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3-D Printed Hybrid Propulsion Solutions for SmallSat Lunar Landing and Sample Return

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Types of data produced

Describe the types of data to be produced in the course of the project. For NASA's Earth Science Program and according to the NASA Earth Science Data & Information Policy, the term "data" includes observation data, metadata, products, information, algorithms, including scientific source code, documentation, models, images, and research results.

Analytical and Experimental data sets. A significant portion of proposed work for year 1 will include trades studies to determine the best approach for closed-loop energy management during descent. Control system design considerations will include TRL, mass-optimization, system complexity, cost, and reliability. The control method that allows the overall trade-solution, will be down selected for follow-on open-loop and hard-ware-in the loop, closed-loop testing later in year 1 and in year 2.

For the experimental campaign, it is proposed to package a 25-50 N HPGHP system into a 12-U form factor, leaving sufficient volume for simulated spacecraft avionics, camera, and lava-tube surface sensors. On-demand ignition reliability will be demonstrated under both ambient and vacuum conditions. Long-duration tests will be performed to demonstrate that the system can be fired for a sufficient period of time to achieve the *DV* requirements of the ScMC lunar landing mission. More than 100 test firings are proposed for this initial quality assessment (*QA*) campaign. Results of the long-duration and *QA* testing will determine the size of the motor that is best suited for this mission.

Following the successful completion of the initial *QA* campaign, hardware will be configured for closed-loop energy tracking using the best method down-selected by the initial trade study. Hardware in the loop (*HIL*) simulations are proposed. Initial tests at ambient conditions (allowing for reduced optimal expansion ratio), will first demonstrate operations using an open-loop time dependent schedule. If successful, follow-on experiments will demonstrate the capability to fire in pulsed or throttled mode in real time, with the sensed motor response fed back to a 3-DOF landing trajectory simulation.

Ground tests will use lab-weight motor components; however, trade studies are proposed to identify properly sized and compatible flight weight, space qualified components to be used as the actual spaceflight hardware. After successful completion of the testing campaign, road-mapping activities will allow flight experiments *within both the CubeSat Launch Initiative (CSLI) and Flight Opportunities Program (FOP)* to be investigated, developed, and proposed.

Data and metadata standards

Standards to be used for data and metadata format and content

Test data will be stored in an text-based LVM format. LVM is a National-Lnstruments® developed format. **LVM** files are stored in an ASCII text**format** arranged by rows and columns. Each line stores a tab or comma-delimited record with an identifier tag and its corresponding **data**. They can be edited in any text editor or in Microsoft Excel.

Each .lvm file consists of a file header section, followed by the data arranged in segments. Each segment represents a call to the Write LabVIEW Measurement File Express VI. The header includes information about how the how the data should be parsed, such as the separator character used, as well as time format used.

Each segment can have each its own header section, which is useful if each segment comes from a different source, such as different channels. The Read LabVIEW Measurement File Express VI can read each segment individually from each .lvm file, or you can specify how much data to read from the file regardless of how the segments are divided. Each segment can contain a single reading, such as a temperature reading, or a large collection of data, such as the data that makes up a sine wave. Each header includes information about the data, such the time the data were acquired and the increment values for the x-axis of each segment.

.lvm files are ASCII text files arranged in rows and columns. An end-of-line character, usually CR-LF, separates each row. A separator character, such as a tab, separates each column. The separator character also is defined in the header. Information within the file is in a tagged field format. Each piece of information is contained in a single row. The first column contains a tag that identifies the information. The second column contains the information. Each tag is unique and no tag is dependent upon information found in another tag. This facilitates easy line-by-line parsing of the file.

The data block has a single header with the parameter names and units specified. Parameter names and units are delimited by tabs. Following the channel header, each row is a time-tagged data frame with values in ASCII fixes-point format. Parameter values are separated by tabs. The file is terminated by a single blank line.

All associated graphics will be distributed in Joint Photographic Experts Group (.jpg) format. All descriptive documents and narratives will be distributed in Portable Document Format (.pdf).

Policies for access and sharing

Policies for accessing and sharing the data, including provisions for the appropriate protection of privacy, confidentiality, security, intellectual property, and other rights or requirements

Distribution of raw data will be by formal request only. Documents and publications will be through formal peer review processes.Peer reviewed publications will be submitted to NASA for review before submission. Release of developed software, and Intellectual property (IP) will be managed by the USU Office of Technology Commercialization. No sensitive Personal information will be included on archival information.

Policies for reuse, redistribution, and derivates

Policies and provisions for reuse, redistribution, and the production of derivatives

Utah State University will retain copyright on all publications. Reuse will be by formal request only.

Plans for access to data used in publications

Plans for providing access to the data used in any science publication

Distribution of raw data will be by formal request only.

Plans for archiving and preservation

Plans for archiving and preserving the data, as appropriate (use of existing databases or public repositories will be strongly encouraged), including how long the data will be preserved and accessible

All data will be archived on the USU Digital Commons Archival System. *Utah State University, through the Merrill-Cazier Library, provides institutional repository services through the bepress Digital Commons platform. DigitalCommons@USU supports all file types and formats. File are provided with persistent URLs, and if needed, Library staff can obtain DOIs for datasets. The system is able to produce license and copyright statement as needed, and creates standard citations. All files are backed up at multiple sites, including cloud storage. Preservation copies are stored in Amazon Web Services, with redundant storage across multiple facilities and are regularly verified for integrity of data using checksums.*