



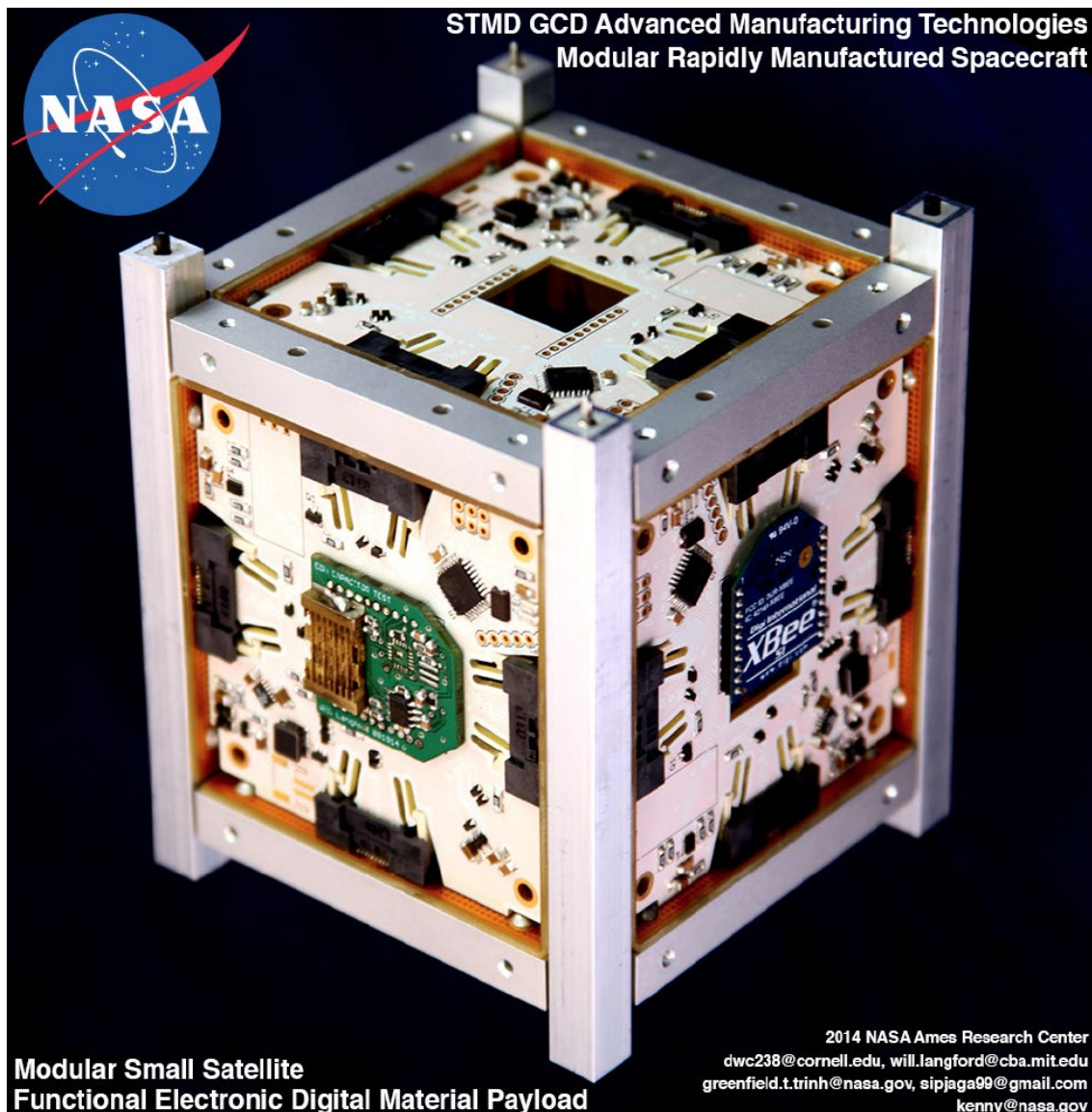
OuroboroSats

A Modular, CubeSat-Scale Instrumentation Platform

OuroboroSats (also known as MRMS: the Modular Rapidly Manufactured Spacecraft System) is a modular instrumentation platform consisting of multiple 3 inch (7.5 centimeter) square printed circuit boards that are mechanically and electrically connected to one another in order to produce a fully-functioning payload facility system. Each OuroboroSats module consists of a microcontroller, a battery, conditioning and monitoring

circuitry for the battery, optional space for solar panels, and an expansion area where an experimental payload or specialized functionality (such as wireless communication submodules) can be attached.

A typical OuroboroSats mission involves many modules connected together, each of which can host an experimental payload. The microcontroller on each board communicates



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Figure 1: Six OuroboroSats boards arranged in a cube. This configuration conforms to the CubeSat specification with regards to the overall dimensions and limit-switch placement.

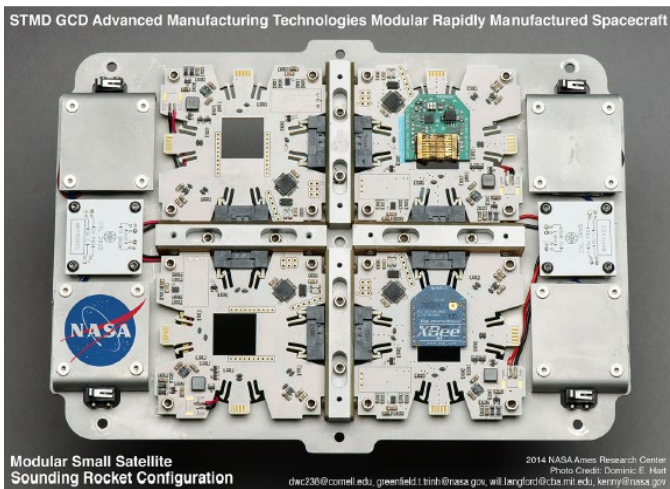


Figure 2: The OuroboroSats boards in the sounding rocket configuration. In order to conform to the low vertical clearance, the boards were arranged in a 2D array.

with the experimental payload, packages the received information, and sends the data to a dedicated OuroboroSats board with a communication submodule to relay back to the ground. In addition to allowing data to be transferred from one module to another, the OuroboroSats modules can also enter a mode where one board can transfer power to another. In this way, boards with resource-intensive payloads or those in eclipse can request power from their neighbors in order to continue functionality.

The core components of an OuroboroSats module can be produced, on a breadboard, for less than \$100, enabling initial prototyping and integration of scientific payloads with near-negligible investment. The board designs are available online at no cost, and are modeled in software available as a freeware version. The microcontroller uses the Atmel AVR toolchain with an Arduino bootloader, which has extensive documentation and support. Taken together, this platform promises to further reduce spacecraft costs by removing the required investment in platform development testing, and significantly reducing integration cost. Furthermore, the use of a common platform that is available open-source will allow multiple parties to more easily aggregate their efforts into a single launch, further reducing the barrier of entry into space.

The initial flight-test of the OuroboroSats system occurred as an element of the Sub-orbital Aerodynamic Re-entry Experiments (SOAREX-8) Exo-Brake experiment, that

was launched from NASA's Wallops Flight Facility on July 7, 2015. For this experiment, four OuroboroSats boards were configured in a two-dimensional array, in order to fit a 0.5 inch (1.27 centimeter) vertical clearance. **Figure 2** shows this arrangement. The components used in this configuration were identical to those shown in **Figure 1**, which illustrates the flexibility that the system allows in providing a consistent platform regardless of the external constraints on volume and area.

The sounding rocket test article included two specialized payloads, one containing a digital materials experiment developed by Will Langford at the MIT Center for Bits and Atoms, and the other containing an xBee wireless communication module which transmitted data back to the SOAREX-8 experiment for transmission to the ground. The flight successfully validated the ability of multiple specialized OuroboroSats modules to act in tandem to behave as an instrumentation platform. These capabilities include: inter-board communication and multi-board routing, successful hosting an independently-developed experimental payload, and the successful relay of data collected from the payload over the xBee's 802.15.4 wireless protocol.

Future experiments will characterize the ability of the modules to perform power sharing in the operational environment, and will expand the scale to explore the efficiency of the communication system for large numbers (> 10) of modules.

The OuroboroSats project is based at NASA Ames Research Center, Moffett Field, California. It is funded by the Space Technology Mission Directorate's (STMD) Game Changing Development (GCD) Program.

For more information about STMD's GCD, visit:
gameon.nasa.gov

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