Astro 2010 Townhall Meeting
Baltimore Maryland, March 27 2009

The Johns Hopkins University Bloomberg Center for Physics and Astronomy

Meeting Web Site: http://www.stsci.edu/institute/conference/astro2010
(webcast available)

Notes compiled by Stefano Casertano, Anton Koekemoer, Eric McKenzie and Henry Ferguson

Astro2010 Survey, Panel, and Study Group Participants
Carol Christian, Julianne Dalcanton, Debra Elmegreen, Tim Heckman, Richard Mushotzky, Antonella Nota, Neill Reid, Chris Reynolds, Eun-Suk Seo, Mike Shull, David Spergel, Jason Tumlinson

NAS Representative: Michael Maloney

Organizing Committee
Henry Ferguson (STScI), Daniel Apai (STScI), Stefano Casertano (STScI), Suvi Gezari (JHU), Eric Grove (NRL), Anton Koekemoer (STScI), Erick McKenzie (UMD), Warren Moos (JHU), William Oegerle (NASA/GSFC), Andrew Ptak (JHU), Ken Sembach (STScI), Kent Wood (NRL)

Minutes

Harry Ferguson: Welcome

Tim Heckman: Introduction and Astro2010 survey status (see slide package)

Science Frontiers Discussion

Jon Gardner (NASA/GSFC) [moderator]: To start off the discussion, would like to hear just a brief summary from a few of the panel members on what they would like to see come out from this discussion.

Dave Spergel [panelist]**:** Assignment for the science panel is to report what they consider to be 4 fundamental science questions along with a significant new discovery area. The white papers have been wonderful, although they tended to be mission driven, so more eager to hear scientific questions that the community thinks are very important but not necessarily identified with big missions.

Mike Shull [panelist]**:** Would like to add that the recent "Beyond JWST" meeting concluded with an exhortation from Matt Mountain to "inspire the nation" – similarly, would like to ask the community here to inspire the Decadal Panels, who need to come up with the exciting new

science questions and discovery area(s). So, would like the discussion to focus on exciting, inspiring new science questions.

Open question/discussion session:

Charles Sven: Quoting Sean Carroll at COSMO-02, also Michael Turner: *"we know much (in relation to cosmology) but we understand little"*. A fundamental question in cosmology is to understand in more detail the big bang explosion, drawing from recent observations of quasars, 2dF results, and the +/-0.2% CMB anomaly. These should be investigated further, see http://www.allnewuniverse.com, a talk at the Denver APS in May ("Big bang field discovered and demonstrated"), and a submitted white paper.

Steve McCandliss, JHU: How driven will the committee be by the "Wordle"? (graphic showing the relative number of times that each word appears in the titles of white papers)

> **David Spergel:** Spent most of their first meeting on the white papers, which are viewed as a source of information but not a unique source – NAS tried to put together a broad group of scientists in each of these areas, who will draw more from their own knowledge and interactions with the community – ie not so much "wordle-driven", but instead be "informed" by it.
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> **Julianne Dalcanton:** Also add that the wordle suffers from the same problem as the citation index – an excellent paper in one field may end up with less citations than a bad paper in another field which happens to have more people working in it.

Kirk Borne, GMU: While traditionally we have written observing proposals to physical telescopes, the recent advent of VO together with large surveys like PANSTARRS, LSST, DES etc are changing the way we do research. So, would be interested in hearing the panels' ideas about having new funding programs above and beyond the severely underfunded NASA/ADP, to something more similar to, eg HST, Chandra observing programs to fund innovative new science that use these new databases.

> **Debra Elmegreen:** Indeed; many whitepapers emphasize that we are in a new era regarding data collection, archiving/analysis, so this should be considered particularly within the Facilities & Funding Panel or study group within the State of the Profession of the Profession subgroup. These issues are actually new to this decadal survey and they will indeed be considered.
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> **Mike Shull:** Would actually broaden the question to computation, visualization – is there a breakthrough area that we should be thinking about that might be just around the corner? (or is it just Moore's law)

Jason Kalirai, STScI: back to what David and Steve were talking about: there's some inherent bias in the way that some of the whitepapers are written, by teams that were pre-existing collaborations for future telescopes, which is part of the reason why some of the missions are specified so strongly in some of the whitepapers. So, interested in how the panels will filter the information in these 320 whitepapers to come up with a prioritization?

> **Mike Shull:** In his panel, trying to go from ~95 whitepapers to a smaller number of questions, and finally then to 4 questions, which may be cross-cutting. A lot of the whitepapers will end up embedded in some of those questions, and in the end each panel may end up with about a ~40 page report which will be published by the NAS.

Jason Tumlinson: Panels are trying to add value to the whitepapers by synthesizing ideas that cut across fields. However, the time may be too limited – so if anyone has noticed synergies between their whitepaper and others, please let the panels know about it!

Richard Mushotzky: Galaxies panel has ~110 papers – almost impossible to synthesize a discussion given the limited time available, so would appreciate ideas from the community on how to synthesize these.

Jon Gardner: Is there an email address or place on the website where community can submit comments?

Debra Elmegreen: Any comments can be emailed to astro2010@nas.edu and it will go to the right place.

David Spergel: Re-iterate that, while they are reading through the whitepapers, the role of the committee is not so much to synthesize all of the whitepapers but rather to be informed by them. So, in practice, this committee has identified about a dozen areas that are potentially important; committee members are reporting on them, having weekly telecons, etc. Careful to try and ensure that all the issues raised in the whitepapers can fit into these areas – however, it's not a mapping of whitepapers, rather a best attempt to identify important science questions in which they think significant progress may be made in the next decade.

Gerhardt Meurer, JHU: Has recently published a paper showing that the IMF is not uniform, not universal at the top end, which may result in a lot of new work – wants to point out that this used a small telescope in space and small telescopes on the ground, but was quite underfunded, being an NOAO survey project which never received NSF funding, thus delaying project by ~2 years. Would be nice if we could get to a scheme where ground-based facilities are funded in the same way as large space programs.

Julianne Dalcanton: Fairly active discussion [see Astro2010 facebook] about how to make this happen; suggests checking this website and contributing further to the discussion there.

Tommy Grav, JHU: Several projects looking into near-earth objects eg with PANSTARRS, LSST, WISE mission, with several NASA committees involved – so are the Astro2010 committees considering this and working with the NASA committees, or instead letting the NASA committees do it separately?

Tim Heckman: The NASA, NSF contracts with the NRC have terms that exclude solar system work, so apart from some solar physics (observing the sun from the ground), the rest of solar system science (incl studies of near-earth asteroids etc) are really not included.

Tommy Grav: So what does this mean for, eg solar system studies that want to apply for NSF funding?

Tim Heckman: The question really isn't part of this decadal survey – basically do what the agencies have paid for, which does not really cover this type of solar system work at all.

Mike Shull: Similarly, some other themes have come up eg cosmic rays (interstellar shock acceleration) in the galactic panel, ultra-high energy cosmic rays in David's panel, because there may be some fundamental physics to be learned.

Bob Brown, STScI: Was reminded of the importance of other parts of the NASA program for the development of space astronomy, eg human servicing of HST to maintain long-term operation. With a change of administration, and a new space policy likely, how will the decadal survey take into account (1) Matt Mountain's point that we should look for opportunities that may

be available based on decisions in other areas of the space program, and (2) how will the committee adapt their answers to the possibility of a change in the space program that may occur beyond the period of time of the committee's deliberations?

> **Mike Maloney**: Primarily interested in being told what the NAS should be doing, and that's the point of these townhalls – not so much in answering questions about the process, although this is fine but is rather limited because of the confidentiality of the process; rather, NAS is mostly interested in seeing a discussion amongst the community members, in the presence of the panelists, about issues like this, so that these ideas can be fed into the process – so a bit of a plea to start arguing amongst ourselves!

Ken Sembach, STScI: At the end of the process, there are these 4 questions that have to be brought forward, and the community has been asked as to what these will be – so how do the panels envision coming up with these 4 questions, and do they have some thoughts about the 4 questions already that might be used to seed some of the discussion?

> **David Spergel:** This is just the kind of thing that the panels don't want to do, primarily because it may bias the discussion, when instead the discussion should be less constrained.
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> **Ken Sembach:** So, could certainly tell the panel what he thinks the 4 questions should be: (1) are we alone in the universe? (2) how does gas get into galaxies from the IGM? (3) how does gas get from the ISM to form stars? (4) what's the ultimate fate of the universe?
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> **David Spergel + panelists:** You also get to nominate one new discovery area – not technology-driven but science-driven: what big new discovery area might be just right around the corner?
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> **Ken Sembach:** Time-variable phenomena (in real-time) would be a nice example

Rob Olling, Maryland: One issue generally not considered is nearby stars, many too bright for study, and would also like to suggest for the panels to list some "minority opinions" in addition to the 4 questions.

John Baker, GSFC: Interesting theme is the role of gravity – eg LISA provides opportunity to probe extremely strong gravity domain, test Einstein's theory. Also point out that gravity's role goes in a lot of directions, incl success with numerical relativists, black hole mergers, etc, with many new ideas from astronomy community about eg observing BH mergers at other wavebands, also time-variable astronomy.

Dave Soderblom, STScI: While he likes Ken's questions, some of them (eg "are we alone") are so big they can't be answered by themselves – really break down into smaller questions, so when the panels are considering the big (too big?) questions, are the pieces in place (in terms of smaller questions) that are needed to support the very big questions?

Randall Smith, CfA: Also likes Ken's questions, for their brevity, much more so than eg addressing NASA theme III.3.c(d5) – so please, make the questions pithy, short, and if they need to be expanded then that's what the 40 pages are for, but would much rather look at the big picture.

> **Jason Tumlinson:** will certainly aim to phrase the questions to be very clear not just to scientists but also to the general public.
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> **David Spergel:** Interesting document to look at for discussion is the European effort to do this ("astronet").

Hannah Jang-Condell, UMD/GSFC: Regarding wide community involvement, what efforts are being made to bring young people into the discussion? Eg what is the average age of people on the committees, or the whitepapers which in many cases may have been led by people who are used to being "in charge", PI's of projects, etc – so how do the committees hope to bring in more postdocs, grad students, etc, since that's where much of the energy is and where many of the new frontiers will be?

> **Michael Maloney:** In earlier townhall meetings, committee/panel members have been emphasizing that there were no restrictions on who could submit whitepapers or input to the process; has heard some maybe apocryphal stories that some postdocs and others were being dissuaded locally from putting in position papers; also at the June AAS there will be a graduate-student-only townhall meeting to interact with Roger Blandford. So, again, anyone can email astro2010@nas.edu - they all come to him (Mike Maloney) and he responds to all of them; they really welcome any and all input.
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> **Mike Shull:** In addition, a lot of the panels tried to have diversity not only of the usual type but also geography, age, and there are several members certainly under 40, and probably nobody over 60; asked for a show of hands as to how many were grad students, also postdocs – good show of hands.
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> **Jason Tumlinson:** Two of the members on his panel got their PhDs after 2000.
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> **Julianne Dalcanton:** Survey issues have also been opened up on blogs where people can comment anonymously, particularly if that's a format that more junior people are more comfortable with, since a sense of "political safety" is often an issue for some of the more junior people. How to find out where the blogs are? Use google.

Jeffrey Linsky, Colorado: The whole idea of searching for life elsewhere is very high priority today; the Greek philosophers also thought it was interesting but didn't try to implement it since they didn't think it was feasible – and if you look at Decadal reports from 30, 20, 10 years ago, this question wasn't near the top at that time since it really wasn't feasible then. So it's one thing to lay out the science issues that you would love to solve at some point in future, but it's important to be practical and think in terms of technological innovations that make the future questions possible – so, the panels should look into practicality and availability of new ideas in technology / detectors etc in deciding the top 4 questions.

> **Neill Reid:** As a Prioritization Panel member, would actually encourage the Science Frontiers panels to ignore that entirely – practicality/implementation is really the domain of the Prioritization Panel, while the Science Frontier panels should actually identify what is the interesting science – and we can't do any of it then that's a different issue. But would rather not pre-judge this at the science stage.

Bill Howard: Was heading the NSF Astronomy Division at the time of the Field Committee Report; has a few notes of advice to the panels: hearing a lot of necessary material, but also hearing a lot of astronomers talking to themselves, and would like to talk about sufficiency as well as necessity. This time around, scrupulous attention to cost is extremely important – if anything, the last decadal review was a bit too much of a wishlist, and each of the agencies responded to it in a different way, eg causing far more panic at NSF than at NASA. So, attention to cost is needed, which means that somehow the panels need to be able to say which programs are the most cost-effective, so the issues of cost, benefit, and risk all come up. When these questions are being narrowed down to 4, they should really be confined to questions that can actually be answered in the next 10 years – because some of them are too far-reaching. It's also important to recognize, from the classified world, eg also in an earlier report from Pete Warden at

a AAS meeting, where developments from DoD (eg CCD research) ultimately leaked into astronomy – often DoD is ~10 years ahead, and some attempt should be made to try to cross this bridge (eg with DARPA etc) and help make new technology relevant to current astronomy. Finally, imagine yourself in the position of OMB in particular, comparing the space science community to the astronomy community, and these questions of balance will need to be tackled.

> **Mike Shull:** Instead of the next 10 years, should we not be considering 20, simply because of the long lead time for these large missions/projects?

John O'Meara: Are we paying enough attention to astronomical software? When we think about really large telescopes with Terabytes of data per night, should we have real money funding for dealing with this data, eg should we fund special types of postdocs for developing astronomical software, going out to industry, google etc? – when we discuss NVO we should also include data reduction as a core issue, not just the products. Worry that when the new telescopes go online, we'll have problems not because of data quality but because of limitations in dealing with it.

> **Debra Elmegreen:** This will be a key issue for the State of the Profession.

Stephan McCandliss: In terms of things that can be done within the next decade, would like to advertise his whitepaper on discovering how the Lyman continuum escapes from star forming galaxies, which is a very important point that can be attacked with a variety of telescopes from FUV to visible.

Ed Shaya, Maryland: A worry is that certain fields will be at a disadvantage because they are too new and not familiar, or too old and not familiar, eg LISA/gravitation, SIM for astrometry – these communities tend to be less visible, because the NASA telescopes of the past few decades have been primarily imaging and spectroscopic facilities, therefore the community tends also to be predominantly oriented towards imaging and spectroscopy. So the tendency is to support the existing community and put off different kinds of facilities, even though there are whitepapers showing a tremendous discovery potential, eg local group dynamics which has suddenly become available to do dark matter measurements out to 200 kpc – quite tired of the assumption that every system is isotropic, it's time to start measuring full 3d velocities in earnest.

> **Mike Shull:** His panel read with interest a lot of those white papers, they were very interesting
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> **David Spergel:** Structure of the panels this time is a lot more open to these types of questions, since they are not organized by wavelength but by science questions, then this flows through to the program panels in terms of what's out there that's do-able.

Frank Summers, STScI: In response to the software issues raised earlier, visualization will play a much larger role over the next decade as we get into these Terabytes of datasets; being able to extract the science from the datasets will require a new level of visualization techniques, and the high-end techniques that are useful in reaching the public can also be used to extract more out of the science. Eg the time domain is particularly challenging in terms of extracting the science and visualizing it, so this will require a significant investment in software – the infrastructure already exists since open-source has shown us how to collaborate on software projects (source-forge etc), but a lot more of this will be needed over the next decade.

Andy Fruchter, STScI: When we look 10 years ahead it's hard to predict what the science will be, except that it will be done by people who may not be us but will have been educated by us (which is a broader discussion in and of itself), and that it will also be based upon what we're going to build, ie what tools will we have to do the science – increasing capability by an order of

magnitude often results in the unexpected being among the most important science. There are 2 areas where it looks like we're going to spend a lot of money and will strongly impact the science we do, and the community needs to think more carefully about what it's going to do, eg:

1) JDEM (which may have a good chance of going forward), may be our only large optical/IR space observatory in the near future, so community need to look very carefully at it as an all-purpose observatory and decide whether it will do that job well, and if not then should it be funded, or should it be revised to do the job well? This community must think about this quickly and seriously.

2) The other area is more of an "American" question (more than eg European) is how will we organize the ground-based optical observatories? Eg a decade ago, the VLT was being built as an integrated multi-instrument facility, while the US 8m-class observatories had more duplication. Maybe now the US community should realize that the model that had worked well previously might no longer be appropriate, but that we really need to think as one community and cannot rely on donations to individual institutions for the major programs. So we really need to come together, as one unified group, to do one large ground-based program besides LSST, and if we don't do that then we won't get it. The claim is that the Europeans have more money than the US for optical astronomy, and the reason for this is because the US optical community has never been as united; the US radio, X-ray and space-based communities are more united, but the ground-based optical community has always been divided – so how will the ground-based optical community become organized to do spectacular science which will require really new instrumentation? Unification is the key to this.

Daniel Apai, STScI: One of the things that may fall outside the committees may be what do we do once we've characterized the planets (eg incl spectra of exoplanets), so we need to begin coordinating more with the geoscientists and identify other cross-discipline collaborations, so it would make sense to identify this as a science component of some of these missions.

Infrastructure and State of the Profession

Moderator: Andy Ptak (JHU)

Debra Elmegreen [panelist]: This committee deals with the whole system of astronomy, from data to education to outreach - all of the things that enable science: people, public, bringing the community together, etc.

Richard Mushotzky [panelist]: one thing missing from white papers: what does the community think we will learn in the next 3 to 7 years? Survey will have to put their questions in the context of what we will know, but is not yet on astro-ph.

Unidentified: What we will learn in the short or medium term may come primarily from the time domain, explored by projects such as PanSTARRs and LSST, and other missions repeatedly covering the sky. It's going to be very important in the short term to figure out how to best take advantage of these data and capture time-dependent phenomena.

Software and visualization are big areas for interaction with other fields. Astronomers are jack of all trades and are used to do things themselves. In big projects, tasks become more focused, e.g., professionals write software, not graduate students. How do we educate the new scientists to fill these more specialized roles? We need computer scientists who know astronomy and are trained to work on these projects.

Debra Elmegreen: we are relying on the community to tell us what to put in the report. Some of the white papers have touched upon these topics. Certainly in the computational and data handling subgroup people are looking at computational resources. In the demographics subgroup we are looking at how people are being trained to do this. We want to be able to include recommendations in this report - for the report to be meaningful, it should include not only what we need, but how to achieve our goals.

Mike Shull: Computational theory programs are getting very large - codes take 20-30 person years to develop. How do we train graduate students in this area?

Stephan McCandliss: There are two cultures in space astronomy: sub-orbital and explorer vs. flagship development. I don't feel that these two cultures collaborate in a effective ways. Matt Mountain says incremental doesn't work, but much progress in science is incremental. We have grand projects we want to accomplish, but we need people at the base of the pyramid to accomplish these projects. How can we develop a work force that is vested in achieving these projects?

Richard Mushotzky: This is a view of the optical community. In other communities, such as x-ray, gamma-ray, and infrared, there is no separation between the two cultures; instruments are built and tested in balloon and rockets, and then put into major missions. Optical get their tech from DOD.

Andy Ptak [moderator]: Can extend the argument to interfaces to other branches of physics - for example detector technology that comes from particle physics.

Matt Mountain, STSCI: It's incremental thinking I am worried about, not incremental action. Technology has to be developed incrementally. There is another issue associated with the classical academics culture: how do you get tenure building detector electronics? But those are necessary for systems. The University system needs a way to incorporate people with these skills. Software development focused astronomers are typically not given tenure.

Debra Elmegreen: agree. EPO and demographics study groups are looking at this. Small colleges shouldn't be the fall-back position. Industry is also a good career path, but most professors don't know how to advise students who want to follow that route. It's going to be crucial to mesh together all these opportunities to make the system work, but I don't know who.

Mike Shull: there are universities that have instrumentalists on their faculty and have trained graduate students. The key issue is what are the opportunities for these people. If it's only Gemini and large telescopes, the opportunities will be limited; small telescopes, balloons, and the like will provide the bulk of opportunities.

Neill Reid: Echoing a comment from Micheal Strauss at he Princeton meeting: it's not just about instrumentalists; universities need to find a way to reward people who work on software and who participate in large projects, such as SDSS.

Jeff Kruk, JHU: technology is chicken-and-egg for explorer. For an explorer mission, the technology has to exist already, or the mission is not going to be approved. Yesterday, Tupper Hyde said that the tech is developed for a large mission and will trickle down. But even for a large mission, such as JWST, the technology already existed, and only tweaks were needed. NASA did not foment the technology revolution that made those detectors possible. The real

bare-bones infrastructure has been funded elsewhere. This needs to change if we are to develop revolutionary technology for missions ten years into the future.

Steve Unwin, JPL: Most of the instrumentation is geared towards photometry, imaging, and spectroscopy. I'd like to make a plea for astrometry, which is not well represented in the US community. Europe understands the broad appeal of astrometry. I'd like to point out the white paper by Todd Henry particularly on ground-based astrometry. Astrometry is not being taught in the universities. There is a great deal of science coming up, and new missions, especially in Europe. There will be a session at the Pasadena AAS called "2010-2020 the decade of astrometry". I encourage all to participate and learn all that's going on in astrometry.

Frank Summers: For what concerns EPO and visualization, Hollywood is the enemy: it looks really cool, but is not accurate. A major problem in teaching is getting rid of the misconceptions about science and the Universe set up by Hollywood. We can do them correctly, but most are done by companies who sell them and don't give them away. STScI does develop some freely available material, but it's focused on press releases. Need to develop high-quality visualizations that can be disseminated to every textbook publisher, teachers, and get the right information out early into young students' heads.

> **Mike Shull:** Great idea - what about planetariums?

Frank Summers: Even public planetariums need to bring in the money, so they cannot always share their products. We share freely, so we are very popular with planetariums.

> **Carol Christian:** great points, but I have a question for the community. How much are you willing to fund out of your research budget? Used to be 7-8% of a NASA budget in 2000, now it is down to 1-2%. Where does the funding come from? Do postdocs want a broader scope of education to support alternate career paths? How do we get faculties at most universities to prepare their students for all these options? What is the right metric? How do we fund this? What is the process, the incentive? These are the kinds of things the committee needs to know.

Jeff Linsky: A recent paper received was very bad, not just poorly written, but also the scientific case was not made. Before I could send in the report, the paper had already been published on astro-ph! Instant publication on astro-ph is no-cost; the refereeing process adds a lot. If astro-ph becomes the way we publish, then we will have lost a great deal.

Phil Stahl, MSFC: To increase the technical competency of the population we cannot wait until undergraduate or graduate school; we need to capture people in elementary and middle school. The math classes taken in 6th-8th grades determine if they take calculus in High School, and that determines a technical career. Teachers have to teach to the curriculum and to the test. We must change what the states require teachers to teach at Elementary, Middle and High School level. We cannot drag students into tech careers. They have to be internally motivated. However, students also need to have chance of success. I develped a physics and applied optics program; we had many students the first year, and they worked hard, but most did not find good career opportunities. We had very few students after that. Students are willing to work hard, but they need opportunities for success. How can we motivate middle school students? I go to science fairs and give out cash prizes. The things you learn by doing something yourself and presenting it to others you don't learn anywhere else. My half recommendation is for professional societies to encourage giving small cash prizes at science fairs. We have to mentor and encourage people when they are young.

Erin Smith (GSFC): It's important not to lose sight of the role of small telescopes, which are a great training for grad students in instrumentation. As telescopes and projects get larger, the contribution of a single graduate student gets lost in the noise. Small telescopes are where you can experiment and learn, and you can see what works and what doesn't. Big things are important, but small telescopes allow risk-taking. [Contribution of small telescopes. Great training tools for graduate students. Large collaborations, contribution of one grad student lost. Small telescopes can showcase grad student projects.]

Jason Kalirai: In response to Carol Christian's question, absolutely I think the funding of projects should be tied to the public outreach component. At STScI, EPO is taken seriously. As an example, we give a box of goodies to staff members who speak at local schools or science fairs. This really works - you get emails, follow-ups, and thank you notes, and young students are inspired and motivated.

Andy Ptak: Keep in mind other direct ways to get people directly interested; for example, the galaxy zoo.

Ed Shaya: I'd like to advocate the idea of prototypes. Even in the current economic climate, it seems that proper engineering procedures should be followed. If you are building a $4 B space mission, it pays to first build something that is 10% of the cost that uses all the new technologies. This will save more than 10% on the final cost, plus you have something that can be used to train people early. Somehow NASA is not following this procedure, perhaps because we haven't insisted on it.

Rob Olling: There are a handful of large missions that are needed, but there is only room for 1 or 1.5 missions in the coming decade. How do we keep the communities going when they don't have a mission? Perhaps we should consider international collaborations as a way to keep these communities active.

> **Antonella Nota:** How does the community want to approach international partnerships? What works, what doesn't?

Rob Olling: It's very hard to figure out what to do, whom to talk to. Rules are complex; for example, in Europe you can only talk to one country at a time, or you have to go through ESA; Japan is even more complex.

John Baker: It may be obvious, but let's keep in mind the history of the Internet. The services that people use are less than 10 years old. So, information technology and use is likely to change in the next 10 years. The expectations of the public will also change. Probably people will expect all information to be out in the open and easily available at the touch of a button.
Andy Ptak: maybe there is already a blog out there where the public can put in their four questions...

Bill Blair, JHU: A dynamic that occurs at JHU and probably elsewhere is that a number of small and medium projects have allowed the luxury of people who are researchers, not tenured, but project-supported over a number of years. This is changing dramatically in the last 5 years. The projects provided a lot of money to maintain an intellectual environment, postdocs, grad students. As projects go away, individuals will need projects to support their own salary, and will no longer be able to support this research environment. Also, archives keep getting bigger. More missions keep getting data into the archives. However, noone pays me to look at the NVO data.

We need a mechanism for support of archival research. NASA ADP is not funded well enough to support this type of activities on the scale that is needed.

> **Richard Mushotzky:** Also, remember that ADP only funds space-based research. There is little or no venue for ground-based archival funding.
> **David Spergel:** NSF.

Joseph Fazio, NRL: Three quick comments. First, I like the structure of the decadal survey: you ask us to tell you first *what* we are going to discover, and then ask about the telescope. Second, reinforce the previous comments about time-domain discovery space over the next 5-7 years. Third, following Andy Fruchter's earlier comments: we are in an international community, and yet you are responding to the US government. We are now in a multipolar world, in which there are many opportunities overseas. I strongly encourage the panel to seek international input if it has not already done so.

Kirk Borne: A few comments on building bridges to other disciplines. The site grants.gov has announcements for all agencies, and other disciplines are doing things we should learn from. For example, the National Endowment for the Arts has a Tera-scale data challenge for visualizations. Computer scientists are researching ApJ as a text-mining experiment. Other areas are mining/visualizing large datasets, looking for transformations that make data more amenable to visual analysis. There have programs that have existed, such as Math at the Science frontier, but have not been well advertised in astronomy. As a consequence the program was cancelled due to lack of interest. Most people I talked to were not aware of this program. Another example from health informatics: a big area of future expansion is health information management, how do deal with large amount of data and investigate them, something similar to what we need to do with astronomical data. We need recommendations to the agencies to fund joint research projects with shared resources and benefits.

John Mather, GSFC: We have demographics scares every so often, such as the Rising Above the Gathering Storm report that suggested that we would run out of engineers and scientists, against the history of our profession, which is that we have many more graduates than can replace the professors. Are demographic studies seriously data driven and properly reviewed, so we can be confident that they are correct? Stories are conflicting: either not enough jobs, or not enough people, depending on your perspective. Second, we need to talk about organizational relations. We have several organizations that need to partner together, including NASA, NSF, and DOE on the funding side, and universities, labs, centers of excellence. With the rise of full-cost accounting, some of the partnerships that used to be easy in the past have now become difficult, as organizations are required to compete with each other. This needs to be addressed in the report. Third, organizational continuity plays into some of the earlier comments about precursor missions. A mission will not learn from the success of the precursor unless there are people that transfer with it. We can say that we learn from Spitzer and Hubble how to run JWST, and that's partly true, but organizationally they are separate missions, only touching at the edges. Technology exists in the people that do things, so people need to transfer in order for technology to benefit. We did try to run a precursor to JWST but we could not find something that was a) affordable and b) worth doing, so we have to declare that Spitzer and HST are precursors for JWST, and the same will probably be true in the future.

Andy Ptak: in the computer science area, it is often said that code reuse is rare, but knowledge reuse is extremely valuable.

Hannah Jang-Condell: When I think about the state of the profession, my question is whether I will have a permanent position some day. Many jobs were cancelled this past year. From my perspective, this situation is scary; all I know to do is astronomy. What prospects are there for me? If I leave astronomy, will I ever be able to get back in? People are being squeezed out; we need more off-ramps and on-ramps. How will I be able to get back in when the situation improves?

Steve Merkowitz, GSFC: I am pleased to see that gravitational physics and fundamental physics is included in this review. From the science side, dark energy and the accelerating universe have revived the interest in fundamental gravitational physics. The field has suffered from its own success, as the ground-based tests of general relativity have exceeded the theoretical predictions of violations. It's hard to motivate measuring zero to the 13th decimal place. We need to encourage the theory side to produce more predictions that experimenters can look into. This also makes it hard to attract young people. We need to support cross-cutting missions such as LISA and JDEM which also have a fundamental physics component and can reinvigorate the field. Another problem is that there are resources out there that are not being utilized. For example, the Lunar Ranging experiment left over from Apollo languished for decades until it was recently revived and is producing interesting results. Why did it anguish when this was an available resource? My recommendation for the panel is to look at how to restore interest in fundamental physics; right now there is no good funding opportunity in this area. Also recommend encouraging cross-cutting missions. I suggest that one of the big questions from the panel include a fundamental physics aspect; rather than a focused question, such as "what is dark energy", consider a question that addresses a piece of fundamental physics, such as "what is the nature of gravity", which would be able to cover more than just a narrow topic.

> **Mike Shull:** Can you elaborate on your "measuring zero" comment? What accuracy is required?

Steve Merkowitz: That's the problem. We are motivated to continue the measurement to arbitrary precision, but there is a lack of a good motivation for a particular number. There are theories now coming out that predict a violation of the equivalence principle, but they don't predict a specific value. Let the theory catch up to the experiments, but we can't let the experiments languish.

> **Richard Mushotzky:** Why do you think that dark energy people have been successful, given that they also don't have a strongly motivated accuracy target?

Steve Merkowitz: Because there are some measurements that we don't understand, while the equivalence principle is exact so far as we can tell. If there was a hint of a deviation, the field would become very excited.

John O'Merrigan: I'd like to ask an interesting question with regards to outreach: how many astronomy ads have we seen during the Super Bowl? The people who advertise Budweiser know nothing about brewing. We should hire professionals. HST does this well; in terms of excitement, HST is fantastic, but in funding, it is dwarfed by the Space Station. Package it differently.

Frank Summers: I agree with what was just said. One reason STScI OPO is successful is because it is the best funded outreach in the country. OPO is funded separately, and has 20-30 people who specialize in outreach: scientists, writers, graphics. If your mission got outreach

funding, be it 2% or up to 7-8%, would you be willing to use it to fund a national organization that specializes in outreach?

> **Carol Christian:** We would like to have a recommendation from the community whether NASA, NSF, and other funding agencies should change how they evaluate EPO proposals to encourage partnerships with EPO professionals, which are currently discouraged. Please send your comments and opinions so that we know how to formulate our recommendations.

[Unidentified]: We are at a critical juncture in our profession. A lot of young people live off of grants, which are now shrinking. Because of the economy, older astronomers are not retiring, and this limits the opportunities for young people to compete for positions as well as for grant support. It is becoming increasingly hard for young scientists to enter the circle. There is no organization that takes our problems to heart. The committee could recommend funding an organization that supports young scientists and guides them in their career.

Rob Olling: This should include not just grants for people just completing graduate school, but also support for people who have been out there for several years who can no longer compete for early career grants.

Brian Fleming, JHU: I come from Alaska, and back home for every letter I write to my congressman supporting science there are 9 saying that we are fat cats. Part of the reason is that there is no outreach program in Alaska. Outreach is important because it's the future; not only it provides an avenue for young people to become astronomers, but also provides mentality so that people grow up to write letters to congressmen to say that science is important. Usually outreach is aimed at Universities, but we need a national outlook.

> **Richard Mushotzky:** John McCain used astronomy as a direct example of fat in government.

David Axon, RIT: I am on the USRA policies committee. We just spent two days discussing the crisis in the technology base of space scientists. In the latest NASA bill there is language saying that at least 1% must be spent on sub-orbital missions. We need to address fundamental questions, but we also need to train people. During the 1960s Apollo generated stipends for young graduate students in science areas. It is not just astronomy: keep in mind that we train many people that go into other fields, such as national security, which also need technical training. Only 20% of physical scientists go into academia. We should not be so insular as to forget the impact we have on other fields, such as remote sensing and similar areas.

[Unidentified]: Regarding time domain, I recall the late 70s book by Martin Harwit stating that big advances are made by instruments that have the capability to do something that could not be done before. A prime example is in radio astronomy, where better S/N produced the unexpected discovery of pulsars. If you look at the multitude of white papers that have been submitted and throw away the normal filters, look at them in the context of Harwit's prescription, you will see that many of them suggest doing something that has never been done before. That's where discoveries will come from.

Randall Smith: I had a student who wanted to come to GSFC for a month. I found an advisor and funding. Unfortunately the student is from a "designated country". There aren't many descignated countries, but they include India and China, so they do include a number of people. People from designated countries need to be escorted at all times by a US citizen. If you have to be escorted at all times, it makes your life... difficult. Simple things like this have a profound

effect on how well international partnerships work. If can't visit a NASA center, you are much less likely to work together. It's a reasonable guess that over the next ten years, India and China may be countries that we would like to work with.
[General approval from audience]

Antonella Nota: As an ESA employee, I know very well what you describe.

Chris Reynolds: It's not just NASA centers. Starting next month, University of Maryland will require extensive paperwork for international visitors, and such changes may extend to the whole country.

Antonella Nota: Let me take this opportunity to ask people about ITAR.

Mary-Beth Kaiser, JHU: As commented before, this goes beyond visiting NASA centers. I have an infrared detector in my lab; that eliminates almost every graduate student in the Department from being able to work in my lab. So there is much technology in our labs that graduate students are not allowed to work with.

David Axon: It is understood now that ITAR is harming national security. This is supported by senior people in the military. There is a will on the Hill to make fundamental changes. It is clear that training Chinese students in technology and then sending them back to China to develop the technology there, rather than enticing them to stay here, harms national security. Chances are that some of this will be changed; but legislation does not happen over night. Still, there appears to be significant will within this administration to make changes as soon as possible.

Phil Stahl: The rules associated with ITAR are developed by citizen committees. People can volunteer to be part of such committees if interested.

Program Priorities and Open Mic

Moderator: Daniel Apai (STScI)

Neil Reid [panelist]**:** There have been no meetings yet regarding program priorities. An idea of what we are looking for can be given by the Statement of Task from NAS, which asks for:

- Status of existing facilities.
- Preview & compare proposed activities.
- State relative importance of projects depending on competitive peer-review vs. programs that leverage public/private investments.
- Estimates of construction costs.
  - (Projects on ground are reaching the costs of mid-level space missions.)
- Risks for each research activity.
- Prioritized and balanced program.

- 3 questions:
- 1) Tell us what we should be doing, e.g. with regard to the interface between ground and space-based observations.
- 2) What is a balanced ground-based program, and how do we get there?
- 3) What is the role of archives on the ground?

Stephan McCandliss: We should advocate that small sub-orbital missions enable significant science and development of technology → FUSE and COS started with sub-orbital rocketry. We

want a lot of small missions that develop technology that will trickle up. We should develop an orbital sounding rocket program for live testing of 1 to 30 day missions.

Jeff Kruk: The stated policy has been a much larger number of small missions than large missions. But counting missions, there are only 4 astrophysics Explorers operating (SWIFT, RXTE, WMAP, & GALEX), and 5 to 6 Great Observatory-class missions (incl. HST, Chandra, Spitzer, & Fermi). The same holds if you count launches. This does not meet the objectives of the Explorer program.

Marc Postman, STScI: We should stop counting large, medium, and small missions and instead look at the mix of science that is being done. The big missions are getting a lot of science done and also fund graduate students & postdocs. What is the reality of the funding balance?

Dave Axon: The US is bad at putting small payloads in rockets, instead putting in ballast. The private sector is putting together new launch opportunities for small missions.

Stephan McCandliss: Big missions fund grad students in data reduction, but not hardware.

Ken Sembach: There is a State of the Profession white paper on the value of Observatory-class missions. It describes the benefits of HST, Spitzer, and Chandra, and encourages you to think where astronomy would be right now without them. Flagship general-purpose observatories are coming back in vogue. Although they cost a lot, they return a lot to the community that other missions can't, including longevity. They can impact important fields that were not anticipated, thanks to suites of instruments and a variety of capabilities. Examples include dark energy and transiting planets. Great Observatories are not simply big science. They also spread the science opportunities to a large community. HST's proposal pressure is high, but includes 46 of 50 states and 20+ countries. Great Observatories have national and international impact, with small and large programs, and they also impact education and public outreach. They inspire the nation in ways that is not possible for smaller missions. In 2005-2007, HST, Spitzer, and Chandra gave out nearly $200M of Guest Observer grants.

> **Mike Shull:** What about multi-spectral use, i.e. two or more Great Observatories at once?

Ken Sembach: Of course we need multi-spectral use. An advantage of Great Observatories is that the typical observer does not have to be an expert in their use due to the high quality backend data products. There are examples where HST, Chandra and Spitzer were pointed at the same target synergistically (e.g. exoplanet atmospheres, deep fields).

Jason Kalirai: It's important to have imaging and spectroscopy combined. SDSS was both in one survey. LSST needs spectroscopy follow-up. We need a large aperture telescope that focuses on spectroscopy, e.g. to follow-up on LSST.

> **Neill Reid:** We shouldn't assume that LSST will happen by default. If you think it's important, it would be wise to say so.

Jeff Kruk: Great Observatories are very useful, but there are things you can't do with them. WMAP was a well-formed MIDEX. There is lots of proposal pressure for Explorers. The point is that even though there was a stated policy in favor of Explorers, it didn't happen. Why is this, and how can we change it?

Eric Smith, NASA HQ: The Explorer program is shared between astrophysics and heliophysics, and there have in fact been 20 launches since RXTE. (Of course we would like more.)

Harry Ferguson, STScI: We've been asked for a prioritized and balanced program. How can the panels convey priorities? We have two jobs. 1) Inspire the public, funding agencies, and Congress with big yet simple proposals that float all boats and allow us to produce the compelling science. This is part of the role of the flagship missions. 2) Identify how to keep the field healthy and in balance. For this, we need a pyramid of required infrastructure, even though this cannot be justified based on answering some fundamental question or developing cutting-edge technology. An example is software for running HST, which is not necessarily cutting-edge but provides necessary infrastructure and costs money. EPO doesn't push intellectual boundaries of our field but is still fundamental to our role as astronomers. We should set up 'firewalls': a balance of total fraction of budget applied to various endeavors. The boundaries must adapt in the future, so we also need metrics for communities & funding agencies to adjust the balance.

Kirk Borne: What is the role of the archives? The SDSS archives benefit thousands of astronomers. For all of the people who have looked at the archive, only 10-20% of the data have been looked at. LSST will produce an SDSS quantity of data per night for 10 years. Archives should be elevated to an Observatory-class mission level. The NASA ADP is woefully underfunded.

Rick White, STScI: He and other NASA archivists have submitted a white paper on the value of archival science. A project like SDSS is built around the archival science. HST is built around the PI science, but more than half of HST science is archival now. At end of the HST mission, the archive will have the biggest impact on science. The same is true for Chandra. Archives for ground-based observatories are in an abysmal state. They do not generate the archival science that they could. They don't have the resources to generate the high-level, 'science ready' data products. Instead, you have to be an expert with the data/mission, which is a major problem since each ground-based system is different. An example: VLA archival data is raw visibility. You need to know how to run AIPS, etc. We need additional funding going to ground-based archives. Archives (and data reduction software) should not be penalized when an instrument runs behind schedule.

Ethan Schreier, AUI: Within five years of the start of the HST archive, there was far more data 'going out' than 'going in'. We need funding to develop good ground-based archives. Gemini was the first in the US; the VLT is well-funded. ALMA has a serious plan for the same quality of user support as HST. Something has to be said about ADP. In the NSF, you can propose to do anything you want. Will NASA and NSF get together to fund research with the VO, as they have funded the VO itself? The Decadal Survey should think about this. There should not be an artificial dividing line (e.g. between NASA and NSF) about where you get your funding.

Rob Olling: If you're on soft money, ground-based archives are useless, since they don't come with money. The SDSS archive is not user-friendly for external users. On a separate note, it is important to invest money on better detectors such as those that can do spectrophotometry/imaging in one go.

Matt Mountain: The decision of Gemini to have an archive cost tens of millions of dollars and came at the expense of an instrument.

Phil Stahl: Joined industry 15 years ago. Building space telescopes has an economic impact multiplier effect. We need the infrastructure in industry to build new telescopes. There should be

a minimum investment of the GDP to keep it going, based on better times for telescope building. No one in the government outside of NASA cares much about NASA telescopes. The budgets and vendor community is shrinking. We used to have Itek, Kodak, Perkin Elmer, etc., but we are now down to one vendor for large space telescopes. We may be getting to a tipping point and going below the minimum necessary to keep the industry going.

Wilma Anderson, Rayleigh Optical Corporation: Involved with building optics for ground-based telescopes. As an engineer, she supports science, but the Decadal Survey needs a balance between the desire for science and the practicality of the projects. The economy is having problems. We need to do the projects that will support the industry/infrastructure, as Phil Stahl said. Loss of manufacturers is an important issue. Ongoing projects need funding to get finished.

> **Neill Reid:** We haven't heard much about ground-based astronomy. Is it that people don't do it? Or that we are happy with it?

Matt Mountain: The Decadal Survey shouldn't assume that half private and half public will work. We need recommendations that benefit U.S. astronomy rather than U.S. institutions. We don't want a 'balanced program' if it doesn't lead to data. We need to develop metrics to justify our recommendations to avoid repeating the mistakes of the last decadal survey.

> **Neill Reid:** A balanced program doesn't have to balance in the middle.

> **Mike Shull:** There is an interesting white paper written by Riccardo Giacconi. It includes very controversial comments about ground-based astronomy.

Matt Mountain: The point in that paper is that by being organized the Europeans have taken the lead from the U.S. The U.S. ground-based model has failed. We must agree on this as a community, but we have not done this in the U.S. due to fragmentation and internal competition, thereby losing the resources to do anything on the ground and ceding leadership to Europe just as particle physics has done. Riccardo's paper tells you how not to do things. We all know what the science questions will be. The challenge is how to overcome conflicts of interest to establish U.S. leadership.

Jeff Kruk: There are things you can't do well with a great observatory. WMAP is one example. There's a lot of proposal pressure and great ideas for Explorers. Even though there was a stated policy for frequent Explorers, it didn't happen. What have we been doing wrong?

Eric Smith: The explorer program is shared between Astrophysics and Geophysics. There have been 20 launches since RXTE.

Open mic:

Moderator: Suvi Gezari (JHU)

Stephen Unwin: We need long-term goals for questions like "Are we alone?" We won't answer that in this decade or maybe even in the following. A workshop on exo-planets will be held in April in Pasadena to discuss the mission concepts that are vying for attention. The results will be provided to the panel. We need a systematic program for longer than a decade, bearing in mind that this is a multi-dimensional problem involving technological priorities, etc. It's good to have one goal that catches the public's imagination.

Ken Sembach: We need more emphasis on UV technology development. The UV detectors on HST-COS have a QE of 10 to 20% over the bandpass. A white paper discusses investments in detectors and coatings. If we can increase the throughput by x4, that is equivalent to a x2 diameter in glass. For ATLAST, THEIA, etc., it doesn't make sense to let the photons die at the detector. Better optical reflectivities could allow more complex, more compact systems, allowing us to do many of the things we can do in the optical (e.g. multi-object spectroscopy or long-slit spectroscopy without aberrations).

Rob Olling: We should enable the technology of micro-arcsec astrometry to focus on getting distances to stars by means of wide-field studies. There are surprising applications for precision astrometry. Astrometry such as that from GAIA will open up the area of galactic archeology, allowing us to reconstruct the Milky Way's assembly history and evolution by obtaining highly accurate (percent-level) stellar ages from distances. Finding the distance to M31 to 1% would enable the same analysis, allowing for comparison with the Milky Way. Stars that end up in the Milky Way keep some of their dynamic origins in their orbits, allowing analysis of subsystems' histories and telling how gas was accreted into the MW.