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Reliability of Small Satellites 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. The two MarCo CubeSats are heading towards Mars while the Asteria mission has met all its level one requirements and is in extended mission searching for exoplanets. More planetary CubeSats or SmallSats are planned. In the future we anticipate that SmallSats will be used routinely for Planetary missions often using CubeSat components and subsystems but not necessarily using the CubeSat form factor. In general, however, CubeSat components and buses are not appropriate for planetary missions where significant risk of failure, or the inability to quantify risk or confidence is unacceptable. 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 some available and upcoming technologies that will enable planetary missions. It will also discuss the genesis of and drivers for a Small Satellite Reliability Initiative, how a public-private collaboration is being executed, progress in recommendations and next steps towards broadening small satellite mission potential.

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 the NASA Planetary Science Division call for Deep Space SmallSat Studies and the Simplex call for SmallSats for Planetary exploration. In addition, the two MarCo spacecraft are heading towards Mars while Asteria mission has met all its level one requirements and is in extended mission looking for exoplanets. More planetary CubeSats/SmallSats are planned and in the future we anticipate that SmallSats will be used for routinely for Planetary missions often using CubeSat components and subsystems but not necessarily using the CubeSat form factor. In the past, CubeSat components and buses have not been appropriate for planetary missions where significant risk of failure, or the inability to quantify risk or confidence is unacceptable. Historically, it was understood and accepted that "high risk" and "CubeSat" were largely synonymous; expectations were set accordingly. However, commercial and various government agency ventures are improving the quality of these spacecraft and in the future we anticipate that CubeSats will be used for 1-3 years Earth science missions requiring and even longer for Planetary and Exoplanet missions. 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. Their growing potential utility is driving an interagency effort to improve and quantify CubeSat reliability, and more generally, small satellite mission risk.

2. Small Initiative Reliability (SSRI)

The Small Satellite Reliability Initiative (SSRI)—an activity with broad participation from civil, DoD, and commercial space systems providers and stakeholders—has been targeting this challenge. The collaborative team has made significant progress towards defining and documenting the full range of best practices and design/development guidelines—from those aligned with "do no harm" missions, to

those whose failure would result in loss or delay of key national objectives. The approach addresses two architectural scopes—the mission/system-level, and the component/subsystem-level. The mission/system-level scope recommends strategies or best practices that increase resiliency to mission or system anomalies. The component/subsystem-level scope addresses the challenges at lower architectural levels.

SSRI is intently focused on maintaining to the extent practical, cost efficiencies associated with small satellite missions. In addition, the team is looking for thoughts on novel and innovative solutions instead of limiting recommended strategies to proven and traditional methodologies. Finally, Initiative recommendations target a range of SmallSat communities—from system developers to mission architects and persons acquiring SmallSat-based systems and missions.

3. Summary and Conclusions

This paper will update the community on how the public-private collaboration is being executed, discuss the next steps the team will implement to broaden small satellite mission potential. SSRI is intently focused on maintaining to the extent practical, cost efficiencies associated with small satellite missions. In addition, the team is looking for thoughts on novel and innovative solutions instead of limiting recommended strategies to proven and traditional methodologies. Initiative recommendations target a range of SmallSat communities—from system developers to mission architects and persons acquiring SmallSat-based systems and missions. In addition to a discussion of the Initiative, some examples will be given of potential technological advances that can enable planetary SmallSat missions.

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