May 31, 2013

Dr. Jessica Gaskin (jessica.gaskin@nasa.gov)
NASA/Marshall Space Flight Center
Huntsville, AL 35812

Subject: Final Report
"Compact Vacuum Pump for Titan Lander Missions"
NASA Contract No. NNX11CB90C

Dear Dr. Gaskin:

Enclosed is the Final Report (including the Project Summary and Final Phase II Summary Chart) for Creare's SBIR Phase II project titled "Compact Vacuum Pump for Titan Lander Missions." This report covers the period June 1, 2011, through May 31, 2013.

Please call (603-640-2340) or e-mail (phs@creare.com) if you have any questions.

Sincerely,

Paul H. Sorensen
Project Director

6366.006/btt
Enclosure: TM-3499
cc: CASI (casiac@sti.nasa.gov) (*transmittal letter only)*
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By NASA SBIR Electronic Handbook

PROJECT SUMMARY

The overall goal of the Phase II project is to develop and test a complete vacuum system capable of generating a high vacuum (~10^{-8} torr) and exhausting to a pressure in excess of 1 atm in a compact, low-power consumption package optimized for supporting portable analytical instruments. The two principal targeted applications are for use on a Titan probe and for analytical applications on Earth. To achieve this overall goal, in Phase II we built a stand-alone roughing pump with a tailored motor drive, mated the pump with a turbomolecular pump/molecular drag pump (TMP/MDP) to form a compact vacuum system for benchtop testing, and developed custom control electronics for the integrated pumping system.

During the Phase II project, we achieved all our technical objectives. In May 2013, we delivered a complete pumping system to NASA. To achieve this, we started the Phase II project by further evaluating our Phase I regenerative roughing pump concept. Upon careful consideration, we determined that the approach did not meet NASA's needs. Specifically, the power consumption was too high. As a result, we opted for a stand-alone scroll roughing pump, developed on a parallel project for the Department of Homeland Security (DHS). This miniature scroll pump has excellent performance, with power consumption significantly below the 25 W target specified in our Phase II proposal.

In addition, this Phase II project significantly advanced the control electronics required to operate the vacuum pumping system. In the past, Creare relied on an analog control method derived from a sensorless permanent motor control chip from the Philips Corporation. However, this method does not allow tight speed control and automated start-up for the TMP/MDP. We therefore developed a new controller based on a field-programmable gate array (FPGA) implementation that allows automated startup, closed-loop speed control, current monitoring, and data logging.

The project culminated with the delivery of the complete pumping system, including (1) a TMP/MDP, (2) a rough pump, and (3) an electronic control system required to operate the pumps autonomously. The delivered hardware was tested extensively in a laboratory environment.