Internal Research and Development (IRAD)
Step-2 Proposal

Design and Assess A Post-JWST Observatory Mission

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Focus area:

Early Career Innovator: No
Early Stage Innovation: Yes
Type: New

1. Abstract

We propose a multi-Center/STScI initiative with GSFC as lead institution that will (1) develop the priority science goals and requirements; (2) carry out early engineering concept and trade studies likely using the Center's design laboratories, including support for a number of ongoing community strategic planning activities; (3) initiate modest support for key GSFC technology areas (e.g., visual nulling coronagraphy); (4) coordinate with the priorities of the NASA HQ Science, Human Exploration and Operations, and Space Technology Mission Directorates; and (5) develop science and human space flight community support. IRAD support in this proposal is solicited primarily to enable #2.

A primary science goal for this observatory will be the search for evidence of biological activity in the spectra of Earth-like planets around stars in the solar neighborhood. The observatory will also be capable of a wide range of high-priority astronomical programs as identified by community assessment activities.

This activity will target major national decision-making activities to influence: the NAC "astrophysics roadmap," the AURA "Beyond JWST" review, the National Research Council (NRC) mid-decade review of astronomy and astrophysics, and – eventually – the 2020 NRC Decadal Survey of Astronomy & Astrophysics.

2. Objectives

The ultimate objective of this activity is to develop and operate the next observatory-class astronomical mission to follow JWST, which may be possible in the late 2020s, although only if the design work and technology investments begin in the very near future.

Objectives over the coming decade include input to and support for a series of national priority-setting activities in astrophysics: (1) a series of NRC reviews leading to its influential Decadal Survey in 2020; (2) the AURA assessment of options for post-JWST and -WFIRST/AFTA major missions; (3) the series of NASA Authorization Acts in 2013, 2016, and 2019; (4) the current NASA Advisory Committee

development of decades-long priorities for astronomy; and (5) priorities for three NASA HQ Mission Directorates: Science, Human Exploration and Operations, and Space Technology.

Our activities for the rest of the fiscal year may be summarized as

1. Develop priority science goals and requirements for the mission

Working with our Science Definition Team (SDT), which we are currently establishing and chaired by STScI, Center scientists will propose and assess in detail candidate priority science goals for the mission. These are expected to evolve as our concept matures. In addition, GSFC will host its own internal science prioritization activity via a Center Science Working Group (SWG), which is intended to explore additional (secondary or tertiary) science capabilities of the mission. The SWG will meet approximately every two weeks at the start to vet candidate science priorities and define the mission hardware/instrument requirements (e.g., observatory aperture, notional instrument suite, observational scenarios). The GSFC scientists will not require additional FTE support for this activity, as we expect this modest effort to be covered as part of regular duties.

2. Use the FTE resources from this IRAD to fund targeted science requirements and mission architecture trade studies to identify the most likely designs for a post-JWST observatory

GSFC's impressive capabilities in end-to-end mission design, from concept to reality, will be incorporated from the start by pre-Phase A designs based on the science goals and requirements. These designs will allow us to identify technology "tall poles" that will require early investments in advance of a credible candidate for the 2020 NRC Decadal Survey. In addition, these designs will be shared with the various ongoing community reviews to enhance the credibility of their recommendations.

More specifically, for the rest of this fiscal year, we will

- Establish an internal GSFC science and engineering team;
- This team will identify priority science goals, in addition to the "killer app" of finding bio-signatures in the atmospheres of Earth-like planets in the solar neighborhood;
- Derive science requirements to identify hardware requirements;
- Assess multiple design options, including ground-to-space development flows showing minimum-to-maximum required ground assembly, testing, to orbit assembly and testing options; and
- Using these assessments, identify technology "tall poles" from each major engineering discipline.

Identification of technology investment priorities is a major objective of this FY13 IRAD, which we intend to advocate as a priority NASA goal to be ready for the NRC 2020 Decadal Survey.

3. Initiate modest support for key GSFC technology areas (e.g., visual nulling coronagraphy)

Our preliminary team meetings to date have identified a high-priority candidate technology capability at GSFC that shows great promise to achieve a priority science goal of this mission: visual nulling coronagraphy (VNC) to permit spectroscopic study of candidate exo-Earths. This can be advanced significantly with relatively modest support. In close coordination with Rick Lyon, the GSFC lead in the development of the VNC, we are currently actively seeking FY14 funding from the NASA HQ STMD Game-Changing Division.

We intend to be alert to other opportunities where very modest additional support would permit significant advancement: e.g., new generation very lightweight structures and optics, communication systems, onboard computing systems.

4. Coordinate with the priorities of the NASA HQ Science, Human Exploration and Operations, and Space Technology Mission Directorates

Our multi-Center/STScI STD has as a priority activity the identification of key scientific programs for ATST, including – but not limited to – the spectroscopic search for biosignatures in the atmospheres of exo-Earths. These science goals will be consistent, although not identical, with the stated science goals of NASA HQ SMD. In fact, we will challenge our STD to develop science goals as input to the ongoing development of priority NASA science goals; e.g., the NAC "astrophysics roadmap," AURA "Beyond JWST" process, and the NRC "future of human space flight" processes. We expect increases for technology development from NASA HQ SMD sources later in the decade as the costs for JWST ramp down. We do not expect very substantial funding for the development of the mission until after the 2020 NRC Decadal Survey.

Similarly in working with the NASA HQ Space Technology Mission Directorate (STMD), we estimate (Section 5.2) that modest support for this activity will be necessary for the next two to three years, including early technology development. We are therefore actively discussing with STMD opportunities for funding.

The Human Exploration and Operations Mission Directorate (HEOMD) continues to evaluate options for human space flight in the post-ISS period (i.e., mid-2020s and beyond), which includes human/robotic operations in the vicinity of the Moon. Although the priorities for human space flight change faster than those for NASA's science programs, long-duration human operations beyond LEO offer an opportunity for assembly and upgrade of a future large observatory. We intend to follow HEOMD priorities closely and will engage them as opportunities present themselves.

5. Develop science community support

An essential early and continuing effort by our team will be the development of science and engineering community support for this mission, which will become increasingly important as the start of the NRC 2020 Decadal Survey approaches. In coordination with collaborating institutions and individuals, we will present our concept designs and priority science goals at relevant professional conferences. We intend to host science conferences and workshops with our partner institutions. Finally, we have offered GSFC design capabilities in support of the current, ongoing long-range planning activities noted above by the NRC, AURA, and NAC.

6. Develop human space flight community support

A major programmatic goal for our team is that our adopted architecture(s) for this telescope will shift the astronomy community to a new paradigm for the development (assembly, build, and testing/verification) of a future very large space telescope. To build upon what NASA has learned and invested in with JWST, the GSFC-led team we are assembling has initially done some high-level trades indicating that this telescope will also be segmented and, moreover, due to the required size, may need to be assembled and upgraded in space by a combination of robots and astronauts. Until now, all large science facilities have been built and tested on the ground. We are considering an international telescope that would be assembled and tested in space, a major challenge with promising cost savings

as well. The HEOMD would play a large role in this, which could possibly be a "post-ISS" joint endeavor among the SMD, HEOMD, and STMD. The Goddard SSPO/Code 408 has begun seeking support in the HEOMD, which we will continue.

2. Justification

There is no future astronomical mission comparable to that which we propose to initiate and no greater opportunity for GSFC in this scientific field.

This proposed activity will lead to the primary space astronomy mission of the mid-21st Century, from which GSFC will benefit immeasurably over time: significant design work and technology investment here at the Center, continued science leadership, and – eventually – development and operation. The total budget for this mission and its long-term advantages to the Center, including funding for GSFC, is likely to be comparable to that for JWST.

We propose that with this initiative, GSFC will be the lead in a multi-Center/multi-Agency activity that will continue the Center's leadership in the most ambitious astrophysics missions and extend the Center's international stature as a major scientific institution.

More specifically, although we plan this observatory to be a powerful general-purpose mission, one of its "killer apps" is at present intended to be the spectroscopic study of the atmospheres of candidate exo-Earths searching for the signatures of the effects of life (aka, "biosignatures"). The science behind this goal is one of the combined strengths of GSFC Codes 660 (Astrophysics) and 690 (Planetary Science), including strong research programs in the evolution of planetary atmospheres, the search for extra-solar planets, and the technologies of extra-solar detection. About two dozen individual scientists from 660 and 690 have agreed to participate in the activity described in the next section without requiring additional support.

3. Research and Development Plan

Establish Working Groups: Now through 15 May

Multi-institution Science Definition Team (SDT): STScI, JPL, MSFC, JSC
GSFC Science Working Group: 660, 690

Priority Observatory Science Goals and Mission Requirements: 1 September

High-Contrast Demonstration of VNC [supported via separate IRAD and other funding]: Summer and ongoing

First Mission Concept(s): End of FY13; use of GSFC Design Labs TBD

Deliverable	***Date***
Work Plan	15 days after award
Quad Chart	15 days after award
End-of-year Report, Narrative, and Quad Chart	October 1, 2013

4. Future Development and Funding Plan

We are proposing to formulate an early science case, viable mission architecture(s) and engineering technology trade studies to enable the major very large space observatory to follow JWST. This requires identification of technology "tall poles" in the near term to enable sufficient investments in time for the NRC Decadal Survey to begin in 2019. We will begin to muster the science, human operations, industrial, and academia support for such a telescope. If successful, this will lead to the awe-inspiring legacy of finding a true Earth-like planet in our solar neighborhood.

There is not at present e will remain opportunistic especially during this early phase and seek external support should it become available. The NASA Advisory Committee "Astrophysics Roadmap", for example, is currently assessing very long-range options on behalf of the NASA HQ SMD Astrophysics Division. This may result in modest funding in FY14 for design work for future major astrophysics missions. In addition, the President's FY14 budget for NASA includes states "[Until after the launch of JWST] For the next few years, activities on [subsequent] missions will be limited to early mission studies and technology efforts, for a few million dollars annually." We intend to seek this funding especially to support the GSFC visible nulling coronagraph (VNC) technology development work, led by Richard Lyon. This promises to be a significant – perhaps critical – demonstration milestone eventually necessary for a successful exo-Earth observatory.

5. Budget

5.1 Procurement

No procurement is requested.

5.2 Civil Servant Team Activities and Support Requested (FTE)

Core Team:
Harley Thronson and Julie Crooke, GSFC Co-Leads (No support request)
Kate Hartman, Code 400 Study Manager (Paid for out of Astro LOB)
Science Team: Two GSFC Scientists: @ 0.1 FTE each = (Paid for out of 660)
TBD, Mission Systems Engineer (0.4 FTE requested here)
Matt Bolcar, Optical Systems Engineer (0.3 FTE requested here)
Frank Cepollina, SSPO
Mike Kienlan, SSPO
Ben Reed, SSPO

Support as Needed in the Future:
Systems Modeling and Simulations Engineer: 0.2 FTE
Mechanical Systems Engineer: 0.2 FTE
Mechanical Design Engineer: 0.2 FTE
Mechanisms Engineer: 0.1 FTE
Robotics Engineer: 0.2 FTE

I&T Engineer: 0.1 FTE
Electrical and Power Systems: 0.1 FTE
Thermal Engineer: 0.1 FTE

TOTAL: 1.9 FTE (in man-months) for 5 man-months = 0.8 FTE requested for the remainder of FY13.