New Worlds, New Horizons
in Astronomy and Astrophysics
U.S. Decadal Surveys

- 1964: Ground-based Astronomy: A Ten Year Program (Whitford)
- 1972: Astronomy and Astrophysics for the 1970s (Greenstein)
- 1982: Astronomy and Astrophysics for the 1980s (Field)
- 1991: The Decade of Discovery in Astronomy and Astrophysics (Bahcall)
- 2001: Astronomy and Astrophysics in the New Millennium (McKee-Taylor)
- 2010: New Worlds, New Horizons in Astronomy and Astrophysics

Other surveys: Elementary Particles, Nuclear, AMO, Planetary Science, (Space) Heliophysics…
Negotiated by NRC with Agencies; accepted by chair

- The Committee on Astro2010 will survey the field of space- and ground-based astronomy and astrophysics, recommending priorities for the most important scientific and technical activities of the decade 2010-2020. The principal goals of the study will be to carry out an assessment of activities in astronomy and astrophysics, including both new and previously identified concepts, and to prepare a concise report that will be addressed to the agencies supporting the field, the Congressional committees with jurisdiction over those agencies, the scientific community, and the public.

- In proposing a decadal U.S. research strategy for astronomy and astrophysics, the committee is expected to consider and make recommendations relating to the allocation of future budgets and address choices which may be faced, given a range of budget scenarios. For each prioritized activity, the committee will establish criteria on which its recommendations depend. The committee will make recommendations to the agencies on how to rebalance programs within budgetary scenarios upon failure of one or more of the criteria.

Decadal Surveys are >2 year deliberative exercises
They have detailed charges and extensive review
They should emphasize scientific prioritization over mission planning
They should not be expected to react to latest budgetary crisis
Summary

• This is an extraordinary time in the study of the cosmos, but also a time of serious constraints on federal discretionary budgets.

• The recommended program is science-driven and will enable progress across a large swath of research and open up more discovery space.

• A balanced program should be maintained throughout the decade. Effective international, public-private and inter-agency collaboration is required for success of the program.

• A serious effort has been made to appraise activity cost, risk and technical readiness.

• Mid-decade decisions should be made based on recommendations from an independent, strategic advisory committee.

• Astro2010 has had unprecedented involvement and support by the astronomical community and immense effort by the committee, panels and consultants, as well as the strong cooperation of the agencies and professional societies.
Budgetary Context

• Agency Guidelines (the pessimistic scenario)
  – NSF and DOE – constant budgets in fixed dollars ($FY2010)
    • NSF initiatives only possible at expense of existing program through Senior Review
    • Modest DOE program
  – NASA – constant real year dollars (declining budget in $FY2010)
    • WFIRST, Explorer augmentation, “small” program

• Survey Budgets (the optimistic scenario)
  – NSF and DOE – “doubling” = 4% per year growth in $FY2010
  – NASA – constant in $FY2010 dollars

• Notional “sand charts”
  – Exhibit possible spending profiles consistent with committee budgets and
    the recommended program, i.e. phasing
  – Allowed the committee to examine possible programmatic scenarios
  – Provide advice in less optimistic budget scenarios
What CATE is and isn’t

• Is:
  • Based on detailed project input
  • Application of uniform and historical data-informed risk analysis
  • Independent appraisal of project budget, schedule and technical risk
  • Considerate of a wide range of maturity in the concepts with respect to total life cycle, including “pre-Phase A” and designed to be fair and neutral
  • Projection through the decade considering potential cost/schedule growth
  • Probabilistic assessment of required reserves and identification of cost/schedule liens and threats
  • Generation of a 70% confidence cost appraisal
  • Input to the committee and program prioritization panels

• Is Not:
  • A bottoms-up costing exercise
  • A traditional non-advocate ICE (Independent Cost Evaluation) or TMC (Technical, Management, Cost) process which generally occur later in project lifecycles.
Cost, Risk, and Technical Evaluation

- Early call for Notices of Intent followed by open Request for Information
  - Activities selected by PPPs and committee for a 2nd Request for Information

- Subset selected by PPPs and committee for CATE review
  - Independent cost appraisals
  - Evaluations of technical readiness schedule and risk assessment
Where the money comes from:

- Individual income taxes $1.1 trillion
- Corporate income taxes $297 billion
- Social Security and other payroll taxes $934 billion
- Excise taxes $74 billion
- Estate and gift taxes $25 billion
- Customs duties $27 billion
- Other $87 billion

Total Revenue: $2.57 trillion

Deficit: $1.27 trillion

Where the money goes:

- Defense $895 billion
- Other discretionary $520 billion
- Social Security $730 billion
- Medicare $491 billion
- Medicaid $297 billion
- Troubled Asset Relief $11 billion
- Jobs initiatives $25 billion
- Other $612 billion
- Interest on debt $251 billion
- Potential disaster costs $3 billion

Total Spending: $3.83 trillion

**Challenges linked to S&T: US national**

- economic recovery & growth: S&T as drivers (infotech, biotech, nanotech, greentech...?)
- health care: better outcomes for all at lower cost
- energy: reduced oil imports, reduced conventional & climate-altering pollution
- other resources & environment: water, land use, biodiversity, toxics, climate-change adaptation
- national & homeland security: scientific intelligence, cyber- & power-grid security, maintaining safety/reliability of shrinking nuclear stockpile without nuclear testing

**Science and Technology on the President’s Mind**

(left-side material from John Holdren)

- Jobs, economy
- Health care
- Renewable energy
- Climate research
- Homeland security
- STEM education

**NOTE: Astronomy is not generally viewed as part of the nation’s agenda.**
Balancing the Program

- Large \textit{and} small/medium activities
- Existing \textit{and} new facilities
- Known science objectives \textit{and} discovery space
- Promise \textit{vs.} risk
- Ground \textit{and} Space
- 2020 \textit{and} 2030
Large Scale Space Program - Prioritized

1. Wide Field InfraRed Survey Telescope (WFIRST)

1. Explorer Program Augmentation

2. Laser Interferometer Space Antenna (LISA)

3. International X-ray Observatory (IXO)
Medium-Scale Space Program - Prioritized

1. **New Worlds** Technology Development Program

2. **Inflation** Technology Development Program
Large-scale Ground-based Program - Prioritized

1. Large Synoptic Survey Telescope (LSST)
2. Mid-Scale Innovations Program
3. Giant Segmented Mirror Telescope (GSMT)
4. Atmospheric Cerenkov Telescope Array (ACTA)
LSST- Science

• Efficient, deep optical survey telescope

• Will transform observation of the variable universe and address broad questions:
  – Dark energy using gravitational lensing and supernovae
  – Dark matter
  – Near-Earth, Kuiper-belt objects
  – Solar neighborhood
  – Transient phenomena
    ▪ Gamma-ray bursts, Variable stars, Supernovae…

• Publicly accessible archive – >100 Pbyte
LSST – Program Details

• 8.4 m diameter telescope located in Chile
• 3.5 degree field of view -- Observe half sky every four days using six filters from 0.3-1\(\mu\)m
• NSF-DOE partnership with private and international contributions
• Total appraised cost $465M; Annual operation $42M
• Medium/Low risk excepting data management and archive software
• RECOMMEND entry into MREFC line as soon as possible
• Ten year lifetime, followed by Senior Review
Mid-Scale Innovations Program - Details

- RECOMMEND annual proposals for:
  - Conceptual and preliminary design activities
  - Detailed design and construction

- ~7 projects funded over decade
  - Possible exemplars include: BigBOSS, CMB, ExoPlanet initiatives, FASR, HAWC, HERA, Adaptive Optics, NanoGRAV

- Funding increase from ~$18M currently to competed $40M per year
Medium-scale Ground-based Program

1. Cerro Chajnantor Atacama Telescope (CCAT)
## Small-scale Program (Ground and Space – not prioritized)

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<th>Program Augmentation</th>
<th>Agency</th>
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<th>New Initiatives</th>
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<td>Development of future UV-optical space capability</td>
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<tr>
<td>Leadership in Gemini international partnership (increment)</td>
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<tr>
<td>Participation in JAXA’s SPICA mission</td>
<td>NASA</td>
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<tr>
<td>Theory and Computation Networks</td>
<td>NASA, NSF, DOE</td>
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NASA

- Expectation under survey’s budget scenario:
  - launch WFIRST
  - augment Explorers
  - start LISA
  - timely contribution to SPICA
  - advance
    - IXO
    - Exoplanet and Inflation technology development
- Details depend upon ESA negotiations and decisions

- If budgets are lower, SPICA contribution dropped and
  - First priority: WFIRST, Explorer augmentation and small program
  - Second priority: New Worlds (Exoplanet) Technology Development, LISA and IXO Technology Development
  - Third priority: Inflation Technology Development
NSF

- Program dependent upon MREFC
  - early entry of LSST
  - followed by GSMT

- In event NSF budget is as projected by agency, there can be **no new starts without closure of major facilities** following senior review

- If moderate budget increase
  - First priority is small program (including time-critical Gemini augmentation), Mid-scale Innovations program, and starting LSST operations.
  - Second priority is GSMT operations, and starting ACTA
DOE

- **Survey’s budget scenario** allows investment in
  - LSST
  - WFIRST
  - other PASAG recommendations.

- **In lower budget scenarios**, DOE participation in LSST is recommended ahead of WFIRST as contribution relatively larger and technical role relatively more critical.

- Small-scale program and ACTA have lower priority.
Other Recommendations & Conclusions

- International Matters: collaboration, coordination; open skies
- Stewardship of the Survey: independent, strategic advisory group
- Benefits to the Nation: STEM literacy; technology spin-offs; citizen science
- Astronomers: career mentoring; demographics; public policy
- Computation and Data: archive and curate data
- Laboratory Astrophysics: support at current or higher levels
- NSF/AST Senior Review: conduct early in decade
- NOAO and Gemini: explore management and operations consolidation
- Solar Astronomy: maintain multidisciplinary ties
- Radio Astronomy: SKA pathfinder opportunities
Astronomy in Society

- Engagement to improve science literacy, education
- Technology gateway
- Supply of employable scientists
  - …imaging, computing, oil, finance, defense…
  - Energy and climate
- America Competes, Gathering Storm
- Under-represented minorities, gender balance
Summary of NASA response

- JWST replan (September 2011)
- WFIRST, Imp. Rec. Rev., SDT, Euclid
- Explorer - notional budget $M75pa, “on track”
- LISA, IXO teams disbanded
- R&A, Tech Dev
- Senior Review
- JAXA-Astro-H, SPICA. Earthquake!
Summary of NSF Response

• Move towards MREFC start for LSST in 2014
• Facilities Review
• NSB Mid-scale review Jan 2012
• Discussions of management of solar astronomy and siting of NSO
• Discussion of Theory and Computation Networks with NASA
Summary of DOE Response

• Move towards CD0 for LSST Camera
• Withdrawal from JDEM/WFIRST
JWST

• Top recommendation of 2000 Survey
• Not studied by Astro2010; NASA costs assumed
• Science is foundation of Astro2010 program
• Casani reports; Nov 10
  – Serious management issues
    • “The problems causing cost growth and schedule delays on the JWST Project are associated with budgeting and program management, not technical performance. The technical performance on the Project has been commendable and often excellent.”
  – $5.0B->$6.5+/-0.3B, if +$0.25B in 2011, 2012
  – Removed from Astrophysics, NASA management
  – Change in GSFC project management
• Serious impact on Astro2010 implementation?
• June 2011? revised cost and schedule
WFIRST - Science

Near infrared wide-field telescope with a set of key science objectives:

- **Dark energy** (part of a coherent ground-space strategy):
  - Baryon acoustic oscillations
  - Distant supernovae
  - Weak lensing

- **Exoplanet statistics**
  - Gravitational microlensing

- Guest investigator mode enabling survey investigations
Explorer Program - Science

- Rapid, targeted, competed investigations
- Versatile program delivers high scientific return
- WMAP, Swift, GALEX, WISE… are extraordinarily successful past examples
- NuSTAR, GEMS, Astro-H very promising
Space Mission Discoveries!!

- HST/Chandra/Spitzer
- GALEX
- WISE
- Kepler
- Fermi
- Herschel/Planck
- SOFIA
- SDO
- Messenger

29 iv 2011
UPCOMING LAUNCHES

NuSTAR - SMEX 2012
Astro-H - MoO JAXA-led 2014
GEMS - SMEX 2014
JWST – “>=2018”
NSF Program

- ALMA dishes
  - Early science call for proposals
- EVLA 2012
- Gemini
  - Response to UK withdrawal
  - Instruments coming online

Exciting Program just starting
Summary

• Astro2010 recommended a realizable, science-driven, community supported program
• Post-survey budgetary developments have led to deferral of major projects
• Agencies are trying to implement less expensive parts of the program and
• Need for DSIAC to provide strategic guidance
Some talking points

- **Response to future budgets**
  - Manpower/human resource/durability of centers/labs
  - Versatility of workforce?
  - Incremental cost of well-managed new programs
  - Aerospace costs

- **Communicating role of basic science in innovation cycle**
  - iPhones, medicine, energy, agriculture…
  - Federal vs commercial investment

- **International “leadership” in science**
  - Europe, Japan, China, India…
  - Private support of science

- **Fate of high visibility science impacts STEM education**
  - Quality of graduates and postdocs
  - Retention? of foreign graduate students
  - Where are the jobs for new graduates?