S3.01 Precision Spacecraft Formations for Advanced Telescope Systems

Lead Center: JPL

Participating Center(s): GSFC

This subtopic seeks hardware and software technologies necessary to establish, maintain, and operate hyper-precision spacecraft formations to a level that enables cost effective large aperture and separated spacecraft optical telescopes and interferometers. Also sought are technologies (analysis, algorithms, testbeds) to enable detailed analysis, synthesis, modeling, and visualization of such constellations.

In a formation for large effective telescope apertures, multiple, collaborative spacecraft in a precision formation collectively form a variable-baseline interferometer. Large effective apertures can also be achieved by tiling curved segments to form an aperture larger than can be achieved in a single launch, for deep-space high resolution imaging of faint astrophysical sources. These formations require the capability for autonomous precision alignment and synchronized maneuvers, reconfigurations, and collision avoidance. It is important that, in order to enable precision spacecraft formation keeping from coarse requirements (relative position control of any two spacecraft to less than 1 cm, and relative bearing of 1 arcmin over target range of separations from a few meters to tens of kilometers) to fine requirements (micron relative position control and relative bearing control of 0.1 arcsec), the interferometer payload would still need to provide at least 1 - 3 orders of magnitude improvement on top of the S/C control requirements. The spacecraft also require onboard capability for optimal path planning and time optimal maneuver design and execution.

Development of combined nanometer-level precision formation flying control of numerous spacecraft and their optics is required to enable large baseline (1 to 10's of km), sparse aperture UV/optical (and perhaps X-ray) telescopes and interferometers needed for ultra-high angular resolution imagery.

Proposals addressing staged-control experiments that combine coarse formation control with fine-level wavefront sensing based control are particularly encouraged. Innovations that address the above precision requirements are solicited for formation systems in the following areas:

- Integrated optical/formation/control simulation tools;
• Distributed, multi-timing, high fidelity simulations;
• Formation modeling techniques;
• Precision guidance and control architectures and design methodologies;
• Centralized and decentralized formation estimation;
• Distributed sensor fusion;
• RF and optical precision metrology systems;
• Formation sensors;
• Precision microthrusters/actuators;
• Autonomous reconfigurable formation techniques;
• Optimal, synchronized, maneuver design methodologies;
• Collision avoidance mechanisms;
• Formation management and station keeping; and
• Six degrees of freedom precision formation test beds.