

CARNEGIE INSTITUTION FOR SCIENCE

DEPARTMENT OF TERRESTRIAL MAGNETISM
5241 BROAD BRANCH ROAD, N.W.
WASHINGTON DC 20015-1305

Tel: 202/478-8858

<http://www.dtm.ciw.edu/boss/>
boss@dtm.ciw.edu

Fax: 202/478-8821

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TO: Wes Huntress, Chair, NASA Advisory Council Science Committee
RE: Report from the Astrophysics Subcommittee (APS)
FROM: Alan Boss, Chair, APS

This letter report summarizes the APS meeting held on September 16-17, 2010 at NASA HQ in Washington, D.C. All of the members of the APS participated in this unusually well-attended meeting, either in person or through Webex and telephones, as well as a standing-room-only group of the public.

The Subcommittee is grateful for presentations from Jon Morse, Roger Blandford, Jason Rhodes, Eric Smith, Linda Sparke, Fabio Favata, and the chance to speak with Ed Weiler for an extended period of time. Special thanks are due to Jason Rhodes and Fabio Favata, both of whom agreed to speak to us on short notice and while they were on travel in Japan, resulting in a teleconference with us close to their local midnight. We are also thankful for the ongoing NASA staff support, in particular the work by Hashima Hasan.

Division Update: Jon Morse presented the status of the Astrophysics Division (APD), beginning with several examples of the latest science results being returned by operating APD missions, such as the Hubble, Chandra, Spitzer, and Fermi space telescopes. The Wide-field Infrared Survey Explorer (WISE) completed a survey of the entire sky in four mid-infrared wavelength bands, and plans its first data release in Spring 2011. The Wilkinson Microwave Anisotropy Probe (WMAP) completed its science data collection in August and is in the process of being decommissioned. The Stratospheric Observatory for Infrared Astronomy (SOFIA) plans to begin early science observations this November. The Kepler space telescope revealed the detection of the first planetary system with at least two transiting planets in August; a third transiting planet is suspected as well in this system. While APD currently has 15 operational space telescopes across the electromagnetic spectrum, that number is expected to drop to 9 (including the SOFIA aircraft) by 2016.

Astro2010 Decadal Survey: Roger Blandford described the process and results of the latest astronomical decadal survey, which he chaired, entitled *New Worlds, New Horizons in Astronomy and Astrophysics* (NWNH) and released on August 13, 2010. The top priority of NWNH for large space projects is the Wide-Field Infrared Survey Telescope (WFIRST), with three equal priority science goals: large-area galactic and extragalactic

surveys, gravitational microlensing exoplanet searches, and dark energy/cosmic expansion studies of several types (baryonic acoustic oscillations - BAO, distant supernovae, and weak gravitational lensing - WGL). WFIRST would accomplish the dark energy goals in concert with the Large Synoptic Survey Telescope (LSST), which was the top large ground-based project in NWNH. WFIRST is estimated to cost \$1.6B in 2010 dollars, and would thus be the next flagship mission after JWST. NWNH explicitly states that the United States should have ``a leading role'' in the event that the US should join with the European Space Agency (ESA) in flying a joint mission to achieve WFIRST's goals.

The second priority large project of NWNH is an augmentation to the APD portion of the Explorer Program. The third and fourth priorities are the Laser Interferometer Space Antenna (LISA), designed to detect gravity waves, and the International X-Ray Observatory (IXO), a large x-ray space telescope, respectively. Both LISA and IXO rely on international partnerships and would launch no earlier than the following decade (i.e., in the 2020s).

Both APD's Jon Morse and the Science Mission Directorate's (SMD's) Ed Weiler pledged to accept and implement the top priorities of NWNH, and **the APS supports this intention.**

JWST Update: Eric Smith presented the status of the James Webb Space Telescope (JWST), which is being built with a planned launch date in mid-2014. Most of the hardware for JWST has already been fabricated, so the remaining schedule and budget challenges center on the integration and testing phase of the mission. As a result of concerns raised during the mission Critical Design Review (CDR) earlier this year, a Testing Assessment Task (TAT) group was formed and charged with reviewing the integration and testing plans for JWST. The TAT found that while a significant amount of testing is required to reach a reasonable level of mission risk, the time required for testing could be shortened by a period of 2 to 6 months without incurring unacceptable risk. **While the TAT report is available on the JWST web site, the APS has requested that the CDR report by the JWST Standing Review Board (SRB) be provided to the Subcommittee prior to the next APS meeting.**

As a result of the cost overruns to date in the JWST program and a request by Senator Barbara Mikulski, JWST is currently undergoing an extensive programmatic review by the Independent Comprehensive Review Panel (ICRP), with a report due on October 1 to the NASA Administrator's Office. The ICRP will provide an assessment of the JWST launch date, schedule, funding profile, and reserves. JWST currently utilizes ~ 40% of the total APD budget, and subsequent flagship-class missions must await the launch of JWST before they can be started. The outcome of the ICRP is thus critical for the implementation of any APD plans for future space telescopes. **The APS awaits the release of the ICRP report, and wishes to schedule a Subcommittee meeting as soon as possible in order to assess the implications of the ICRP report for APD missions for the rest of this decade and beyond.**

Senior Review of APD R&T: Linda Sparke presented the status of the plan for a Senior Review (SR) of the APD's Research & Technology (R&T) Programs, which were last reviewed nearly a decade ago, along with Planetary Science and Heliophysics research programs, in 2000-2001. The review is intended to follow the advice of the December 2009 National Research Council (NRC) report that mission-enabling activities should be clearly linked to NASA's strategic goals (as well as those of NWNH) and that metrics should be used to actively manage the portfolio of R&T programs. **The APS had requested the chance to review the charge for this SR of R&T, and concurred to a large extent with the charge presented.** A group of 8 to 12 panel members will be appointed in time for the panel to hold a first meeting in November or December 2010 in order to plan their SR and to agree upon the metrics to be used. A public comment session will be held at the American Astronomical Society (AAS) meeting in Seattle in January 2011, and an interim report will be made to the APS at the Winter 2011 Subcommittee meeting. The SR final report will be available in Summer 2011. **The APS agreed with the time line proposed for the SR,** given that this SR will be breaking new ground and will need some time to decide how to proceed. **The APS expects to review the final report of the R&T SR,** and suggests that the R&T SR should be performed on a regular basis, perhaps with the same period as the updates to the NASA Strategic Plan (every three years). Subsequent SRs should be easier to accomplish once the process and metrics are agreed upon.

Specific suggestions by the APS for the R&T SR include the following: 1) Issue a "Dear Colleague" letter to the community inviting nominations for members of the SR, in order to solicit the best possible SR members and to alert the community to the SR plans. In parallel, APD should actively solicit applications from senior members of the community. 2) Invite input from the public electronically, for those who are unable to attend the AAS meeting at Seattle, or who have an idea at another time. This announcement should be made through the AAS and the American Physical Society's Division of Astrophysics (DAP) e-mail systems. 3) The charge to the SR should include the question "is the range of award sizes suited to the ... challenges addressed?" for the sub-orbital and lab astrophysics programs as well as for the theory program. 4) The Astrophysics Data Analysis Program (ADAP) and Guest Investigator funding models need to be considered not just with respect to each other, but with respect to the Astrophysics Theory Program (ATP) as well. 5) The review of the Origins of Solar Systems (OSS) Program needs to address the question of the proper support of ground-based exoplanet detection efforts by NASA and NSF, given the loss of the Terrestrial Planet Finder (TPF) Foundation Science element of OSS several years ago, the discovery of 500-odd planets by ground-based techniques to date, and the need to prepare for a possible TPF-like mission in the 2020-2030 time frame—a goal that is clearly envisioned in the NWNH report.

The APS concurs with the Small Programs recommendations of NWNH and assumes that the recommended augmentations to the R&T programs will be made by the APD over the next decade.

Program Analysis Groups (PAGs): Jim Kasting, Steve Ritz, and John Huchra presented the plans for the meetings of their groups at the AAS meeting in Seattle, the ExoPAG, PhysPAG, and COPAG groups, representing respectively the Exoplanet Exploration, Physics of the Cosmos, and Cosmic Origins themes of APD. **The APS concurs with the request that the ExoPAG add two new Study Analysis Groups (SAGs)** in the areas of internal coronagraphs and interferometric imaging, in addition to the existing external occulter SAG. These SAGs are intended to provide APD with a source of advice and expertise on how best to pursue the technology development called for in NWNH's top priority Medium Program recommendation, the New Worlds Technology Development Program. The PhysPAG and COPAG are still in the process of selecting their Executive Committees and both plan to be operational in time for the AAS meeting in Seattle. **The APS supports the agendas of all three PAGs for this first AAS meeting after the release of NWNH.**

Decadal Survey Independent Advisory Committee (DSIAC): **The APS concurs with the recommendation of NWNH that a DSIAC be created, and as soon as possible,** in order to provide independent advice about Decadal Survey-level recommendations on a shorter time scale than once every decade. However, some care needs to be taken with defining the role of the DSIAC relative to the APS and the Congressionally-chartered Astronomy and Astrophysics Advisory Committee (AAAC), in particular in distinguishing between strategic issues regarding the Decadal Survey priorities versus tactical implementation issues. One hypothetical example for the DSIAC would be if the phasing of NWNH mission initiatives had to be re-assessed for budgetary reasons.

PLATO: One of the missions currently competing for an M-class mission in ESA's Cosmic Vision 2015-2025 planning effort is PLATO, a space telescope intended to discover exoplanets by transits, as does NASA's Kepler mission. The US has been offered a junior role in the PLATO mission. However, given that NWNH did not support such an investment in PLATO, or in any transit-search telescope following Kepler, **the APS concurs with the intent of the APD to inform ESA that NASA will not pursue a strategic partnership on the PLATO mission.**

Euclid and WFIRST: By far the most contentious issue debated at this APS meeting was the question of how to proceed with the NWNH recommendation for the WFIRST mission, given the offer by ESA for US involvement in the Euclid mission as a junior partner. Euclid is effectively competing with PLATO for one M-class mission launch in 2018, given that ESA's Solar Orbiter is expected to take the 2017 M-class mission launch date due to being closer to launch readiness. The recent economic recession has affected science budgets in Europe as well as in the USA, but the launch date of the chosen second M-class mission is not currently expected to slip by more than a few months as a result, according to ESA's Dr. Fabio Favata. Euclid's science goals are very similar to two of the dark energy goals (BAO and WGL) of WFIRST. Given the estimate by NASA APD that WFIRST cannot expect to be launched any earlier than ~ 7 years after JWST is launched, if JWST launches in mid-2014 as currently planned, WFIRST could not launch before 2021-22, several years after Euclid. Euclid would then be able to spend 3-4 years making measurements similar to some of those planned for WFIRST, effectively

skimming the cream off of the dark energy pail envisioned for WFIRST by NWNH. The science impact of WFIRST could be diluted if Euclid flies first.

ESA's decision about PLATO versus Euclid is expected in June 2011. ESA's Announcement of Opportunity (AO) for Euclid and PLATO requires responses by the end of October 2010. At this time, NASA is assumed to be participating in both PLATO and Euclid at the 20% level. If this assumption is not correct, NASA needs to inform ESA as soon as possible, so that ESA's AO can be properly modified as needed. Concern was expressed that US participation in Euclid at the 20% level, or through the provision of near-infrared detectors, could influence the outcome of the ESA selection process in favor of Euclid, and consequently affect the impact of WFIRST.

Jon Morse presented a draft plan for how to address ESA's needs in the context of NWNH. Given the top ranking of WFIRST in NWNH, NASA intends to proceed with planning for WFIRST as the next flagship mission, following JWST. A WFIRST Science Definition Team (SDT) will be formed this Fall, following an open call for participation by scientists representing all three of the WFIRST science goals specified by NWNH (wide field surveys, exoplanets, and dark energy), including all three of the dark energy search techniques. The SDT will be charged with developing detailed science goals and an implementation plan for WFIRST. Relevant technology development will also begin on a limited basis.

At the same time, NASA APD proposes to continue to pursue a potential partnership with ESA on Euclid. In response to concerns that a 20% share would not be adequate, NASA SMD negotiated with ESA the possibility of increasing the US level of participation from 20% to 33%, so that 4 of 12 Euclid Science Team members would be US scientists. This US share would roughly equate to \$260M, with a cost-neutral outcome being possible if ESA is able to take a reciprocal role on WFIRST. Participation in Euclid would then be the first element in a US near-infrared space telescope program leading to WFIRST. Continuing this partnership with ESA on the Euclid and potentially WFIRST missions would fulfill a NASA objective of pursuing a new era of international cooperation in space.

While this proposal has the merit of allowing US scientists early access to the dark energy data to be collected by Euclid, the APS discussed in great detail many of the complications of this approach, such as the following: 1) US participation in Euclid is not specifically called for in NWNH. 2) Euclid followed by WFIRST would mean NASA's next two missions would both involve dark energy, possibly leading to a perceived program imbalance. 3) Euclid would use only two of WFIRST's dark energy science techniques, though perhaps not as definitively. 4) Euclid's secondary science priority is a gravitational microlensing exoplanet search, but this search might not be as thorough as that planned for WFIRST. 5) Euclid would not achieve the additional large surveys intended for WFIRST in NWNH. 6) Spending \$260M on Euclid in the next decade could mean \$260M less for other NASA missions and technology development in the same time period, though if there is a future agreement for cost-neutral ESA participation in WFIRST, the \$260M investment would be returned later. 7) NASA would not be able to

start work on any other space missions other than Euclid, WFIRST, and Explorers in this decade. Funding for Euclid, as with all of the Decadal Survey mission initiatives, would come out of the APD's Future Missions budget lines.

The APS discussed the possibility that if Euclid is chosen by ESA for launch, US participation, coupled with the NWNH recommendation for WFIRST, could result in Euclid evolving into a joint mission that meets all of the NWNH goals for WFIRST. However, neither ESA nor NASA can guarantee this desirable outcome at the present time. Dr. Favata stated that ESA is committed to pursuing the Cosmic Vision competitive selection process as presently defined.

The APS supports NASA's plan to issue a "Dear Colleague" letter (DCL) soliciting nominations for the WFIRST SDT this Fall and calling for participation by scientists from all three of the WFIRST science areas specified by NWNH, including international scientists (particularly those involved in Euclid), as well as those from the previous Joint Dark Energy Mission (JDEM) teams. If possible, **the APS would like to review the SDT Charter prior to its release**, though Federal Advisory Committee Act regulations and the need for a timely release of the DCL may preclude this request from being granted.

The APS decided to support NASA's plan to continue a possible partnership with ESA in the Euclid mission, by a large majority (10 in favor, 2 opposed, 2 abstentions, 1 not able to comply with the request, 1 not voting – the Chair = 16 in all). The APS intent is primarily to keep the Euclid option open at this time, not endorsement of proceeding to a legally binding Memorandum of Understanding (MOU). The merits and drawbacks of proceeding toward an MOU on Euclid will be a primary concern not only of the APS, but also of the WFIRST SDT once it is formed. By a closer vote, **the APS also indicated a preference that the US share of Euclid be kept at the present 20% level**, rather than being raised to 33% as proposed (7 in favor of 20%, 4 in favor of 33%, 3 abstentions, 1 member not present, 1 not voting – the Chair = 16 in all).

The APS anticipates returning to the major issues of 1) JWST's progress toward launch, 2) implementing the recommendations of NWNH, 3) planning for Euclid/WFIRST, and 4) the R&T SR throughout the coming year. In the future, **questions to be asked of the APS about such important issues should be provided to the APS in advance of the meeting**, so that APS members have time to provide thoughtful advice, and, when needed, consult with their colleagues in the community.

Best wishes,

A handwritten signature in blue ink that reads "Alan Boss".

Alan Boss, Chair, APS