**Project Introduction**

Proposed here is a full performance characterization of the X3 Nested-channel Hall Thruster (NHT), a 100-kW class thruster developed jointly by the Plasmadynamics and Electric Propulsion Laboratory (PEPL) at the University of Michigan, NASA, and the Air Force Office of Scientific Research. The thruster has been built and run through a burn-in procedure, but a performance characterization is the vital next step in its development. This characterization will include gathering thrust measurements, a detailed analysis of the plasma plume of the thruster, calculating efficiencies, a study of the interactions between multiple discharge channels running at one time, and an investigation of the effect of magnetic field shape on thruster performance. The characterization will occur at multiple points across the entire operating envelope of the thruster, ranging from 2 kW to over 200 kW of discharge power. The discharge power levels of the X3 cause unique facility issues that will be addressed by testing at two different facilities during this characterization. The low half of the performance envelope of the thruster will be investigated inside the Large Vacuum Test Facility at PEPL. At higher power levels, the X3 will be investigated in Vacuum Facility 5 (VF-5) at NASA's Glenn Research Center. VF-5 offers the ideal facility in which to run the X3 in the upper half of its performance envelope. This has been planned since the genesis of the project, and much of the infrastructure related to the X3 was designed with testing at VF-5 in mind. The thrust measurements will be collected using an inverted-pendulum thrust stand. Thrust measurements are an important metric on their own, but also are used to calculate a number of important parameters including anode specific impulse. The analysis of the plasma plume will be done with an array of probes, including a Faraday probe, a Langmuir probe, an ExB probe, and a Retarding Potential Analyzer. The data from these probes additionally will be used to calculate a number of thruster efficiencies. These efficiencies are indicators of thruster performance, and will be used as a comparative tool across multiple operating points. The work proposed here is important on its own, but has further-reaching implications as well. The two biggest technical challenges with Hall Thrusters, as identified by NASA, are increasing discharge power and increasing lifetime. The X3's main contribution is its power level, but what is proposed here with it will also have influence on thruster lifetime. Magnetic shielding has shown great promise in the area of extending lifetimes, and the data collected in this work can be used to explore the possibility of designing the world's first magnetically-shielded NHT. The X3 is a monumental step forward for the field of electric propulsion. Goals stated by NASA put targeted discharge power levels in the 100s of kW, and this thruster should achieve that. However, if future, flight-qualified thrusters are to be built, the X3 must be interrogated fully. Understanding not only the performance values but the phenomena from which they come is essential engineering knowledge to apply to future thruster designs.

**Anticipated Benefits**
The work proposed here is important on its own, but has further-reaching implications as well. The two biggest technical challenges with Hall Thrusters, as identified by NASA, are increasing discharge power and increasing lifetime. The X3’s main contribution is its power level, but what is proposed here with it will also have influence on thruster lifetime. Magnetic shielding has shown great promise in the area of extending lifetimes, and the data collected in this work can be used to explore the possibility of designing the world’s first magnetically-shielded NHT.

**Primary U.S. Work Locations and Key Partners**

<table>
<thead>
<tr>
<th>Organizations Performing Work</th>
<th>Role</th>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Michigan</td>
<td>Lead Organization</td>
<td>Academic</td>
<td>Ann Arbor, MI</td>
</tr>
</tbody>
</table>

**Organizational Responsibility**

**Responsible Mission Directorate:**
Space Technology Mission Directorate (STMD)

**Lead Organization:**
University of Michigan

**Responsible Program:**
Space Technology Research Grants

**Project Management**

**Program Director:**
Claudia M Meyer

**Program Manager:**
Hung D Nguyen

**Principal Investigator:**
Alec Gallimore

**Co-Investigator:**
Scott Hall

**Project Website:**
https://www.nasa.gov/directorates/spacetech/home/index.html

For more information and an accessible alternative, please visit:
https://techport.nasa.gov/view/91457
Space Technology Research Grants

Characterization of a 100-kW Three Channel Nested Hall Thruster

Completed Technology Project (2014 - 2018)

Technology Maturity (TRL)

Start: 2
Current: 2
Estimated End: 3

Target Destination
Earth