Planning for the 2020 Decadal Survey
An Astrophysics Division White Paper

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January 4, 2015

Background

The next Decadal Survey in Astronomy and Astrophysics will be conducted by the National Research Council (NRC) in response to a charge set by NASA and NSF, and possibly DOE. Nominally this survey will be carried out in the years 2018-2020.

One of the important tasks of the 2020 Decadal Survey will be to prioritize large missions to follow JWST (the highest priority large space mission of the 2000 Decadal Survey) and WFIRST (the highest priority large space mission of the 2010 Decadal Survey). To enable this prioritization, NASA will provide information on several candidate large mission concepts for consideration by the 2020 Decadal Survey Committee.

A well informed prioritization by the 2020 Decadal Survey Committee requires that any large mission be studied sufficiently to provide, at a minimum, the following information for the consideration of the 2020 Decadal Survey Committee:

- Science case
- Design reference mission with strawman payload
- Technology development needs
- Cost requirements assessment

In the 2010 Decadal Survey, a large mission was defined as one having a total cost exceeding $1B. For the purpose of this white paper, NASA adopts the same definition.

The 2020 Decadal Survey Committee will consider a broad range of activities in addition to large space missions; these activities will certainly include medium-size, or probe-class, space missions. This white paper only addresses the plans for providing information to the 2020 Decadal Survey Committee regarding large mission concepts. No decision has been made by NASA at this time on how to provide input to the 2020 Decadal Survey Committee regarding probe-class missions, technology development, or other programmatic areas.

This white paper presents the Astrophysics Division's plans for providing the appropriate information on a small set of large mission concepts to the 2020 Decadal Survey Committee.

Overall Process

The process of developing the necessary science case and technical information for candidate large mission concepts may be described as a two-part process:

- Part A: Identification of a small set of candidate large missions, and
- Part B: Development of the science case and technical information for each member of the small set of candidate large missions.

Part A must include community discussion followed by a NASA decision on which candidate large mission concepts to study. Part B must include designation of appropriate community-based science and technical teams, an iterative study process, and a cost and technology readiness assessment.

Part A: Identification of mission concepts for study

It is not necessary to start from a blank sheet of paper to identify the community's highest priority mission concepts for the coming decades. The community has invested considerable resources in discussing notional mission concepts for consideration as large missions following JWST and WFIRST.

The 2010 Decadal Survey, *New Worlds New Horizons in Astronomy and Astrophysics*[1], provides advice to NASA on technology investments that should be made to enable consideration of missions by future NRC studies, including the 2020 Decadal Survey.

The 2014 NASA Visionary Roadmap, *Enduring Quests, Daring Visions*[2], provides multiple notional missions in the so-called formative era which have been identified as the missions required to advance NASA's strategic objective in astrophysics, as well as the science goals of the 2010 Decadal Survey, in the period beyond the current decade.

NASA expects to draw candidate mission concepts from the missions discussed in these strategic documents.

The following missions (in alphabetical order) are explicitly discussed in these documents, and these missions form the starting place for any discussion:

- CMB Polarization Surveyor – 2010 Decadal Survey and Visionary Roadmap; consider studying as a Probe
- Far-IR Surveyor – Visionary Roadmap
- Gravitational Wave Surveyor – 2010 Decadal Survey and Visionary Roadmap; to be implemented as US contribution to ESA L3 mission
- Habitable-Exoplanet Imaging Mission – 2010 Decadal Survey
- UV/Optical/IR Surveyor – 2010 Decadal Survey and Visionary Roadmap; science case assumes successful JWST and WFIRST missions
- X-ray Surveyor – Visionary Roadmap; science case assumes successful ESA Athena (2010 Decadal Survey) mission

The Gravitational Wave (GW) Surveyor is the highest ranked large mission after WFIRST in the 2010 Decadal Survey. NASA is planning to partner with ESA on its L3 GW observatory. As long as that mission remains viable, NASA's plans for realizing a space-based GW observatory are focused on an ESA-led, NASA-supported L3 mission. During the current decade, NASA will

[1] http://www.nap.edu/openbook.php?record_id=12951
[2] http://science.nasa.gov/astrophysics/documents/

participate with ESA in the preparatory studies that will lead toward the L3 GW observatory. NASA and the U.S. community participate in ESA's Gravitational Observatory Assessment Team (GOAT) and will participate in subsequent studies. NASA will also study participation in L3 at various levels to identify its proper role in the L3 mission, and conduct the necessary technology development and other activities (including a successful LISA Pathfinder) that will lead toward the L3 mission. Therefore a large mission study similar to the ones discussed here is not required for the GW Surveyor.

Based on concepts that have been proposed as a NASA Astrophysics Explorer, as an ESA M-class mission, and as a JAXA strategic mission, a CMB Polarization Surveyor should be realizable as a probe-class mission; for this reason, a CMB Polarization Surveyor is not included as a candidate large mission concept. The 2010 Decadal Survey specifically calls out for a mid-decade review of the science and technology that support a CMB Polarization Surveyor. The mid-decade review, rather than a large mission concept study, will provide input regarding the future of a CMB Polarization Surveyor.

Recognizing that, at most, 1-2 large missions prioritized by the 2020 Decadal Survey will result in new starts as NASA-led missions prior to the 2030 Decadal Survey, and recognizing that limited technology development funds are available to advance any technology needs identified for these mission concepts, NASA intends to study a set containing only a small number (~3-4) of candidate large mission concepts.

The process planned for identifying a small set of candidate mission concepts is as follows.

1. A small set of notional large mission concepts will be nominated by the Director of the NASA Astrophysics Division. Nominated large mission concepts will be drawn from existing strategic planning studies: *New Worlds, New Horizons in Astronomy and Astrophysics* and *Enduring Quests, Daring Visions*.
2. Each of the three astrophysics Program Analysis Groups (PAGs: Cosmic Origins PAG[3], Exoplanet Exploration PAG[4], Physics of the Cosmos PAG[5]) will solicit community input to modify the starting set of mission concepts by adding or subtracting large mission concepts. The PAGs will consider what set of mission concepts should be studied to advance astrophysics as a whole; there is no desire for mission concepts to be identified as "belonging" to specific Programs or PAGs. Each PAG will submit a report for consideration by the NAC Astrophysics Subcommittee; the PAGs may choose to work together and submit coordinated or joint reports.
3. At its fall 2015 meeting, the NAC Astrophysics Subcommittee will consider the three PAG reports and suggest to NASA a consolidated small set of large mission concepts for study.
4. The Director of the NASA Astrophysics Division will decide which large mission concepts will be studied as input for the 2020 Decadal Survey. The reports from the PAGs and the Astrophysics Subcommittee will inform this decision. An important consideration will be the likelihood that the 2020 Decadal Survey Committee will prioritize the mission as a large strategic mission to follow JWST and WFIRST in the 2020s.

[3] http://cor.gsfc.nasa.gov/copag/
[4] https://exep.jpl.nasa.gov/exopag/
[5] http://pcos.gsfc.nasa.gov/physpag/

The anticipated timeline for the identification of a small set of large mission concept studies is:

November 2014	Discussion of this plan with the NAC Astrophysics Subcommittee and the NRC Committee on Astronomy and Astrophysics[6]
December 2014	Presentation of this plan to the Executive Committees of the PAGs
January 2015	Announcement of this process to the PAGs, including formal charges, in a joint PAG meeting prior to the AAS meeting in Seattle[7]
January 2015 – Summer 2015	Community discussion and input led by the PAG Executive Committees. Each PAG will determine an appropriate process for community discussion and input. The PAG process will include input from the broad astronomical community, optionally including one or more open meetings of the PAG (associated with an existing community meeting, a stand-alone meeting, or a virtual meeting). Each PAG will develop a public report for submission to the NAC Astrophysics Subcommittee.
Fall 2015	Meeting of the NAC Astrophysics Subcommittee to consider the three PAG reports and report to NASA a small set of large mission concepts for study.
Fall 2015	Decision by the Astrophysics Division Director identifying the small set of candidate large missions that will be studied by NASA as input for the 2020 Decadal Survey.

The large mission concept studies will be identified and announced in time for proposals addressing technology needs to be submitted in March 2016 to the APRA and SAT elements of ROSES-15.

The Astrophysics Program Offices at GSFC (Cosmic Origins/Physics of the Cosmos Program Office) and JPL (Exoplanet Exploration Program Office) will support the PAG activities in their program areas including support for workshops, communication, and reports.

Part B: Mission concept studies

The detailed process through which NASA will conduct a small number of mission concept studies will be fleshed out between now and the beginning of the studies in early FY2016. It is anticipated at the time of the writing of this document that the process will include the following:

- A Science and Technology Definition Team (STDT) will be appointed for each mission concept study selected by the Astrophysics Division Director. The Astrophysics Division will issue an open call to the community for applications for membership. Membership, including a Chair or Co-Chairs, will be appointed for each STDT by the Astrophysics Division Director. A charter will be created for each STDT as well. A NASA Center scientist will be appointed as the study scientist for each study.
- Each study will be assigned by the Astrophysics Division Director to a NASA Center for execution; this could be any Center with capability and interest in managing the study. The

[6] http://science.nasa.gov/science-committee/subcommittees/nac-astrophysics-subcommittee/
[7] http://science.nasa.gov/astrophysics/documents

Center will provide a study manager and appropriate engineering support to the STDT. A Center scientist will be appointed as the study scientist for each study.

- Oversight of each study will be assigned to an Astrophysics Program Office at GSFC (Cosmic Origins/Physics of the Cosmos Program Office) or JPL (Exoplanet Exploration Program Office). Oversight includes representing HQ to ensure that the "right" product is delivered to HQ and eventually to the NRC.
- The STDT will define science objectives and a strawman payload for the mission concept. The STDT will also identify the technology development requirements for the mission concept. The Center study team will develop a design reference mission and conduct a cost assessment, with the participation of the STDT, and with the possibility of iteration in order to identify a cost-effective approach.
- The STDT will issue at least one interim report that includes a draft science case, a draft strawman payload and design reference mission, and technology development requirements. This draft report will be used as input to NASA's technology development funding process, including funding by SMD's Strategic Astrophysics Technology (SAT) and Astrophysics Research and Analysis (APRA) programs and by STMD's technology development or SBIR/STTR programs.
- It is anticipated that the process will require multiple meetings of the STDT, usually by phone and occasionally in person. It is also anticipated that the process will require several iterations between the STDT and the Center study team to develop a cost-effective design reference mission.
- The STDT will issue a final report that includes a science case with proposed science objectives, a strawman payload, a design reference mission, and technology development required to enable a new mission start.
- NASA will also conduct a cost assessment. These products will be developed in time to be submitted to the 2020 Decadal Survey Committee at an appropriate point in its study process.

Management

The process will be overseen by the Astrophysics Division, specifically the Program-level Program Scientists and Program Executives at HQ. A HQ study-level program scientist and/or program executive may be designated for each study.

The Astrophysics Division will be supported by the Astrophysics Program Offices at GSFC (PCOS/COR) and JPL (ExEP). Oversight of each study will be assigned to one of the three Astrophysics Program Offices. The assigned Astrophysics Program Office will appoint an appropriate mission manager to oversee each study.

Execution of the studies will be led by a Study manager and engineering support at a designated NASA Center. This could be any Center with capability and interest in managing the study. A study team could involve personnel and capabilities from more than one center.

Funding for the studies will be provided through the Astrophysics Programs' SR&T budget line.

Funding for identified technology development may be provided through the SAT program and other funding lines (including APRA and, if appropriate, STMD technology development

programs). It is likely that there will be insufficient technology funding to advance all technologies to the targeted TRLs, so prioritization will be made by the Astrophysics Division based on peer review and other programmatic considerations.

Eventually, one or more of the mission concepts studied will become formal NASA projects and pass through the phases of formulation, implementation, and operation. The decision on assigning a project to a Center belongs to the NASA Administrator and his senior managers. There is no guarantee that the Center that leads a large mission concept study will be the Center selected to implement the mission.

Probe-class (medium size) mission concepts

No decision has been made by NASA at this time on how to provide input to the 2020 Decadal Survey Committee regarding probe-class missions. There are multiple paths to identifying probe-class mission concepts, and none have been precluded at this time.

During the process of considering large mission concepts, probe-class mission concepts might be identified. Should a PAG wish to highlight potential probe-class missions, to inform any future process for considering probe-class mission studies, such information may be appended to its report.

Each of the STDTs for large mission concepts will be challenged to identify one or more probe-class versions of their mission and to estimate the percentage of the original science case that can be achieved.

The Mid-Decade Review may provide recommendations to NASA regarding the value of probe-class mission concept studies in advance of the 2020 Decadal Survey. Should NASA conduct stand-alone probe-class mission concept studies, they would be initiated no earlier than FY2017.

Acronym Glossary

APRA	Astrophysics Research and Analysis (a ROSES program element)
CMB	Cosmic Microwave Background
COPAG	Cosmic Origins PAG
COR	Cosmic Origins Program (a NASA Astrophysics Program)
DOE	Department of Energy
ESA	European Space Agency
ExEP	Exoplanet Exploration Program (a NASA Astrophysics Program)
ExoPAG	Exoplanet Exploration PAG
GSFC	Goddard Space Flight Center
GW	Gravitational Wave
HQ	NASA Headquarters
IR	Infrared
JAXA	Japanese Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
JWST	James Webb Space Telescope

NAC	NASA Advisory Council
NASA	National Aeronautics and Space Administration
NRC	National Research Council
NSF	National Science Foundation
PAG	Program Analysis Group
PCOS	Physics of the Cosmos Program (a NASA Astrophysics Program)
PhysPAG	Physics of the Cosmos PAG
ROSES	Research Opportunities in Space and Earth Sciences (a NASA solicitation)
SAT	Strategic Astrophysics Technology (a ROSES program element)
SBIR	Small Business Innovation Research program
SMD	Science Mission Directorate
SR&T	Supporting Research and Technology
STDT	Science and Technology Definition Team
STMD	Space Technology Mission Directorate
STTR	Small Business Technology Transfer program
TRL	Technology Readiness Level
UV	Ultraviolet
WFIRST	Wide Field Infrared Survey Telescope

End of White Paper

Charge to the Astrophysics PAGs regarding Large Mission Concept Studies
January 4, 2015

Background

One of the important tasks of the 2020 Decadal Survey will be to prioritize large missions to follow JWST (the highest priority large space mission of the 2000 Decadal Survey) and WFIRST (the highest priority large space mission of the 2010 Decadal Survey). To enable this prioritization, NASA will provide information on several candidate large mission concepts for consideration by the 2020 Decadal Survey Committee.

Existing strategic planning documents, including the 2010 Decadal Survey, *New Worlds, New Horizons in Astronomy and Astrophysics*, and the NASA Astrophysics Visionary Roadmap, *Enduring Quests, Daring Visions: NASA Astrophysics in the Next Three Decades*, provide candidate mission concepts for the large missions that will follow JWST and WFIRST and could be developed in parallel to ESA's Euclid, Athena, and L3 missions in which NASA is participating. These documents have been developed by the astrophysics community and provide the starting point for planning future missions.

Taking into account current programmatic considerations, NASA has identified a small set of candidate large mission concepts to be studied sufficiently to provide appropriate information for the consideration of the 2020 Decadal Survey Committee. The members of the small set follow, in alphabetical order.

- Far IR Surveyor – The Astrophysics Visionary Roadmap identifies a Far IR Surveyor with improvements in sensitivity, spectroscopy, and angular resolution.
- Habitable-Exoplanet Imaging Mission – The 2010 Decadal Survey recommends that a habitable-exoplanet imaging mission be studied in time for consideration by the 2020 decadal survey.
- UV/Optical/IR Surveyor –The Astrophysics Visionary Roadmap identifies a UV/Optical/IR Surveyor with improvements in sensitivity, spectroscopy, high contrast imaging, astrometry, angular resolution and/or wavelength coverage. The 2010 Decadal Survey recommends that NASA prepare for a UV mission to be considered by the 2020 decadal survey.
- X-ray Surveyor – The Astrophysics Visionary Roadmap identifies an X-ray Surveyor with improvements in sensitivity, spectroscopy, and angular resolution.

The rationale for this small set of candidate large mission concepts is provided in the Astrophysics Division White Paper, *Planning for the 2020 Decadal Survey*[8].

[8] http://science.nasa.gov/astrophysics/documents

Specific Charge to the Program Analysis Groups

Each of the three Astrophysics Program Analysis Groups (PAGs) – the Cosmic Origins Program Analysis Group (COPAG), the Exoplanet Exploration Program Analysis Group (ExoPAG), and the Physics of the Cosmos Program Analysis Group (PhysPAG) – are charged with reviewing this small set of candidate large mission concepts and suggesting additions, subtractions, and other useful commentary. The results of this review shall be reported to the NAC Astrophysics Subcommittee in the form of a report.

In particular,

1. Each PAG, under the leadership of its Executive Committee, shall broadly solicit the astronomy and astrophysics community for input to the report in an open and inclusive manner. To accomplish this, each PAG is empowered to envision and use its own process.
2. Each PAG will consider what set of mission concepts should be studied to advance astrophysics as a whole; there is no desire for mission concepts to be identified as "belonging" to a specific Program or PAG. Each PAG shall keep the number of large mission concepts in the set as small as possible. Each PAG is specifically charged to consider modifications and subtractions from the small set, and not just additions.
3. Each PAG shall produce a report, where it shall comment on all large mission concepts in its small set of large missions, including those in the initial small set and those added or subtracted. Where there is existing analysis to support it, PAGs are encouraged to comment on the cost range anticipated for large mission concepts. A suggested template for the report is given below. The PAGs may choose to work together and submit coordinated or joint reports.
4. Each PAG may choose to have one or more face-to-face or virtual meetings or workshops in developing its report; said meetings may be scheduled in proximity to existing community meetings or conferences. Limited funding is anticipated by the Astrophysics Division to support a dedicated face-to-face workshop. The Astrophysics Program Offices will support the PAGs in any logistics required to facilitate these activities.
5. Although there is no page limit for the report, each PAG shall strive to be succinct.
6. Each PAG shall submit its report in writing to the NAC Astrophysics Subcommittee no later than two weeks prior to its fall 2015 meeting (meeting schedule not yet known).

Suggested Report Format

Every PAG is asked to submit a short public report of its analysis to the NAC Astrophysics Subcommittee by the date specified above. While there are no prescriptions for the format of the report (other than being succinct), some guidelines are provided. Each PAG will be free to structure its report as it sees fit.

It is suggested that each PAG report include the following:

1. Process followed by the PAG to solicit input from community (meetings, white papers, emails, etc.);
2. Brief description of the community response;

3. Procedure and criteria used for PAG analysis of the community response;
4. Outcome of the analysis and final small set of mission concepts submitted to the NAC Astrophysics Subcommittee; every mission concept that is retained, added, or subtracted must be accompanied by a short rationale; and
5. Any additional considerations for NASA.

Should a PAG wish to provide NASA information regarding potential probe-class missions, to inform any future process for considering probe-class mission studies, such information may be appended to the report.

Points of Contact

The NASA HQ points-of-contact are

COPAG	Mario Perez, COPAG Exec Secretary (mario.perez@nasa.gov)
ExoPAG	Douglas Hudgins, ExoPAG Exec Secretary (douglas.m.hudgins@nasa.gov)
PhysPAG	Rita Sambruna, PhysPAG Exec Secretary (rita.m.sambruna@nasa.gov)

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Paul Hertz — date
Director, Astrophysics Division
Science Mission Directorate

End of Charge to the PAGs