COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

HEARING CHARTER

National Imperatives for Earth and Climate Science Research and Applications Investments over the Next Decade

The Findings and Recommendations of the National Academies' Decadal Survey of Earth Science and Applications from Space

Tuesday, February 13, 2007
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On February 13, 2007 the Committee on Science and Technology will hold a hearing to examine the findings and recommendations of the National Academies report *"Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond"*, also known as the Decadal Survey. The report recommends a prioritized set of investments in new satellite-borne instruments and spacecraft to gather earth, atmospheric, and climate data. These new satellites would replace our aging space-based observing system to support national needs for research and monitoring of the dynamic Earth system during the next decade, as well as identifying important research and applications directions that should influence planning for the following decade.

The Decadal Survey panel described the national strategy outlined in its report as having *"as its overarching objective a program of scientific discovery and development of applications that will enhance economic competitiveness, protect life and property, and assist in the stewardship of the planet for this and future generations."*

The Committee will hear testimony from three witnesses. Two of the witnesses were the co-chairs of the Decadal Survey, and they will discuss the findings and recommendations of their report. The third witness will discuss the application of remote sensing data to meet agricultural, resource management, and other needs.

Background

Although the development of decadal strategies for astronomy and astrophysics research has been the practice since the 1980s, the report examined at this hearing represents the first such decadal strategy to be developed for Earth science. The National Academies of Science and Engineering was asked to undertake the task by NASA's Office of Earth Science, NOAA's National Environmental Satellite Data and Information Service (NESDIS), and the U.S. Geological Survey (USGS) Geography Division. The study was overseen by an 18-member executive committee and carried out be seven-thematically organized panels with a total of more than 80 members. The panels consisted of the following:

1. Earth Science Applications and Societal Needs
2. Land-use Change, Ecosystem Dynamics and Biodiversity
3. Weather (including space weather and chemical weather)
4. Climate Variability and Change
5. Water Resources and the Global Hydrologic Cycle
6. Human Health and Security
7. Solid-Earth Hazards, Resources and Dynamics

Major Findings and Recommendations of the Decadal Survey

Interim Report

The Decadal Survey panel issued an interim report in the spring of 2005, entitled *Earth Science and Applications from Space: Urgent Needs and Opportunities to Serve the Nation*. In that report, the panel made the following observations:

"The current U.S. civilian Earth observing system centers on the environmental satellites operated by NOAA; the atmosphere-, biospheres-, ocean-, ice-, and land-observation satellites of NASA's Earth Observing System (EOS); and the Landsat satellites, which are operated by a cooperative arrangement involving NASA, NOAA, and the U.S. Geological Survey (USGS). Today, this system of environmental satellites is at risk of collapse. Although NOAA plans to modernize and refresh its weather satellites, NASA has no plan to replace its EOS platforms after their nominal 6-year lifetimes end (beginning with the Terra satellite in 2005), and it has cancelled, descoped, or delayed at least six planned missions, including the Landsat Data Continuity Mission.

"These decisions appear to be driven by a major shift in priorities at a time when NASA is moving to implement a new vision for space exploration. This change in priorities jeopardizes NASA's ability to fulfill its obligations in other important presidential initiatives, such as the Climate Change Research Initiative and the subsequent Climate Change Science Program. It also calls into question future U.S. leadership in the Global Earth Observing System of Systems, an international effort initiated by the current Administration. The nation's ability to pursue a visionary space exploration agenda depends critically on its success in applying knowledge of the Earth to maintain economic growth and security at home.

"Moreover, a substantial reduction in Earth observation programs today will result in a loss of U.S. scientific and technical capacity, which will decrease the competitiveness of the United States internationally for years to come. U.S. leadership in science, technology development, and societal applications depends on sustaining competence across a broad range of disciplines that include the Earth sciences."

Final Report

In January 2007, the National Academies released the final report of the Decadal Survey panel. In the final report, the panel reiterated the concerns expressed in the Interim Report about the nation's system of environmental satellites being *"at risk of collapse"*. In that regard, the final report states: *"In the short period since the publication of the Interim Report, budgetary constraints and programmatic difficulties at NASA and NOAA have greatly exacerbated this concern. At a time of unprecedented need, the nation's Earth observation satellite programs, once the envy of the world, are in disarray."*

The Decadal Survey panel made a series of recommendations in its report to address the perceived problems. The first was an overarching recommendation that:

- **The U.S. government, working in concert with the private sector, academe, the public, and its international partners, should renew its investment in Earth observing systems and restore its leadership in Earth science and applications.**

Other major recommendations of the report are as follows:

- **NASA should ensure continuity of measurements of precipitation and land cover by:**
  - **Launching the Global Precipitation Measurement (GPM) mission in or before 2012**
  - **Securing a replacement to Landsat 7 data before 2012**

The Landsat program has operated for over 30 years. Landsat images are used by governments, the research community, and the private sector in a wide variety of applications including monitoring of crop productivity, documenting changes in land use, water management, monitoring and tracking "red" tides, monitoring changes in coastal wetlands, citing power and transportation routes, monitoring changes in glacial features, and many other applications. The current Landsat instrument is in need of replacement. It is currently producing degraded imagery and may not have many more years of functionality.

- **In addition to implementing the re-baselined National Polar-orbiting Operational Environmental Satellite System (NPOESS) and Geostationary Operational Environmental Satellite (GOES) program and completing research missions currently in development, NASA and NOAA should undertake a set of 17 recommended missions, comprised of small (<$300 million), medium ($300 million to $600 million), and large ($600 million to $900 million) cost missions, and phased appropriately over the next decade. Larger facility-class (>$1 billion) missions are not recommended. [See Attachment 1 for list of recommended missions]**

NOAA operates two satellite systems that collect data for weather forecasting. The polar satellites orbit the earth and provide information for medium to long-range weather forecasts. The geostationary satellites gather data above a fixed position on the earth's surface and provide information for short-range warnings and current weather conditions. Both of these systems are scheduled for replacement through the NPOESS and GOES-R programs, respectively.

Significant cost and schedule problems have arisen in the NPOESS program. A number of instruments that would have provided continuity of our current earth and climate monitoring programs were planned to fly on the NPOESS satellites were eliminated from the program to reduce its cost and complexity.

The suite of 17 priority missions outlined by the NAS are intended to provide continuity of the earth science and climate data sets as well as advance our understanding of the Earth system and climate.

- **U.S. civil space agencies should aggressively pursue technology development that supports the recommended missions; plan for transitions to continue demonstrably useful research observations on a sustained, or operational, basis; and foster innovative new space-based concepts.**

The above recommendation includes three main points: NASA, as the primary space research and development agency should increase funding allotted for the early design and testing phases of technology development that serves the research and operational missions recommended in this NAS report. The Panel believes that greater investments made early in the development of new instrumentation and spacecraft will result in more robust designs and prototypes which then move to development and deployment on a smoother, less risky path (and therefore with a more predictable budget).

The Panel also recommends that NASA develop a new Program to take on newer, more risky projects and demonstrate their feasibility and applicability to research and operational needs. The NAS recommends this program focus on low-cost missions ($100-200 million) and that it have a strong focus on technical innovation as well as education and training of future scientists and engineers working in the field of earth and climate science.

Finally, the Panel recommended that NOAA allocate increased funding to support the transition of NASA-developed satellites and spacecraft that are identified as having operational utility to NOAA's missions.

The transition from research to operations continues to be a problem for NOAA because there are no funds specified for the transition activities that must occur to move research satellites and spacecraft to operational status. Consequently, procurement programs for operational systems now often carry these costs resulting in higher risks of cost overruns, schedule slips, and higher risk of breaks in operational data for weather forecasting.

- **The NASA Science Mission Directorate should develop a science strategy for obtaining long-term, continuous, stable observations of the**

Earth system that are distinct from observations to meet requirements by NOAA in support of numerical weather prediction.

- **Earth system observations should be accompanied by a complementary system of observations of human activities and their effects on Earth, and socioeconomic factors should be considered in the planning and implementation of Earth observation missions and in developing the Earth Information System.**

- **NOAA, working with the Climate Change Science Program and the international Group on Earth Observations, should create a climate data and information system to meet the challenge of ensuring the production, distribution, and stewardship of high-accuracy climate records from NPOESS and other relevant observational platforms.**

- **As new Earth observation missions are developed, there must also be early attention to developing the requisite data processing and distribution system, and data archive. Distribution of data should be free or at low cost to users, and provided in an easily-accessible manner.**

- **NASA should increase support of its Research and Analysis (R&A) program to a level commensurate with its ongoing and planned missions.**

Data gathered by satellite-based instruments and spacecraft must be properly documented, analyzed and archived to be useful. Funding for these activities has traditionally lagged behind funding for the hardware and software needed to build, launch and operate satellite-based instruments and spacecraft. In addition to R&A cuts made as part of an overall budget-balancing exercise, cost-overruns experienced in the development and procurement of an observing system may lead to cuts in the funding allocated for analysis of the data generated by the observing system.

- **NASA, NOAA, and USGS should increase their support for Earth system modeling, including provision of high-performance computing facilities and support for scientists working in the areas of modeling and data assimilation.**

- **A formal interagency planning and review process should be put into place that focuses on effectively implementing the recommendations made in the present decadal survey report and sustaining and building the knowledge and information system for the next decade and beyond.**

- **NASA, NOAA, and USGS should pursue innovative approaches to educate and train scientists and users of Earth observations and applications. A particularly important role is to assist educators in inspiring and training students in the use of Earth observations and the information derived from them.**

Witnesses

Dr. Richard Anthes, President of the University Corporation for Atmospheric Research (UCAR):

Dr. Anthes served as co-chair of the Decadal Survey. He has conducted research directed at better understanding of tropical cyclones and mesoscale meteorology, as well as on techniques for doing atmospheric sounding. He chaired the 2003 National Academies Committee on NASA-NOAA Transition of Research to Operations. Dr. Anthes is a fellow of the American Meteorological Society and the American Geophysical Union.

Dr. Berrien Moore, Professor and Director of the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire:

Dr. Moore served as co-chair of the Decadal Survey. His research has focused on the carbon cycle, global biogeochemical cycles, and global change. Dr. Moore has served on a number of NASA advisory committees, and he chaired the Scientific Committee of the International Geosphere-Biosphere Programme (IGBP) from 1998-2002. He currently seves on the Science Advisory Board of NOAA and the Advisory Board of the National Center for Atmospheric Research (NCAR).

Dr. Anthes and Dr. Moore will discuss the criteria the Decadal Survey Committee used to determine the priorities recommended in the Report. They will also discuss the utility of the research and application activities to the nation and the international community. Dr. Anthes and Dr. Moore will also provide an assessment of the President's FY 2008 budget request for NASA and NOAA as they relate to the recommendations included in the Decadal Survey Report.

Honorable James Geringer, Director of Policy at the Environmental Systems Research Institute in Wyoming and former Governor of Wyoming:

Former Wyoming Governor James Geringer has been active in the Alliance for Earth Observations and was the force behind the Western Governors Association's call for a National Integrated Drought Information System (NIDIS).

Governor Geringer will discuss the utility of data derived from the current earth observing systems we have in place. He will discuss the applicability of remote sensing data to agriculture, natural resource management, municipal water supply management, and to tourism and recreation. The Governor will provide information regarding the accessibility of remote sensing data to different user communities and discuss the role of private sector companies that provide value-added products from remote sensing data. He will also provide a perspective on how widely remote sensing data are used by government and industry people working in agriculture and natural resource management.

ATTACHMENT 1

TABLE 2.1 Launch, orbit, and instrument specifications for the recommended NOAA missions. Missions are listed in order of ascending cost within each launch timeframe.

Decadal Survey Mission	Mission Description	Orbit	Instruments	Rough Cost Estimate
Timeframe 2010 - 2013—Missions listed by cost				
CLARREO (NOAA portion)	Solar and Earth radiation characteristics for understanding climate forcing	LEO, SSO	Broadband radiometer	$65 M
GPSRO	High accuracy, all-weather temperature, water vapor, and electron density profiles for weather, climate and space weather	LEO	GPS receiver	$150 M
Timeframe 2013 – 2016				
XOVWM	Sea surface wind vectors for weather and ocean ecosystems	LEO, SSO	Backscatter radar	$350 M

TABLE 2.2 Launch, orbit, and instrument specifications for the recommended NASA missions. Missions are listed in order of ascending cost within each launch timeframe.

Decadal Survey Mission	Mission Description	Orbit	Instruments	Rough Cost Estimate
Timeframe 2010 – 2013, Missions listed by cost				
CLARREO (NASA portion)	Solar radiation: spectrally resolved forcing and response of the climate system	LEO, Precessing	Absolute, spectrally-resolved interferometer	$200 M
SMAP	Soil moisture and freeze/thaw for weather and water cycle processes	LEO, SSO	L-band radar L-band radiometer	$300 M
ICESat-II	Ice sheet height changes for climate change diagnosis	LEO, Non-SSO	Laser altimeter	$300 M
DESDynI	Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health	LEO, SSO	L-band InSAR Laser altimeter	$700 M
Timeframe: 2013 – 2016, Missions listed by cost				
HyspIRI	Land surface composition for agriculture and mineral characterization; vegetation types for ecosystem health	LEO, SSO	Hyperspectral spectrometer	$300 M
ASCENDS	Day/night, all-latitude, all-season CO_2 column integrals for climate emissions	LEO, SSO	Multifrequency laser	$400 M
SWOT	Ocean, lake, and river water levels for ocean and inland water dynamics	LEO, SSO	Ka-band wide swath radar C-band radar	$450 M
GEO-CAPE	Atmospheric gas columns for air quality forecasts; ocean color for coastal ecosystem health and climate emissions	GEO	High and low spatial resolution hyperspectral imagers	$550 M
ACE	Aerosol and cloud profiles for climate and water cycle; ocean color for open ocean biogeochemistry	LEO, SSO	Backscatter lidar Multiangle polarimeter Doppler radar	$800 M
Timeframe: 2016 -2020, Missions listed by cost				
LIST	Land surface topography for landslide hazards and water runoff	LEO, SSO	Laser altimeter	$300 M
PATH	High frequency, all-weather temperature and humidity soundings for weather forecasting and SST[a]	GEO	MW array spectrometer	$450 M
GRACE-II	High temporal resolution gravity fields for tracking large-scale water movement	LEO, SSO	Microwave or laser ranging system	$450 M
SCLP	Snow accumulation for fresh water availability	LEO, SSO	Ku and X-band radars K and Ka-band radiometers	$500 M
GACM	Ozone and related gases for intercontinental air quality and stratospheric ozone layer prediction	LEO, SSO	UV spectrometer IR spectrometer Microwave limb sounder	$600 M
3D-Winds (Demo)	Tropospheric winds for weather forecasting and pollution transport	LEO, SSO	Doppler lidar	$650 M

[a] Cloud-independent, high temporal resolution, lower accuracy SST to complement, not replace, global operational high accuracy SST measurement.