EPSC Abstracts
Vol. 13, EPSC-DPS2019-730-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Smallsat Innovations for Planetary Science Missions

Rebecca Schindhelm, Karen McConnell, David Osterman, Shane Roark, Reuben Rohrschneider, Jeffrey Van Cleve, Michael Veto and Jonathan Weinberg
Ball Aerospace, Colorado, USA (rschindh@ball.com)

Abstract

As NASA continues to look for ways to fly smaller planetary missions such as SIMPLEX, MoO, and Venus Bridge, it is important that spacecraft and instrument capabilities keep pace to allow these missions to move forward. As spacecraft become smaller, it is necessary to balance size with capability, reliability and payload capacity. Ball Aerospace offers extensive Small Sat capabilities matured over the past decade, utilizing our broad experience developing mission architecture, assembling spacecraft and instruments, and testing advanced enabling technologies. We present here recent efforts in pioneering both instrument miniaturization and Small Sat development through mission design and implementation.

1. Small Spacecraft

The Ball Small Satellite bus is a fully capable, configurable spacecraft in a compact form factor. With a mass of less than 220 kg and a volume of 61 × 71 × 96.5 cm, it is fully compliant with ESPA ring single port secondary launch requirements (Figure 1). The spacecraft is three-axis stabilized with precision attitude knowledge (0.003°) and control (0.008°) to meet the demands of a planetary science mission. The bus provides data, command and telemetry interfaces for up to four science payloads, each with data transfer rates of up to 2.0 Mbps. Available total payload mass is up to 150 kg with 100-500 W total available payload power (at 1 AU) in a volume of 49 × 67 × 45 cm. An optional solar electric propulsion (SEP) module offers up to 1.5 km/s of ΔV [1]

Ball SmallSats inherit their software capabilities from the flight proven Ball Configurable Platform (BCP) line of spacecraft, and may be tailored to meet the unique requirements of Planetary Science missions. Ball has flown multiple missions with these small, yet capable spacecraft. STPSat 2 (Figure 1, left) and 3, flown for the Air Force, have 7+ and 4+ years of on-orbit operation, respectively. The Green Propellant Infusion Mission (Figure 1, right) is scheduled for flight in June 2019, and the Imaging X-ray Polarimetry Explorer (IXPE) is in development, scheduled for Critical Development Review in June 2019. Ball recently was selected to deliver the small spacecraft bus for NASA's Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer (SPHEREx) mission.

Figure 1: STPSat-2 (left) and GPIM (right) smallsats

2. Miniaturized Science Instrumentation

With a small spacecraft bus comes the need for science instrumentation with significantly less size, weight and power than their traditional mission counterparts. Through a mix of internal research and development and NASA funding, Ball is focusing its efforts in four key areas described below.

(1) Leveraging miniaturization efforts from other areas: Ball has developed several imaging technologies for multiple programs with a path to space flight. The Compact Hyperspectral Prism Spectrometer (CHPS) [3] and Reduced Envelope Multispectral Imager (REMI) [4] are alternate architectures for meeting Sustained Land Imaging goals in Earth Science. For Planetary Science, Ball has adapted an existing high dynamic range visible CMOS device to develop a low volume, weight, and power imager (Figure 2, left).

(2) State of the Art Calibration: Ball is developing a low volume, highly accurate radiometric calibration approach for the Compact Infrared Radiometer in Space (CIRiS) mission (Figure 2, right). The advanced carbon nanotube sources and uncooled microbolometer Focal Plane Arrays (FPAs) in the CIRiS instrument will be demonstrated in low earth orbit on a 6U cubesat (12 × 24 × 36 cm). [2]

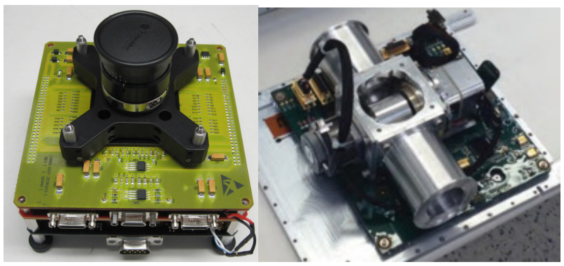

Figure 2: Ball has developed a high dynamic range visible imager (left) and compact multi-band high accuracy thermal imager (right).

(3) Cross-Technology Infusion: Ball is developing a highly miniaturized microwave radiometer utilizing advances in Photonic Integrated Circuits (PICs). caption. Fusing PICs technology with a microwave instrument allows for a significantly greater number of observing channels in an area less than 150 times smaller than existing filters.

(4) Enabling Advanced Algorithms: With Smallsats possessing more limited resources than their full-sized counterparts, autonomy and selective data collection become important for keeping data storage, data downlink volume and spacecraft commanding to a minimum. Ball has demonstrated a variety of enhanced spacecraft and instrument capabilities in both the laboratory and in-flight to advance autonomy and control for spaceflight hardware. One example of this is the use of Model Predictive Control Algorithms (PCAs). Ball has developed PCAs to provide autonomous instrument operations and spacecraft control to maximize observing opportunities. Using a LIDAR instrument as a sample application, a PCA was developed to autonomously and dynamically steer laser beams to maximize observations of desired features – e.g., waterways or clouds on Earth (Figure 3). [5]

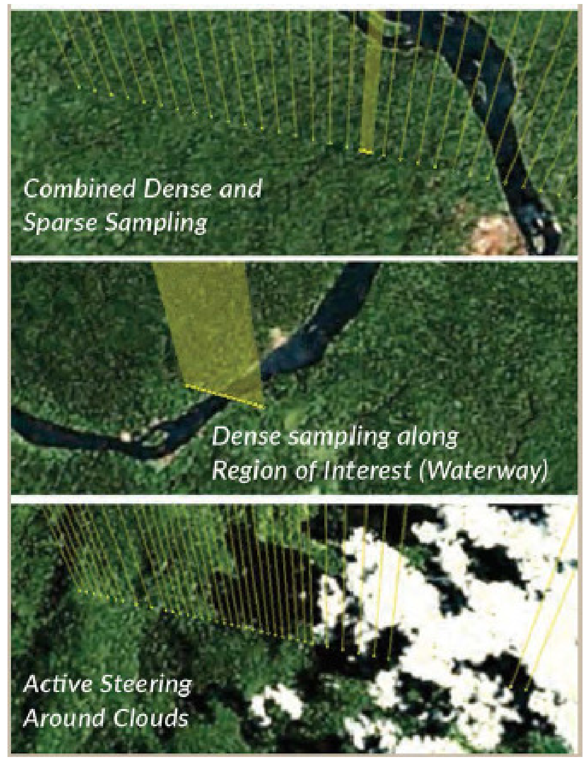

Figure 3: Predictive Control Algorithms enable intelligent instrument operations to optimize power distribution and downlinked data volume.

References

[1] Enger, S. et al. *IEEE Aerospace Conference,* Big Sky, MT, 2015, pp.1-10 (2015).

[2] Osterman, D. et al. Proceedings of the SPIE, Vol 9978, id. 99780E (2016).

[3] Kampe, T. and Good, W. (*Earth Observing Systems Conference XXII, Proc. Of SPIE Vol. 10402, 1040208, pp 1-11, (*2017)

[4] Wamsley, P. et al., *NASA ESTO Earth Science Technology Forum (ESTF2017)*

[5] M. Lieber, M, et al. *Low Cost Planetary Missions 12, SESS04b-02 (2017).*