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Increasing Small Satellite Reliability for Planetary Science Missions

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Abstract

Planetary Science is expected to benefit greatly from the advent of CubeSats and/or SmallSats and the science community is embracing this. Three deep space planetary CubeSats have been built at JPL but at present, CubeSat components and buses are generally not appropriate for planetary missions where significant risk of failure, or the inability to quantify risk or confidence is unacceptable. However, in the future we anticipate that CubeSats will be used for missions routinely for Planetary missions. In addition, SmallSats using CubeSat components and subsystems but not having the CubeSat form factor will likely be developed for many Planetary applications. Both CubeSats and SmallSats could then be used where their attributes enable or enhance mission objectives or provide other meaningful benefits—e.g. lower cost, increased coverage (spatial, temporal, spectral), agility, resiliency, etc. This paper will discuss the genesis of and drivers for a Small Satellite Reliability Initiative, how a public-private collaboration is being executed, findings and recommendations derived to date, and next steps towards broadening small satellite mission potential. It will also discuss some available and upcoming technologies that will enable planetary missions

1. Introduction

Planetary Science is expected to benefit greatly from the advent of CubeSats and/or SmallSats and the science community is embracing this as evidenced by the 102 submissions to a recent NASA PSD call for Planetary Science Deep Space SmallSat Studies. Three planetary CubeSats have been built at JPL but at present, CubeSat components and buses are generally not appropriate for missions where significant risk of failure, or the inability to quantify risk or confidence is unacceptable. However, in the future we anticipate that CubeSats will be used for missions requiring reliability of 1-3 years for Earth missions and even longer for Planetary missions. In addition, SmallSats could be developed using CubeSat components and subsystems but will not have the CubeSat form factor, which will be likely for most Planetary applications. Both CubeSats and SmallSats could then be used where their attributes enable or enhance mission objectives or provide other meaningful benefits—e.g. lower cost, increased coverage (spatial, temporal, spectral), agility, resiliency, etc. Historically, it was understood and accepted that "high risk" and "CubeSat" were largely synonymous; expectations were set accordingly. But their growing potential utility is driving an interagency effort to improve and quantify CubeSat reliability, and more generally, small satellite mission risk.

2. Small Satellite Reliability Initiative (SSRI)

The Small Satellite Reliability Initiative (SSRI)—an ongoing activity with broad collaborative participation from civil, DoD, and commercial space systems providers and stakeholders—targets this challenge. The Initiative seeks to define implementable and broadly accepted approaches to achieve reliability and acceptable risk postures associated with several SmallSat mission risk classes—from "do no harm" missions, to those associated with missions whose failure would result in loss or delay of key national objectives. These approaches will maintain, to the extent practical, cost efficiencies associated with small satellite missions and consider constraints associated with supply chain elements, as appropriate. The SSRI addresses this

challenge from two architectural scopes—the mission- and system-level, and the component- and subsystem-level. The mission- and system-level scope targets assessment approaches that are efficient and effective, and mitigation strategies that facilitate resiliency to mission or system anomalies while the component- and subsystem-level scope addresses the challenge at lower architectural levels. The initiative is not limiting recommended strategies and approaches to proven and traditional methodologies, but is focused on fomenting thought on novel and innovative solutions.

This paper will discuss the genesis of and drivers for this initiative, how the public-private collaboration is being executed, findings and recommendations derived to date, and next steps towards broadening small satellite mission potential. It will also discuss some available and upcoming technologies that will enable planetary missions.