Annapolis MD, 24 Jan 2016

General impressions for the SSWG

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Framing the discussion of starshade technology readiness

- The technologies needed to support the mission fall into two categories: Enabling & Enhancing
- Mission formulation requirements pertaining to technology readiness focus exclusively on *enabling* technologies

- From a systems engineering perspective, the starshade space vehicle consists of two clean interface system elements: Spacecraft & Starshade
  - Mission requirements under discussion today (e.g. Exo-S report) are most stressing wrt star shade element technology readiness
  - Technology readiness issues in the spacecraft element appear to be minor to none

- Readiness of starshade element enabling technologies should be the primary focus of this SSWG

What is limiting our understanding of star shade readiness wrt enabling technologies?

Design concept:

- **What's missing:**
  - A complete set of error budgets (optical, mechanical, thermal, etc)
  - Understanding of how budget allocations scale with Fresnel number
    - Enables model validation through subscale testing
  - Integrated system model to inform systems engineering and enable "verification by analysis" approach

Deployment:

- **What's missing:**
  - Concept demonstrated for pedals only
  - Need to include: Star shade membrane design; Membrane management concept; Accommodation of harnessing; Thermal control; Stray light control

Alignment:

- **What's missing:**
  - Step-by-step CONOPS for targeting sequence involving both spacecraft
    - Exo-S report too high level to enable technology assessment wrt targeting aspect

- Overall, appendix C of the Exo-S report does not delineate a complete set of mission enabling technology gaps

When is a technology demonstration flight necessary?

NASA engineering perspective:

- When performance verification of a new technology must be empirical, we turn to space as a laboratory if (and only if) we cannot adequately simulate the operational environment in a ground-based facility
  - Typical example: need for a microgravity environment (LISA Pathfinder)

Programmatic perspective & boundary conditions:

- Mission success criteria for a technology development flight are limited to the technology development objective
  - For example, a starshade technology development mission that is in line with the above limitation would be built with Class-D fault tolerance for an engineering lifetime of a few months
  - A technology development mission through STMD does not provide opportunity to avoid alignment with Decadal Survey priorities or other science mission approval processes
    - Level 1 requirements pertaining to scientific use of the “test article” beyond technology development objectives would require SMD approval

My general impression to date …

- The science case for the Rendezvous mission is fabulous
  - It should be proposed through the Decadal Survey as a probe-class science mission
    - 5 year development beginning during 2022 timeframe
      - Would arrive on station during the WFIRST prime mission
    - Approved by the Decadal Survey in one of two ways (in order of preference):
      1. As the first project for a new AO-selected medium mission program element
         - AO solicitation could occur as early as 2022 in response to Decadal Survey approval of the medium mission program
      2. Direct selection as the top priority medium-scale initiative via white paper submission
  - The most common reason that mission proposals are not approved is failure to make a compelling "why now" case. The Rendezvous mission has a very strong advantage from this perspective
- The existing CATE provides confidence that the Rendezvous mission objectives can be studied as a probe-class project
- Although the Rendezvous Mission would add technology maturation value to flagship applications beyond WFIRST, it is a science mission that can stand tall & proud as such, and should go through the front door of Decadal Survey prioritization

In order to enable Decadal Survey prioritization of the Rendezvous mission

- WFIRST must be scared for star shade capability prior to the Decadal Survey
  - Understanding this set of requirements is pressing and as important as getting the technology ready
    - Suspect that most lie in the alignment and science instrument areas
  - Willingness to scar WFIRST for star shade compatibility is a HQ decision
    - If the Astronomy Division wants the Rendezvous mission concept to be in the trade space for the Decadal Survey, then they will act accordingly -- if (and only if) the needed scaring can be understood
- Scaring the coronagraph to enable the star shade is a high risk “house of cards” approach
  - The coronagraph is a tech development ride-along that is outside the mission success criteria and for which there is no Level-1 requirement
    - When WFIRST or the coronagraph get into cost/schedule trouble, the coronagraph is the lowest hanging de-scope fruit in the program
- To move beyond the design lab level of study (Exo-S report), a “projectized” engineering team must be formed
  - Emphasis on system engineering and implementation of formal engineering process
  - This engineering team should set star shade technology development priorities for TDEM, SAT, Probe Study and should oversee projects that are initiated

Next steps for understanding the technology challenge

- Need a (small team) focused TIM to flesh-out the guidance navigation & control CONOPS and associated systems

- Need to build an integrated model of the star shade element to inform development of a complete and self consistent set of requirements, budget allocations, and performance sensitivities