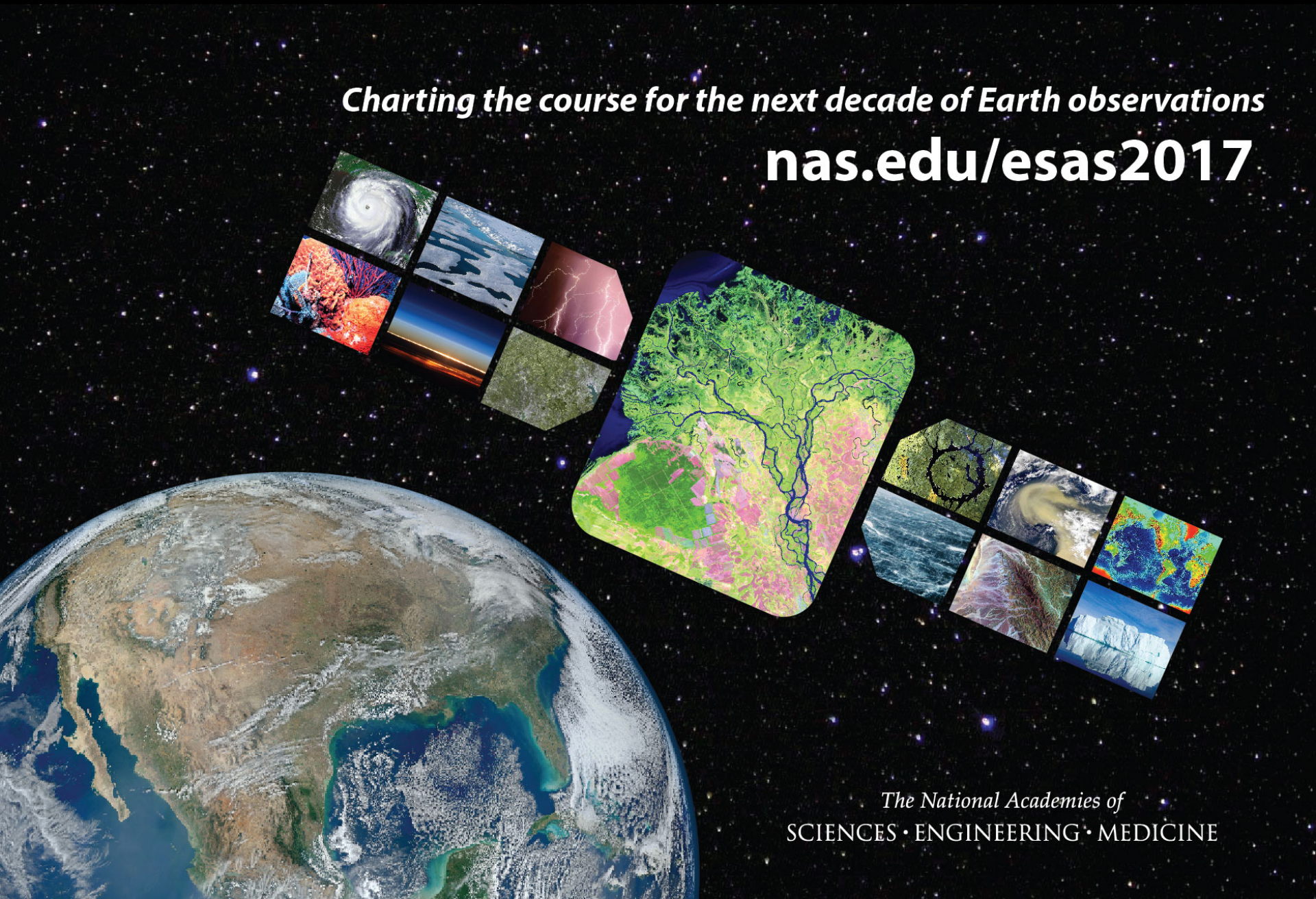

Charting the course for the next decade of Earth observations
nas.edu/esas2017
The National Academies of
SCIENCES · ENGINEERING · MEDICINE

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

ESAS 2017: The 2017-2027 Decadal Survey for Earth Science and Applications from Space

Waleed Abdalati, Co-Chair, Survey Steering Committee
University of Colorado

Antonio J. Busalacchi, Co-Chair, Survey Steering Committee
University of Maryland

AGU Town Hall, December 14, 2015

ESAS 2017 Town Hall

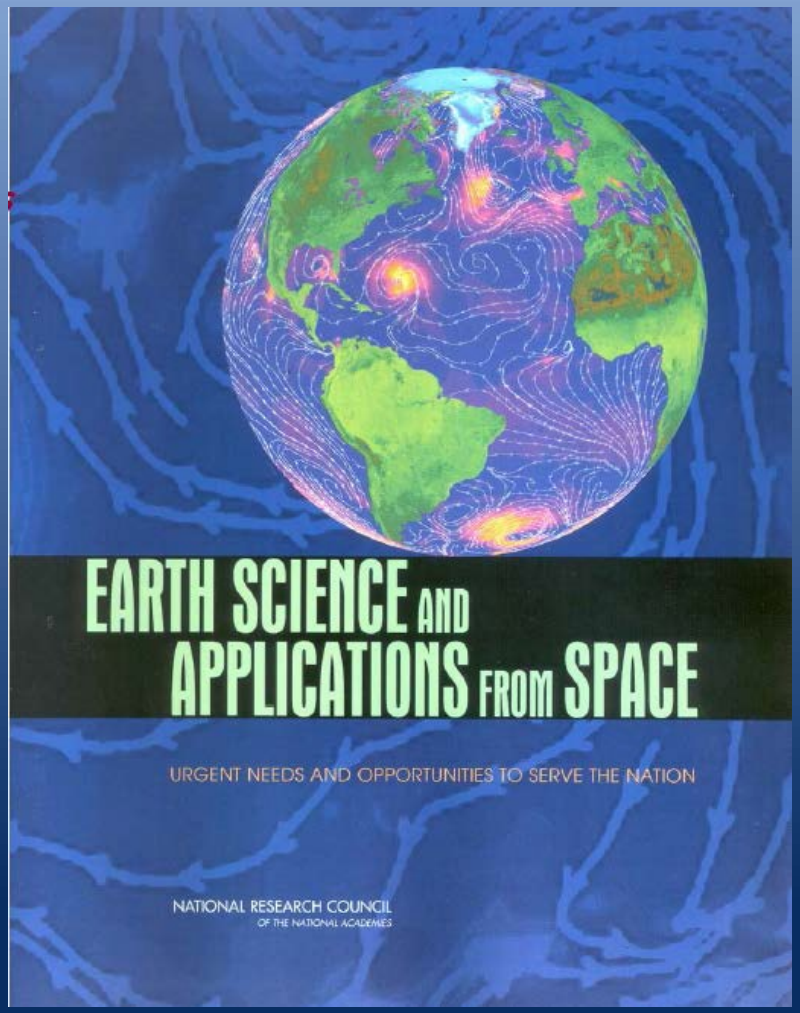
- ESAS 2007, the inaugural decadal survey
- ESAS 2017 versus ESAS 2007
- Agency Backdrop
- ESAS 2017 Statement of Task
- Request for Information
- Timeline
- Lessons Learned from the “Survey of Surveys” Report
- Decision Frameworks and the “Continuity” Study
- Challenges
- Comments and Questions

Vision of the Inaugural Decadal Survey

Advancing Earth System Science to Benefit Society

"Understanding the complex, changing planet on which we live, how it supports life, & how human activities affect its ability to do so in the future is one of the greatest intellectual challenges facing humanity. It is also one of the most important for society as it seeks to achieve prosperity & sustainability."

-- Interim Report of the Decadal Survey, April 2005



US Missions

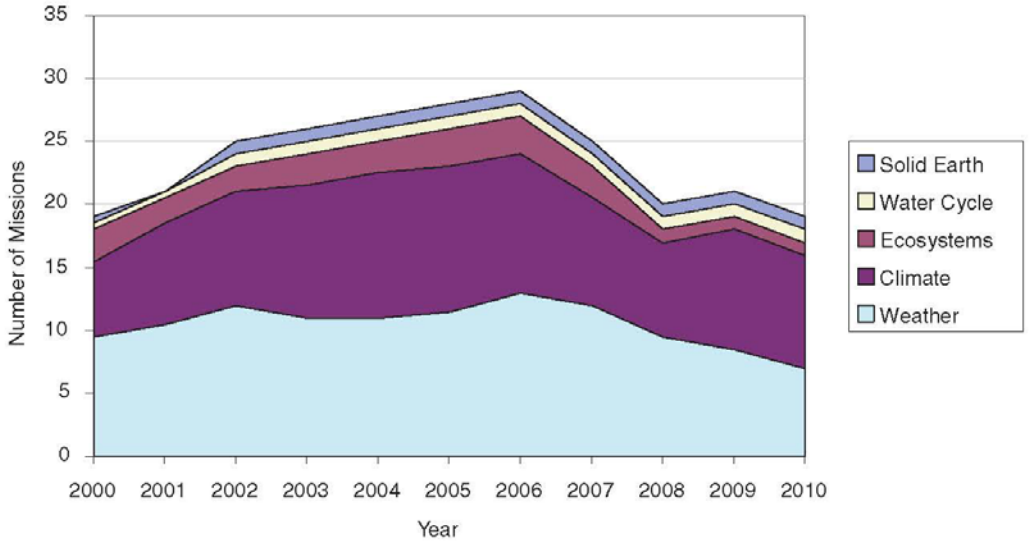


FIGURE ES.1 Number of U.S. space-based Earth observation missions in the current decade. An emphasis on climate and weather is evident, as is a decline in the number of missions near the end of the decade. For the period from 2007 to 2010, missions were generally assumed to operate for 4 years past their nominal lifetimes. Most of the missions were deemed to contribute at least slightly to human health issues, and so health is not presented as a separate category. SOURCE: Information from NASA and NOAA Web sites for mission durations.

US Instruments

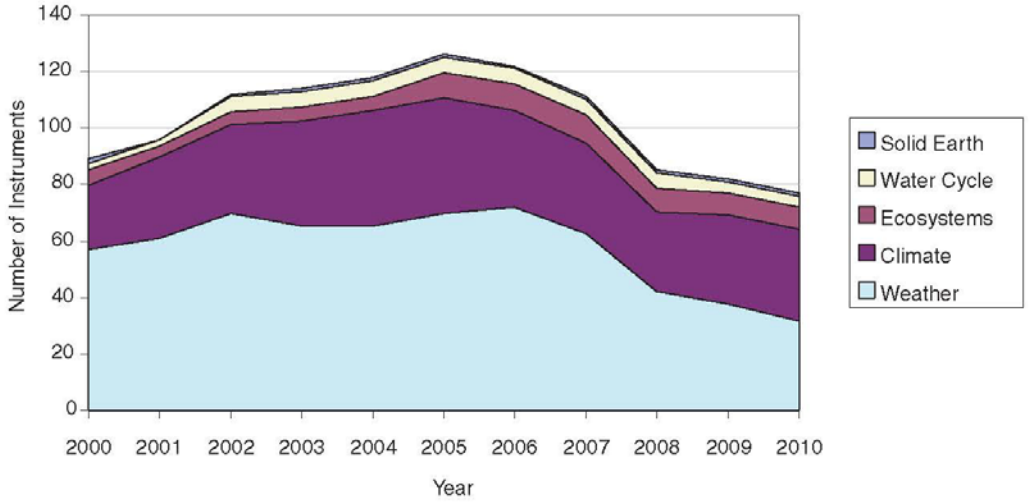


FIGURE ES.2 Number of U.S. space-based Earth observation instruments in the current decade. An emphasis on climate and weather is evident, as is a decline in the number of instruments near the end of the decade. For the period from 2007 to 2010, missions were generally assumed to operate for 4 years past their nominal lifetimes. Most of the missions were deemed to contribute at least slightly to human health issues, and so health is not presented as a separate category. SOURCE: Information from NASA and NOAA Web sites for mission durations.

Earth Science Missions and Instruments

ESAS 2017

- Agency Sponsors:
  - NASA—Earth Science Division
  - NOAA—NESDIS
  - USGS—Climate & Land Use Change

  Will actively seek the participation of other relevant federal agencies regarding in situ and other relevant programs

- Within the Academy:

  - Collaboration (inc. staff) of the Space Studies Board (lead) with the Board on Atmospheric Sciences and Climate, Ocean Studies Board, Board on Earth Sciences and Resources, and Water Sciences and Technology Board. Consulting with other relevant Boards.

ESAS 2017 vs. ESAS 2007

- No longer appropriate to base recommendations on an aspirational budget
- Congressionally-mandated independent cost appraisal and technical evaluation (CATE) for big ticket items
- Likely that the science will be "valued" to avoid having one recommended activity grow at expense of all others
- Increased opportunities to consider "new space" ideas—new players, smaller and less costly platforms, constellations, hosted payloads
  - Challenge: developing *credible* evaluations of their potential
- Improved consideration of international partners
- Existence of high-level guidance regarding Earth observations: NASA Climate-centric Architecture; OSTP National Strategy for Civil Earth Observations (2014); 2nd National Earth Observation Assessment, forthcoming

Agency Backdrop

NASA:

- Earth Science Div. has a backlog of missions recommended in 2007 survey
- Increased responsibility—without commensurate budget increases—for "continuity" measurements
- Budget under particular scrutiny, but to date has stayed roughly level

NOAA:

- Top priority: stabilize the weather satellite portfolio and avoid a gap in the polar orbiters
- "Climate"-related missions/instruments moving to NASA
  - Earth Radiation Budget, Total Solar Irradiance, Ozone Profiles, Altimetry
- Limited budget flexibility; direction to focus on core mission

USGS:

- Landsat-8 launched in February 2013
- Interest in adding new capabilities to Sustained Land Imaging Program
- Landsat-9 projected to be a near-rebuild of L-8 for launch in in 2023 (unless accelerated); lifetime of TIRS on L-8 is of concern

Primary Elements of the SOT

- Assess progress in addressing the major scientific and application challenges outlined in the 2007 Earth Science Decadal Survey.
- Develop a prioritized list of top-level science and application objectives to guide space-based Earth observations over a 10-year period commencing approximately at the start of fiscal year 2018 (October 1, 2017).
- Identify gaps and opportunities in the programs of record at NASA, NOAA, and USGS in pursuit of the top-level science and application challenges—including space-based opportunities that provide both sustained and experimental observations.
- Recommend approaches to facilitate the development of a robust, resilient, and appropriately balanced U.S. program of Earth observations from space. Consider: Science priorities, implementation costs, new technologies and platforms, interagency partnerships, international partners, and the *in situ* and other complementary programs carried out at NSF, DoE, DoA, DoD.

ESAS 2017 Steering Committee

Dr. Waleed Abdalati, Co-Chair
University of Colorado Boulder

Dr. Antonio Busalacchi, Co-Chair
University of Maryland

Mr. Steven J. Battel
Battel Engineering

Dr. Stacey W. Boland
Jet Propulsion Laboratory

Dr. Robert D. Braun
Georgia Institute of Technology

Dr. Shuyi S. Chen
University of Miami

Dr. William E. Dietrich
University of California, Berkeley

Dr. Scott C. Doney
Woods Hole Oceanographic Inst.

Dr. Christopher B. Field
Carnegie Institution for Science

Dr. Helen A. Fricker
Scripps Inst. of Oceanography

Dr. William B. Gail
Global Weather Corporation

Dr. Sarah T. Gille
Scripps Inst. of Oceanography

Dr. Dennis L. Hartmann
University of Washington

Dr. Anthony C. Janetos
Boston University

Dr. Everette Joseph
University at Albany, SUNY

Dr. Molly K. Macauley
Resources for the Future

Dr. Joyce E. Penner
University of Michigan

Dr. Soroosh Sorooshian
University of California, Irvine

Dr. Graeme L. Stephens
Jet Propulsion Laboratory

Dr. Byron D. Tapley
The University of Texas at Austin

Dr. W. Stanley Wilson
NOAA/NESDIS, Retired

Steering Committee Staff

Dr. Arthur Charo
Study Director

Ms. Lauren Everett
Program Officer

Mr. Charles Harris
Research Associate

Dr. Michael Moloney
Director, Space Studies Board

Survey Initial RFI

responses at: www.nas.edu/esas2017

Issued in late September 2015 to inform the steering committee and the organization of the panels:

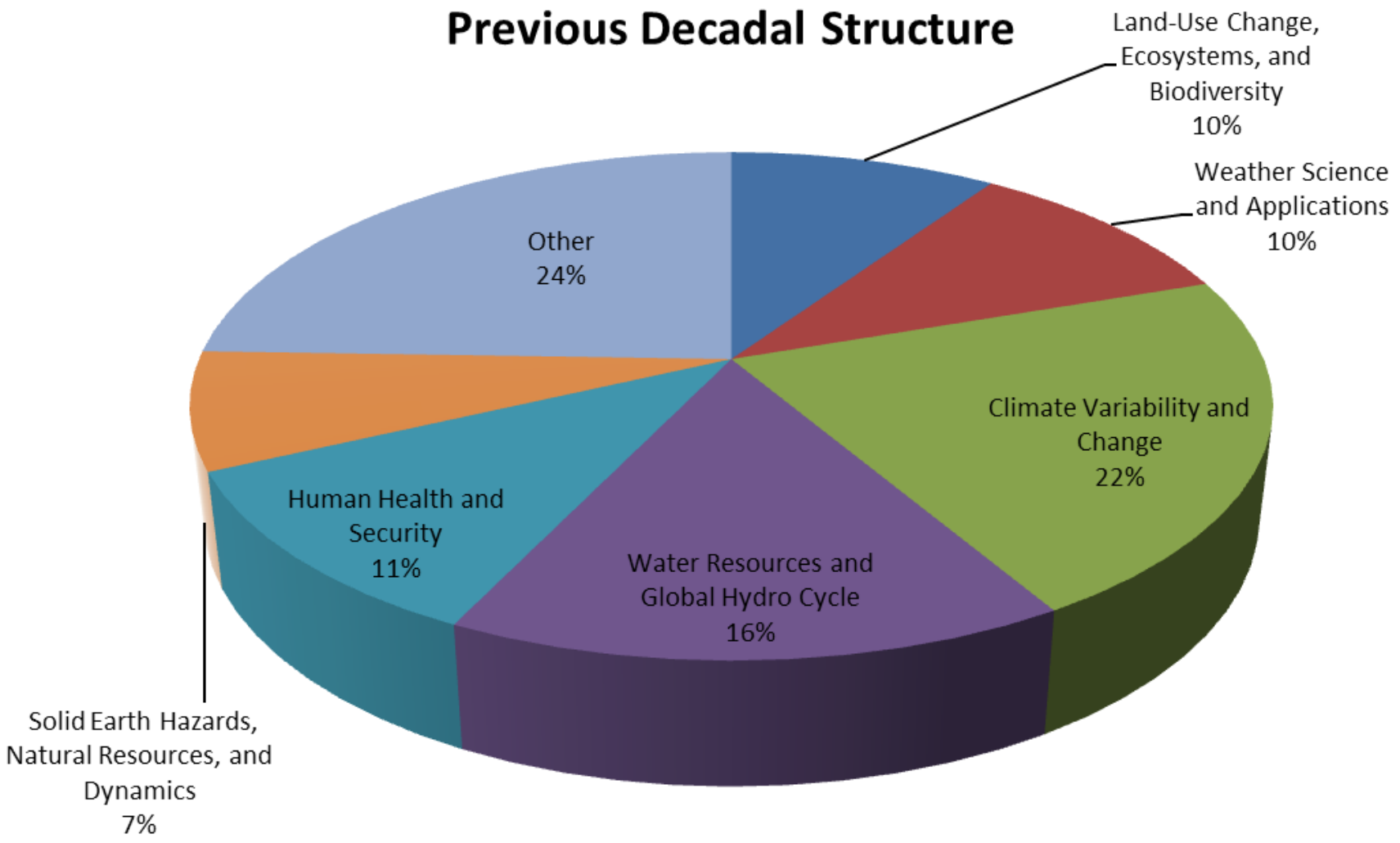
1. What are the key challenges or questions for Earth System Science across the spectrum of basic research, applied research, applications, and/or operations in the coming decade?
2. Why are these challenge/questions timely to address now especially with respect to readiness?
3. Why are space-based observations fundamental to addressing these challenges/questions?

Study Panel Organization

TBD, however:

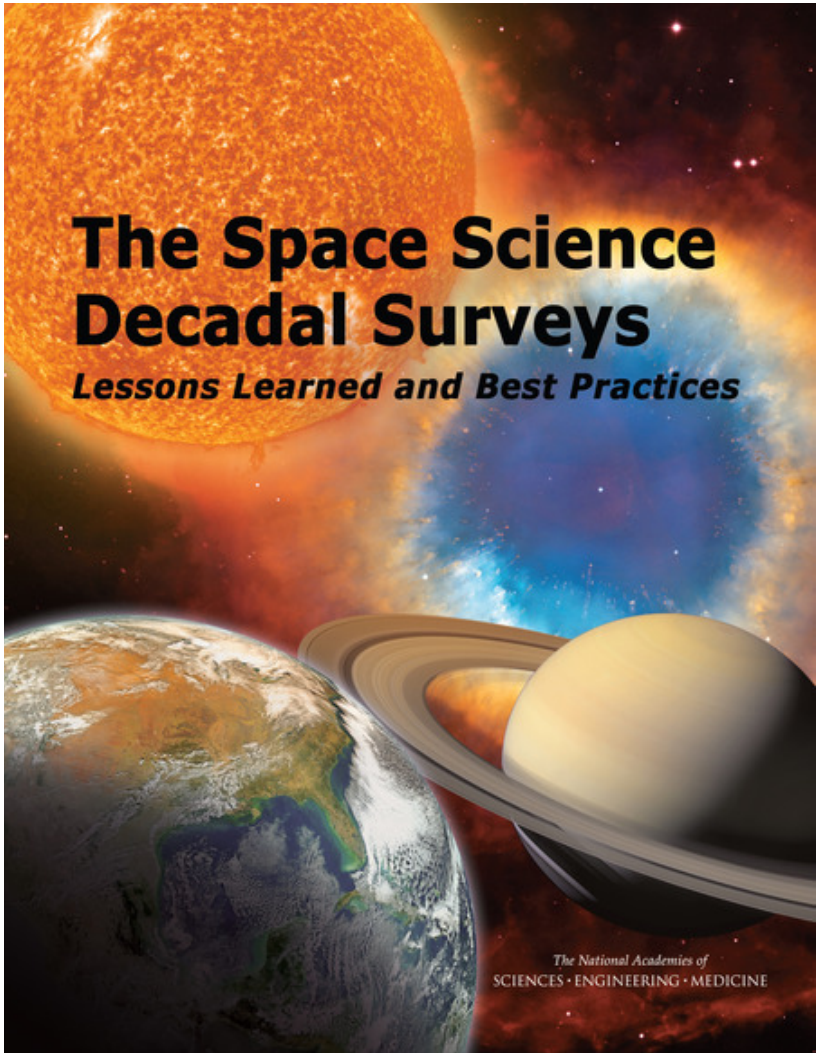
- While addressing Earth System Science, should provide the opportunity for input from traditional disciplines
  - Organize by societal benefit areas, key science questions, fundamental couplings within the Earth System, or traditional disciplines?
  - Adapt matrix model of overarching survey committee, supported by panels, but also the possibility of cross-cuts or limited term working groups?
    - Should ESAS 2017 also have topical focus groups on key, policy-relevant questions such as sea-level rise, extreme weather events, changes in freshwater availability, etc.?

RFI Categories: Previous Decadal Structure



ESAS 2017 Timeline

- Provision of funds/Formal Start — August 17, 2015
- Appointment of survey chairs — August 20, 2015
- First RFI (ESS objectives) — September 28, 2015
- Steering Committee (SC) approved — December 2, 2015
- Panels appointed — early 2016
- Town Halls: AGU, AMS, Ocean Sciences — Dec. 14th, Jan. 13th, and Feb. 22nd
- First meeting of the SC — January 18-20, 2016 in Washington DC
- Second RFI (targets/implementation focus?) likely timed to front-end panels
- SC Meetings 2-4 — 2016
- SC Meetings 4-6 — by end of April 2017
  - Additional splinter meetings likely
- Panel Meetings — 3 in 2016; 1st targeted for April
- Panel Outputs to Steering Committee — NLT January 2017
- Pre-Pub Report approval — NLT July 31, 2017



COMMITTEE ON SURVEY OF SURVEYS: LESSONS LEARNED FROM THE DECADAL SURVEY PROCESS

ALAN DRESSLER, Observatories of the Carnegie Institution for Science, Chair
DANIEL N. BAKER, University of Colorado Boulder
DAVID A. BEARDEN, The Aerospace Corporation
ROGER D. BLANDFORD, Stanford University
STACEY W. BOLAND, Jet Propulsion Laboratory
WENDY M. CALVIN, University of Nevada, Reno
ATHENA COUSTENIS, National Centre for Scientific Research of France
J. TODD HOEKSEMA, Stanford University
ANTHONY C. JANETOS, Joint Global Change Research Institute
STEPHEN J. MACKWELL, Lunar and Planetary Institute
J. DOUGLAS MCCUISTION, X-energy, LLC
NORMANL H. SLEEP, Stanford University
CHARLES WOODWARD, University of Minnesota
THOMAS YOUNG, Lockheed Martin Corporation (retired)

Staff:
DAVID H. SMITH, Senior Program Officer, Study Director
DIONNA J. WILLIAMS, Program Coordinator
CATHERINE A. GRUBER, Editor
KATIE E. DAUD, Research Associate
ANGELA M. DAPREMONT, Lloyd V. Berkner Space Policy Intern

MICHAEL H. MOLONEY, Director, Space Studies Board

http://www.nap.edu/
Search for report 21788

About the Study

- Follow-on to the November 2012 Workshop “Lessons Learned in Decadal Planning in Space Science”
- Collects lessons learned from planetary, heliophysics, astronomy & astrophysics, and Earth science experiences with decadal surveys and mid-term assessments
- Written with future survey committees in mind
  - “Handbook” approach
  - Time-ordered discussion with collection of lessons learned and best practices as an appendix

U52A: The Concept and Conduct of Decadal Surveys and Strategies for Developing Research Priorities

Friday, 18 December 2015
10:20 - 12:20
Moscone South- 102

Near-term Considerations for the Earth Science Decadal

- Budget
  - Historical vs. aspirational
- CATE & Mission Recommendations
  - Need for clear communication of intent (Reference Missions vs. Implementation Recommendations)
  - High-Profile Missions & need for decision rules
- Interagency Challenges
  - Three sponsoring agencies

A Framework for Analyzing the Needs for NASA-Sustained Remote Sensing Observations of the Earth: Background

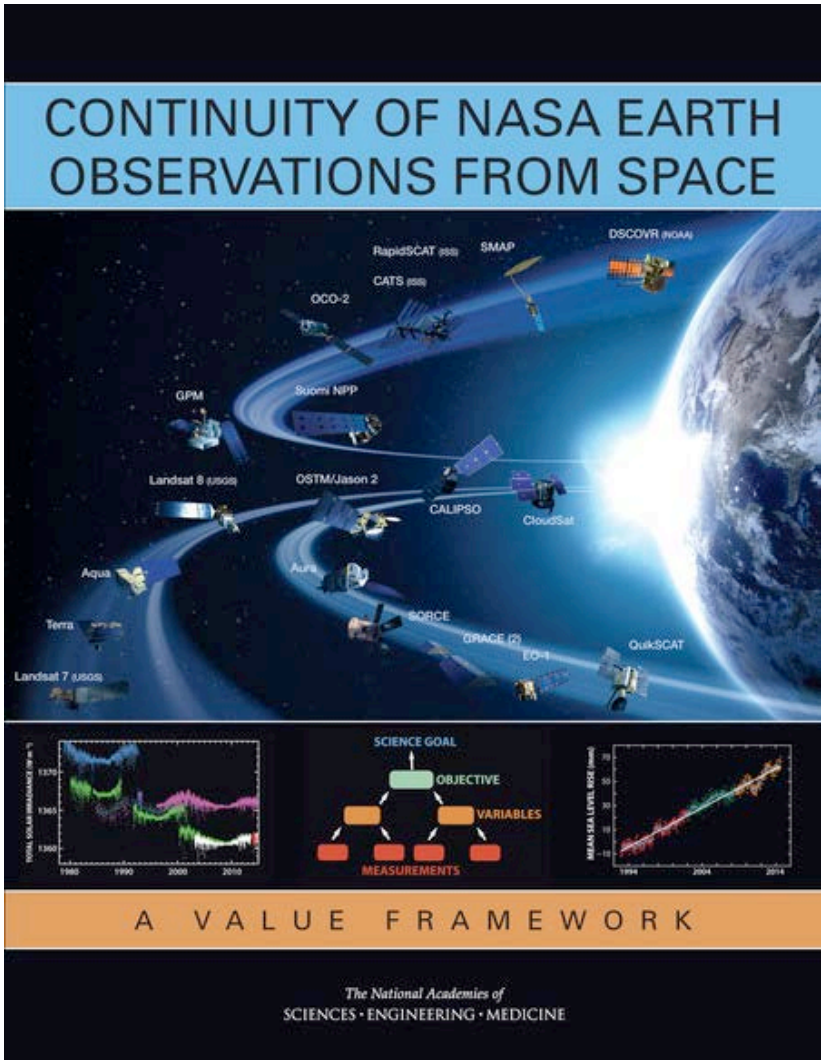
- **NASA's Earth Science Division (ESD) faces difficult choices among competing priorities, including new responsibilities, without commensurate budget increases, for the continuation of existing measurements and developing new measurement capability to address new research priorities**
- **The problem is compounded by responsibility for existing missions from:**
  - ***Foundational Continuity Measurements*: Stratospheric and Upper Tropospheric Ozone (OMPS-L), Solar Irradiance (TSIS), Earth Radiation Budget (CERES), and Ocean Altimetry (Jason-3 FO)**
  - ***2010 Climate Architecture*: Global Temporal Mass Change(GRACE – FO, Polar Ice Mass Change(ICESat-2), Ocean Color and Clouds/Aerosols (PACE), Ozone and Aerosols(SAGE III) and Atmospheric CO_2(OCO-2)**
  - ***Federal Concerns:* Landsat Data Continuity (Landsat-8 FO)**
- **In 2013, at the request of the ESD, an ad hoc committee of the Academies was convened to recommend a framework for deciding when an ESD measurement or dataset should be collected for extended periods.**

STUDY COMMITTEE

BYRON D. TAPLEY, Univ. of Texas at Austin, Chair
MICHAEL D. KING*, Univ. of Colorado, Boulder, Vice Chair
MARK R. ABBOTT*, Oregon State University
STEVEN A. ACKERMAN*, University of Wisconsin, Madison
JOHN J. BATES, NOAA/NESDIS National Climate Data Center
RAFAEL L. BRAS, Georgia Institute of Technology
ROBERT E. DICKINSON, University of Texas at Austin
RANDALL R. FRIEDL, Jet Propulsion Laboratory
LEE-LUENG FU*, Jet Propulsion Laboratory
CHELLE L. GENTEMANN*, Remote Sensing Systems
KATHRYN A. KELLY, University of Washington
JUDITH L. LEAN, Naval Research Laboratory
JOYCE E. PENNER*, University of Michigan
MICHAEL J. PRATHER, University of California, Irvine
ERIC J. RIGNOT, University of California, Irvine
WILLIAM L. SMITH, Hampton University
COMPTON J. TUCKER, NASA Goddard Space Flight Center
BRUCE A. WIELICKI, NASA Langley Research Center

Staff

ARTHUR A. CHARO, Senior Program Officer, Study Director
LEWIS B. GROSWALD, Associate Program Officer



http://www.nap.edu/catalog/21789/continuity-of-nasa-earth-observations-from-space-a-value-framework

* Represents members of CESAS, the oversight committee for the decadal survey

Summary of the Study

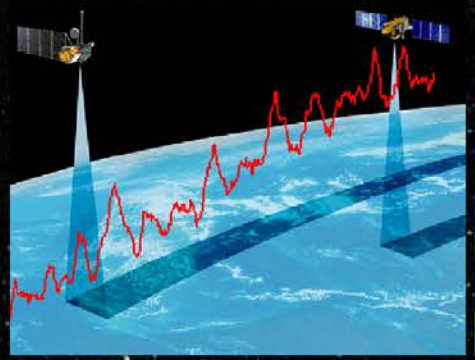
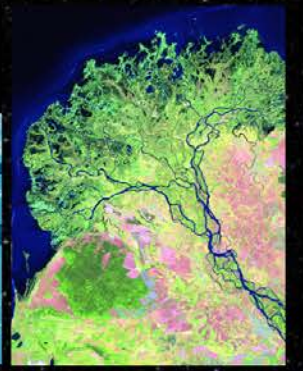
- **NASA ESD is in a capped budget environment**
  - **Increasing demand for implementation of new measurements**
  - **Growing demand for continuing important measurements from current mission suite**
    - **-- Executive and Congressional Branch priorities**
    - **-- ESD Program Plans**
    - **-- Survey from NRC Decadal Survey**
    - **-- International Collaboration opportunities**
- **Response to the study charge is constrained to Climate Change focus**
  - **Most demanding requirements and likely largest set of actionable options**
  - **Include issues of instrument performance, stability, cross calibration and the data issues associated with algorithm change in processing and reprocessing**
- **Recommendations focus is on the *measurements required to determine geophysical variables*, not on instruments or missions**
  - **NRC Decadal Survey will recommend a prioritized set of science objectives and associated geophysical variables**
  - **ESD will provide the instrument and missions required to meet the science objectives.**
- **Emphasis placed on quantitative decision approaches**
  - **A valuation framework is recommended, but implementation data base still needs development**

ESAS 2017
Challenges and Considerations

- Budget
  - Historical vs. Aspirational—Even Inspirational—and Being Realistic
- "CATE" and Recommendations to NASA:
  - Reference Missions vs. Implementation
  - High-profile missions & need for decision rules
- For NOAA and USGS:
  - Actionable recommendations to improve services
- A Question of Balance:
  - Across societal benefit areas, application science, size/class of missions
  - Balance is also required across R+A, technology development, and the missions themselves, i.e., flight/non-flight

EARTH SCIENCE AND APPLICATIONS FROM SPACE



DECADAL SURVEY 2017-2027

Survey Information: www.nas.edu/esas2017
Survey Mailbox: ESAS2017@nas.edu

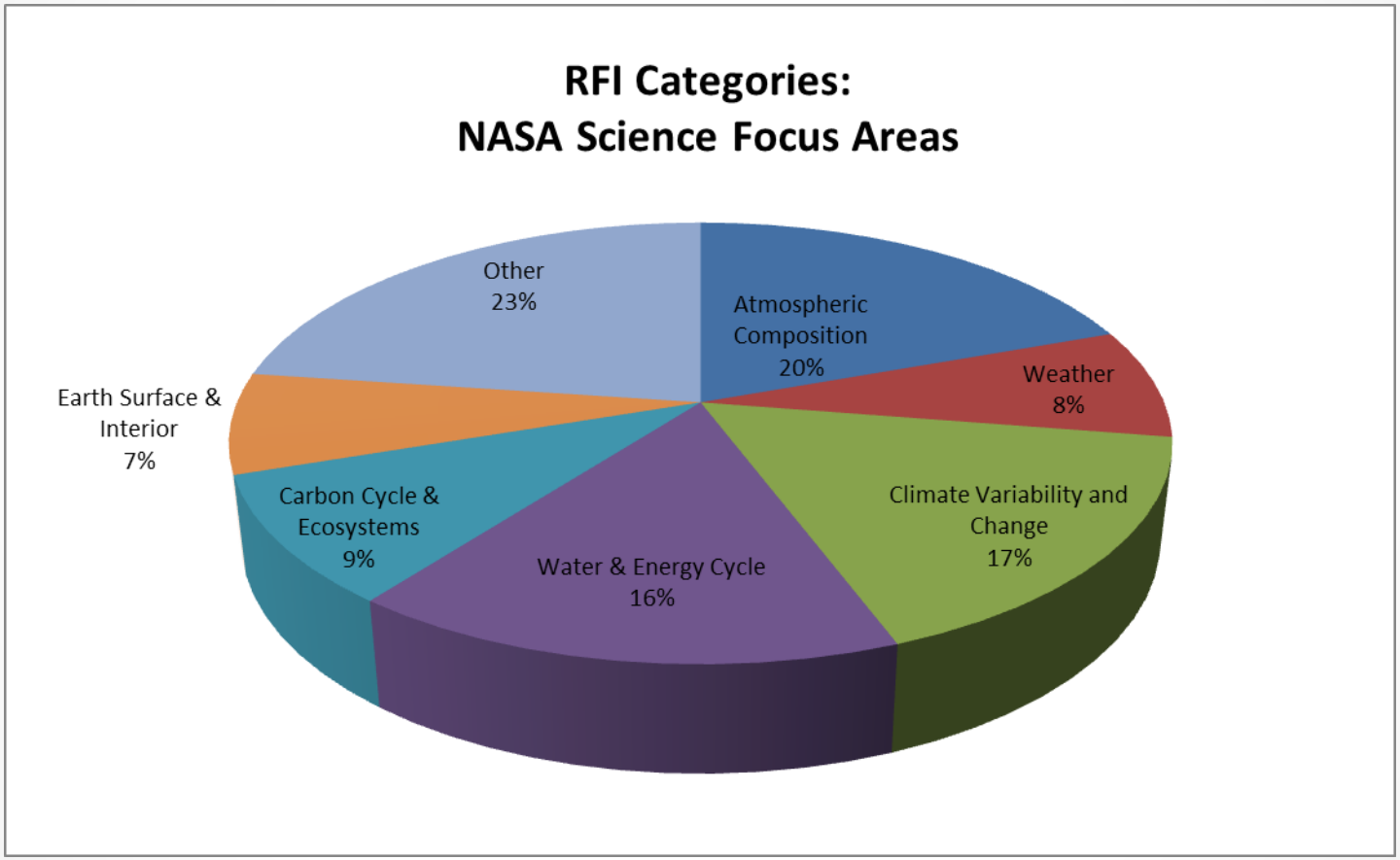
Comments Welcome-Participation Needed!

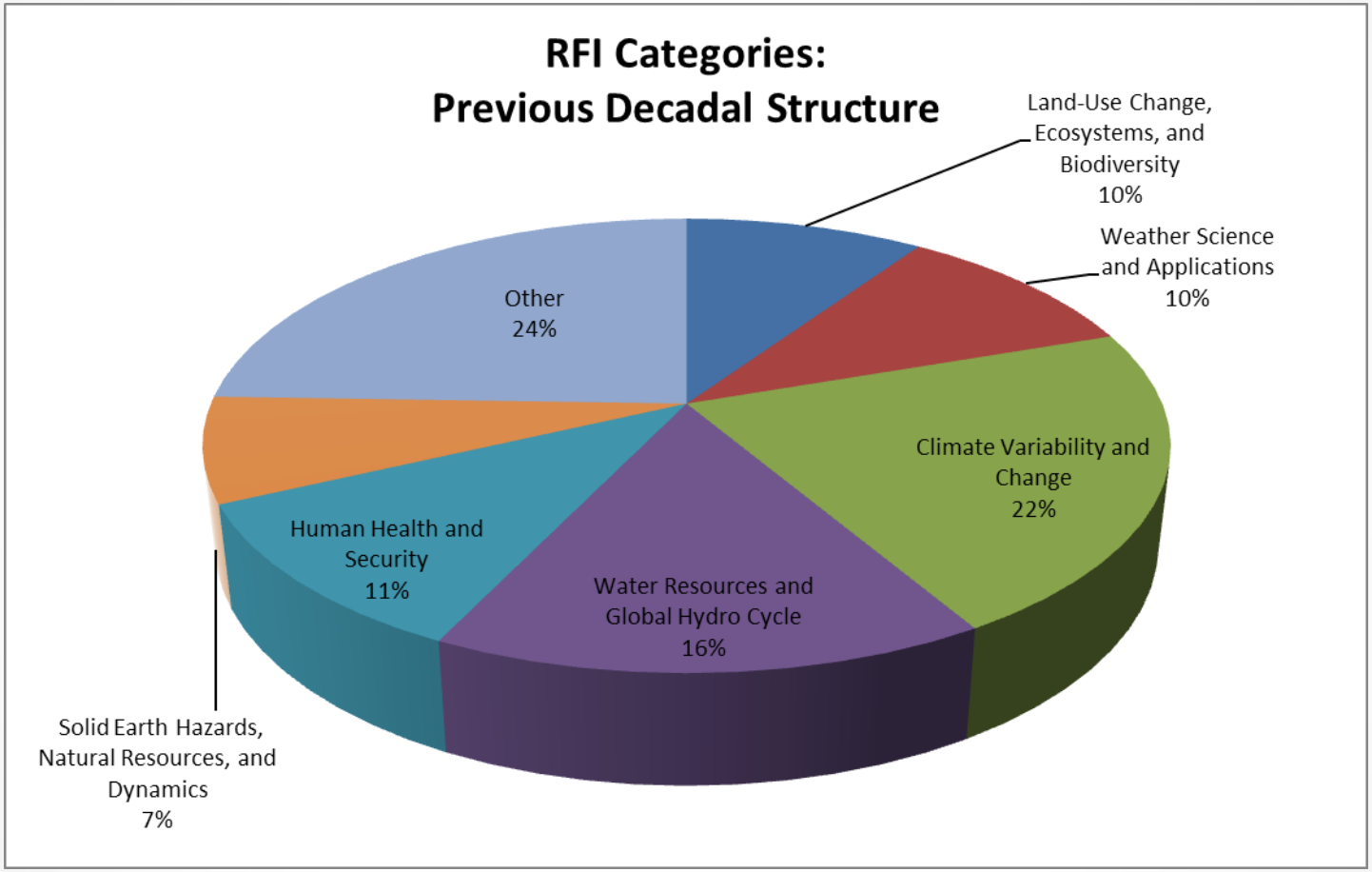
BACKUP SLIDES

What Happens to Missions Recommended in the Previous Survey?

TBD, but:

- In developing its recommendations, survey to "include reconsideration of the scientific priorities associated with the named missions from the 2007 decadal survey."
  - The 2007 survey did not prioritize among the 15 missions for NASA; placement in 1 of 3 time periods (Tiers I, II, III: 2010-13, 2013-2016, 2016-2020) based on factors including technical readiness; cost; synergy with existing, planned, or recommended missions; and consideration of int'l activities.
- ESD has expressed an interest in having the survey provide guidance on technology investments that will be needed to address recommended science targets.
- Previous surveys treated missions in formulation as part of the baseline program of record—they were not prioritized.


RFI Categories:
NASA Science Focus Areas
Other
23%
Atmospheric
Composition
20%
Weather
8%
Earth Surface &
Interior
7%
Carbon Cycle &
Ecosystems
9%
Water & Energy Cycle
16%
Climate Variability and
Change
17%


RFI Categories:
Previous Decadal Structure
Land-Use Change, Ecosystems, and Biodiversity 10%
Weather Science and Applications 10%
Climate Variability and Change 22%
Water Resources and Global Hydro Cycle 16%
Human Health and Security 11%
Solid Earth Hazards, Natural Resources, and Dynamics 7%
Other 24%

WHY UNDERTAKE A "DECADAL SURVEY"

- Take a long-term look at the field and recommend top priority scientific goals and directions for the future;
- Direct recommendations to the principal agencies that support facilities and research in the relevant fields;
- Provide recommendations for programmatic directions and explicit priorities for government investment in research facilities, including space flight missions; and
- Address issues of advanced technology, infrastructure, interagency coordination, education, and international cooperation.

Facilitates Planning, Coordination, Advocacy, and Outreach

Study Panels for ESAS 2007

1. Earth Science Applications and Societal Needs
   - » Tony Janetos, PNL/Univ. of Maryland, chair
   - » Roberta Balstad, Columbia Univ, vice-chair
2. Land-use Change, Ecosystem Dynamics and Biodiversity
   - » Ruth DeFries, Columbia, chair
   - » Otis Brown, Univ. of Miami, vice-chair
3. Weather (including space weather and chemical weather)
   - » Susan Avery, Univ. of Colorado, chair
   - » Tom Vonder Haar, Colorado State, vice-chair
4. Climate Variability and Change
   - » Eric Barron, Penn State, chair
   - » Joyce Penner, Univ. of Michigan, vice-chair
5. Water Resources and the Global Hydrologic Cycle
   - » Dennis Lettenmaier, Univ. of Washington, chair
   - » Anne Nolin, Oregon State Univ., vice-chair
6. Human Health and Security
   - » Mark Wilson, Univ. of Michigan, chair
   - » Rita Colwell, Univ. of Maryland, vice-chair
7. Solid-Earth Hazards, Resources and Dynamics
   - » Brad Hager, MIT, chair
   - » Susan Brantley, Penn State, vice-chair

2007 ESAS Decadal Survey Final Report

- Overarching recommendation: *Renew investment in satellite Earth observing systems*
- Recommended specific, integrated mission suite
  - Rolled-up panel recommendations preserve highest priorities
  - Sequenced 2010-2020+ launches
  - Full execution of the plan over the decade required NASA ESD yearly budgets to increase by ~ $550M and remain steady at this level (approximately equal to the budget in 2000)
- Guidance on actions to take in the event of budget shortfalls or technology problems

Recommendations build on current instruments & offer a new level of integration to address key science & yield critical societal benefits

Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (January 2007)

- Referring to the 2005 interim report's warning of a system in danger of collapse, the 2007 final report stated:

  "In the short period since the Interim Report, budgetary constraints and programmatic difficulties at NASA 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."

Agency-Specific Tasks-I

NASA

- Recommend NASA research activities to advance Earth system science and applications by means of a set of prioritized strategic "science targets" for the space-based observation opportunities in the decade 2018-2027. (A science target in this instance comprises a set of science objectives that could be pursued and significantly advanced by means of a space- based observation.) …… For each science target, the committee will identify a set of objectives and measurement requirements/capabilities for space-based data acquisitions.

  If appropriate and usually only for recommendations associated with major investments, the committee will (via a "CATE" process) assemble notional proof-of-concept missions with the recommended capabilities in order to better understand the top-level scientific performance and technical risk options associated with mission development and execution.

- Other NASA tasks include: The committee will pay particular attention to prioritizing and recommending balances among the full suite of Earth system science research, technology development, flight mission development and operation, and applications/capacity building development conducted in the Earth Science Division (ESD) of the Science Mission Directorate.

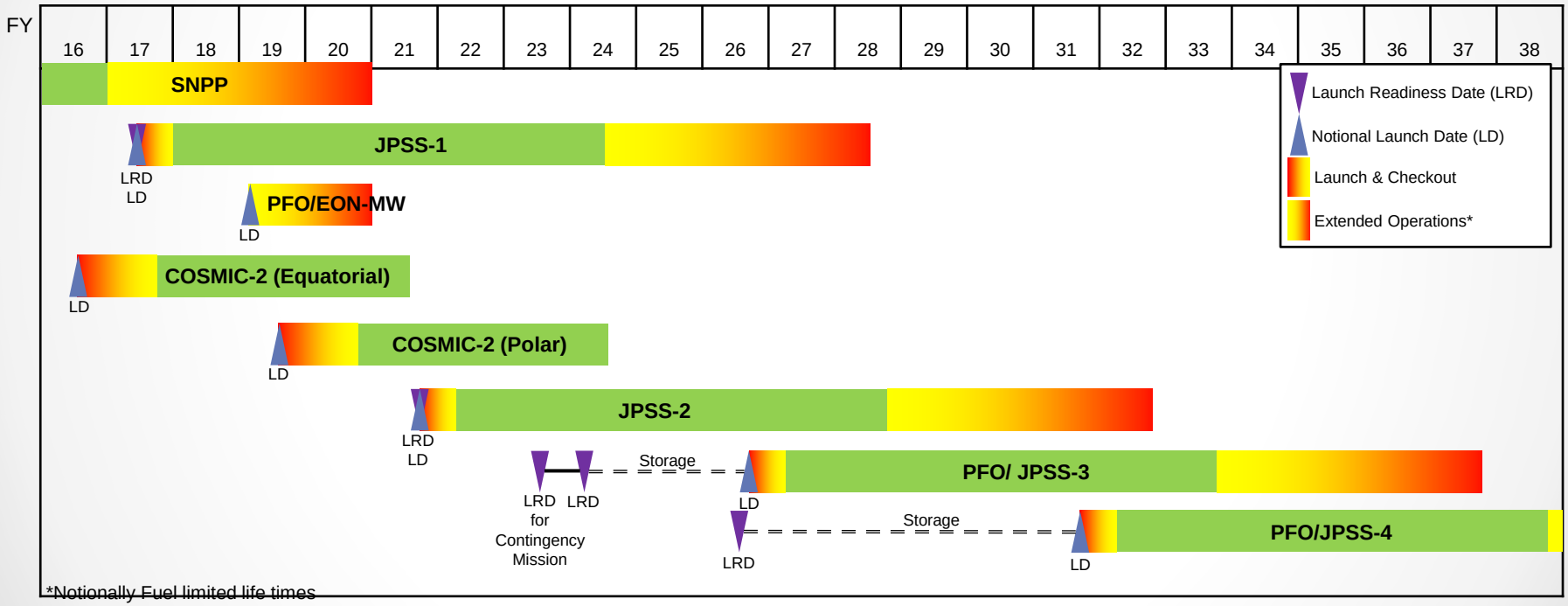
Agency-Specific Tasks-II

NOAA & USGS

- The decadal survey committee's recommendations will be framed around national needs, including, but not limited to research priorities. …. Recommendations may be organized around 1) how new technology may enhance current operations, and 2) what new science is needed to expand current operations, either to enable new capabilities or to include new areas of interest. In making these recommendations, the committee will consider the need to bridge current operations and support a viable path forward for the uninterrupted delivery of public services through these generational changes.

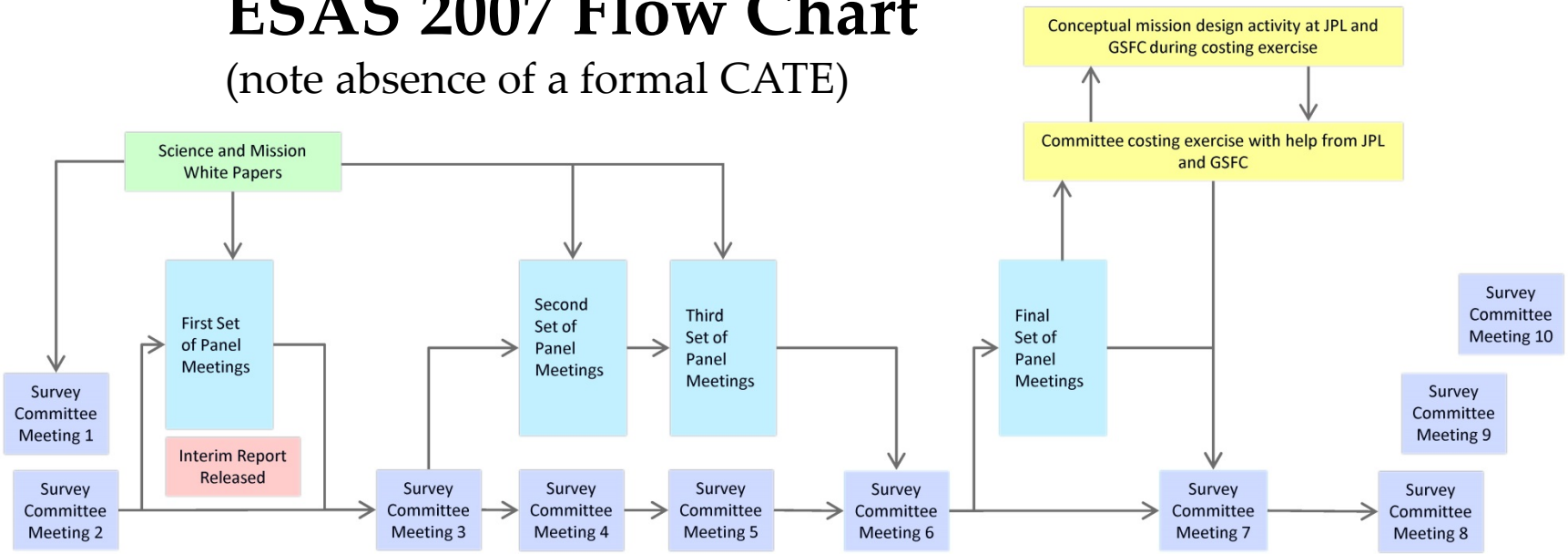
- Other tasks include: suggest approaches for evaluating and integrating new capabilities from non traditional suppliers of Earth observations; may offer recommendations concerning "research to operations" (or "innovation for continuity and service improvements across agencies"); and consider the agencies' ability to replicate existing technologies to improve and sustain operational delivery of public services.

NOAA NESDIS' Plan for Polar Continuity



ESAS 2007 Flow Chart

(note absence of a formal CATE)



Personal solicitations and a community-wide request for information, released following the second meeting of the survey committee, leads to the generation of white papers relating to science and mission activities. An interim report is issued following the second meeting of the survey committee. The first panel meetings are held.

Fourth meeting of the survey committee coincides with the second set of panel meetings. Panels hear briefings, assess science and mission activities proposed in white papers, and hear from the authors of selected white papers.

Fifth meeting of the survey committee coincides with the third set of panel meetings. Assessment of white papers continues. Conceptual missions are devised.

The final panel meetings are held in Spring 2006. NASA mission designers assist the survey committee in developing a budget spreadsheet to determine the likely costs of mission components (e.g., instruments, spacecraft, launch vehicle, integration and test, ground data system, mission operations, data downlink and archiving, science team, and data validation). At the seventh meeting of the survey committee in May 2006, the panels present their prioritized missions. The survey committee sets the final science and mission priorities. Three subsequent meetings are devoted to the drafting of the survey report. Report is delivered to sponsors in January 2007.