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
Task and Charge

Negotiated by NRC with Agencies

- 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.

Scope

- NASA, NSF, DOE
- Remote observing of cosmos, theory, physics, computation and simulation, laboratory astrophysics, solar astronomy (excluding space missions), and technology development
- Activities and infrastructure (broadly defined)
- Balance
- Partnerships: international, private, state ….
Astro2010 Committee

Roger Blandford, Chair, Stanford University
Lynne Hillenbrand, Executive Officer, California Institute of Technology

Subcommittee on Science
Martha P. Haynes, Vice Chair – Science Frontiers, Cornell University
  Lars Bildsten, University of California, Santa Barbara
  John E. Carlstrom, The University of Chicago
  Fiona A. Harrison, California Institute of Technology
  Timothy M. Heckman, Johns Hopkins University
  Jonathan I. Lunine, University of Rome Tor Vergata
  Juri Toomre, University of Colorado at Boulder
  Scott D. Tremaine, Institute for Advanced Study

Subcommittee on State of the Profession
John P. Huchra, Vice Chair – State of the Profession, Harvard-University
  Debra M. Elmegreen, Vassar College
  Joshua Frieman, Fermi National Accelerator Laboratory
  Robert C. Kennicutt, Jr., University of Cambridge
  Dan McCammon, University of Wisconsin-Madison
  Neil de Grasse Tyson, American Museum of Natural History

Subcommittee on Programs
Marcia J. Rieke, Vice Chair – Program Prioritization, University of Arizona
  Steven J. Battel, Battel Engineering
  Claire E. Max, University of California, Santa Cruz
  Steven M. Ritz, University of California, Santa Cruz
  Michael S. Turner, The University of Chicago
  Paul Adrian Vanden Bout, National Radio Astronomy Observatory
  A. Thomas Young, Lockheed Martin Corporation [Retired]
Community Input

An unprecedented response

- 324 Science White Papers (a unique snapshot of the field)
- 69 State Of The Profession Position Papers
- 70 White Paper on Technology Development, Theory, Computation, and Laboratory Astrophysics
- 108 Community Responses to a Request for Information on Research Activity Proposals
- Email Inputs to the Committee
- Community-organized Town Halls
Science Frontier Panels

Planetary Systems and Star Formation (PSF) - Lee Hartmann
- Solar system bodies (other than the Sun) and extrasolar planets, debris disks, exobiology, formation of individual stars, protostellar and protoplanetary disks, molecular clouds and the cold ISM, dust, and astrochemistry.

Stars and Stellar Evolution (SSE) - Roger Chevalier
- The Sun as a star, stellar astrophysics, structure and evolution of single and multiple stars, compact objects, supernovae, gamma-ray bursts and solar neutrinos. Extreme physics on stellar scales.

The Galactic Neighborhood (GAN) - Mike Shull
- Structure and properties of nearby galaxies including the Milky Way and their stellar populations, interstellar media, star clusters. Evolution of stellar populations.

Galaxies across Cosmic Time (GCT) - Meg Urry
- Formation and evolution of galaxies and galaxy clusters, active galactic nuclei and QSOs, mergers, star formation rate, gas accretion, global properties of galaxies and galaxy clusters, supermassive black holes.

Cosmology and Fundamental Physics (CFP) - David Spergel
- Early universe, microwave background, reionization and galaxy formation up to virialization of protogalaxies. Large scale structure, intergalactic medium, determination of cosmological parameters, dark matter, dark energy. High energy physics using astronomical messengers, tests of gravity, physical constants as determined astronomically.
The Science Frontier

discovery areas and principal questions

Discovery areas:
- Identification and characterization of nearby habitable exoplanets
- Gravitational wave astronomy
- Time-domain astronomy
- Astrometry
- The epoch of reionization

Questions:
- How did the universe begin?
- What were the first objects to light up the universe and when did they do it?
- How do cosmic structures form and evolve?
- What are the connections between dark and luminous matter?
- What is the fossil record of galaxy assembly and evolution from the first stars to the present?
- How do stars and black holes form?
- How do circumstellar disks evolve and form planetary systems?
- How do baryons cycle in and out of galaxies and what do they do while they are there?
- What are the flows of matter and energy in the circumgalactic medium?
- What controls the mass-energy-chemical cycles within galaxies?
- How do black holes work and influence their surroundings?
- How do rotation and magnetic fields affect stars?
- How do massive stars end their lives?
- What are the progenitors of Type Ia supernovae and how do they explode?
- How diverse are planetary systems and can we identify the telltale signs of life on an exoplanet?
- Why is the universe accelerating?
- What is dark matter?
- What are the properties of the neutrinos?
- What controls the masses, spins and radii of compact stellar remnants?
Science Objectives

• Building on the science priorities identified by the survey, the recommended program is organized by three science objectives that represent its scope:
  − Cosmic Dawn
  − New Worlds
  − Physics of the Universe

• Success in attaining these science goals will enable progress on a much broader front

• Also foster unanticipated discoveries
Cosmic Dawn
Searching for the first stars, galaxies, and black holes

- We have learned much about the history of the universe, from the Big Bang to today
- A great mystery now confronts us: when and how the first galaxies formed and the earliest stars started to shine - our cosmic dawn
- JWST, ALMA and radio telescopes already under construction will help point the way
- Approaches:
  - Locating “reionization” – finding the epoch ~0.5 billion years, when light from the first stars split interstellar hydrogen atoms into protons and electrons
  - “Cosmic paleontology” – finding the rare stars with the lowest concentrations of heavy elements
Status of Profession

- Astronomy and Public Policy
- Computation and Data-Handling
- Demographics
- Education and Public Outreach
- Infrastructure
- International and Public-Private Partnerships

Large impact on report but output never published
International Matters

- Astronomy is more collaborative, international and interdisciplinary than ever. Most major facilities and spacecraft are multi-national and/or public/private.

- Principle of open skies is compatible with maximizing scientific output.

- RECOMMENDATION: U.S. investors in astronomy and astrophysics, both public and private, should consider a wide range of approaches to realize participation in international projects and to provide access for the U.S. astronomy and astrophysics community to a larger suite of facilities than can be supported within the United States. The long-term goal should be to maximize the scientific output from major astronomical facilities throughout the world, a goal that is best achieved through opening access to all astronomers.
International Context

• Most major projects are multinational
  – Private initiatives (GMT, TMT) intrinsically international
    • Cost and complexity vs stability

• Increasing foreign investment in fundamental research
  – Traditionally, Europe, Japan, Canada, Australia …
  – Now China, India, Korea, Taiwan, Africa, South America, Mexico…
    • FAST, AstroSAT, GMT, radio instrumentation, MeerKAT, optical, HAWC, LMT…
    • Is US becoming too risk averse, conservative, slow…?

• Major -> Equal -> Minor -> No role??
  – HST -> ALMA -> Planck -> SKA??
  – LSST, JWST (but Ariane launch!) vs Euclid, Astro-H

• Technology, visa limitations
  – Has US gained more than it has given?

• Open skies
  – Political considerations

US has to adjust to growing non-US program
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
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
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)
Mid-Decadal 2016

• Ch. Jackie Hewitt
• Did not revise science priorities
• Science progress since 2010
• Agency responses to recommended program
Set up of Astro 2020

- Lessons Learned report (Space Science)
  - Consensus, CATE, budget, balance, stewardship…
- Clear charge from agencies
  - Add OMB/OSTP?; integrate SR?
- Smaller, younger committee
  - Individual breadth of experience, interests
- Engage community early
  - Acceptance of recommendations essential
- Formalize international coordination
  - Start early, keep IAU, AAS engaged
- Organize Profession/Infrastructure output
  - Plan dissemination of reports, data
- Long-term stewardship
  - AAS?, CAA/DSIAC

Candidate programs will be more mature this time