AAReST

Description of Research Project

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1 INTRODUCTION TO AAReST

In recent years, there has been a desire to develop space-based optical telescopes with large primary apertures of over 10 m in diameter. Currently the largest primary aperture under development is that of the James Webb Space Telescope with a diameter of 6.5 m. It represents a major shift in telescope design due to the use of a deployable primary mirror. However, its size is still limited by the diameter of the launch vehicle – a limitation for all current space-borne telescopes.

One method to overcome this obstacle is to autonomously assemble small independent spacecraft, each with their own mirror, while in orbit. In doing so, a telescope with a large, segmented primary mirror can be constructed. Furthermore, if each of these mirrors is manufactured to have an identical initial shape, and then adjusted upon assembly in-flight, a substantial reduction in manufacturing costs can be realized. In order to prove the feasibility of such a concept, a collaborative effort between the California Institute of Technology (Caltech), the University of Surrey and Indian Institute of Space Technology (IIST) has been formed.

1.1 GOALS AND OBJECTIVES

AAReST is a collaborative project between Caltech, University of Surrey, and IIST. It is a student run project with oversight from faculty with experience in all aspects of satellite design from the three involved institutions. The primary goals of the AAReST project are to:

- Allow Caltech, University of Surrey and IIST students hands-on experience designing, planning, and constructing a satellite
- Promote relations between Caltech, University of Surrey, and IIST
- Demonstrate novel technologies developed in the Caltech Space Structures Laboratory

As a demonstrative project, AAReST seeks to validate the use of novel technologies and techniques in LEO environment. The primary objectives of AAReST are to:

- Deploy a hinged boom after insertion into LEO
- Calibrate the deformable mirror to focus and image a star
- Re-arrange the deformable mirrors
- Re-calibrate and image after re-arrangement

The successful completion of these objectives will be used to define success for this mission.

1.2 MISSION OVERVIEW

The AAReST mission has been developed to meet the goals and objectives above. The satellite is a prime focus design (1.2 m focal length, 0.3° field-of-view) with the primary mirror divided up into a sparse aperture consisting of an arrangement of 10 cm diameter circular mirrors. The primary mirror segments are attached to a cluster of CubeSats, two of which are able to undock from the cluster and navigate independently. The telescope would launch as a small secondary payload in a stowed state. The stowed volume of the telescope is approximately 0.3 m x 0.4 m x 0.5 m. After separation from the primary payload, the telescope would deploy its camera package at the end of a 1.2 m long hinged composite boom to the focus of the mirror array.

Using wavefront sensors, the deformable mirrors would be adjusted and calibrated in order to minimize the size of the mirrors' individual point spread function (PSF). The mirrors would not be co-phased down to subwavelength levels, as would be required for a more advanced science mission, as this would require an additional metrology system that is prohibitively expensive for a small mission such as this. Instead, images would be taken to demonstrate the ability of the mirrors to self-correct their shape, as well as the ability to re-point and correct the individual PSFs.

Once the initial calibration and imaging demonstration is completed, two of the mirror segments, which are carried by independent CubeSats, would detach from the mirror cluster and then re-dock to the cluster in a different configuration. This would demonstrate on-orbit assembly of the mirror segments. Once the cluster is reassembled, the mirror calibration and imaging would be performed again in order to show the capability of calibration in two mirror configurations.