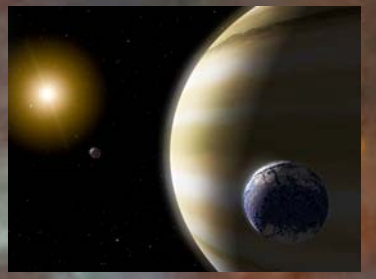
1897 - 2007

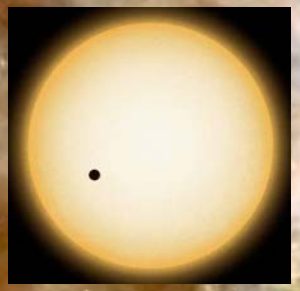
In the spirit of Bernard Lyot

The direct detection of planets and circumstellar disks in the 21st century.

-- University of California, Berkeley, 2007



Challenges and Opportunities: the Decadal Survey and Science Funding



Garth Illingworth

University of California, Santa Cruz

Chair, Astronomy and Astrophysics Advisory Committee (AAAC)

Spirit of Lyot June 07

CfAO

CIDPS

GEMINI OBSERVATORY

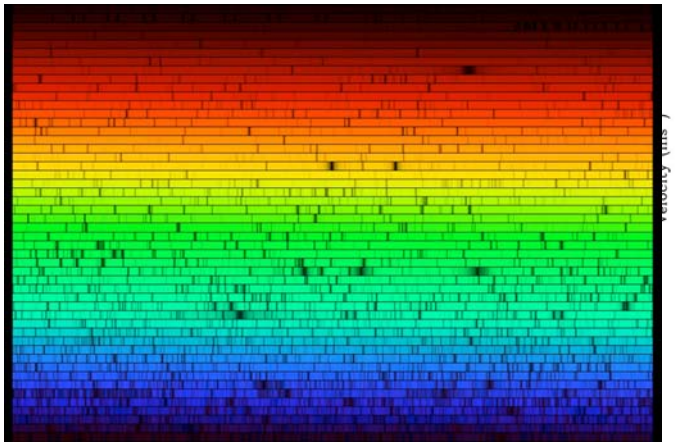
UNIVERSITY OF CALIFORNIA BERKELEY ASTRONOMY DEPARTMENT

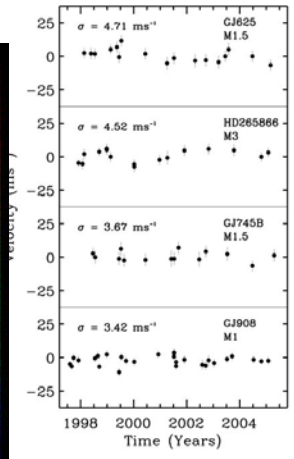
JPL

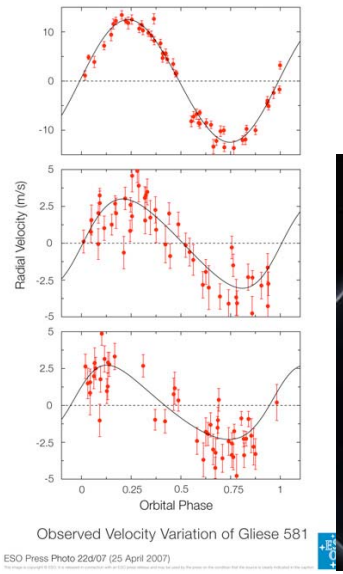
tinsley

ExoPlanet Science

- Vibrant, exciting, dynamic, competitive field
- Broadening science goals: planet formation, development, detection, characterization…
- Great interest, particularly among young researchers
- Challenging technologies, but rapid developments
- Exoplanet science and projects should be very competitive in next Decadal Survey
- Challenge will be to develop a “doable” suite of projects and missions







AAAC

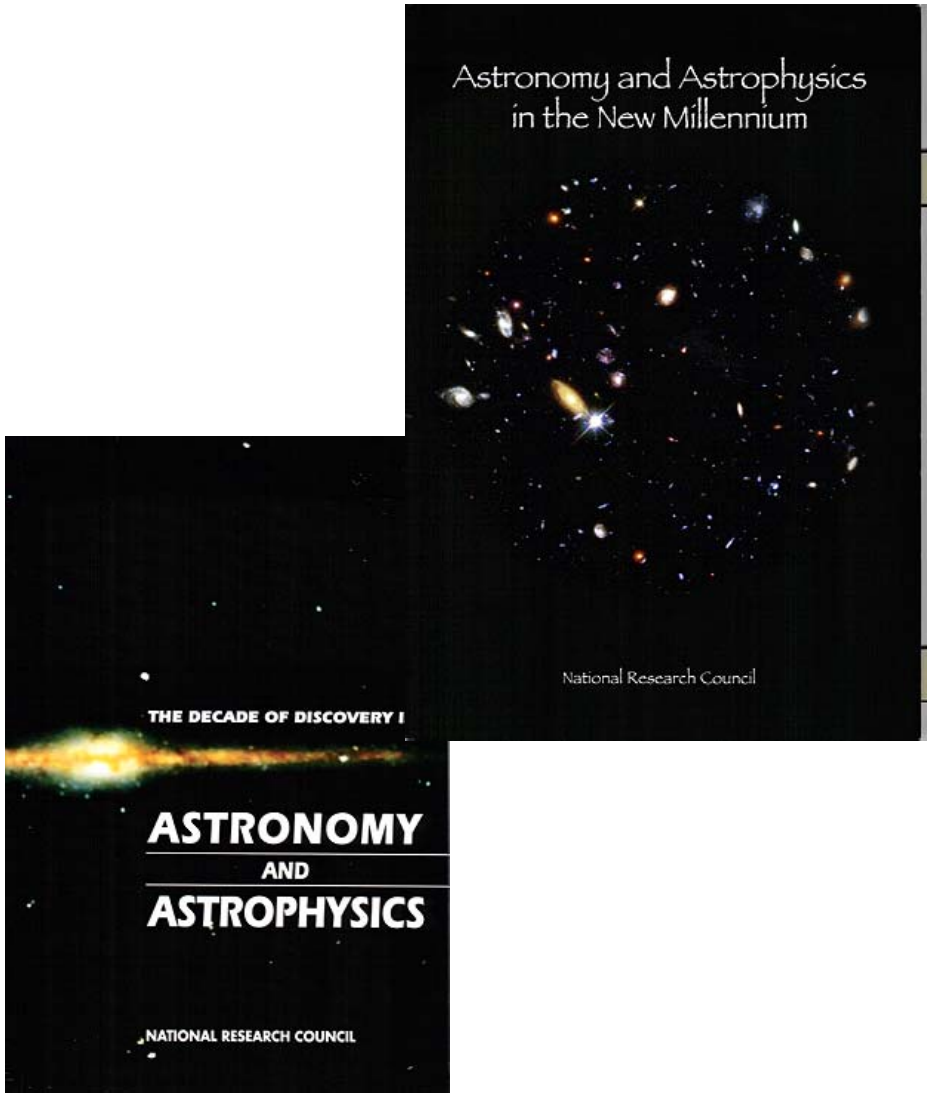
Astronomy and Astrophysics Advisory Committee

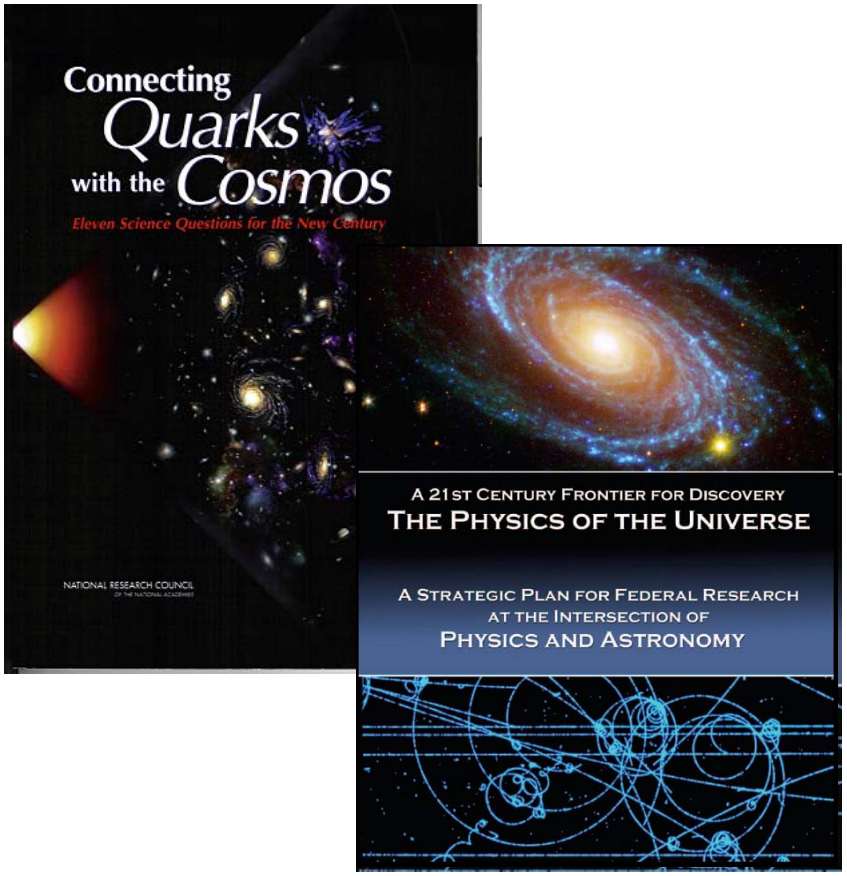
Astronomy and Astrophysics Advisory Committee

AAAC

Garth Illingworth, UCSC - Chair

Reports/Letters etc: www.nsf.gov/mps/ast/aaac/





AAAC

Astronomy and Astrophysics Advisory Committee Background

- Grew out of Office of Management and Budget (OMB) and Congressional interest in optimizing return on astronomy investment - minimizing duplication of effort coordination => cost-effectiveness (maximize science return for $$)

- COMRAA study (NAS/NRC Committee on the Organization and Management of Research in Astronomy and Astrophysics)
  ⇒ explicit recommendation for AAAC-like committee

- Established by Congress in 2002 NSF Authorization Act and formally constituted late 2003, modified 2005 to add DOE. 13 members selected by science agencies (NASA, NSF, DOE) and the Office of Science Technology Policy - OSTP

Astronomy and Astrophysics Advisory Committee Background cont.

AAAC

- AAAC meets four times per year
- Updates from agency astronomy representatives, plus discussions with science community groups, OSTP staff, OMB examiners, Congressional staff, agency leadership…..
- AAAC is constituted under FACA (Federal Advisory Committee Act) rules so can formally offer advice to the government (can advise agencies). Required through its annual report (March 15), but also through letters at other times of the year
- March 15 Annual Report sent to Chairs of several Congressional committees plus NASA Administrator, NSF Director, (DOE) Secretary of Energy; widely distributed to other Congressional committees, OMB, OSTP and agency personnel, NAS/NRC committees.

AAAC

Congressional Language: "the charge"

(1) assess, and make recommendations regarding, the coordination of astronomy and astrophysics programs of the Foundation and the National Aeronautics and Space Administration, and the Department of Energy

(2) assess, and make recommendations regarding, the status of the activities of the Foundation and the National Aeronautics and Space Administration, and the Department of Energy as they relate to the recommendations contained in the National Research Council's 2001 report entitled ``Astronomy and Astrophysics in the New Millennium'', and the recommendations contained in subsequent National Research Council reports of a similar nature *(….Decadal survey…)*

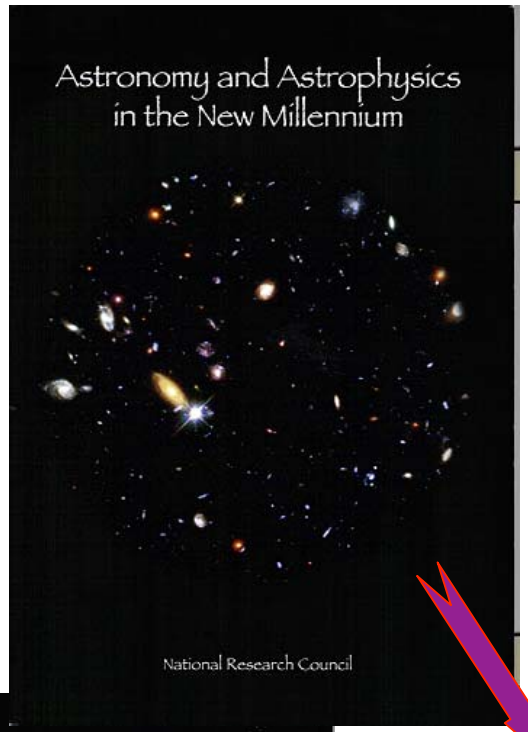
MEMBERS (2006-7)

(*** Through July 1 2007)

AAAC

Neta Bahcall	Princeton University***
John Carlstrom (Vice-Chair)	University of Chicago***
Bruce Carney	University of North Carolina at Chapel Hill
Wendy Freedman	Carnegie Observatories
Katie Freese	University of Michigan
Garth Illingworth (Chair)	University of California, Santa Cruz
Scott Dodelson	FermiLab/Chicago
Dan Lester	University of Texas at Austin
Keivan Kassun	Vanderbilt
Rene Ong	University of California, Los Angeles***
Sterl Phinney	California Institute of Technology
Marcia Rieke	University of Arizona
Alycia Weinberger	DTM Carnegie Institute of Washington

05-6: Bob Kirshner, Angela Olinto, Caty Pilachowski, Abhijit Saha

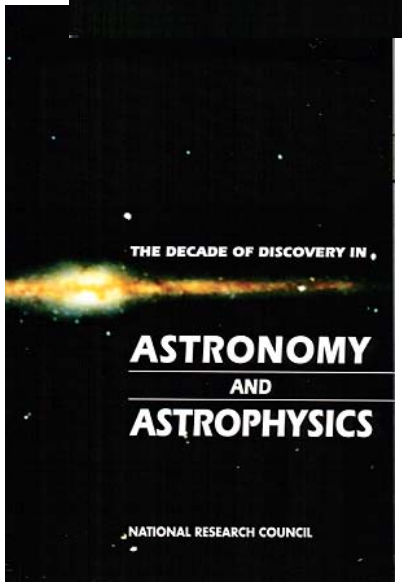


2000

AAAC

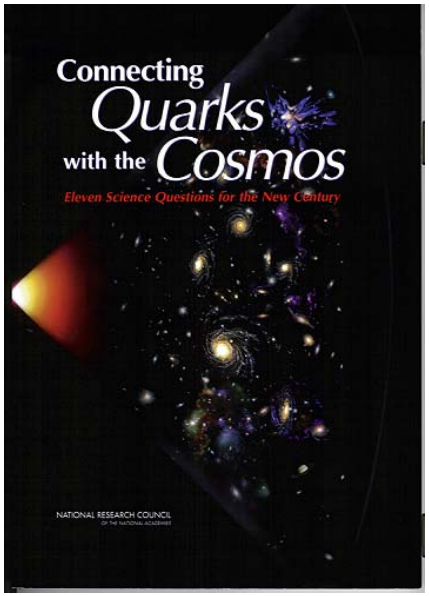
AAAC is focused on implementation of Decadal Survey(s), and other comparable NAS/NRC reports, particularly involving interagency coordination.

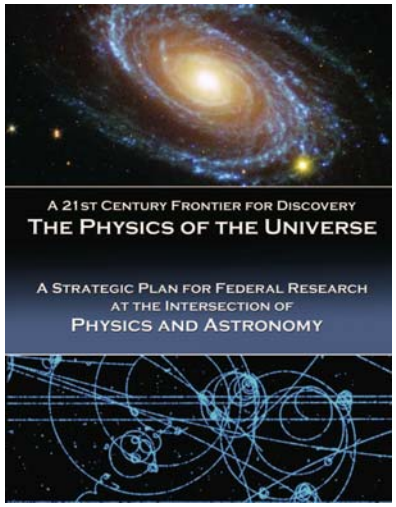
Strategic framework: NAS/NRC
Tactical implementation: AAAC



1990

ExoPTF
ExoPlanet Task Force



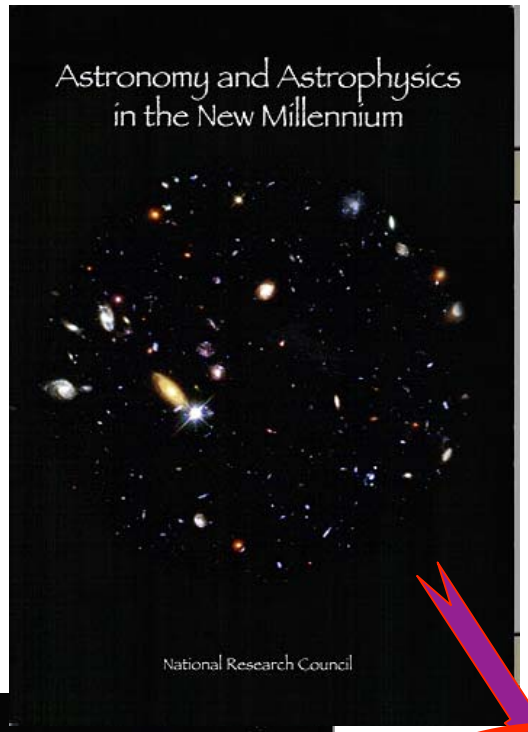


TFCR
Cosmic Microwave Background Task Force

DETF
Dark Energy Task Force

DMSAG
Dark Matter Science Assessment Group

AAAC + HEPAP



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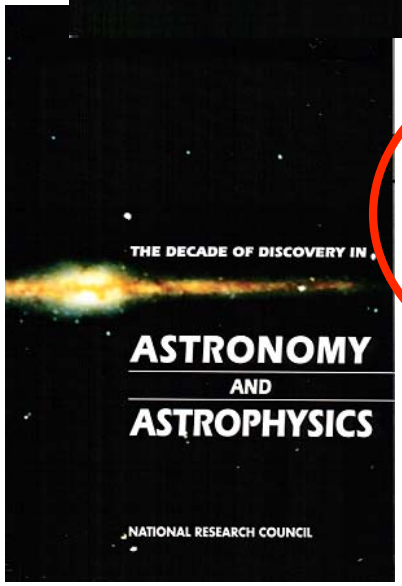
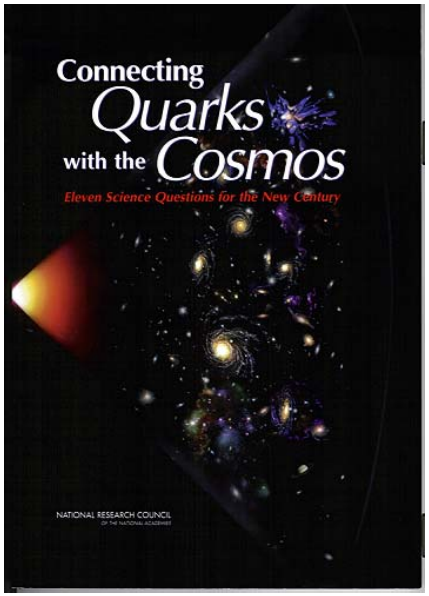
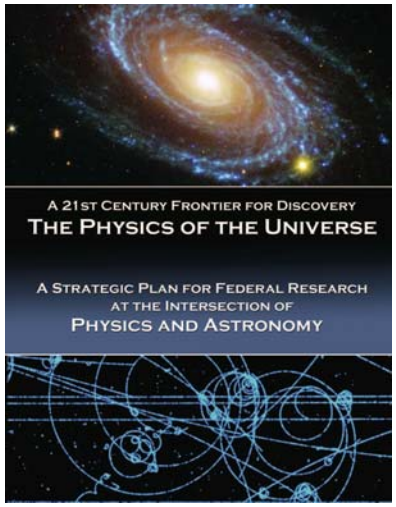


ExoPTF
ExoPlanet Task Force





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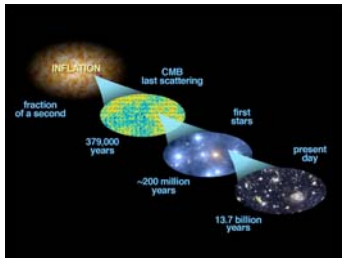
1990

AAAC + HEPAP



AAAC Task Forces and Studies

Reports: www.nsf.gov/mps/ast/aaac/

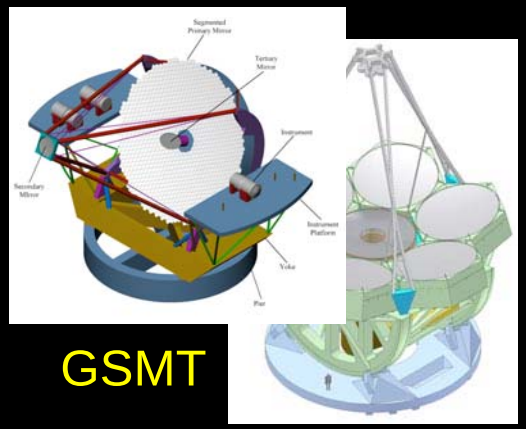
- TFCR - Task Force on CMB Research (2005) - Polarization => Inflation Probe. (EPP2010 Action Item #4_2) To NSF/NASA/DOE?
- DETF - Dark Energy Task Force (2006) - near-term programs, JDEM, LST (EPP2010 Action Item #4_3). Very strong community interest. To NSF/NASA/DOE.
- DM-SAG - Dark Matter Science Assessment Group - (mid 2007). (EPP2010 Action Item #4_1) Direct Detection. For DOE/NSF.
- ExoPTF - ExoPlanet Task Force - first meeting 02/2007; report late 2007. Searches for (and characterization of) extra-solar planets - many techniques - ground and space roles? For NASA/NSF. International coordination/cooperation.

Reports are public => input to 2010 Decadal Survey

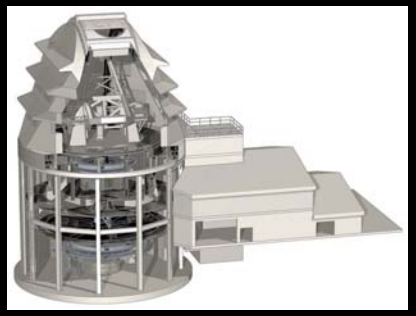
Decadal Survey(s)

We are not doing well accomplishing the goals of the 2000 Astronomy and Astrophysics Decadal Survey…..

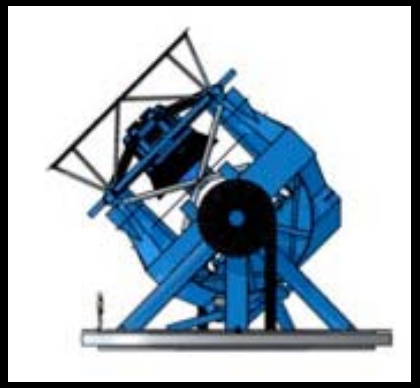
Ground-based in Decadal Survey(s)



GSMT



ATST



LSST

ALMA (1990)

EVLA

Ground-based in Decadal Survey(s)

MA
ILLIMETER ARRAY

1990

Completed this decade….

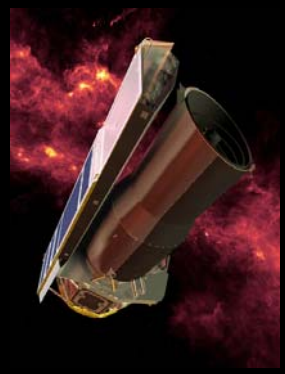
Space in Decadal Survey(s)

SM3 + SM4

SIM

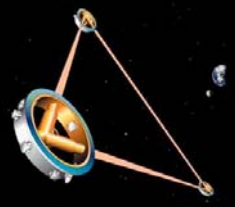
1990

SOFIA

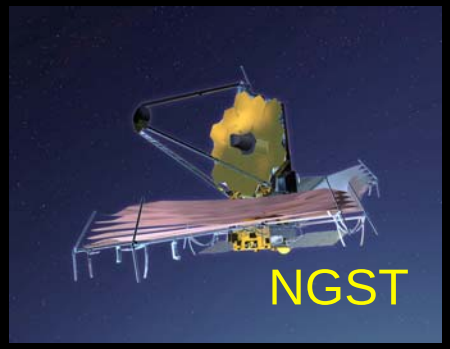


SIRTF

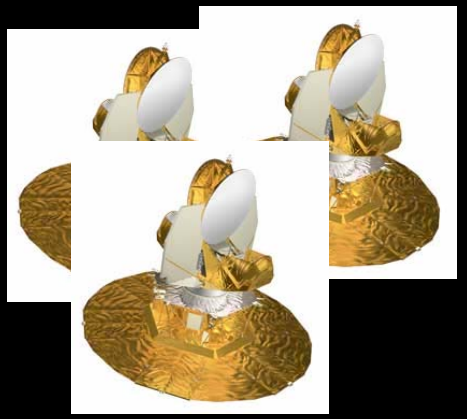
LISA



Con-X

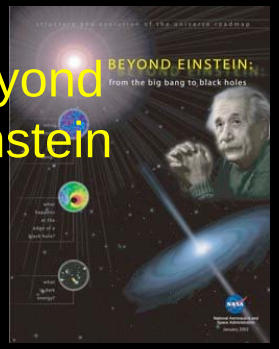


NGST



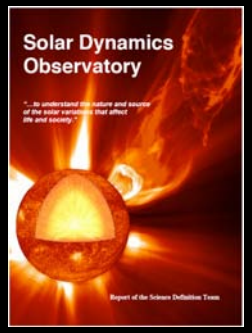
~3-4 Explorers

2000



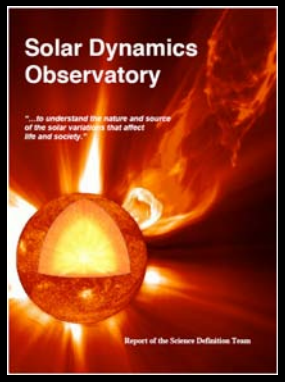
Beyond Einstein

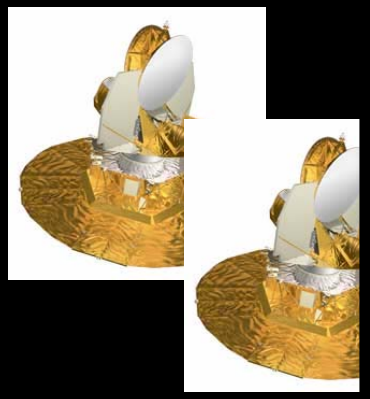
GLAST

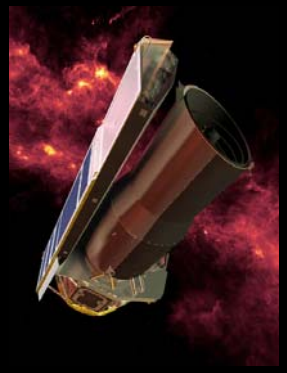


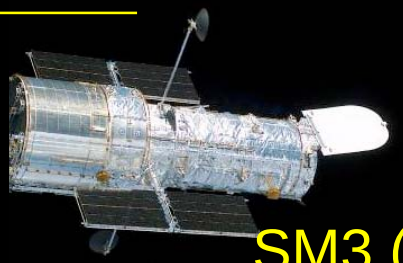
SDO

Space in Decadal Survey(s)









SM3 (& SM4)

Completed in Decade….

Issues impacting the implementation of the 2000 Decadal Survey

- Poor cost estimates
- Technological readiness issues and management concerns
- Government priorities (Administration; Federal Agency; Congress)
- Evolving science goals (e.g., Dark Energy, Planet Searches)
- Federal budgets

Decadal Survey(s)

2000: Too much cost “growth” and too many projects, Federal budget predictions too optimistic

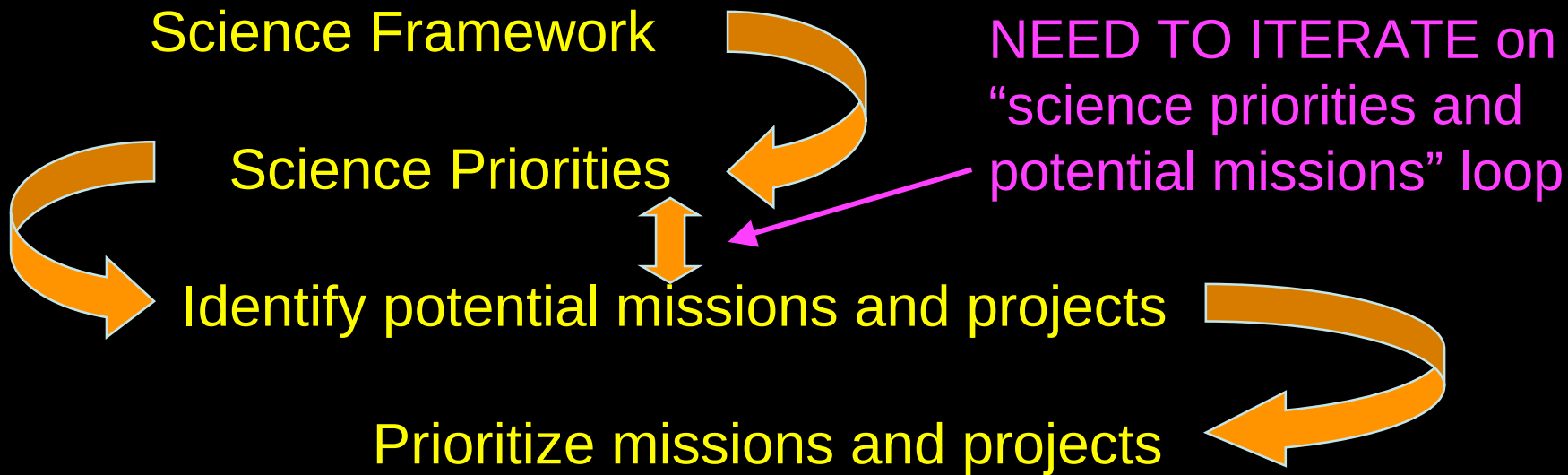
2010: Major challenge is to develop a program for the next decade that is scientifically “cutting edge” but achievable, with a better understanding of the costs and of the budget environment

Improving the next Decadal Survey

- Enhance the Science framework
- Consider and re-assess “carry-over” projects
- Assess technological and management readiness
- Develop realistic “lifecycle” costs 
- Consider likely Federal budgets
- Plan to deal with both evolving science goals and mission “creep” (technical or management problems that increase cost)

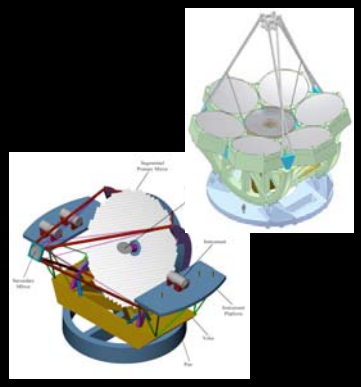
Decadal Survey Science

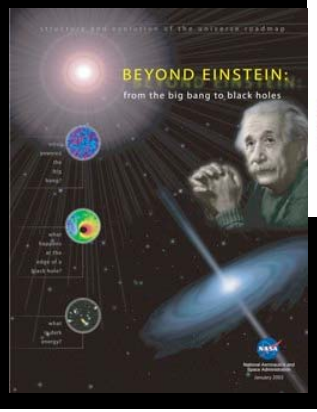
Science first => followed by projects/missions



A (personal) recipe for a successful Astronomy and Astrophysics 2010 Decadal Survey

- Provide a strong science framework and a clear sense of science priorities
- Make the science exciting to a public/political audience
- Make sure that the technological development and management requirements are consistent with timescales and capabilities
- Develop a prioritized mix of small, medium and large
- Provide realistic “lifecycle” cost estimates and cost profiles
- Match, but with some optimism, the likely available funding
- No “carry-over” projects (zero-based assessment - but do wisely!)





Current Issues for Astronomy and Astrophysics

FY07 and FY08 Budgets

- Good news is DOE Office of Science and NSF increases under American Competitiveness Initiative (ACI)
- Strong support in Congress for increases for science in FY07 budget for NSF and DOE science
- Contrast with NASA is large. Why not ACI for NASA? (but NASA science budget was “protected” in FY07 by Congress)
- Continuing major issue is science budget at NASA. Dramatic change in FY07 budget removed ~$3B from FY07-FY11; 1% growth over FY07-11 is decrease after inflation. Severe dislocation to research programs - from R&A to Flagship missions. Continued into FY08 request.
- Challenge is to not get into a human spaceflight vs. science battle - need top level increase for NASA so that science can grow.

NSF Astronomy (AST): Opportunities and Challenges

- ACI led increases provide opportunities 7% and 8% growth (but need to ensure that AST continues as ACI recipient)
- Senior Review recommendations are an opportunity but bring challenges: need to phase out facilities or support.
- Broad Challenges: Major facilities (MREFC) funding? Planning for operations of major new facilities. Getting adequate pre-construction funding. Private and international - opportunities, but also challenges.
- AST Challenges: ALMA cost increase. Many major projects (ATST, LSST, GSMT). Operations costs for big projects. Cost of instruments for large telescopes (AO instruments)

NASA Astrophysics Division Budget

- Astrophysics Division budget takes a major cut in FY09
- Cut is even more dramatic in inflation-adjusted terms with FY06 base
- Essentially cut 25% FY09 through FY12 when we want to begin ramping up on Beyond Einstein Mission and Decadal Survey and cost-capped missions and R&A!

	FY06	FY07	FY08	FY09	FY10	FY11	FY12
Actual Year $M	$1,553	$1,540*	$1,566	$1,304	$1,269	$1,266	$1,393
% change**		-0.8%	1.0%	-16%	-18%	-19%	-10%
Inflation Adjusted***	$1,553	$1,495	$1,476	$1,193	$1,127	$1,092	$1,167
% change**		-2.3%	-5.0%	-23%	-27%	-30%	-25%

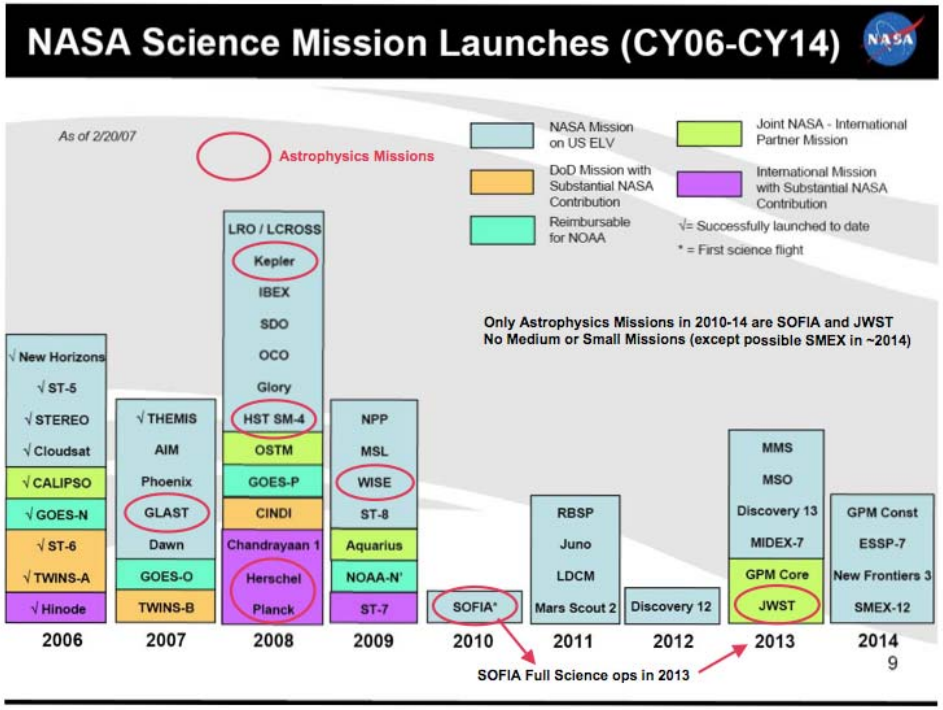
*1.5% decrease from FY07 request **relative to FY06 ***in FY06 dollars with 3% annual inflation

From Congressional Testimony

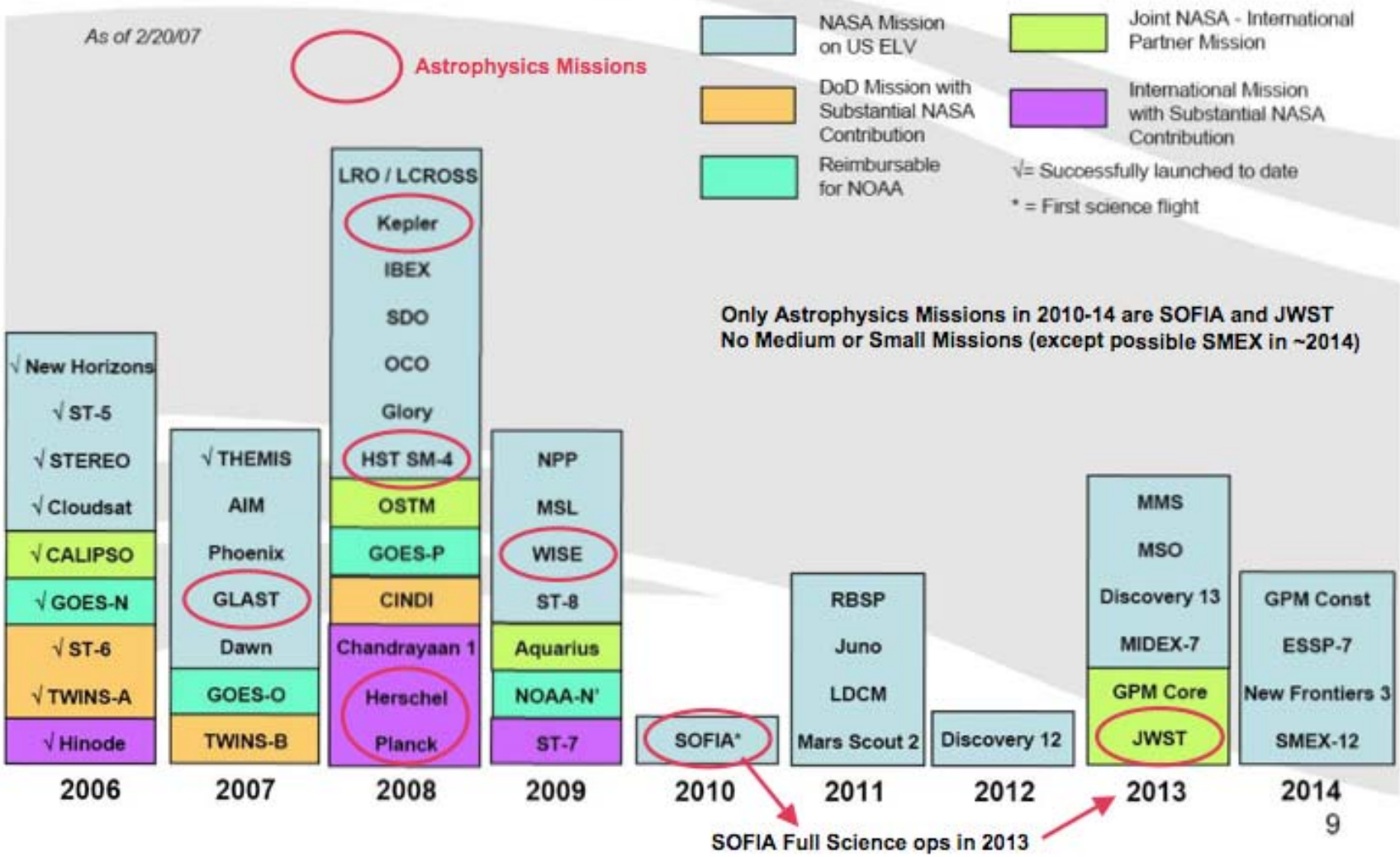
NASA Science Mission Frequency

- Astrophysics has many operating missions and launches now through 2009
- Major issue for Astrophysics (and other Divisions) is mission frequency after 2009 to 2014 (and beyond) - missions take 5-7-10+ years depending on scale

From Congressional Testimony



NASA Science Mission Launches (CY06-CY14)



Key issues for science at NASA

Emphasized need to do three things in congressional testimony (based on strong recommendations in 2007 AAAC report).

Question on three strategic investments:

- R&A funding
- Technology development for missions
- Competed, cost-capped missions (Explorer; Discovery; Probes)

Question re risks:

- Lack of small/medium missions in FY10 and beyond
- Inability to respond to 2010 Decadal
- Current lack of technology development and impact on costing and readiness

AAAC Report on NASA

- The FY07 cuts to the NASA science budget led to serious imbalance in the science program - not rectified in FY08 budget.
- R&A cuts and lack of small/medium missions in FY10 and beyond highlighted
- R&A funds and smaller missions (e.g., Explorers) serve a critical role in supporting the broad fabric of research for realizing the science from future large missions and in enabling the development of the necessary personnel and skills.
- Emphasized need for a strategic approach to R&A (i.e., importance for NASA objectives - not “welfare”) - clear tactical goals (e.g., technology development, theory, data analysis techniques, novel approaches to archival data…)

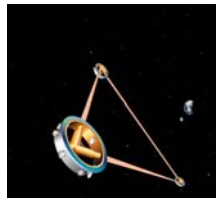
AAAC Report on NASA (cont)

- Emphasized need for technology development programs for major missions like Con-X, LISA, TPF, SIM at ~$10M level or more to make credible and useful gains in mission concept development and retiring technology risk prior to next Decadal Survey

- Continued strong emphasis on (1) improving cost estimates for all phases of mission development and (2) using lifecycle costing to better match needed resources over 10-15 year period of Decadal Survey.

- Emphasized need to be careful to not get bogged down in details re costs. Costs to one significant figure with low systematic uncertainty would be a huge improvement on previous estimates. More cost-capped missions?

“Flagship” Missions



- Flagships are very important - great science and public visibility.

- Flagship missions cost a lot - especially when “lifecycle” costs are used (development+construction+operations). Must understand and use reliable cost estimates and lifecycle costs.

- Lifecycle costs are substantial (~FY06$ inc full cost accounting)
  HST: ~$9B; Chandra: $3.5B; Cassini: $3B; Spitzer: $1.3B;
  JWST: $4.5B; SIM(2007): $3.4B ($2.7B); SOFIA: $3.4B

- Note increases: Original $ => lifecycle FY06 $
  - Chandra/AXAF $500M (1980) => $3.5B
  - SOFIA $230M (1990) => $3.4B
  - SIM $250M (1990) => $2.7B (2011)
  - JWST/NGST $1B (2000) => $4.5B

Costs of Projects at NSF and NASA

Need to use “Lifecycle” Costs

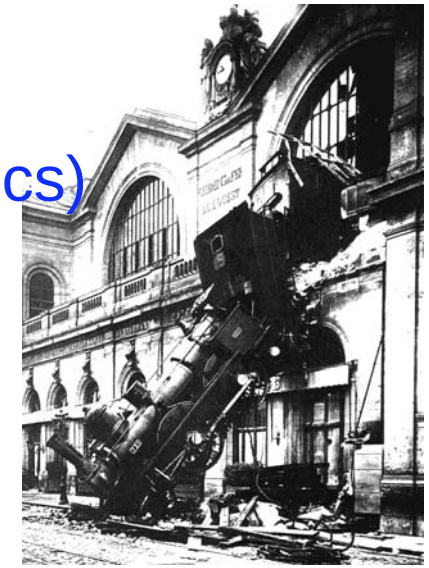
NOTE - the budget numbers here are illustrative to get a sense of the magnitude of the problem. Much more careful analyses will be needed prior to and during the Decadal Survey process

“Lifecycle” Project Costs

- Focus on construction costs underestimates budget impact
- Decadal Survey implementation/operation timescales: 10-15 yrs
- Important to use lifecycle costs to account for impact on budget over the “lifetime” of projects and Decadal Survey
- NASA - Flagships ~$2-4B lifecycle. Medium ~$1B lifecycle like Probes ($6-800M). Smaller: Discovery ~$450M; Explorer ~$300M
- NSF - major programs are also costly: ALMA ~$1.2B lifecycle US cost; LSST $467M + operations ($50M/yr) => ~$1B for 10 yrs

NASA - Project costs through ~2020

(Funds~$13-15B *TOTAL/Decade* for Astrophysics)

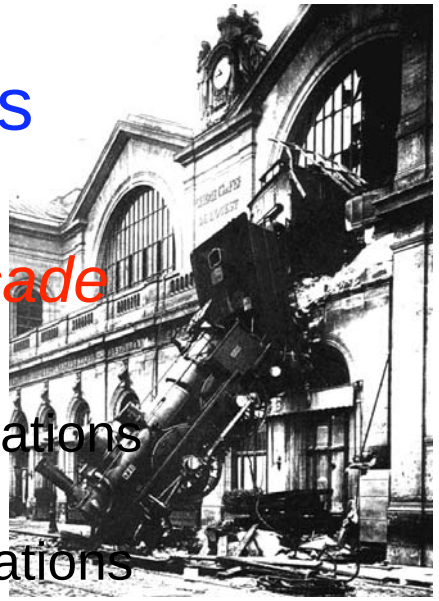


- JWST (Flagship) construction 2008-2012 - 2013 launch ($4.5B lifecycle) $3.4B
- One Flagship) ~$3B
- Two Medium ~$2.5B
- SOFIA (intermediate) ~$3.4B lifecycle ~$1.2B
- Probes - $0.8+B x2 ~$1.6+B
- More Explorers and increase R&A ~$1.5B
- Operating missions from this Decade ~$2B

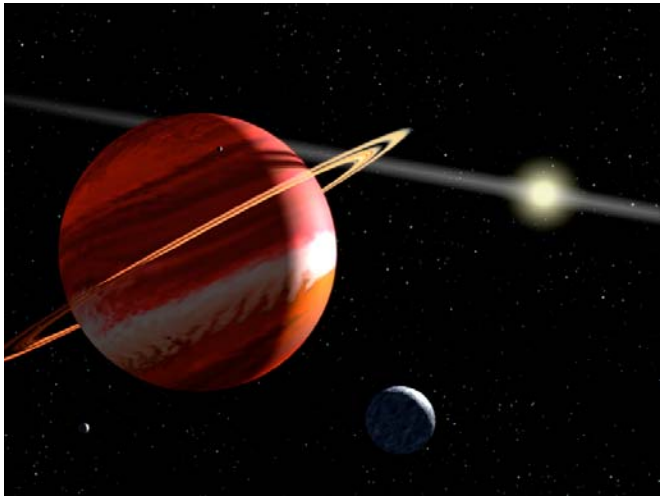
- Suggests we may do 1 Flagship (SIM/TPF/Con-X?) + 2 Medium (LISA + ExoPlanet?). Challenge for next Decadal.

NSF - Construction and Operations costs through ~2020

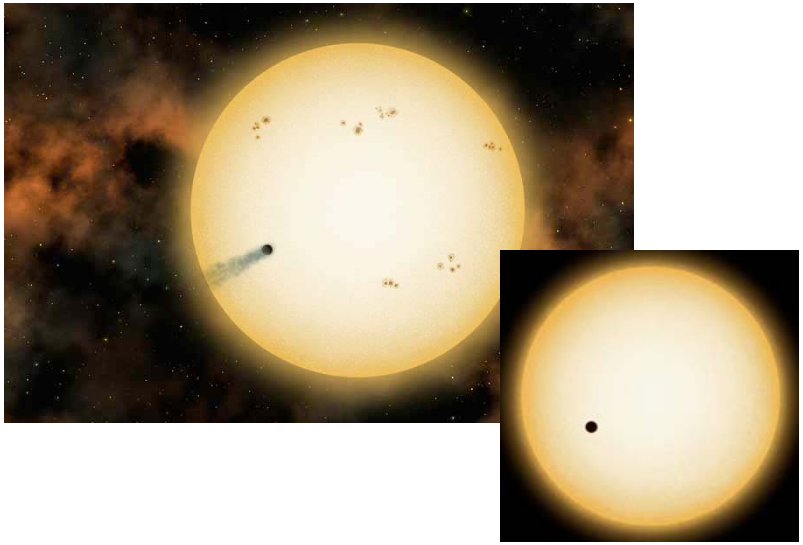
Astronomy Operations funds ~$1.5B *TOTAL/Decade*



- ALMA construction to 2013 ($499M) + $300M Operations
- ATST is new start NET 2009? ($225M) + $100M Operations
- LSST new start NET 2010/11+ (some DOE 1/4-1/3?; private ~13%?) - proposal 2007 - ($467) + $300M Operations
- GSMT (GMT, TMT) construction ~$6-700M+ each (largely private??)
  GSMT new start NET 2012-3+ Federal $0-300+M Ops $TBD?
- How many overlapping construction projects in MREFC in Astronomy?
- How many current facilities get supported? Senior Review.
- Operations $ total is a major challenge for the next Decadal



ExoPlanet Task Force

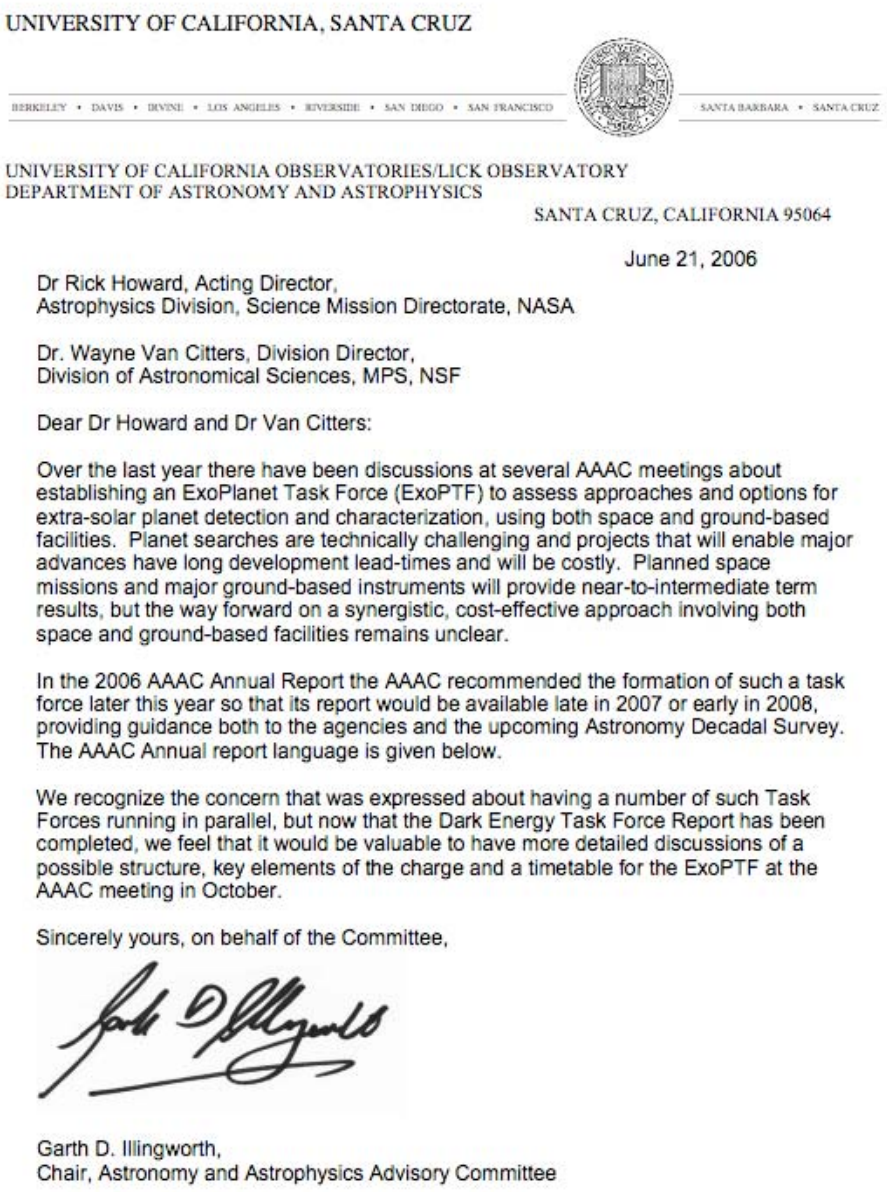


This field provides lots of work for graphic artists……

ExoPlanet Task Force (ExoPTF)

- ExoPTF set up to provide a framework for moving forward on ExoPlanet science, particularly searches and characterization, over the next 10-15 years. See: http://www.nsf.gov/mps/ast/exoptf.jsp

- AAAC letter requests that NSF and NASA set up ExoPTF:



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UNIVERSITY OF CALIFORNIA OBSERVATORIES/LICK OBSERVATORY
DEPARTMENT OF ASTRONOMY AND ASTROPHYSICS

SANTA CRUZ, CALIFORNIA 95064

June 21, 2006

Dr Rick Howard, Acting Director,
Astrophysics Division, Science Mission Directorate, NASA

Dr. Wayne Van Citters, Division Director,
Division of Astronomical Sciences, MPS, NSF

Dear Dr Howard and Dr Van Citters:

Over the last year there have been discussions at several AAAC meetings about establishing an ExoPlanet Task Force (ExoPTF) to assess approaches and options for extra-solar planet detection and characterization, using both space and ground-based facilities. Planet searches are technically challenging and projects that will enable major advances have long development lead-times and will be costly. Planned space missions and major ground-based instruments will provide near-to-intermediate term results, but the way forward on a synergistic, cost-effective approach involving both space and ground-based facilities remains unclear.

In the 2006 AAAC Annual Report the AAAC recommended the formation of such a task force later this year so that its report would be available late in 2007 or early in 2008, providing guidance both to the agencies and the upcoming Astronomy Decadal Survey. The AAAC Annual report language is given below.

We recognize the concern that was expressed about having a number of such Task Forces running in parallel, but now that the Dark Energy Task Force Report has been completed, we feel that it would be valuable to have more detailed discussions of a possible structure, key elements of the charge and a timetable for the ExoPTF at the AAAC meeting in October.

Sincerely yours, on behalf of the Committee,

Garth D. Illingworth,
Chair, Astronomy and Astrophysics Advisory Committee

ExoPlanet Task Force (ExoPTF)

- Key paragraphs in AAAC letter request re ExoPTF:

"Over the last year there have been discussions at several AAAC meetings about establishing an ExoPlanet Task Force (ExoPTF) to assess approaches and options for extra-solar planet detection and characterization, using both space and ground-based facilities. Planet searches are technically challenging and projects that will enable major advances have long development lead-times and will be costly. Planned space missions and major ground-based instruments will provide near-to-intermediate term results, but the way forward on a synergistic, cost-effective approach involving both space and ground-based facilities remains unclear.

In the 2006 AAAC Annual Report the AAAC recommended the formation of such a task force later this year so that its report would be available late in 2007 or early in 2008, providing guidance both to the agencies and the upcoming Astronomy Decadal Survey."

ExoPTF Membership

- ExoPTF is a sub-committee of the AAAC and its report will be transmitted through the AAAC to the agencies
- Committee members are selected by the agencies
- Breadth of topic (science, techniques, ground & space…..) led to large committee:

Jonathan Lunine (Chair) Lunar and Planetary Lab
Bruce Macintosh Lawrence Livermore National Laboratory
Debra Fischer San Francisco State University
Mark Marley NASA Ames Research Center
Heidi B. Hammel Space Science Institute
Gary J. Melnick Harvard-Smithsonian Center for Astrophysics
Lynne Hillenbrand Caltech
David Monet U.S. Naval Observatory
James Kasting Penn State University
Charley Noecker Ball Aerospace,
Gregory Laughlin University of California, Santa Cruz
Stanton Peale University of California, Santa Barbara
Andreas Quirrenbach ZAH Heidelberg
Sara Seager Massachusetts Institute of Technology
Joshua Winn Massachusetts Institute of Technology

ExoPTF Charge

- ExoPTF charge developed by agencies and requests AAAC establish a subcommittee - rather detailed and lengthy charge, again reflecting the complexity of this topic! See: http://www.nsf.gov/mps/ast/exoptf.jsp

National Science Foundation
and the
National Aeronautics and Space Administration

DEC 19 2006

Professor Garth Illingworth
University of California Santa Cruz
Lick Observatory
Santa Cruz, California 95064

Dear Dr. Illingworth:

This letter is to request that the Astronomy and Astrophysics Advisory Committee (AAAC) establish an Exo-Planet Task Force (ExoPTF) as a subcommittee to advise NSF and NASA on the future of the ground-based and space-based search for and study of exo-planets, planetary systems, Earth-like planets and habitable environments around other stars.

Background and Purpose

In the past 10 years more than 200 planets have been detected in orbit around nearby stars. During this time, the study of exo-planets and systems has blossomed into a mainstream activity that engages hundreds of astronomers in the U.S. and around the world, and many community teams have successfully competed for federal support to carry out exo-planet research. Progress in the technologies of precision radial velocity measurement has reinvigorated the classical Doppler shift technique, which is steadily improving capability to find smaller planets close to or in the habitable zone. Transit detections are providing increasingly valuable constraints from both ground and space programs. Gravitational micro-lensing is beginning to probe an Earth-mass planet population. Imagery of pre-planetary and planetary debris disk arcs and rings is becoming available to confront theoretical models for planet formation and evolution. The recent and continuing dramatic successes of exo-planet programs strongly validate the search for Earth-like, habitable planets in orbit around nearby stars.

The study of exo-systems is very challenging and remains strongly limited by the scale and performance of the available tools. Nonetheless, impressive efforts are underway from the ground through existing and new federal, private and international facilities. These include dedicated telescopes and ongoing experiments, as well as traditional telescopes accessed through the normal proposal process, some with specialized instruments. Promising approaches under development include extremely large telescopes, extreme adaptive optics with new coronagraphic methods, millimetric and submillimetric imaging with the Atacama Large Millimeter Array (ALMA), and optical interferometry over long baselines. As exo-planet science addresses increasingly difficult questions, scientists are led to more advanced instrument concepts, with higher costs and longer lead times.

Moreover, while much exo-planet research continues to be carried out on the ground, space platforms will offer a unique advantage for the most sensitive measurements, and NASA has responded to this opportunity. In 1995, the NASA report *Roadmap for Exploration of Neighboring Planetary Systems* (a.k.a. "the Townes report"; http://origins.jpl.nasa.gov/library/exnps/) described a program to detect Earth-like planets orbiting the nearest stars and to characterize the atmospheres of the brightest of these planets. NASA endorsed and responded to this opportunity with the broadly based Origins Theme and Program. More recently, the NASA Navigator Program was established with the prime objective of advanced telescope searches for exo-solar planets and habitable environments. In 2004 the search for exo-planets was featured in the President's Vision for U.S. Space Exploration, and the search is a central element of NASA's Astrophysics Plan. This basic approach to research in exo-planetology has found support in the last two National Research Council Decadal Surveys and has been revalidated and endorsed in three community-prepared Origins Roadmaps. The Kepler transit survey telescope, now in an advanced stage of development, will return measurements of the statistical frequency of Earth-sized planets. Technology development and engineering demonstrations in the Navigator Program have produced mission-enabling technology advances in precision metrology, interferometric nulling, and coronagraphy. The Space Interferometry Mission (SIM-PlanetQuest) is in Phase B (formulation), and the Terrestrial Planet Finder Coronagraph (TPF-C) and Interferometer (TPF-I) missions are in pre-formulation study.

In view of the rapid recent progress, the high scientific and public interest, and the probable large cost, it is timely and appropriate to reassess the national strategy in this area. The task force study wi be conveniently timed for consideration by the next Astronomy and Astrophysics decade review.

Charge to the Task Force

The ExoPTF is asked to recommend a 15-year strategy to detect and characterize exo-planets and planetary systems, and their formation and evolution, including specifically the identification of nearby candidate Earth-like planets and study of their habitability. The strategy may include planning and preparation for facilities and missions beyond the 15-year horizon. Since future funding levels ar uncertain, and project costs are difficult to establish at an early stage, it is important to develop an efficient and adaptable plan. To the extent possible, the recommendations should accommodate a range of funding levels representing conservative and aggressive programs. The ExoPTF will work i cooperation with agency efforts to advance the justification, specification and optimization of planet finding and characterizing opportunities.

The ExoPTF is asked to address the following specific areas:

1. The key scientific questions and issues, in the context of recent developments in exo-planet science and planet formation;
2. Measurement techniques, their enabling technologies and their implications for future survey and measurement directions and priorities;
3. Specific types of experiments (e.g., radial velocity measurements, transit searches, microlensing, adaptive optics, coronagraphy) with respect to their expected scientific return and contributions;
4. The potential and complementary science return from measurements at different wavelengths;
5. The role of theoretical investigations in defining needed capabilities, constraining measurement requirements, and interpreting results in terms of the overarching scientific questions;
6. Major decision points in the exo-planet study process;
7. Identification of key technologies relevant to the scientific goals of the program;
8. Important steps in the development of instrumentation, R&D, and other work required in preparation for or in support of, these and related experiments and missions;
9. The complementary ground-based and space-based research opportunities, coordination between funding agencies and possible synergistic advances;
10. Opportunities for cooperation, coordination or synergy with international programs.

The ExoPTF is not constituted to review individual proposals to determine their technical feasibility or likelihood of meeting performance goals. However, in recognition of the difficult technological challenges associated ultimately with the direct detection of Earth-like planets, the ExoPTF must address carefully a measured program of technology development that can lead to optimal and affordable facilities and missions.

Composition of the Panel and Community Input

The challenge of finding other habitable planets and searching for life will draw on many fields of science and technology. The Task Force should engage these issues with a broad representation of experience and expertise. Early in its activity, the ExoPTF should solicit white papers from the community, in addition to arranging for invited briefings by groups and individuals active in exo-system research.

Reporting

The ExoPTF Chair is responsible for preparing the final report in consultation with all ExoPTF members. In accordance with Federal Advisory Committee Act (FACA) rules, this report will be discussed independently at the first meeting of the AAAC following completion of the report, before formal presentation to the agencies. We request that the ExoPTF prepare their report for submission to the AAAC with a target date of October 1, 2007.

We thank you for your efforts and wish you success in this important endeavor.

Sincerely,

Tony F. Chan
Assistant Director, Directorate for
Mathematical and Physical Sciences
National Science Foundation

Richard J. Howard
Acting Director, Astrophysics Division
Science Mission Directorate
National Aeronautics and Space Administration

cc: G. W. Van Citters, NSF–AST
P. Hertz, NASA–Science Mission Directorate
M. H. Salamon, NASA–Astrophysics Division

ExoPTF Charge

- Key aspects of ExoPTF Charge:

The ExoPTF is asked to recommend a 15-year strategy to detect and characterize exo-planets and planetary systems, and their formation and evolution, including specifically the identification of nearby candidate Earth-like planets and study of their habitability. The strategy may include planning and preparation for facilities and missions beyond the 15-year horizon. Since future funding levels are uncertain, and project costs are difficult to establish at an early stage, it is important to develop an efficient and adaptable plan. To the extent possible, the recommendations should accommodate a range of funding levels representing conservative and aggressive programs. The ExoPTF will work in cooperation with agency efforts to advance the justification, specification and optimization of planet finding and characterizing opportunities.

ExoPTF Charge

- Specific points in the ExoPTF Charge:

1. *The key scientific questions and issues, in the context of recent developments in exo-planet science and planet formation;*
2. *Measurement techniques, their enabling technologies and their implications for future survey and measurement directions and priorities;*
3. *Specific types of experiments (e.g., radial velocity measurements, transit searches, microlensing, adaptive optics, coronagraphy) with respect to their expected scientific return and contributions;*
4. *The potential and complementary science return from measurements at different wavelengths;*
5. *The role of theoretical investigations in defining needed capabilities, constraining measurement requirements, and interpreting results in terms of the overarching scientific questions;*

ExoPTF Charge

- Specific points (2) in the ExoPTF Charge:

6. *Major decision points in the exo-planet study process;*
7. *Identification of key technologies relevant to the scientific goals of the program;*
8. *Important steps in the development of instrumentation, R&D, and other work required in preparation for or in support of, these and related experiments and missions;*
9. *The complementary ground-based and space-based research opportunities, coordination between funding agencies and possible synergistic advances;*
10. *Opportunities for cooperation, coordination or synergy with international programs.*

ExoPTF Charge

- Focus of the ExoPTF approach from the Charge:

  The ExoPTF is not constituted to review individual proposals to determine their technical feasibility or likelihood of meeting performance goals. However, in recognition of the difficult technological challenges associated ultimately with the direct detection of Earth-like planets, the ExoPTF must address carefully a measured program of technology development that can lead to optimal and affordable facilities and missions.

ExoPTF and the Decadal Survey

- The ExoPTF should provide a broad framework and a timeline for generic projects and missions in next 15 years
- This will give ExoPlanet studies further visibility in the next Decadal Survey (=> a well-prepared science community does well)
- Additional community definition of specific missions and opportunities will further strengthen program
- Identification of complementary activities on space and ground and potential missions at all scales desirable (small+medium+large)
- Utilize competed, cost-capped mission opportunities (Discovery, Astrophysics Probes)

Exoplanet Missions in Space in the Decadal

- The optimum scale for space missions on Exoplanets to be successful will likely be at the ~$1B level or less
- Competed, cost-capped programs like Astrophysics Probes ($0.6-0.8B) and Discovery missions likely to be attractive approaches for space
- For any specific medium missions (~$1-1.5B lifecycle) the technology must be demonstrated and the costs robust
- Opportunity exists to compete for a Flagship (SIM, TPF, ?…) but the science case must be very strong, the technology must be demonstrated, and the cost estimates must be convincing
- Emphasize technology development for cases where technology is not demonstrably close to flight readiness

Key issues for Exoplanet Research (cont)

- Need to be aware that cost credibility is now one of our weakest areas => both on the ground and in space
- For ground, using existing facilities with new instruments most cost-effective (but such instruments will still be very major projects for AST)
- Important to define and get into the Decadal some specific recommendations re ExoPlanet instruments for ~8-m class facilities, as well as for GSMT-class facilities
- Possible to do dedicated planet search telescopes on the ground, but will require very careful preparation of science, technical and cost cases

ExoPlanets - Concluding Thoughts

- Exoplanets is an exciting field with a growing and visible science community
- Competition for resources and a high Decadal ranking for the next decade will be ferocious, even if NASA budget grows
- Cost credibility is a problem - for most fields but particularly for this one because of challenging technologies
- Technical readiness will be a key issue for Survey Committee => must be credible to skeptical committees…..
- Decadal Survey will be very challenging for large missions and projects => which science area gets a space flagship? Only one likely to get done. How many ground-based major projects?

Backup detailed slides on Decadal Survey

Personal** Thoughts on Improving the next Decadal Survey

**Based on several years on the AAAC and an awful lot of trips to Washington DC!

Improving the next Decadal Survey

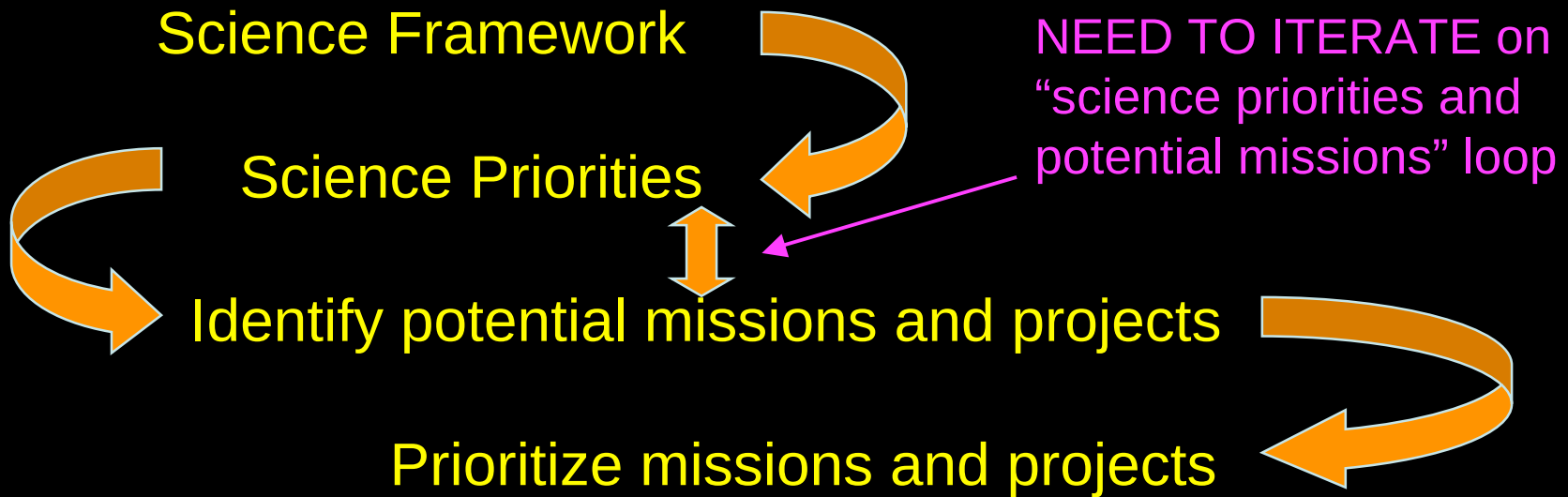
- Enhance the Science framework
- Consider and re-assess “carry-over” projects
- Assess technological and management readiness
- Improve cost realism
- Consider likely Federal budgets
- Plan to deal with both evolving science goals and mission “creep” (technical or management problems that increase cost)

Decadal Survey Science

- Science had a strong role in 2000 Survey, but the final report conveys a mission/project focus
- "Quarks with the Cosmos" had a strong science focus
- But "Quarks" did not develop an implementation plan
- Still deriving a mission/project flowdown from "Quarks"
- Best model is a mix of 2000 Decadal and "Quarks"

Decadal Survey Science, cont

Science first => followed by projects/missions



Decadal Survey Technology and Management Readiness

- Request input from projects on technological readiness
- Independently evaluate state of technology development
- Assess proposed management structure as appropriate
- Methodology should be "trust but verify"

Decadal Survey Cost Estimates

- Need to establish baseline as “lifecycle” costs
- Develop likely spending profile: R&D, Construction, Commissioning, Operations
- Utilize independent cost estimates (not just costs from the proponents: I.e., the project team!!)
- Develop cost methodology with agency
- Be realistic about how well costs can be established at early stages of project
- Fold current projects into consideration - no “carry-over”

Federal Budgets for Science in the coming Decade as a Guide

- Consider likely Federal budget profiles
- Use total available $$ as a guide to set project mix
- Solicit input from agencies on ongoing costs
- Use “lifecycle” costs, along with items like R&A and operations of carryover missions, to evaluate whether proposed program is fiscally realizable.
- Be optimistic - the program will be prioritized so changing budgets can be accommodated later

Evolution of science goals and/or priorities during the Decade

- New discoveries may cause science goals to evolve or cost or technology issues could require a revisit of priorities
- Dark Energy was an excellent science example - but I suspect that this will not happen very often. JWST and SIM and ALMA cost/technology examples of cost growth.
- Set up Decadal Survey committee and its panels with goal of accommodating re-evaluation during Decade
- For example: Small standing (sub)committee of the Decadal committee used, with augmentation depending on the issue, to assess needs for changes in priority or additions (conservative approach a la Supreme Court?)

A (personal) recipe for a successful Astronomy and Astrophysics 2010 Decadal Survey

- Provide a strong science framework and a clear sense of science priorities
- Make the science exciting to a public/political audience
- Make sure that the technological development and management requirements are consistent with timescales and capabilities
- Develop a prioritized mix of small, medium and large
- Provide realistic “lifecycle” cost estimates and cost profiles
- Match, but with some optimism, the likely available funding
- No “carry-over” projects (zero-based assessment - but do wisely!)