Importance of Design Reference Missions for Developing the Next Large Mission Concepts

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The scientific rationale for the next space-based, large mission is maturing in response to NASA 2020 Decadal Survey preparations (e.g. Cosmic Origins Program Analysis Group (COPAG)). The COPAG has requested white paper community inputs "…for the purpose of commenting on the small set, including adding or subtracting large mission concepts; …for consideration by the NAS Astrophysics Subcommittee". The short list of potential large missions is the Far-IR Surveyor, the Habitable-Exoplanet Imaging Mission, the UV/Optical/IR Surveyor, and the X-ray Surveyor. NASA intends to deliver to the Decadal Survey Committee the science case, straw man design reference mission with straw man payload, technology development needs, and cost requirements assessment.

Science communities are actively assembling and prioritizing the science cases for potential missions. For example, the Associated Universities for Research in Astronomy (AURA) "Beyond JWST" Committee has developed a mission concept called "From Cosmic Origins to Living Earths: The future of UVOIR Space Astronomy". The assessments for these options correctly focus on science themes, the types of observations needed to address those themes including the data quality required, and the notional instrumentation capabilities needed.

Critical to the development of a credible mission concept is to have a well-defined Design Reference Mission (DRM). The development of "straw man design reference mission(s)" as inputs to the NASA Decadal Survey Committee is understood by NASA (AAS Presentation by P. Hertz on preparing for the 2020 Decadal Survey). Ball Aerospace supports this vision and encourages that DRMs be required for mission concepts provided to the 2020 Decadal Survey. A DRMs is a critical tool at the mission level for evaluating potential architectural concepts. Without a well thought out DRM, a conceptual mission design is at risk for not optimizing system trades, identifying necessary technology development, managing resources, and achieving a balanced design.

The DRM should be a set of mission observations that will address the desired science objectives that flow from the science themes defined by the scientific community. Creating the DRM around the science objectives helps to clearly articulate the mission goals, prioritize instrumentation needs, and derive system requirements. For example, the capabilities needed for a broad multi-purpose astrophysics mission have components that are different compared to the more narrowly defined capabilities for exoplanet studies. Developing the DRM provides the tool that in turn is used to develop and evaluate conceptualized mission.

The DRM provides the traceability from science objectives to engineering requirements and can be used to examine options and implications for observations; finding "tall poles" and drivers and identifying the ultimate limits of performance. In this manner, it is a crucial tool for recognizing and nourishing the major strengths of the observatory and ranking design drivers.

The description of the observations within a DRM should include the nature of the targets, the type of data to be obtained, and the necessary quality of the data including:

- Spectral resolution & coverage
    - Driver for detector technologies, coating options, instrument technologies
- Spatial resolution and coverage
    - Driver for aperture shapes and sizes, image quality, fields of view, fields of regard
- Radiometric sensitivity
    - Driver for aperture size, image quality, backgrounds, detector performance
- Radiometric contrast and its spatial dependency
    - Driver for coronagraphy which in turn drives dynamic and thermal stability

The DRM is used as a guide and referee for major "big picture" trades such as orbit selection, schedule availability and scheduling approaches for operations, and time-to-complete the DRM as a metric for observational efficiency. It provides the traceability from science objectives to engineering requirements and can be used to examine options and implications for observations; finding "tall poles" and drivers and identifying the ultimate limits of performance. In this manner, it is a crucial tool for recognizing and nourishing the major strengths of the observatory by understanding the partial derivatives of performance capability. It allows the prioritization of design drivers and risks, and can be used to assessment technology readiness and development needs.

A DRM is used to derive the capabilities that must be provided by the architecture such as:

- Exposure times and completion rates (science based metrics)
- Estimates of data rates and volumes
    - On board data handling and communications requirements for transfer to ground
    - Ground system data handling requirements
- Where to operate
    - What are the environments and how are they conducive to the mission?
        - Availability of science fields and flexibility of scheduling
        - Low background
        - Thermal environment
        - Space environment (radiation, micrometeoroids)
- What is required to operate at that location
    - Attitude control, Station keeping, Communications
- How do you get there?
    - Launch considerations – limits and constraints on architecture

The importance of the DRM in critically evaluating and trading system architectures at the early stages of mission development cannot be understated.