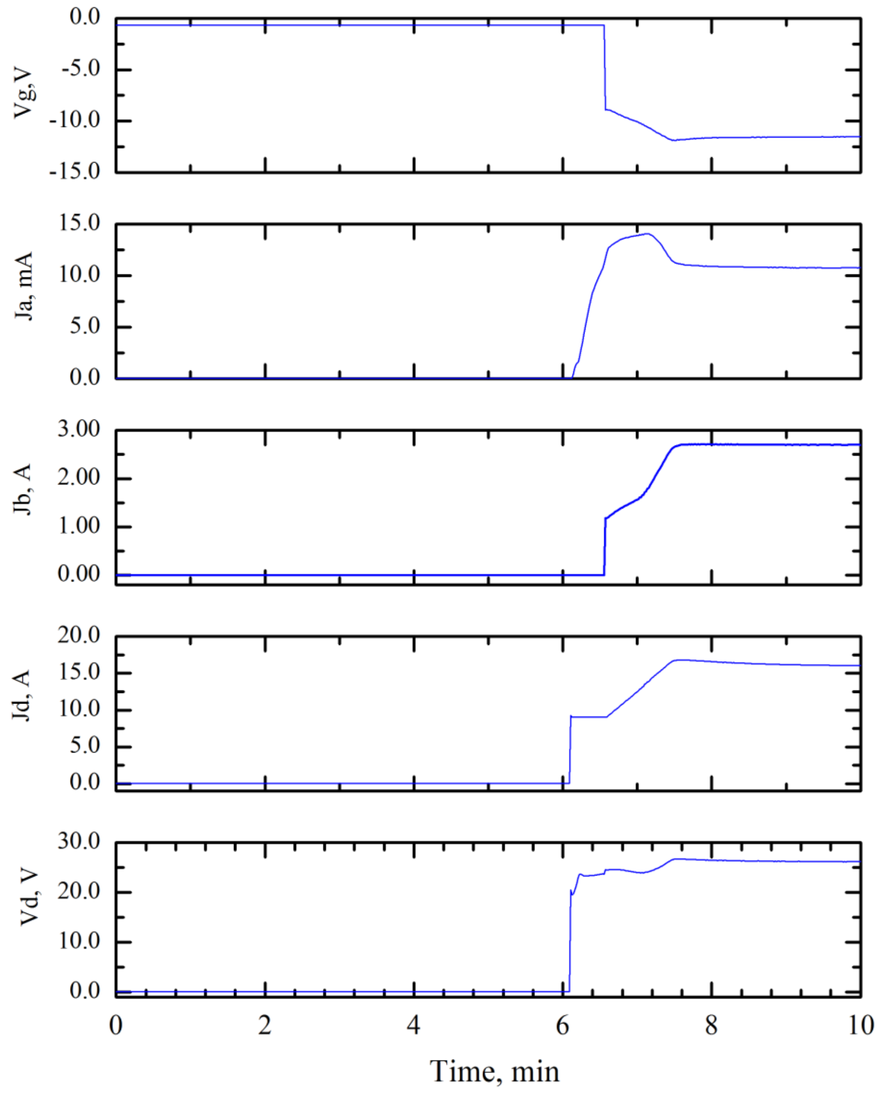
- Thrust vector varies by less than 0.2 deg. across all DART operating conditions
  - within the uncertainty of the measurement



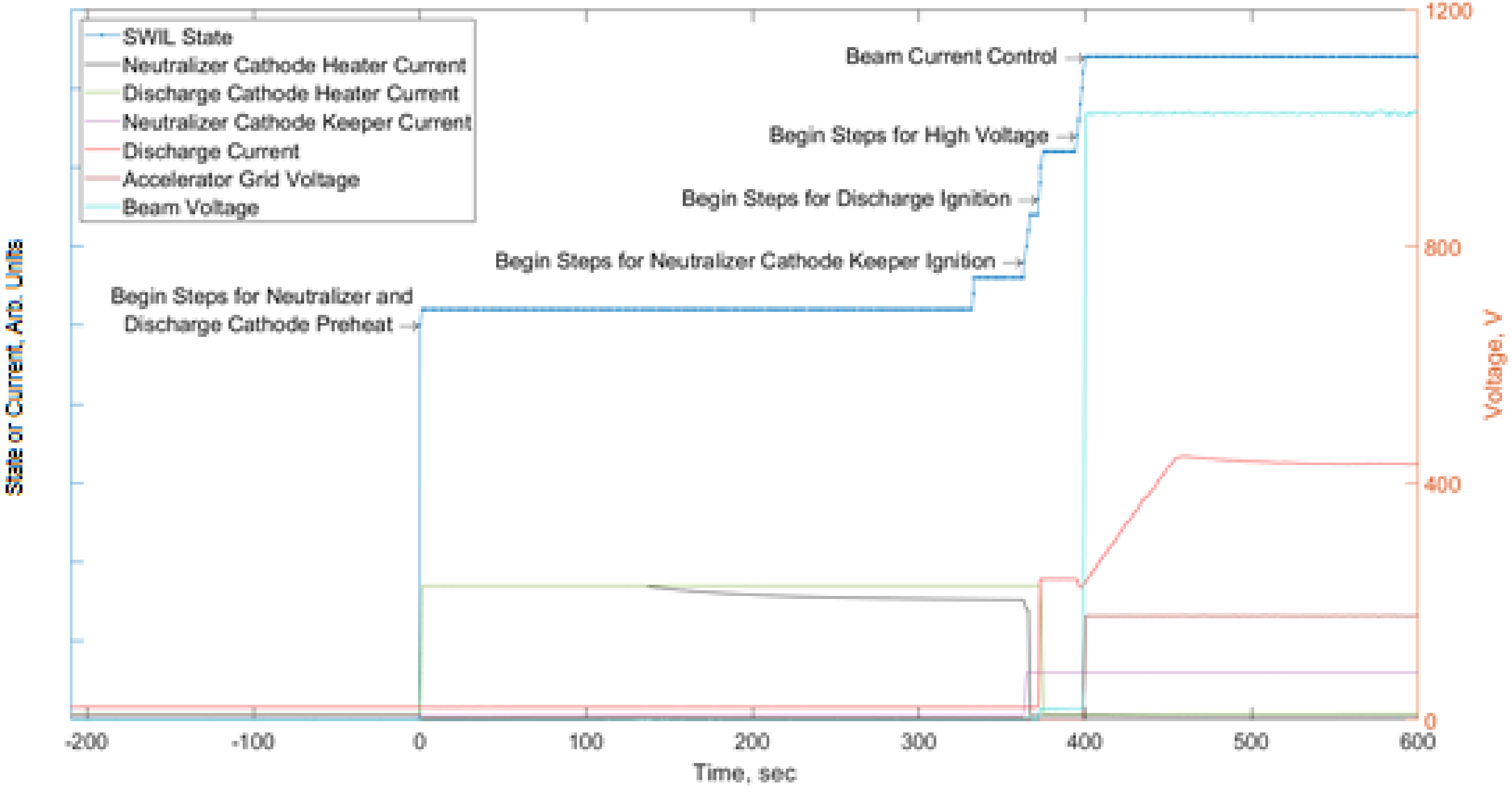
Thruster Behavior During Automated Start-up

- Several parameters of interest with regards to thruster performance/life:

1. Discharge voltage, V_d
2. Discharge current, J_d
3. Beam current, J_b
4. Accelerator current, J_a
5. Coupling voltage, V_g

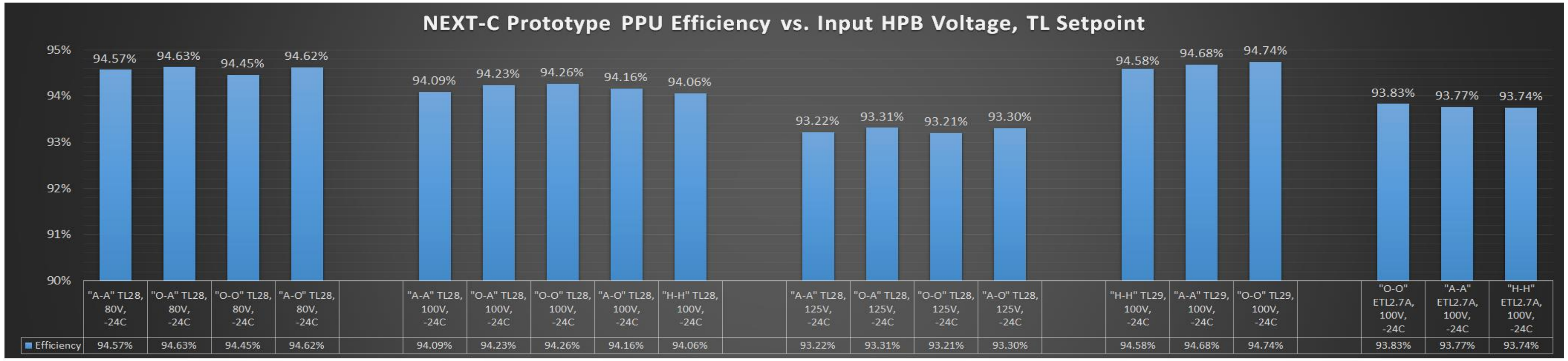


SWIL Simulator Performance

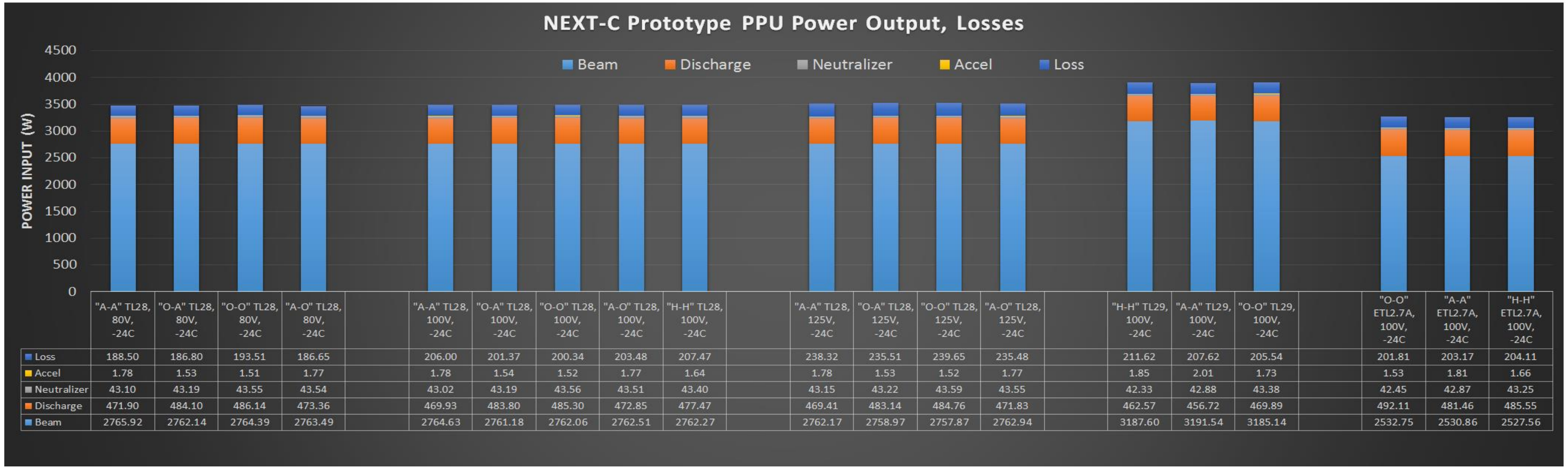


PPU Efficiency at Various Throttle Levels

- PPU efficiency > 90% at all conditions, increased performance at colder temps. and lower input voltages



	"A-A" TL28, 80V, -24C	"O-A" TL28, 80V, -24C	"O-O" TL28, 80V, -24C	"A-O" TL28, 80V, -24C	"A-A" TL28, 100V, -24C	"O-A" TL28, 100V, -24C	"O-O" TL28, 100V, -24C	"A-O" TL28, 100V, -24C	"H-H" TL28, 100V, -24C	"A-A" TL28, 125V, -24C	"O-A" TL28, 125V, -24C	"O-O" TL28, 125V, -24C	"A-O" TL28, 125V, -24C	"H-H" TL29, 100V, -24C	"A-A" TL29, 100V, -24C	"O-O" TL29, 100V, -24C	"O-O" ETL2.7A, 100V, -24C	"A-A" ETL2.7A, 100V, -24C	"H-H" ETL2.7A, 100V, -24C
Efficiency	94.57%	94.63%	94.45%	94.62%	94.09%	94.23%	94.26%	94.16%	94.06%	93.22%	93.31%	93.21%	93.30%	94.58%	94.68%	94.74%	93.83%	93.77%	93.74%



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Loss	188.50	186.80	193.51	186.65	206.00	201.37	200.34	203.48	207.47	238.32	235.51	239.65	235.48	211.62	207.62	205.54	201.81	203.17	204.11
Accel	1.78	1.53	1.51	1.77	1.78	1.54	1.52	1.77	1.64	1.78	1.53	1.52	1.77	1.85	2.01	1.73	1.53	1.81	1.66
Neutralizer	43.10	43.19	43.55	43.54	43.02	43.19	43.56	43.51	43.40	43.15	43.22	43.59	43.55	42.33	42.88	43.38	42.45	42.87	43.25
Discharge	471.90	484.10	486.14	473.36	469.93	483.80	485.30	472.85	477.47	469.41	483.14	484.76	471.83	462.57	456.72	469.89	492.11	481.46	485.55
Beam	2765.92	2762.14	2764.39	2763.49	2764.63	2761.18	2762.06	2762.51	2762.27	2762.17	2758.97	2757.87	2762.94	3187.60	3191.54	3185.14	2532.75	2530.86	2527.56

Summary

- Single string integration test was conducted across anticipated DART flight conditions
- Test included demonstrations of system performance, functionality, and fault handling
- Thruster performance was in-family with prior NEXT data
  - minimal variations in thrust vector across different operating conditions
- SWIL simulator successfully executed DART flight algorithms and captured fault sequences
- PPU efficiency > 90% at all conditions, increased performance at colder temps. and lower input voltages
- Overall tests was successful, results fed into the development of the flight build of software