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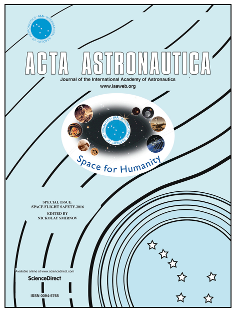

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BUILDING LARGE TELESCOPES IN ORBIT USING SMALL SATELLITES

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Abstract

In many types of space mission there is a constant desire for larger and larger instrument apertures, primarily for the purposes of increased resolution or sensitivity. In the Radio Frequency domain, this is currently addressed by antennas that unfold or deploy on-orbit. However, in the optical and infrared domains, this is a significantly more challenging problem, and has up to now either been addressed by simply having large monolithic mirrors (which are fundamentally limited by the volume and mass lifting capacity of any launch vehicle) or by complex `semi-folding' designs such as the James Webb Space Telescope. An alternative is to consider a fractionated instrument which is launched as a collection of individual smaller elements which are then assembled (or self-assemble) once in space, to form a much larger overall instrument. SSTL has been performing early concept assessment work on such systems for high resolution science observations from high orbits (potentially also for persistent surveillance of Earth). A point design of a 25m sparse aperture (annular ring) telescope is presented. Key characteristics of 1) multiple small elements launched separately and 2) on-orbit assembly to form a larger instrument are included in the architecture. However, on-orbit assembly brings its own challenges in terms of guidance navigation and control, robotics, docking mechanisms, system control and data handling, optical alignment and stability, and many other elements. The number and type of launchers used, and the technologies and systems used heavily affect the outcome and general cost of the telescope. The paper describes one of the fractionated architecture concepts currently being studied by SSTL, including the key technologies and operational concepts that may be possible in the future.

Keywords: on-orbit assembly, large telescopes, fractionated architecture, space robotics and autonomous systems.

Acronyms/Abbreviations

ADR	Active Debris Removal
ARReST	Autonomous Assembly of a Reconfigurable Space Telescope
CCSDS	Consultative Committee on Space Data Systems
CMOS	Complementary metal–oxide–semiconductor
DOF	Degree of Freedom
GEO	Geostationary Orbit
GNC	Guidance, Navigation and Control
GOAT	Giant Orbiting Astronomical Telescope
HST	Hubble Space Telescope
ISL	Inter-Satellite Link
JWST	James Webb Space Telescope
LEO	Low Earth Orbit
LIDAR	Light Detection And Ranging
MTF	Modulation Transfer Function
NIR	Near Infrared
SDR	Software Defined Radio
SIPOD	Scanning Interferometric Pulse Overlap Detection
SSC	Surrey Space Centre
SSTL	Surrey Satellite Technology Level
TFA	Technology Focus Area
TRL	Technology Readiness Level

1. Introduction

Current space mission architectures are fundamentally limited by the mass and volume available on launch vehicles, and a single mission is typically launched 'in one go'. In many types of space mission a payload is carried that is collecting photons, and generally speaking there is a constant desire for larger and larger instrument apertures, primarily for the purposes of increased resolution or sensitivity. This applies both for Earth Observation (EO) and Science (specifically astrophysics) missions, with the former primarily for allowing high resolution imaging over wide areas, whilst in the latter domain is aimed towards increased angular resolution and increased sensitivity for faint astrophysics targets.

SSTL has an interest in both potential application areas, both for persistent high resolution EO from geostationary orbit, and for providing new science opportunities.