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Dellingr- A Path to Compelling Science with CubeSats

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Abstract

Advancements in the capabilities of miniaturized systems are dramatically increasing interest in achieving science from CubeSats. The Dellingr project targets this interest. It will realize compelling science from a 6U spacecraft while developing human and spacecraft systems required to cost-efficiently deliver small satellites capable of reliably achieving mission objectives in divers environments—from low earth orbit to challenging radiation and thermal environments associated with lunar and planetary missions.

1. Introduction

Advancing capabilities of miniaturized systems is dramatically increasing interest in CubeSat-based missions, as the small size and low cost of these platforms relative to traditional spacecraft open new areas of science. For example, they can be deployed to venues and environments considered not reasonable or practical for larger more costly space assets. And the distributed architectures they enable can reveal new science by virtue of the increased temporal, spatial, and angular measurement resolution enabled by simultaneous multi-point observations. Furthermore, they can achieve certain science more cost effectively than traditional platforms.

Historical data shows however, that the potential of these platforms is often not realized due to mission failure. Among the contributing factors are cost-driven tradeoffs within one of more phases of the CubeSat mission life cycle.

Given the potential benefits of these platforms, NASA Goddard Space Flight Center is executing the Dellingr project. This initiative will achieve compelling science from a 6U CubeSat and define systems and processes for reliably *and* cost-efficiently achieving mission objectives in divers environments—from low earth orbit to lunar and planetary.

2. Dellingr Science

The Dellingr spacecraft is a 6U CubeSat that targets compelling Heliophysics science from its instrument complement—a compact Ion and Neutral Mass Spectrometer (INMS), and a 3-axis science magnetometer system comprised of boom- and body-mounted sensors. INMS will measure the composition and density of various ions and neutral elements in Earth's lower exosphere and upper ionosphere, a volatile region of the upper atmosphere that affects satellite communications and creates a drag that can degrade satellite orbits. [1]

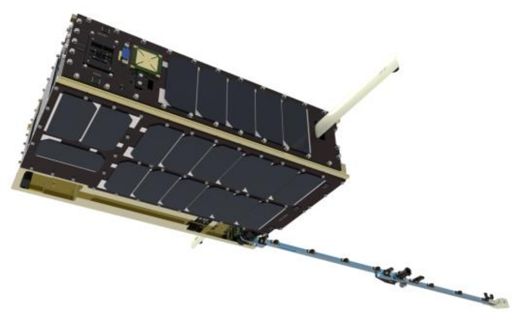

Figure 1. Computer model of the Dellingr 6U spacecraft with magnetometer boom and antennas deployed.

The science magnetometer is a miniaturized fluxgate with better than 0.1nT resolution at 3.5 Hz. The system is comprised of a sensor mounted at the end of a 76 cm boom and three sensors mounted within the spacecraft. The sensed field is comprised of two components—one attributable to science, and the other attributable to disturbances created by bus subsystems. Algorithms created by the science team will analyze field data, identify the disturbance component, and subtract it from the total field to yield the science data.

Dellingr flight readiness will occur late summer 2015.

3. Spacecraft Systems

Dellingr bus systems are partially comprised of commercial off the shelf (COTS) components. The components were selected based on their predicted compliance with mission goals over the six-month low earth orbit mission duration.

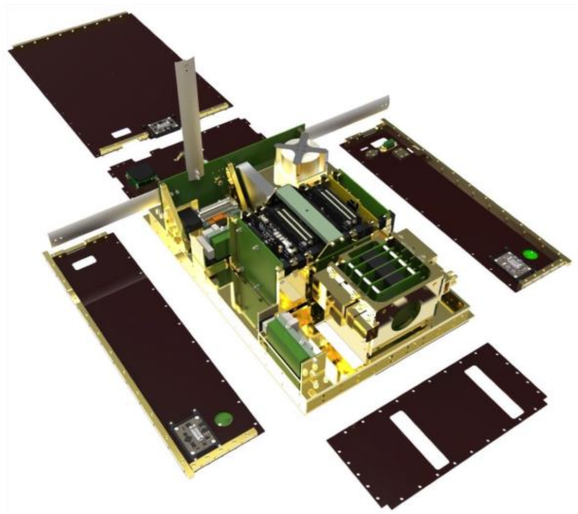

Figure 2- Dellingr computer model. Removing custom designed solar panels reveals Dellingr internal systems.

Selected systems, such as the boom, the antenna, deployment mechanisms, solar panels, the attitude determination and control components, and custom electronics were developed in-house in order to meet mission performance requirements or to realize cost or implementation benefits.

4. Concurrently Achieving Reliability and Cost Efficiency

In addition to the compelling science targeted by Dellingr, a critical project objective is to enable the development of cost-efficient CubeSats that can operate reliably in divers mission environments. Of particular interest are environments associated lunar and planetary missions.

The project targets this objective by leveraging decades of spaceflight systems best practices and lessons learned and by employing a “clean sheet” approach to define a framework that will guide CubeSat development. Lean processes will reduce the overhead typically associated with best practices. Tightly integrating and coordinating mission components—hardware, software, and human—across the full CubeSat project life cycle will yield additional efficiencies.

Project execution is also informing development of a flexible, modular, and extensible spacecraft architecture—the Goddard Modular Spacecraft Architecture or GMSA—that will further lower implementation costs and development risk. GMSA is being applied to GTOSat, a 6U mission concept targeting the severe radiation environment of a geosynchronous transfer orbit.

5. Summary and Conclusions

The Dellingr project will deliver a 6U CubeSat that achieves compelling Heliophysics science and lead to CubeSats that cost-efficiently accommodate divers mission environments and requirements. Of particular interest are missions that require reliable operations in challenging radiation and thermal environments beyond low Earth orbit. Findings are indicating that we can concurrently achieve system robustness and cost efficiency by employing a novel best practices-based framework that spans the full CubeSat life cycle and by basing CubeSat missions on GMSA, a flexible, modular, and extensible architecture.

References

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