Project Introduction

The innovation is a compact, reliable, light weight, electrically driven pump capable of pumping cryogenic liquids, based on scroll pump technology. This pump will fulfill several needs stated in SBIR Research Topic, H2.01: Cryogenic Fluid Management Technologies. Zero gravity cryogenic control devices (spray bars and mixers), require cryogenic liquids to be pumped efficiently. Propellant conditioning and densification technologies require compact, efficient pumps. Broad area cooling of cryopropellant shields can be facilitated by the pumping of a cold gas such as helium in a loop from a cryocooler to a shield. Various methods of liquefaction of oxygen such as passive radiative cooling can be enabled by cryogenic pumping. Other aerospace applications such as a fuel pump for liquid hydrogen fueled aircraft. A compact, reliable, and light weight pump for cryogenic liquids currently does not exist. Our subcontractor, Ball Aerospace and Technologies, has identified the need for such a pump several years ago, but has not found a suitable available product. Scroll pumps have several advantages over other pump technology, including being compact, light weight, reliable and efficient. The pump can be hermetically isolated from the drive motor by the use of a magnetic coupler, allowing the pump to be hermetically sealed. Because of the orbital motion, the scrolls can be placed in a metal bellows that are sealed to the housing which isolates the liquid via a vacuum enclosure for thermal isolation. The bearings can be placed on thermally isolating arms, so they do not need to operate at cryogenic temperatures. Scroll pumps have considerable technical heritage relevant to this application. Air Squared has developed and successfully tested scroll pumps for liquids and for cryogenic gasses. Air Squared has developed several compact pumps for pumping air which has similar viscosity and compressibility to liquid hydrogen.

Anticipated Benefits

Launch Vehicle – Load Responsive Multi-Layer Insulation (LV-LRMLI) could provide a high performance thermal insulation for Launch Vehicles with an integrated lightweight vacuum shell, able to withstand aerodynamic forces during launch, and substantially reducing cryopropellant boil-off. LV-LRMLI could provide benefit to NASA with increased launch vehicle mission capabilities such as longer duration cryogenic powered missions, longer coast times for orbital transitions, higher payload capacity to GSO, enhancements to the workhorse Atlas V and Delta IV launch vehicle families, applicability to upcoming cryogenic upper stage designs such as Advanced Common Evolved Stage and Space Launch System. A small, cryogenic scroll pump would have several NASA cryopropellant applications. It would enable efficient, low boil off or zero boil off cryogenic systems by circulating cryogenic helium gas from a cryocooler to broad area thermal shields surrounding the tanks. This would eliminate the need for high efficiency heat exchangers that are required with ambient temperature circulator pumps. The pump would also enable thermodynamic vent systems in which cryopropellants are dropped in pressure...
and temperature and heat exchanged with liquid pumped in a circulation loop with the tank. NASA Marshall has done considerable work with such systems involving spray bar tank heat exchanger and destratifiers.

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>Johnson Space Center (JSC)</td>
<td>Lead Organization</td>
<td>NASA Center</td>
<td>Houston, TX</td>
</tr>
<tr>
<td>Air Squared Inc.</td>
<td>Supporting Organization</td>
<td>Industry</td>
<td>Broomfield, CO</td>
</tr>
</tbody>
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Organizational Responsibility

Responsible Mission Directorate:  
Space Technology Mission Directorate (STMD)

Lead Center / Facility:  
Johnson Space Center (JSC)

Responsible Program:  
SBIR/STTR

Project Management

Program Director:  
Jennifer L Gustetic

Program Manager:  
Carlos Torrez

Project Manager:  
Joseph Studak

Principal Investigator:  
Bryce R Shaffer

Technology Maturity (TRL)

Start: 2  
Current: 2  
Estimated End: 3

Closeout Documentation

Final Summary Chart  
(https://techport.nasa.gov/file/15672)
Images

Project Image
Small Scroll Pump for Cryogenic Liquids
(https://techport.nasa.gov/image/3647)

Links

Final Patent/New Technology Report
(no url provided)