

Development Status and Performance Metrics of the Advanced NEXT Ion Propulsion System

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I. Background

This manuscript will describe recent technical work performed as part of the Advanced NEXT project, a joint effort between the U.S. Space Force, NASA, and private industry [1]. The project aims to develop a versatile high thrust-to-power gridded ion propulsion system for commercial, military, and interplanetary applications. The technology leverages prior investments in the NASA's Evolutionary Xenon Thruster Commercial (NEXT-C) system [2], a technology demonstrated during the Double Asteroid Redirection Test (DART) mission. This paper will detail advancements in the propulsion system's design, including work on both the thruster and the power processing unit (PPU). The paper will present the results of a system integration test, along with the measured performance metrics.

II. Approach

The work completed thus far has included design, computational analysis, and experimental efforts. The PPU consists of six interconnected DC-DC converters and is designed to operate from a regulated spacecraft power bus. Four of the power supplies (neutralizer keeper, neutralizer and discharge cathode heaters, and accelerator grid) maintain the same technical specifications as the NEXT-C design, while the beam and discharge supplies have been modified to handle higher current levels. The outer dimensions of the Advanced NEXT PPU matches that of the flight NEXT-C design, which is shown for comparative purposes in Fig. 1(a).

The primary thruster modifications relative to the NEXT-C design include a) the integration of carbon-based high-throughput ion optics, b) the addition of a discharge chamber baffle to eliminate a performance-limiting current density peak, and c) the modification of transmission cables to support higher current levels and thermal loads. The work to date has included design trade studies, subcomponent structural analysis, and preliminary lifetime estimates. A series have tests have been

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conducted within Vacuum Facility 16 (VF16) at NASA GRC to establish the performance envelope of the engine. A series of electrostatic probes have been used to measure the near-field current density, doubles-to-singles ion current, and thrust vector. A photograph of the engineering model 6 (EM6) thruster operating during a near-field current density measurement is shown in Fig. 1(b).



Figure 1: (a) Flight NEXT-C PPU (Ref. 3) and (b) EM6 thruster operating during a near-field Faraday probe sweep.

III. Preliminary and/or Anticipated Results

The carbon-based ion optics and prototype PPU will be integrated with the EM6 thruster, and the test data will be presented. The electrostatic performance of the engine will be characterized, including measurements of perveance, electron back-streaming, ion transparency, and arc (“recycle”) frequency. The efficiency of the PPU, defined as the ratio of the total power output from the beam, discharge, accelerator, and neutralizer supplies to the total input power from the high-power bus, will be reported. Table 1 shows approximate thruster performance parameters across a range of different throttle levels, derived from recently acquired test data.

Table 1: Approximate performance values for select operating conditions within the Advanced NEXT throttle table.

Throttle Level	Beam Current, A	Beam Voltage, V	Thrust. mN	Specific Impulse, s	Thruster Efficiency	Thrust/Power, mN/kW
AN1.5B	1.50	900	74	2,663	57%	44
AN14	1.50	1200	87	3,137	61%	40
AN45A	5.50	900	257	2,870	63%	45
2B	6.00	1200	330	3,397	67%	40

References:

- [1] Thomas, R.E., et al., "Development of the Advanced NEXT High thrust-to-power Gridded Ion System," Joint Army Navy NASA Air Force Interagency Propulsion Committee, Oklahoma City, OK, May 6-10, 2024.
- [2] Monheiser, J., et al., "A Summary of the NEXT-C Flight Thruster Proto-flight Testing," AIAA Propulsion and Energy 2021 Forum, AIAA-2021-3408.
- [3] Bontempo, J.J., et al., "The NEXT-C Power Processing Unit: Lessons Learned from the Design, Build, and Test of the NEXT-C PPU for APL's DART Mission," AIAA Propulsion and Energy 2020 Forum, AIAA-2020-3641.

