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COST-EFFECTIVE APERTURE WITH DEFORMABLE MIRROR FOR IMAGING SATELLITES

Abstract

High resolution imaging in space necessitates a large aperture telescope. In order to achieve diffraction limited performance, the mirror surface Root-Mean-Square (RMS) error has to be less than 0.05 wave length. In the case of visible light, it has to less than 30 nm. This requirement is very difficult to satisfy in addition to the challenges of designing a large aperture imaging satellite that meet the mass and volume constraints of a launch vehicle. Current mirror designs are monolithic glass. Significant cost and time are spent in polishing these mirrors to meet surface requirements. These mirrors are also heavy. As an example, aerial density of 2.4 m diameter mirror of Hubble Space Telescope is 240 kg/square meter. Therefore, there is need for cost-effective light weight space mirrors. Graphite-epoxy antennas are commonly used in communication satellites. However, graphite-epoxy mirrors cannot currently meet required surface requirement for imaging satellites.

This paper presents recent research work done to develop cost-effective aperture design for imaging satellites. In this design a deformable mirror is added in the optical path of the telescope. The surface requirements for the primary mirror are relaxed and the residual surface errors of the mirror are corrected by a deformable mirror. This design approach can be used for current monolithic glass design and surface error requirements can be relaxed. This will significantly reduce cost in the development and testing of these mirrors. This will also provide robust design as any residual surface errors can be corrected in orbit. It will also result in cost-effective design for large deployable mirrors. This paper will present the results of application of this approach on two mirror designs. The first is 3 meter diameter, six segments active optics Segmented Mirror Telescope (SMT). The second design is a 1 meter graphite epoxy mirror. The experimental results show that mirror surface error can be reduced by 50 percent by using a deformable mirror.