FORERUNNER for the EVOLVABLE SPACE TELESCOPE (ForEST)

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Polidan et al [1] described a large Evolvable Space Telescope (EST) that meets the requirements for the UV-Optical-IR telescopes defined by the Advanced Technology Large Aperture Space Telescope (ATLAST) [2] and High Definition Space Telescope (HDST) [3] studies, which could be affordably developed in an era of flat NASA budgets. This telescope would be developed, launched and operated in several stages over a period of 20-30 years, using on-orbit assembly and servicing technologies to continually increase its collecting area and instrument capability, while spreading its cost over many years to avoid funding peaks that required an inordinate fraction of NASA's astrophysics budget. We propose a probe-class mission that would provide a modified approach to deploying and further enhancing the affordability of the first stage of an EST.

Starting from the concept of an Evolvable Space Telescope (EST) as developed by Northrop Grumman and external team members and embodying a basic principle of EST (affordable and chronologically level development costs), we envision a new approach to the early stages of such a program. The current EST program assumes deployment of the telescope in three phases (roughly five years apart) with increasing scientific capability to complete a 12 to 20-meter space telescope in a halo orbit about the second Sun-Earth Libration Point SEL2. Phase 1 employs a primary mirror (PM) with three hexagonal segments, Phase 2 has a primary with six segments, and Phase 3 has 18 primary mirror segments. If each segment measures 4 meters from flat-to-flat, the result is a 4 x 12 meter off-axis aperture in Phase 1; a 12 meter filled aperture in Phase 2; and a 20 meter filled aperture in Phase 3.

We propose adding an earlier phase to the EST program, called the ForeRunner (ForEST) that would consist of a single hexagonal 4 meter (flat-to-flat) primary mirror to create an off-axis telescope with (probably) a single instrument (most likely a coronagraph) at the prime focus. This Phase Zero telescope would later be augmented by the launch of two additional segments (plus additional instruments, structure, etc.) and their assembly into a complete three segment Phase 1 telescope, essentially the same as in the original EST concept. Phases 2 and 3 would then follow in much the original manner. Note that this strategy would also provide an opportunity for a gradual buildup of the necessary industrial architecture and testing capability (including in space) of its initial products, followed by a long-term production lifetime with an inherent learning curve.

Design of the initial 4 meter mirror segment and the mechanisms needed for its later attachment could provide a significant programmatic and scientific benefit, since it might be possible for ForEST to begin active observations not too long after the deactivation of the Hubble Space Telescope (HST) and while both the James Webb Space Telescope (JWST) and the Wide Field InfraRed Space Telescope (WFIRST) remain in active operation. This would in turn enable continued observations as JWST and WFIRST were reaching the end of their respective lifetimes and the full EST was in deployment and beginning operations as the complete Phase 1 system.

Adopting this strategy will, of course, require paying careful attention to the use of available in-space infrastructure, as it develops to support human exploration and commercial exploitation of space. The future course of this infrastructure development is not clear at this time, but there are several concepts under consideration that could provide the necessary assembly and deployment support, ranging from

small to very large. For this White Paper, we need only note two mission concepts under consideration by the NASA Satellite Servicing Capabilities Office (SSCO) [4]:

- At the small end of the scale, the SSCO is soliciting information and concepts for a system known as Restore-L, a servicing spacecraft massing around 1,000 kg or slightly more, and designed to refuel low orbit spacecraft (and perform limited other servicing missions as possible) using remote teleoperation of robotic tools.
- At the large end, the SSCO has described a Human/Robotic Telescope Servicer designed to work in deep space in the company of a manned platform to control the operations and intervene directly if necessary. The mass of this system would be around 30,000 kg.

The needs of affordability for ForEST and the schedule urgency created by the coming retirement of major astrophysical telescope systems certainly seem to favor acquisition of servicing spacecraft from the first of these two classes, although this conclusion is subject to modification dependent upon infrastructure developments that may occur to support human exploration missions. To enable servicing operations throughout cislunar space, and to aid human exploration, a somewhat larger vehicle than Restore-L, massing around 5,000 kg and designated MiniServ [5] in earlier publications, may represent the best selection.

Starting from this context, we propose to conduct a study addressing two mission concepts:

- The ForeRunner Evolvable Space Telescope (ForEST) to serve as an affordable, early Phase Zero of a large EST, such as has been proposed in earlier mission concept studies, and
- The MiniServ Satellite Servicing System and its ability to enable assembly of large space telescopes launched in unassembled states (to reduce mass, risk, and cost) that are capable of only limited amounts of self-deployment.

We believe that the combination of these two mission concepts could accelerate the deployment of new, large astrophysical space telescopes in deep space, enhance their affordability, and reduce the risk of long gaps in space-based astronomy across the UV-Visible-IR spectrum that may follow the completion of the HST, JWST, and WFIRST missions.

REFERENCES

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