Key Issues and Challenges for the Decadal Survey for Earth Science and Applications from Space – ESAS 2017

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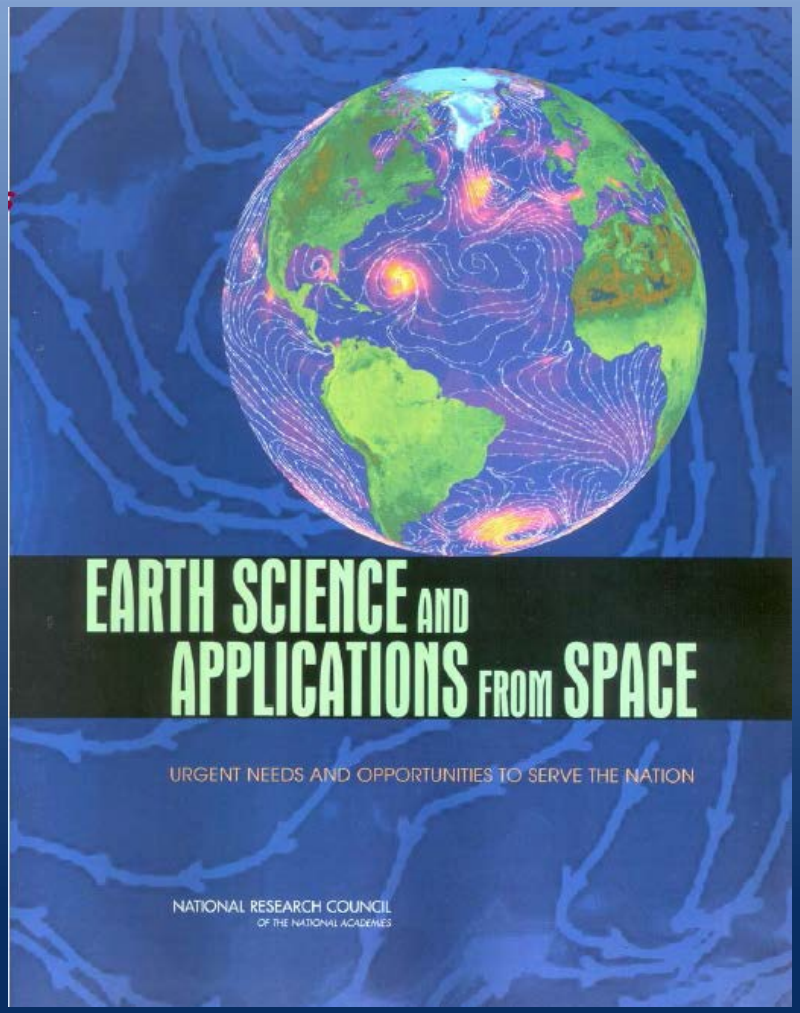
Vision of the Inaugural Decadal Survey

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



The first National Research Council (NRC) decadal survey in Earth science and applications from space, completed in 2006 and published in January 2007, recommended a balanced interdisciplinary program that would observe the atmosphere, oceans, terrestrial biosphere, and solid Earth, and the interactions between these Earth system components, to advance understanding of how the system functions for the benefit of both science and society.

The world faces significant environmental challenges: shortages of clean and accessible freshwater, degradation of terrestrial and aquatic ecosystems, increases in soil erosion, changes in the chemistry of the atmosphere, declines in fisheries, and the likelihood of substantial changes in climate.

These changes are not isolated; they interact with each other and with natural variability in complex ways that cascade through the environment across local, regional, and global scales.

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."

US Missions

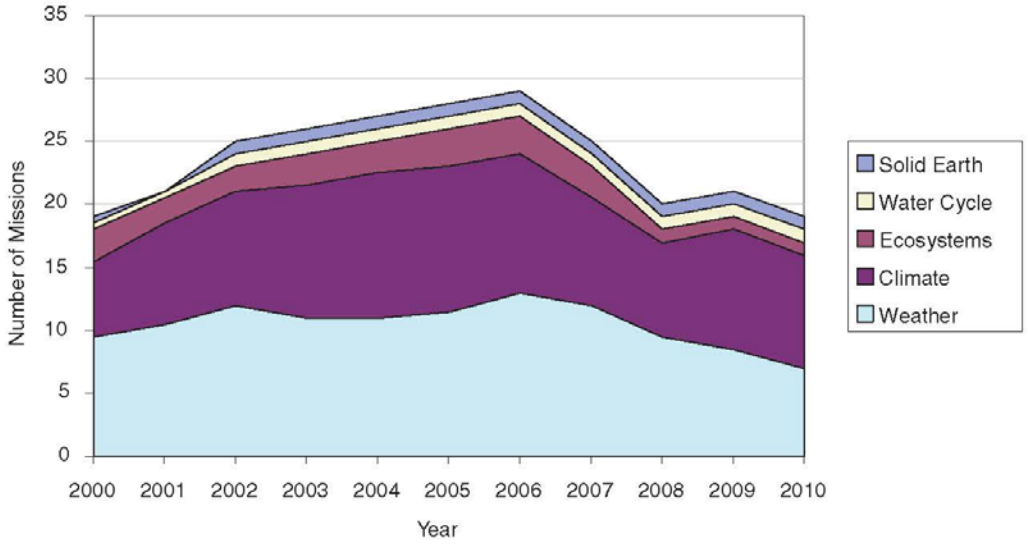


FIGURE ES.1 Number of U.S. space-based Earth observation missions in the current decade. An emphasis on climate and weather is evident, as is a decline in the number of missions near the end of the decade. For the period from 2007 to 2010, missions were generally assumed to operate for 4 years past their 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

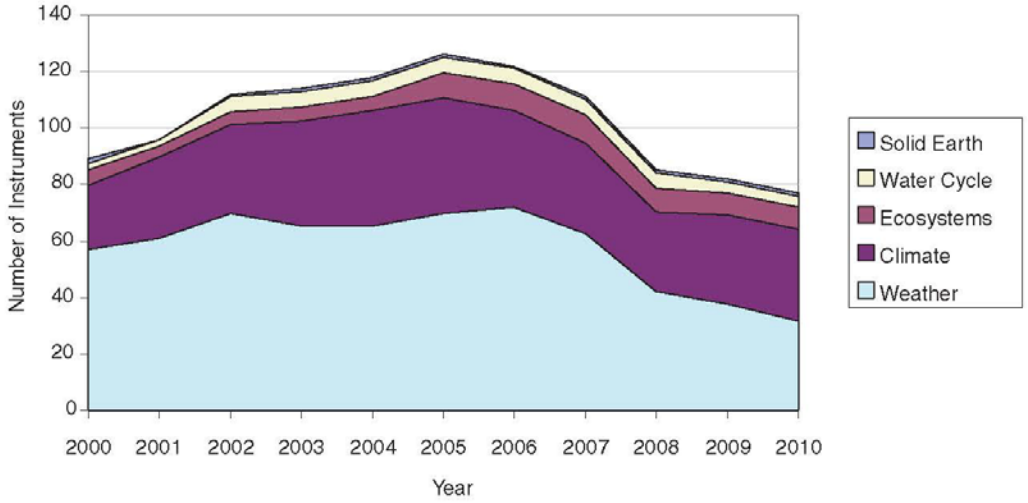


FIGURE ES.2 Number of U.S. space-based Earth observation instruments in the current decade. An emphasis on climate and weather is evident, as is a decline in the number of instruments near the end of the decade. For the period from 2007 to 2010, missions were generally assumed to operate for 4 years 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.

ESAS 2017

- Sponsors:
  - NASA-Earth Science Division;
  - NOAA-NESDIS; and
  - USGS, Climate & Land Use Change

Backdrop: In Addition to Tight Budgets…

- **NASA**: Has a backlog of missions recommended in the inaugural survey as well as increased responsibilities—without commensurate budget increases— starting after the JPSS-1 era for vertical profiles of stratospheric and upper tropospheric ozone, solar irradiance, Earth radiation budget measurements, and altimetry (beyond Jason-3).

- **NOAA**: Stabilizing the weather satellite portfolio and avoiding a potential gap between the NPP spacecraft and the first of the next-generation POES systems, JPSS-1, is a top priority. "Climate"-related instruments moving to NASA.

- **USGS**: Landsat-8 launched Feb. 2013. USGS interested in future capabilities for a sustained land-imaging imaging program. However, Landsat-9 is projected to be a near-rebuild of L-8 for launch in in 2023. (TIRS on L-8 only has 3-year design life; NASA looking at Class-D TIR free-flyer for 2019 launch, but Senate & House have rejected this option and instead ask for acceleration of launch date for L-9.)

ESAS 2017 vs. ESAS 2007

- No longer appropriate to base recommendations on an aspirational budget
- Congressionally-mandated independent Cost and Technical Evaluation (CATE) for big ticket items
- Balance across Earth System Science will likely 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 (2013); 2nd Assessment due 06-16

NATIONAL STRATEGY FOR CIVIL EARTH OBSERVATIONS

Executive Office of the President
National Science and Technology Council

APRIL 2013

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.

New Technologies and Platforms

Will consider the agencies' ability to replicate existing technologies to improve and sustain operational delivery of public services, and also to produce consistent and reliable science and applications data products across different generations of measurement technology, as new measurement innovations are introduced.

Equally important are the roles of new technology and risk tolerance; identifying mission architecture options; outlining choices on the allocation of the overall budget into proportionate pools for small, medium or large missions, or continuous and research and application missions; implementing cost caps and a decision-tree process in the event of cost overruns; and maintaining a solid base for research and analysis

Suggest approaches for evaluating and integrating new capabilities from non traditional suppliers of Earth observations;

Context for "New Space" Options in the 2017-2027 Decadal Survey for Earth Science and Applications from Space

- Highly constrained agency budgets for the foreseeable future
  - NASA's Earth Science budget under particular scrutiny, but to date has stayed roughly level
  - NOAA has limited budget flexibility; budgets driven by requirements for JPSS and need to avoid a gap in the polar orbiters
  - Congress had asked for Landsat-9 options at significantly reduced cost, but has since backed off; plans for L-9 are to be a L-8 clone at similar cost

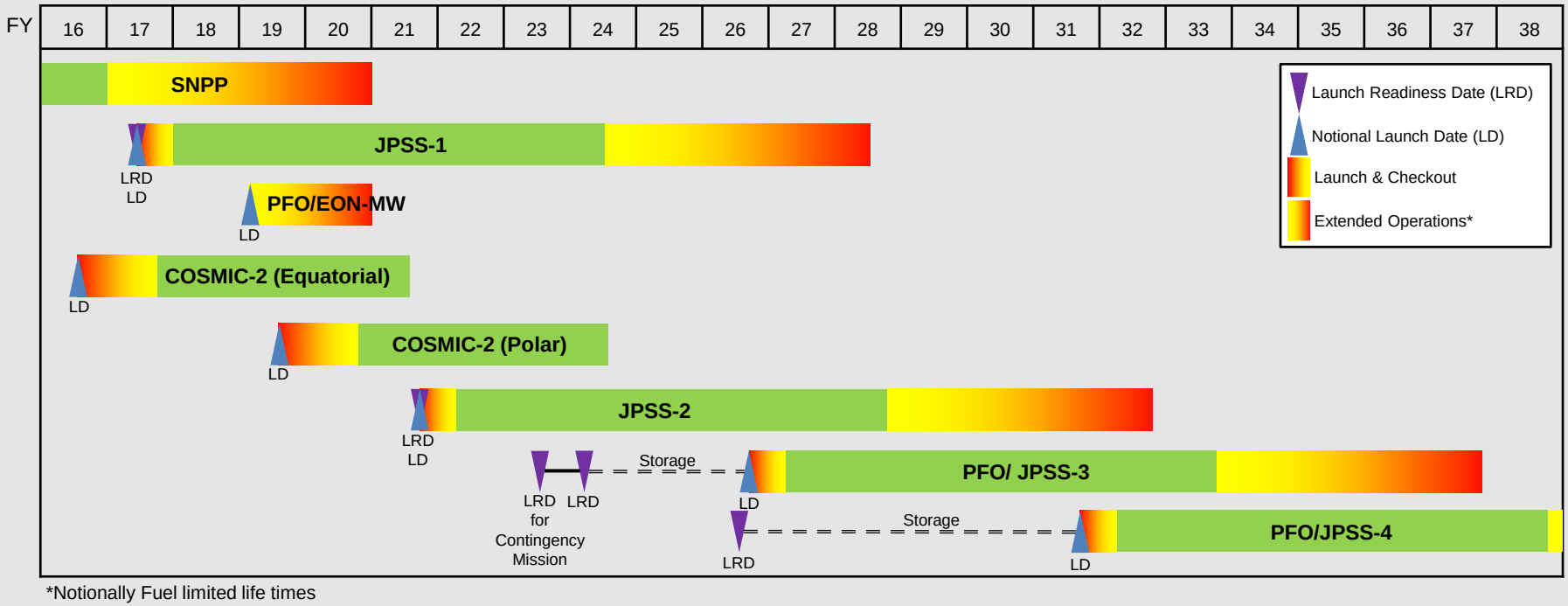
- Backlog of missions for NASA from the inaugural survey and those executed are costing 2x or more than forecast by the survey

- NASA has increased responsibility, but not commensurate budget increases, for "continuity" missions formerly assigned to NOAA: total solar irradiance, ocean surface topography, ozone profile, and Earth radiation budget

"New Space" ideas—new players, smaller and less costly platforms (including CubeSats), constellations, and hosted payloads—as well as small PI-led programs (e.g., NASA's Venture-class) and additional use of the ISS platform hold promise to accomplish "more for less."

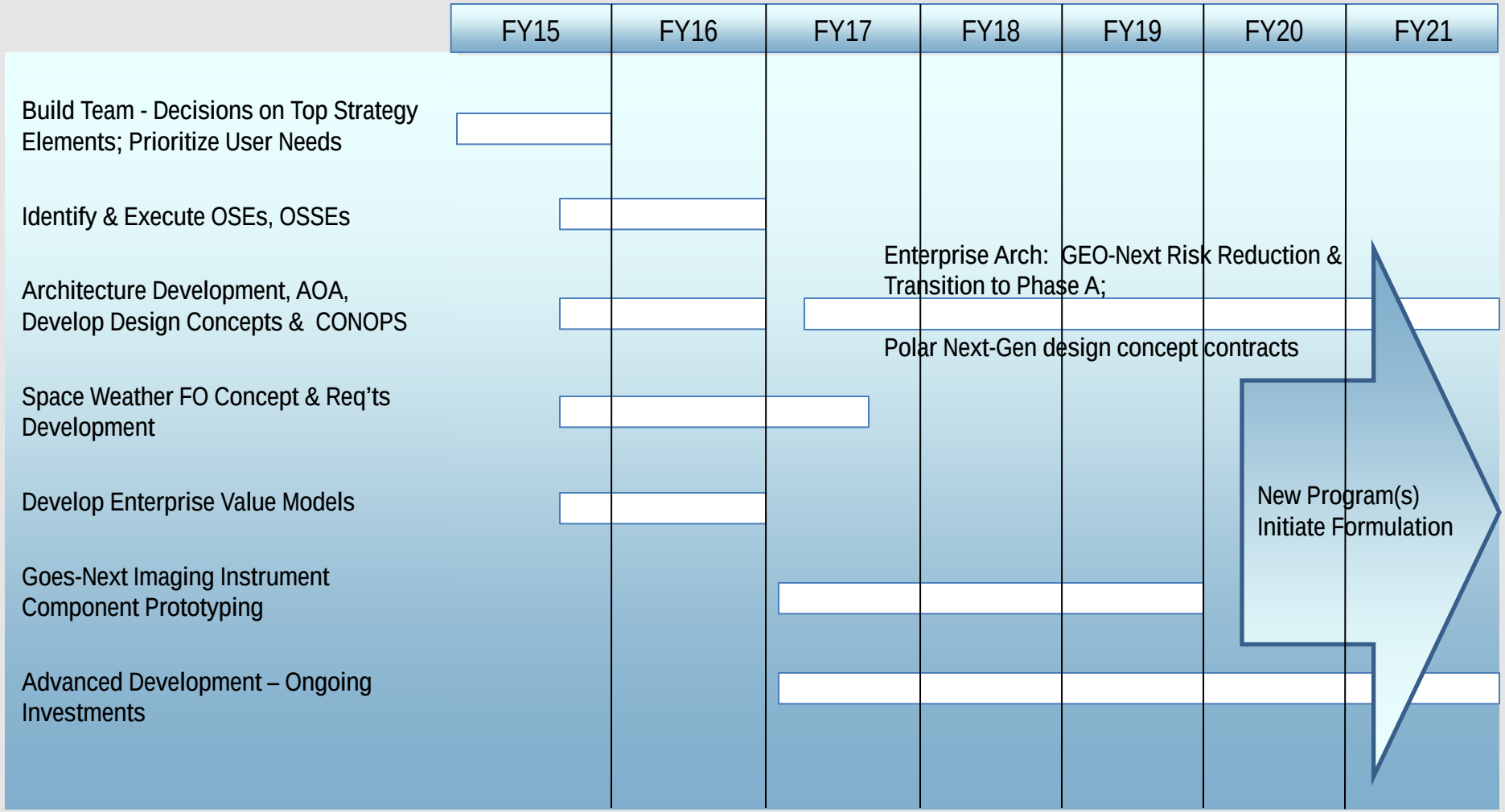
Earth Science Missions and Instruments

NOAA NESDIS plan for polar continuity



*Notionally Fuel limited life times

Notional Next Gen Space Plan



Key Issues and Challenges for ESAS 2017

At the highest level the next survey must answer:

• What are the leading ESS scientific questions/challenges/goals for the decade ahead?, i.e., What is the state of our science inclusive of, applications of our science? Everything must flow from that.

• Science Questions must drive the measurements

• What then are the measurements that are needed? What technologies are needed? What methodologies/architectures are needed with sufficient definition to be costed without being so prescriptive that we fall back onto proposed named missions.

• Given that we are going to be cost constrained, what is the science that needs to be preserved within certain cost envelopes (small, medium, large, center vs competed, venture class, etc) without prescribing detailed implementation recommendations?

Key Issues and Challenges for ESAS 2017

The importance of Input/Engagement from the outset:

• There is going to be a need for full community engagement and buy in from the very beginning. The DS **must** be inclusive.

• This means buy in from the community in the broadest sense: academia, industry, government, scientific organizations

• There will be a need to engage the smaller aerospace companies or the new space world as it is, i.e., next gen technologies

• White papers will be required on science questions and implementation strategies for the next decade.

• Town Hall meetings already scheduled at AGU, AMS, Ocean Sciences

• Need to engage international community

Key Issues and Challenges for ESAS 2017

The importance and challenges of balance:

• A major challenge for any DS is striking the right balance between being aspirational ….even inspirational, and being realistic.

•The Earth System Science that needs to be done will always be more than the available resources. Hence a major challenge will be the process of narrowing down to the key science questions/objectives, then the measurements/missions commensurate with a realistic budget profile

• For Earth Science a robust and balanced program spans exploratory, sustained, operational missions, or put another way, operational weather, sustained climate and land imaging, and earth science missions

• 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

•Given all of the above, it is easy to say there is a need for a balanced program, but such claims in a study report run the risk of being vague, difficult to understand, implement, and evaluate without **specific** definition and guidance.

Key Issues and Challenges for ESAS 2017

Structure and approach to the ESAS 2017:

• I would argue THE Priority for the survey has to be on ESS, the structure needs to reflect this while also providing the opportunity for input from traditional disciplines

•What then is an appropriate structure for the next ES DS? Obviously, an overarching survey committee, supported by panels but also the possibility of crosscuts or limited term working groups

• The survey will need to assess what has changed since last DS: both gaps and opportunities

•The DS will require a structure that promotes integration, interaction, communication, and synergy across panels as a means of more effective and affordable implementation of ESS

•One among many questions that arises: Do you organize by societal benefit areas, key science questions, fundamental couplings within the Earth System, or traditional disciplines?

• Hence a challenge is to balance across disciplines and the advocacy of their needs while maintaining synergy across the breadth and depth of ESS

Structure

ESAS 2007:

Earth Science Applications and Societal Benefits

Land-use Change, Ecosystems, and Biodiversity

Weather Science and Applications

Climate Variability and Change

Water Resources and Global Hydro Cycle

Human Health and Security

Solid Earth Hazards, Natural Resources, and Dynamics

Societal Benefit Areas

Key Issues and Challenges for ESAS 2017

Given constrained budgets, What can be afforded?

• The path we are on with Earth remote sensing is not sustainable, therefore ESAS 2017 will need to engage the "new wave" aerospace community be it smallsats, cubesats, formation flying, constellation, and suborbital approaches, etc

• ESAS 2017 will need to develop a realistic approach to the budget assumptions, is it some sort of baseline determined by the average of the past few years? A baseline plus aspirational?

• The survey will have to wrestle with identifying cost caps needed to maintain a balanced program

• Part of this process will need to take into account the fact that the NASA Queue is filled to 2020 or 2023, so what is left for the DS?

• Assessing the affordability of recommended missions is a major challenge

• To the extent possible, the survey will need to ensure that the mission costs, and associated risks considered during the prioritization process, are well understood

Key Issues and Challenges for ESAS 2017

Cost and Technical Evaluation (CATE) process and decision trees:

- This will be the first time an ES DS is subjected to the CATE process as required by the 2008 NASA Authorization Act

- Previous decadals for the other space science disciplines have demonstrated the need for an efficient CATE process, with fast turn around with more being done upstream

- The overall approach to CATE will require a clear flow from science objectives to measurement requirements to instrument and mission concepts. What is the appropriate scope of mission formulation and design activities will be a key question to be confronted.

- In terms of determining what is affordable this will require an assessment of the trade space spanning continuity, risk, technology, architecture, international contributions, etc

Key Issues and Challenges for ESAS 2017

Cost and Technical Evaluation (CATE) process and decision trees:

- Given past history with budget cuts, mission creep and/or cost growth, there is a clarion call for developing decision trees and frameworks to maintain programmatic balance in the context of ESS at all or any cost

- Related to this is the importance of clear decision rules and decision points to establish cost caps and off ramps, to be applied to adjust priorities and maintain programmatic balance if funding falls below projections or major technical or programmatic changes occur

- Hence the need to clearly articulate the minimum requirements underlying a mission concept, why it is needed, its priority, and decision rules for implementation

- Another aspect of affordability may require a tiered risk framework as there is a different tolerance of risk for exploratory vs say operational missions

Call for Nominations

The inaugural decadal survey of 2007 was accomplished with the help of some 100 scientists, engineers, and policy experts who volunteered their time and served on the survey's steering committee or one of 7 study panels.

We anticipate a similar need for this survey and seek nominees with a broad range of relevant expertise.

Service is open to scientists, engineers and other experts, including those working for a government agency if (1) they have relevant scientific and technical expertise needed to accomplish the committee's task, and (2) their service will not appear to compromise the independence and objectivity of the study.

http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_166359

Preparing for Initiation of the 2017-2027 NRC Decadal Survey in Earth Science and Applications from Space

Initial Request for White Papers

The present RFI is being issued to inform the initial organization and structure of the committee and panels that will conduct the survey, as well as to provide direct input to the work of those groups. Toward that end, we are requesting input from the broad community on the following questions:

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?

Why are these challenge/questions timely to address now especially with respect to readiness?

Why are space-based observations fundamental to addressing these challenges/questions?

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Preparing for Initiation of the 2017-2027 NRC Decadal Survey in Earth Science and Applications from Space

Initial Request for White Papers

Given the focus on the role of space-based observations, input is requested on:

Whether existing and planned U.S. and international programs will provide the capabilities necessary to make substantial progress on the identified challenge and associated questions. If not, what additional investments are needed?

How to link space-based observations with other observations to increase the value of data for addressing key scientific questions and societal needs;

The anticipated scientific and societal benefits; and

The science communities that would be involved.

http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_166359

Bottom Line

Decadal Survey for Earth Science and Applications from Space – ESAS 2017 to:

Recommend approaches to facilitate the development of a robust, resilient, and balanced U.S. program of Earth observations from space.