Science Mission Directorate

Earth System Data Records: Programmatic Considerations

MODIS Science Team Meeting @ BWI Marriot Hotel

March 23, 2005

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Earth-Sun System Division

Topics of this Discussion

- Framework Development for ESDRs
  (Review July 2004)
- Planning Challenges
- ESDR Implementation Options / Management
- Invitation for Input

ESDR Definition

An ESDR is defined as a unified and coherent set of observations of a parameter of the Earth system, which is optimized to meet specific requirements in addressing Earth science questions and/or provide for science applications.

In principle, ESDRs will extent the value of NASA's existing Data Products.

The primary motivation for this plan is the need to develop and generate a unified and coherent data record for a given Earth System parameter by properly merging multi-sensor and multi-platform satellite observations.

These data sets are critical to understanding Earth System processes, assessing variability, long-term trends and change in the Earth System and provide input and validation means to modeling efforts.

Earth System Data Records (ESDRs)

including Climate Data Records (CDRs)

A Framework discussed in July 2004 ESE Quarterly Review

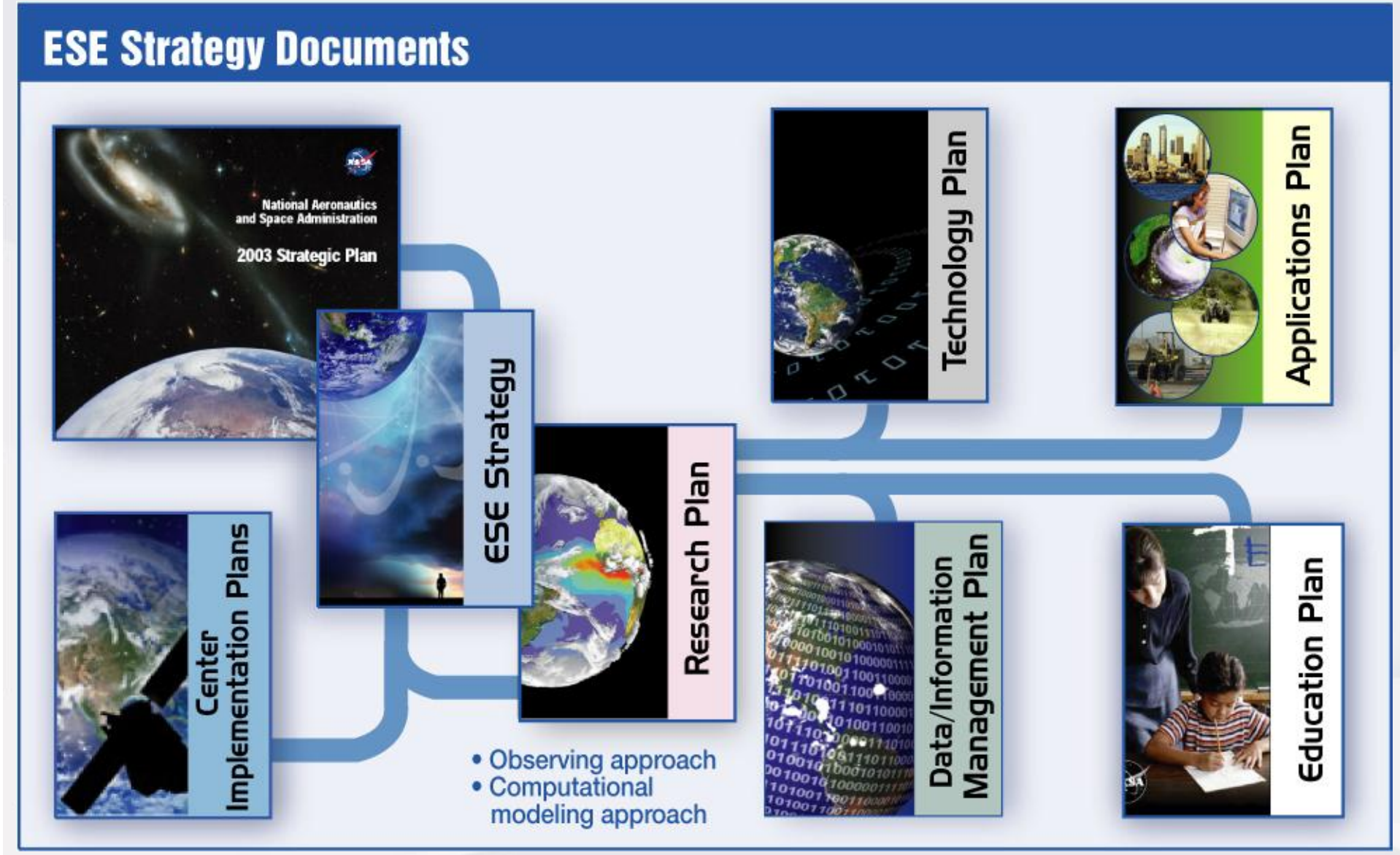
The Plan will describe ESE actions towards:

the development of Earth System Data Records (ESDRs), including Climate Data Records (CDRs) within the context of the ESE Research Plan.

the evolving and systematic generation and distribution of ESDRs and CDRs by leveraging ESE resources and assets.

the plan development process, which will engage the NASA and external science and technology communities and seek final review from the NAS.

ESE Strategy Documents



Relationship to ESE plans

Framework Presented July 2004

Overall this plan is consistent with the ESE mission articulated in the ESE strategy and describes the ESDR development to achieve the ESE goals

ESE Research Plan

The Research plan provides the motivation for ESDRs and justification for their development and use. There is clear connection with the Research implementation plan and this plan in

- deriving detailed requirements for answering science questions;
- identifying scientific challenges; and
- providing means for ESDR evaluation.

Relationship to ESE plans (cont')

Framework Presented July 2004

Data and Information Management Plan

This plan relates to the DIMP in describing the evolution of the ESE data system components to systematically develop and make available to the ESE user communities ESDRs. At least two aspects are key issues: the retrospective ESDR development by re-processing of the current data products, and the continual extension of these data products with newly acquired data

Technology Plan

The technology plan addresses developments driven by requirements to facilitate and improve the ESDR management and distribution.

Applications Plan

This plan will describe the requirements for potential NASA ESDR development for requirements driven by decision support tools (?)

Science ESDR (CDR) plan content

Framework Presented July 2004

Identify key variables in connection with ESE research science questions:

- Provide rationale for each ESDR, explain science pay-off and impact in the context of Science Focus Areas
- Provide priorities for ESDRs in the context of Focus Areas and science questions
- Identify high priority derived products for each recommended ESDR

Define requirements for each selected ESDR and describe attributes in context of the proposed science rationale. Examples are:

- Climate Data Records to establish climate trends (e.g. sea surface temperature)
- Understanding Earth System processes (e.g. Sea surface height)
- Mandatory monitoring (e.g. ozone)
- Establish Earth System baseline (e.g. reference frames)
- Enhance predictive capability, model input/output (e.g. re-analyses)

Identify challenges in the development and production of each selected ESDR and describe effort required.

Science ESDR (CDR) plan content (cont')

Framework Presented July 2004

Develop near-term plan

The goal of the near-term plan is to develop and produce systematically the NASA unique core ESDRs. These selected ESDRs will merge previously NASA acquired data with present and new planned NASA data.

Develop long-term plan

The goal of the long-term plan is to develop observing system requirements. These requirements will be viewed at the higher level as observing system architecture, but should also be addressed as part of the Research Implementation Plan and Technology Plan.

Data System ESDRs plan content

Framework Presented July 2004

This plan should outline implementation steps to accomplish the near-term goals for ESDRs within the existing ESE resources, particularly describing the systematic production and distribution of past and present NASA data, while bringing-in the planned new observations.

The ESE program components to be leveraged are:

- EOSDIS – should consider ESDR plans in its evolution as appropriate
- NPP SDS – and its evolution to Measurement data systems
- Multiple goal programs, with shared management: REASoN
- New program targeting ESDRs? TBD

Management plan content

Framework Presented July 2004

Given that ESE management structure is undergoing significant changes so that the present roles of ESE Divisions will be modified, the principles below describe necessary functions:

Identify all program elements required to accomplish the ESDR goals

- Research and development
- Data production
- Management and Distribution

Assign lead organization to program elements as appropriate

Identify budget and authorize program elements for implementation

Define and implement coordination and shared management mechanism among program components

Extension ESDR plans – Partnerships

Framework Presented July 2004

On the premise that NASA core ESDRs are products of NASA acquired data, identify other data needed for their development and systematic production.

Based on NASA research requirements, consider extension ESDRs which include non-NASA data.

Identify top priority extension ESDRs and CDRs and provide rationale for their development (e.g. synthesis and assessments reports)

Foster and establish partnerships, national and international, for jointly funded efforts and identify co-funding mechanisms for joint ESDRs and CDRs.

Planning and development process

Framework Presented July 2004

Road-mapping groups establish top priorities for NASA core ESDRs

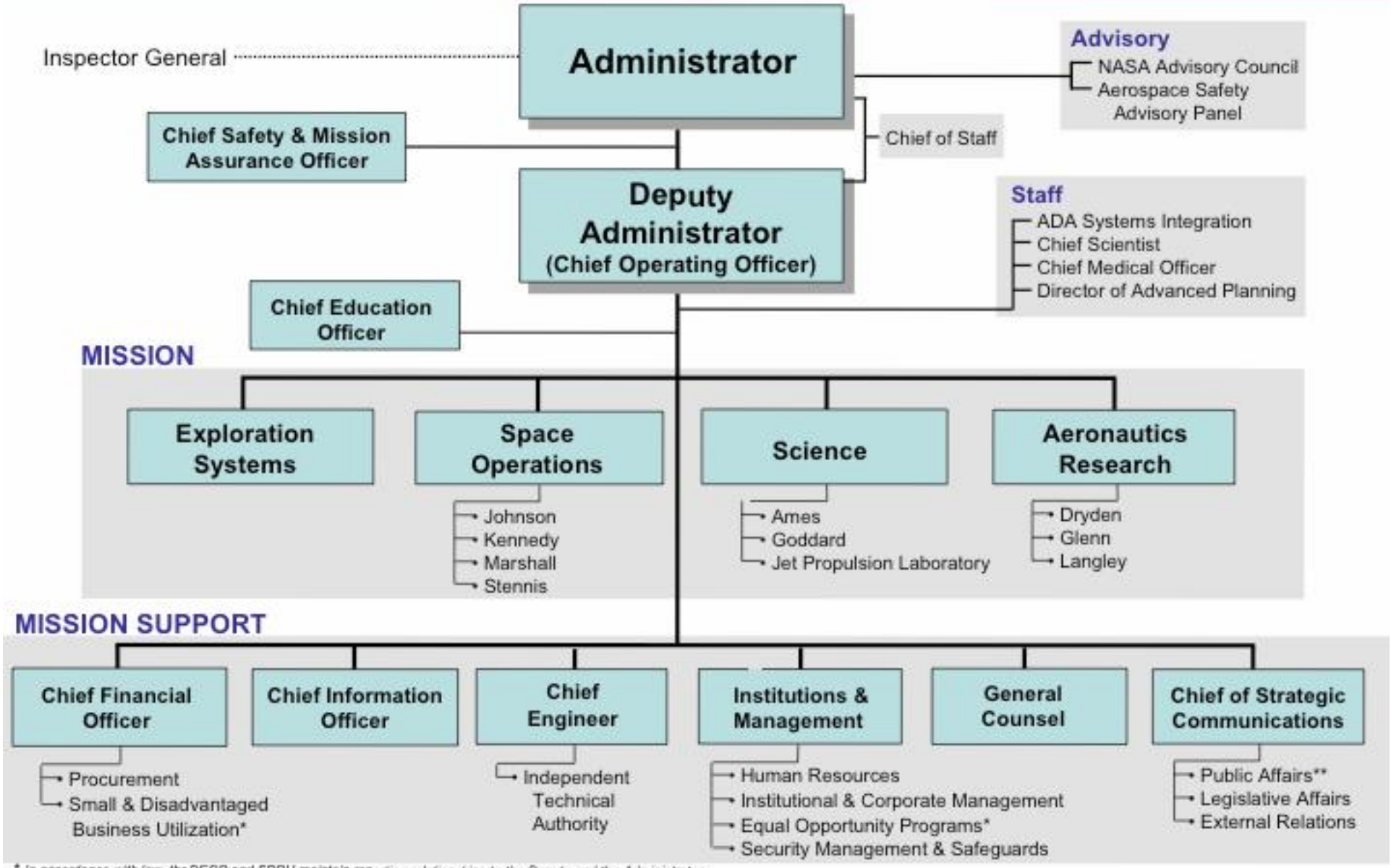
Appropriate discipline programs lead community workshops to develop research requirements for these ESDRs

ESE seeks evaluation/comments on science plan from advisory groups

Management team develops implementation plan across ESE program elements

- Ø Compete R&D (science, other?)
- Ø Implement production/distribution as development phase is completed
- Ø Adopt science, data system and technology program elements to accomplish goals and plans

Transformed Structure

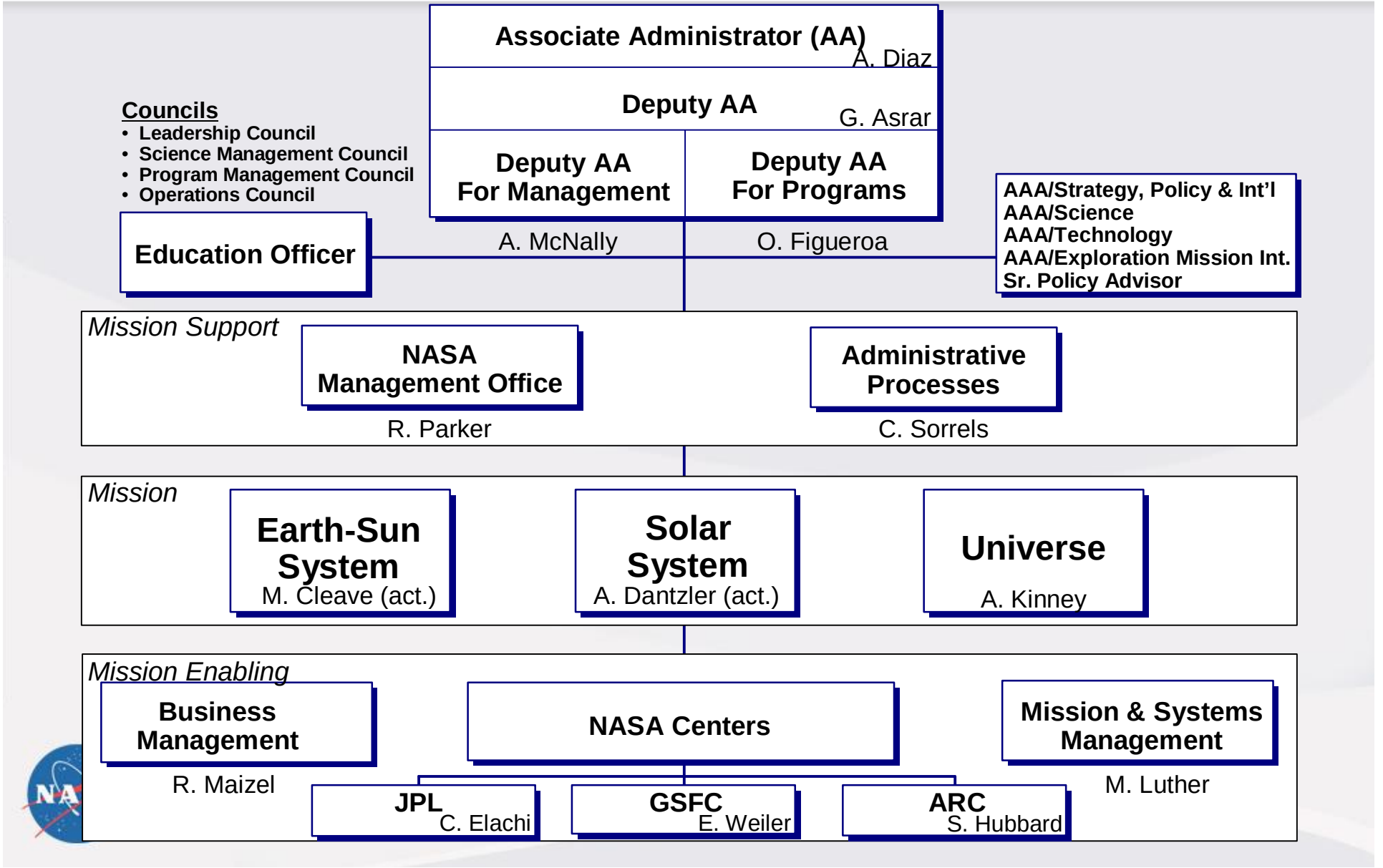


* *In accordance with law, theOEOP and SDBU maintain reporting relationships to the Deputy and the Administrator.*

** *Including a new emphasis on internal communications*

Revised: 02/04

Science Mission Directorate



Topics of this Discussion

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  (Review July 2004)
- Planning Challenges
- ESDR Implementation Options / Management
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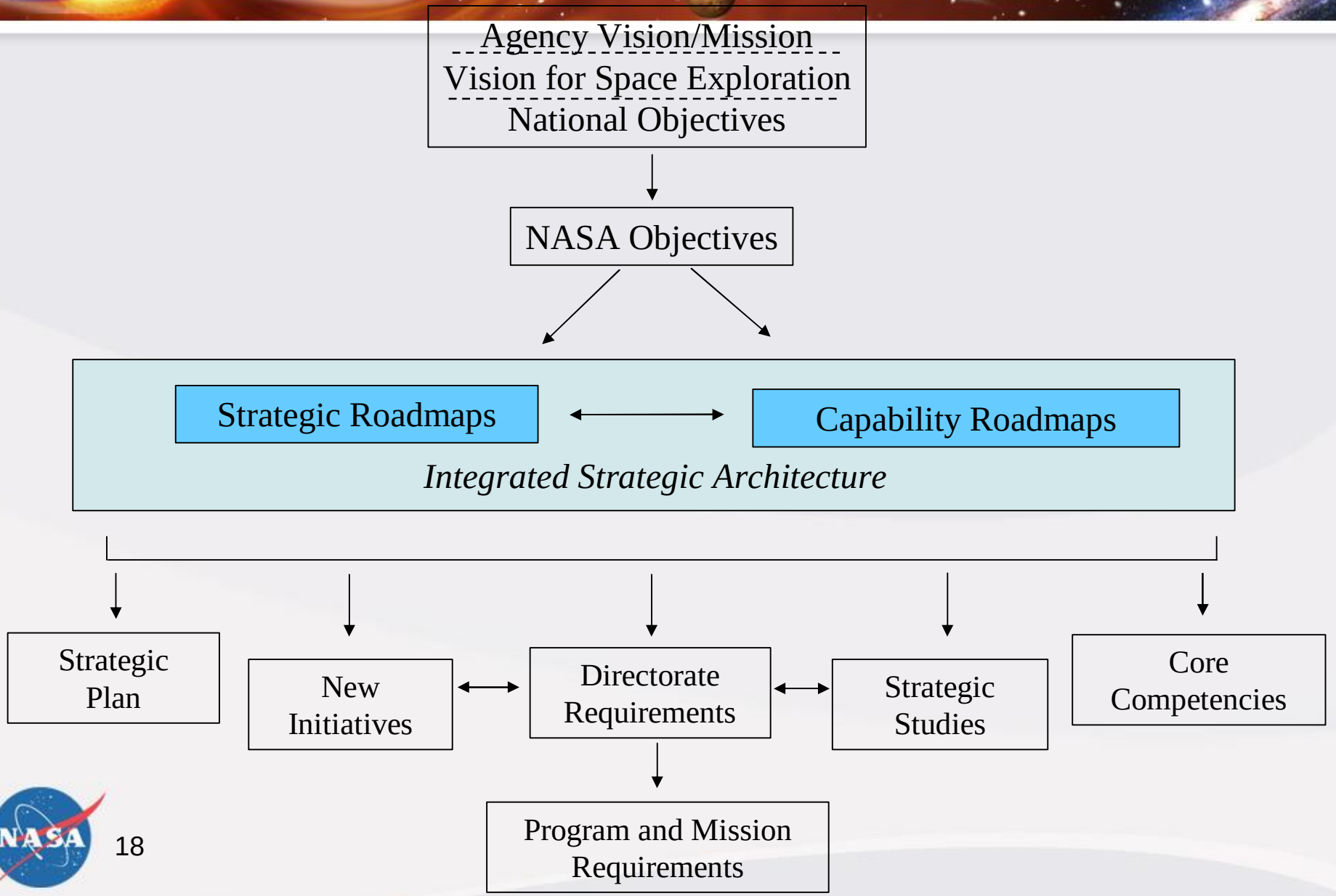
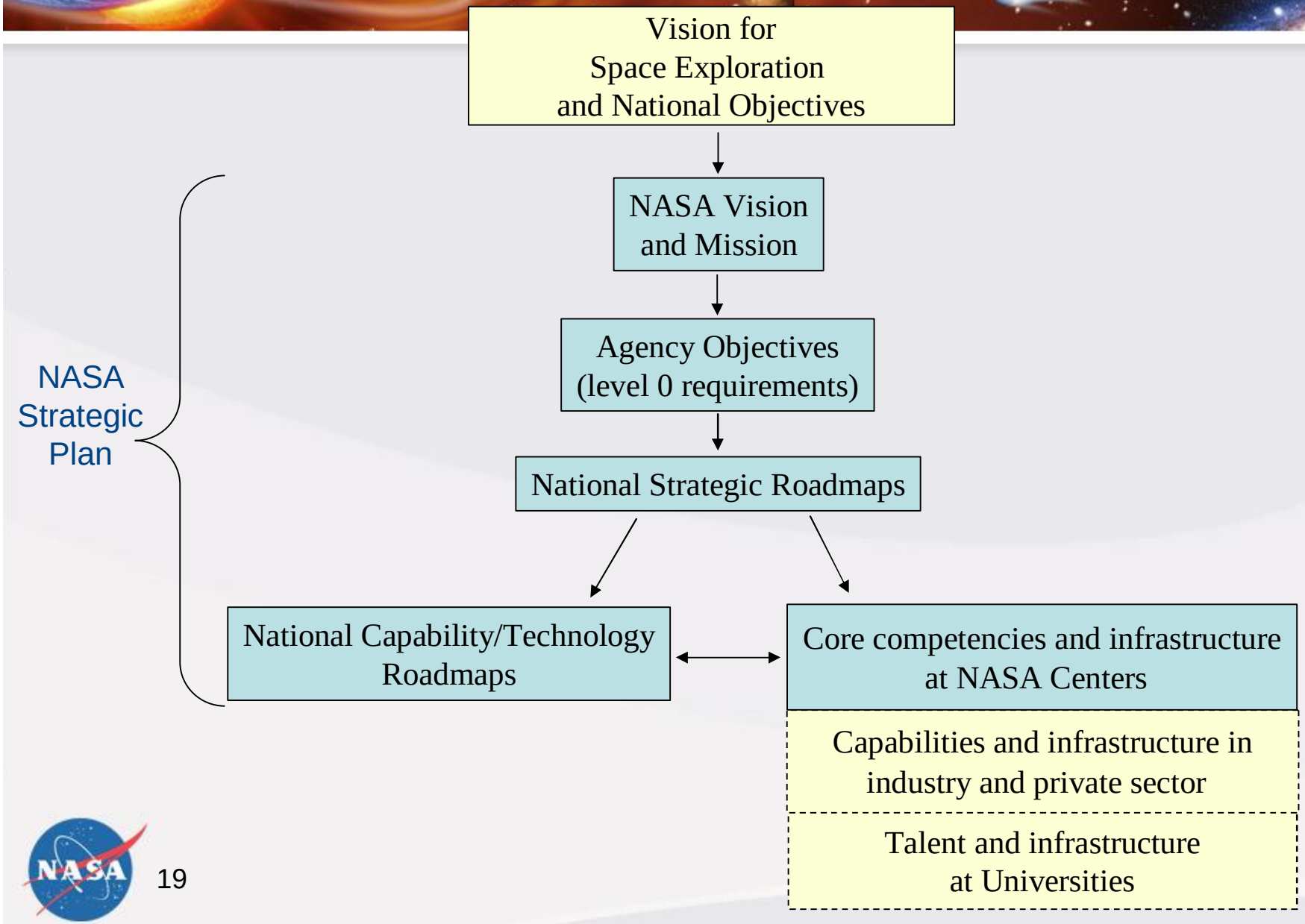
Planning Challenges

- Current Agency Planning Activities
  - Strategic Roadmaps, Capabilities roadmaps
  - NRC Decadal Survey
- ESDR Planning Requirements
  - Science Focus Areas Roadmaps
  - EOSDIS Evolution team
  - Technology Investments
- Interagency Context
  - GEOSS Framework & Implementation Plans
    - CCSP, IOOS, etc

Advanced Planning and Integration



Advanced Planning and Integration



Strategic Roadmaps*

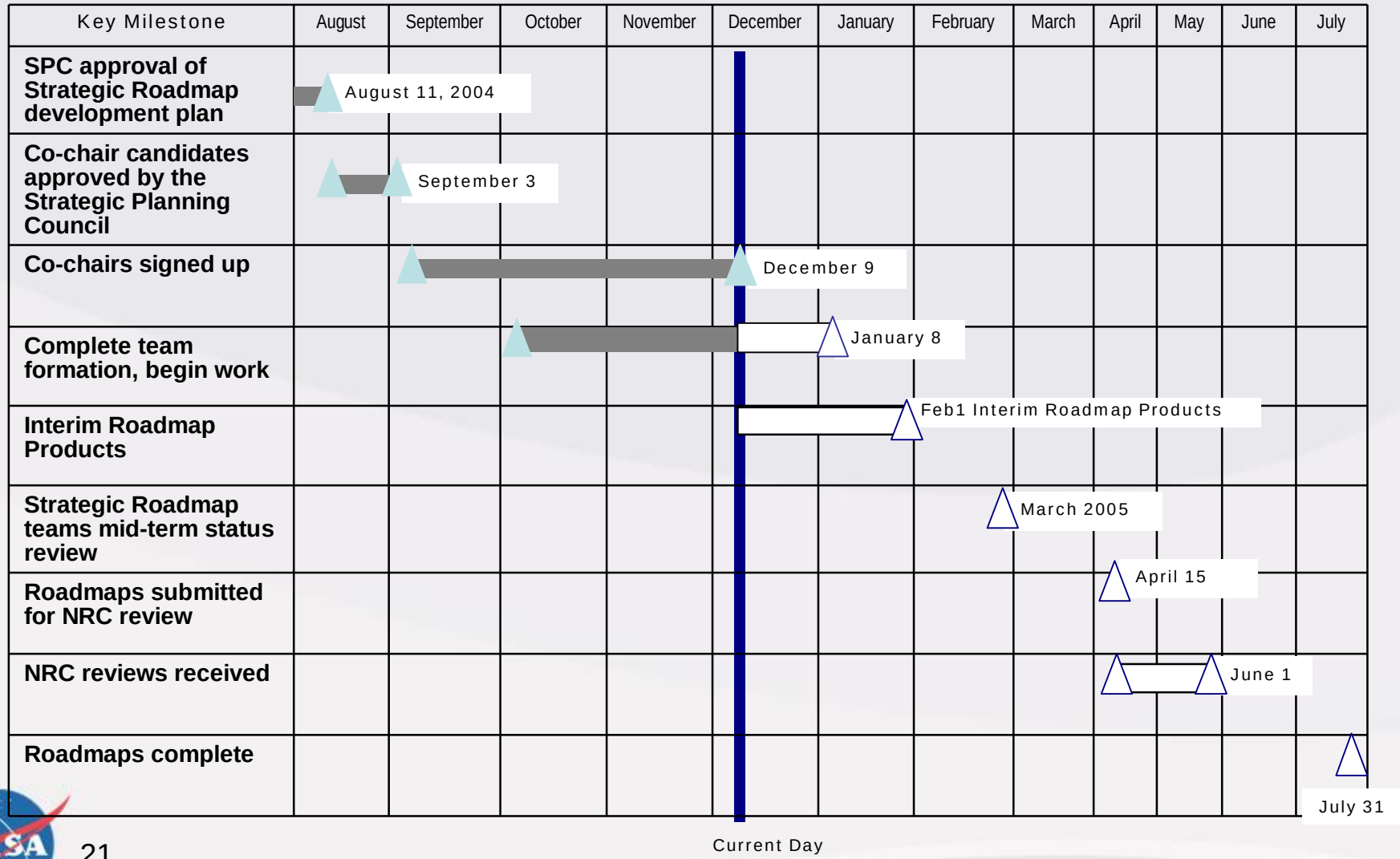
Roadmap	Tri - Chairs		
	Directorate	Center	External
1. Robotic and human lunar expeditions	Steidle/Readdy	Howell	T. Stafford
2. Sustained, long-term robotic and human exploration of Mars	Diaz	Elachi	T. Young
3. Sustained program of solar system exploration	Figueroa	Hubbard	J. Lunine
4. Advanced telescope searches for Earth-like planets and habitable environments	Asrar	Bleichman	A. Burrows
5. Develop an exploration transportation system	Steidle	Kennedy	C. Bolden
6. Complete assembly of the International Space Station and focus utilization	Uhran	Cabana	T. Betterton
7. Safely transition from Space Shuttle to new exploration-focused launch systems*	*Deferred**	*Deferred**	*Deferred**
8. Explore the origin, evolution, structure, and destiny of the Universe	Kinney	White	K. Flanagan
9. Determine how living Earth system is affected by internal dynamics, and understand implications for life	Figueroa	Evans	C. Kennel
10. Explore Sun-Earth system to understand effects on Earth and implications for human exploration	Diaz	Einaudi	T. Killeen
11. Transform air transportation and enable the next generation of atmospheric vehicles	Hertz	N/A	J. Jamieson
12. Educate students and public, and expand national technical skills and capabilities	Loston	Earls	F. Cordova
13. Comprehensive national plan for utilization of nuclear systems	Steidle	Scolese	J. Ahearne

= DoD Participation

* Leverages off Integrated Space Operations Summit, (ISOS) process until RTF

** Roadmap titles to be updated to reflect NASA Strategic Objectives in February*

Strategic Roadmap Development Schedule



Capability Roadmaps

Capability	NASA chair	External chair	Coordinators Directorate	Coordinators APIO
2.) High-energy power and propulsion	J. Nainiger (GRC)	Tom Hughes (Penn State University)	Overall – B. Park Technical – R.Taylor	P. Bankston (JPL)
3.) In-space transportation	P. McConnaughey (MSFC)	Col. Joe Boyles (US Air Force SMC)	Overall – B. Park Technical – G. Lyles	T. Inman (MSFC)
4.) Advanced telescopes and observatories	L. Feinberg (GSFC)	Howard MacEwan (NRO)	H. Thronson	D. Coulter (JPL)
5.) Communication and navigation	R. Spearing	N/A	T. Cremins M. Gates	S. Mecherle (Innocept)
6.) Robotic access to planetary surfaces	M. Adler (JPL)	Robert Braun (Georgia Tech)	H. Thronson	C. Ruoff (JPL)
7.) Human planetary landing systems	R. Manning (JPL)	Harrison Schmitt	Overall – B. Park Technical – J. Trosper	R. Mueller (KSC)
8.) Human health and support systems	D. Grounds (JSC)	Al Boehm (Ret, Hamilton Sunstrand)	Overall – B. Park Technical – G. Trinh	J. Aikins (ARC)
9.) Human exploration systems and mobility	C. Culbert (JSC)	Jeff Taylor	Overall – B. Park Technical – J. Mankins	T. Inman (MSFC)
10.) Autonomous systems and robotics	S. Zornetzer (ARC)	Doug Gage (DARPA ret)	H. Thronson	J. Aikins (ARC)
11.) Transformational spaceport/range	K. Poniatowski (HQ)	Gen Jimmy Morrell	T. Cremins, M. Gates	D. Skelly (KSC)
12.) Scientific instruments/sensors	R. Barney (GSFC)	Maria Zuber (MIT)	H. Thronson	P. Bankston (JPL)
13.) *In situ* resource utilization	J. Sanders (JSC)	Mike Duke (Colorado School of Mines)	Overall – B. Park Technical – J. Mankins	R. Mueller (KSC)
14.) Advanced modeling, simulation, analysis	E. Antonsson (JPL)	Warren Washington (NCAR)	H. Thronson	J. Aikins (ARC)
15.) Systems engineering cost/risk analysis	S. Cavanaugh (LaRC)	Alan Wilhite/ Georgia Institute of Technology	Overall – B. Park Technical – V. Hwa	V. Regenie (DFRC)
16.) Nanotechnology	M. Hirschbein (HQ) Minoo Dastoor	Dimitris Lagoudas (Texas A&M)	H. Thronson	J. Crooke (GSFC)

– DoD Participation

Capability Roadmap Development Schedule

MILESTONE	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Capability Roadmap Teams Formation	▲										
Community Workshop		▲									
Working First Drafts of Capability Roadmaps	▲	———	———	———	▲						
Review with Strategic Planning Council			▲								
Engineering Academy Dialogues - Phased				▲	———	▲					
Identify Potential New Initiatives						▲					
Strategic Roadmap Drafts				▲	———	———	▲				
Align Capabilities with Strategic Roadmaps						▲	———	———	▲		
Engineering Academy Summary Review								▲	———	———	▲
Brief Strategic Planning Council									▲		
Finalize Roadmaps										▲	——— ▲

Earth Science Research Fundamental Science Questions

How is the Earth changing and what are the consequences of life on Earth?

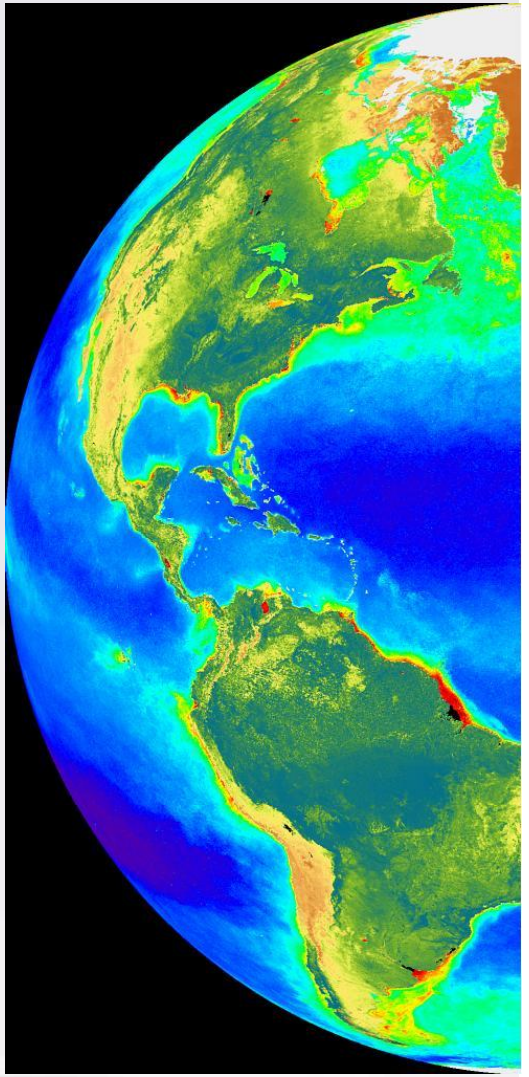
How is the global Earth system *changing*?

What are the primary *forcings* of the Earth system?

How does the Earth system *respond* to natural and human-induced changes?

What are the *consequences* of changes in the Earth system for human civilization?

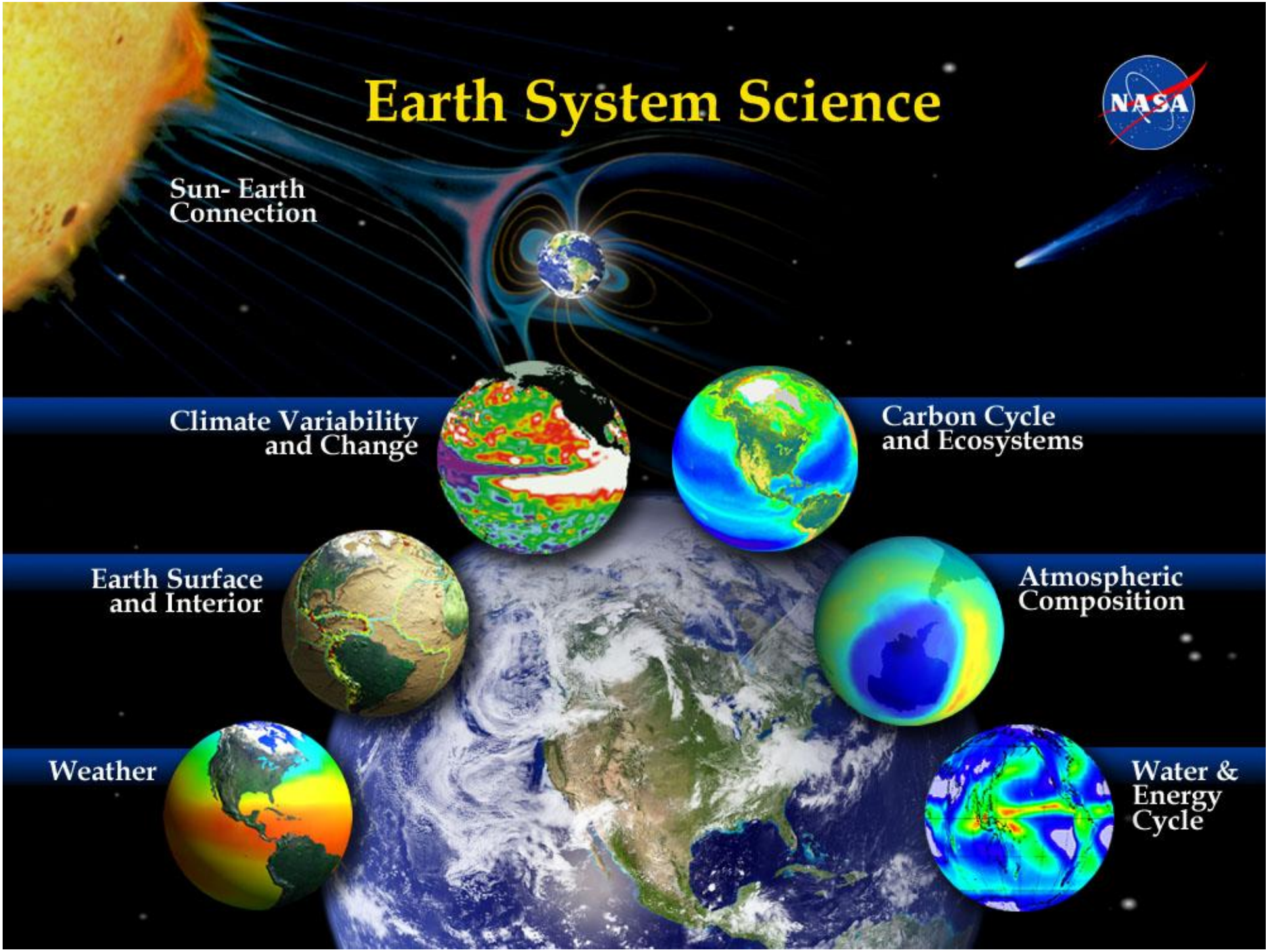
How well can we *predict* future changes in the Earth system?



Science Questions and Focus Areas

Variability	Forcing	Response	Consequence	Prediction
Precipitation, evaporation & cycling of water changing?	Atmospheric constituents & solar radiation on climate?	Clouds & surface hydrological processes on climate?	Weather variation related to climate variation?	Weather forecasting improvement?
Global ocean circulation varying?	Changes in land cover & land use?	Ecosystems, land cover & biogeochemical cycles?	Consequences of land cover & land use change?	Improve prediction of climate variability & change?
Global ecosystems changing?	Motions of the Earth & Earth's interior?	Changes in global ocean circulation?	Coastal region impacts?	Ozone, climate & air quality impacts of atmospheric composition?
Atmospheric composition changing?		Atmospheric trace constituents responses?	Regional air quality impacts?	Carbon cycle & ecosystem change?
Ice cover mass changing?		Sea level affected by Earth system change?		Change in water cycle dynamics?
Earth surface transformation?				Predict & mitigate natural hazards from Earth surface change?

Climate Variability and Change
Atmospheric Composition
Carbon Cycle and Ecosystems
Weather
Water and Energy Cycle
Earth Surface and Interior


Earth System Science
NASA
Sun- Earth Connection
Climate Variability and Change
Carbon Cycle and Ecosystems
Earth Surface and Interior
Atmospheric Composition
Weather
Water & Energy Cycle

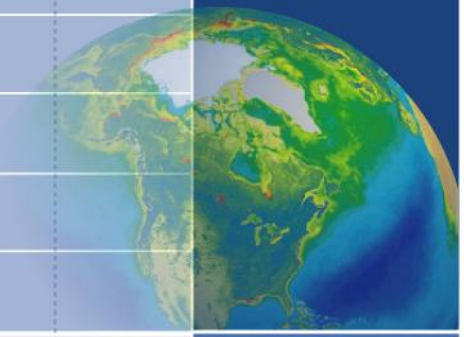
RoadMap
Carbon Cycle & Ecosystems

Field Campaign
Technology
Partnership
Unfunded
Funded

ACTIVITIES	OUTPUTS
Human Ecosystems-Climate Interactions (Coupling Model-Data Fusion, Assimilation)	Integrated Global Analysis
High-Resolution Atmospheric CO_2	Sub-regional sources/sinks
Profiles of Ocean Particles	Carbon export to deep ocean
Physiology & Functional Groups	Models w/improved ecosystem functions
Southern Ocean Carbon Program	Process controls identified; errors in sink reduced
New Ocean Carbon/Coastal Event Observations	Reduced uncertainties in fluxes and coastal C dynamics
Vegetation 3-D Structure, Biomass & Disturbance	Terrestrial carbon stocks & species habitat characterized
Global CH_4: Wetlands, Flooding & Permafrost	CH_4 sources characterized and quantified
Global Atmospheric CO_2(OCO)	Regional carbon sources/sinks quantified for planet
North American Carbon Program	North America's carbon budget quantified
Land Use Change in Amazonia	Effects of tropical deforestation quantified; uncertainties in tropical carbon source reduced

GOALS

Global productivity & land cover change at fine resolution; biomass & carbon fluxes quantified; useful ecological forecasts & improved climate change projections



Knowledge Base Development

Landsat	LDCM	LDCM II	**SYSTEMATIC OBSERVATIONS**
Ocean Color (SeaWiFS, MODIS) Vegetation (AVHRR, MODIS)	Ocean Color/Vegetation (VIIRS/NPP)	Ocean/Land (VIRS/NPOESS)	
Case Studies	Process Understanding	Models & Computing Capacity	**IMPROVEMENTS**
IPCC NA Carbon	NA Carbon	IPCC Global C Cycle	Global C Cycle **REPORTS**

2002 2004 2006 2008 2010 2012 2014 2015

The Need for a Decadal Survey

"In light of this progress, and of our recent success in securing continuity of essential EOS measurements through follow-on missions and transitions to operational satellite systems, it is time for the Earth system **science community** to look afresh into the future and help **NASA** plot its course ahead. I request that the Space Studies Board take the lead in orchestrating a decadal survey by the community to generate research and observation priorities… The resulting study will be most useful if it conveys the Earth system science **community's priorities** for questions and measurements."

From NASA's letter of October 29, 2003 to the SSB

NRC Decadal Survey for Earth System Science

"…look afresh into the future and help NASA chart its course ahead."

What are the significant advances in Earth system science over the past decade?

What are the principal science questions that remain to be answered?

What measurements are most critical to answering those questions?

What types of next generation observing capabilities and orbital vantage points will best enable progress?

Oct. 29, 2003 Letter of request

What opportunities are afforded by the Exploration Vision and NASA Transformation?

July 7, 2004 letter

Provisional Decadal Survey Panels

- Earth Science Applications & Societal Objectives
- Terrestrial, Coastal & Marine Ecosystems & Biodiversity
- Weather
- Climate Variability & Change
- Water Resources & the Global Hydrologic Cycle
- Human Health & Security
- Solid Earth Dynamics, Natural Hazards, and Resources

"Within this structure, some disciplines are not visible in the title of a given panel, but will have a role in several panels."

Provisional Schedule

First committee meeting	Nov 04
Town halls at AGU/AMS	Dec 04, Jan 05
Interim report	Jun 05
Initial input from panels	Jun 05
Final input from panels	Nov 05
Special sessions at AGU/AMS to discuss draft report	Dec 05, Jan 06
Final report	Jun 06

For info from the NRC, see http://qp.nas.edu/decadalsurvey

GEOSS:
Global Earth Observation System of Systems

Earth Observations Summit

Observations to Users to Benefits

And the U.S. Interagency Working Group on Global Earth Observation

A Shared Vision for Earth Observation

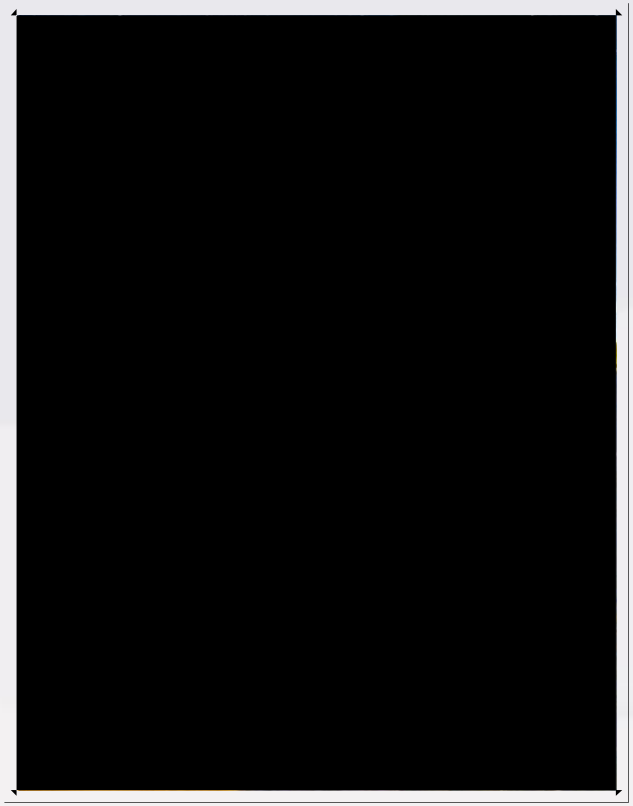
Articulated by 34 Nations in an Earth Observation Summit (July 31, 2003)

An international comprehensive, coordinated and sustained Earth observation system

Comprehensive: meeting the needs of a variety of science and applications disciplines

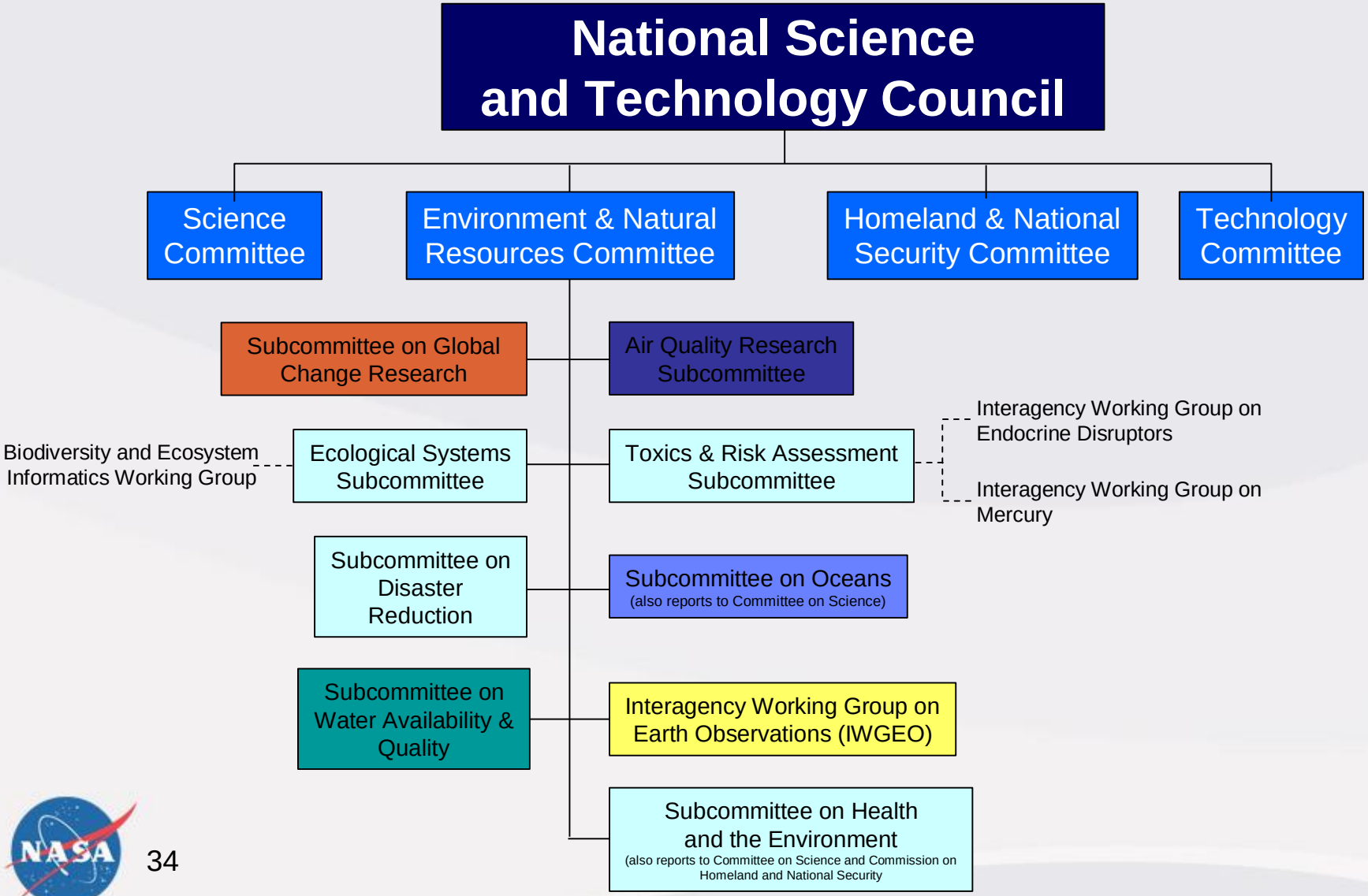
Coordinated: multinational satellite, suborbital and *in situ* observing capabilities strategically coordinated via agreed standards and data exchange

Sustained: long-term, continued financial and in-kind support from funding authorities

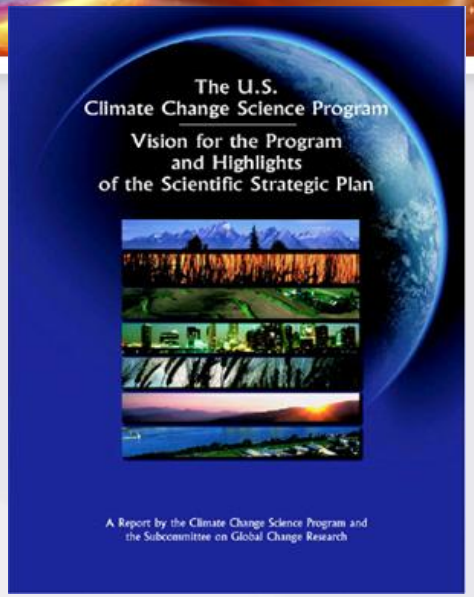


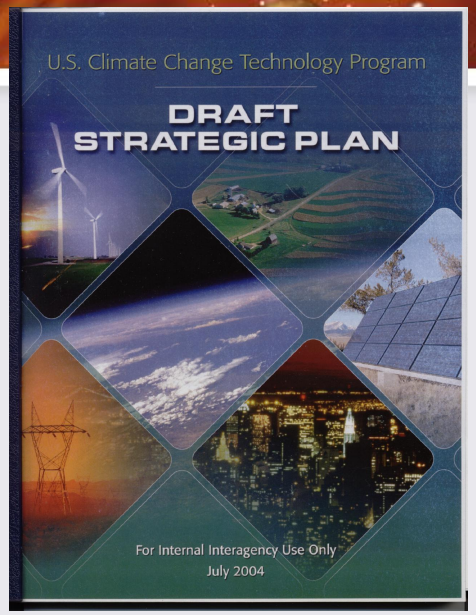
Group on Earth bservations

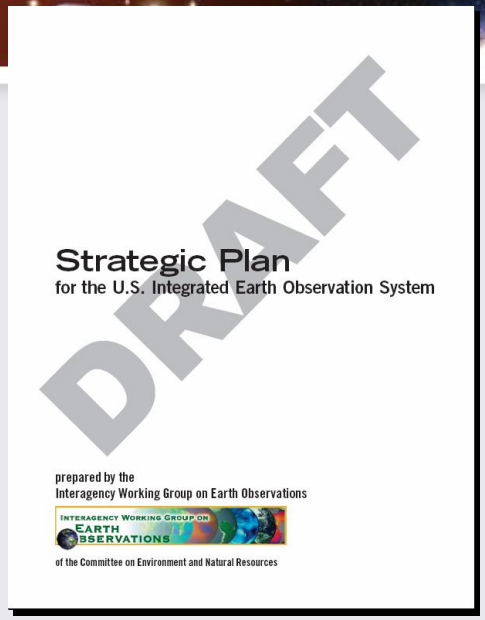
NSTC Structure

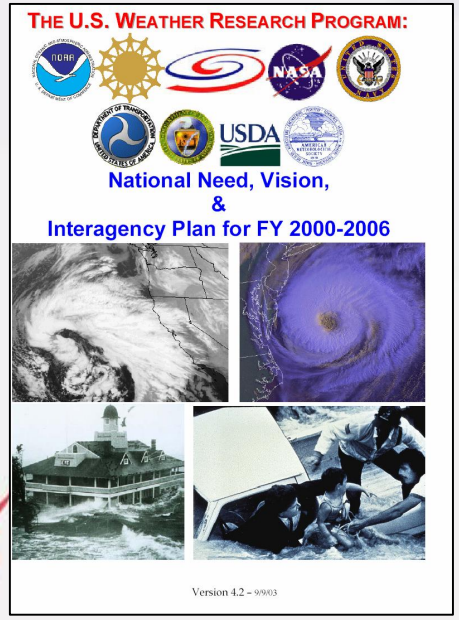


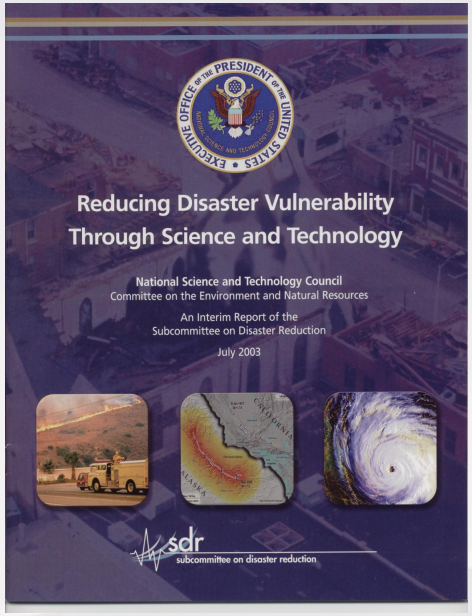
U.S. Plans for extending NASA Science Results











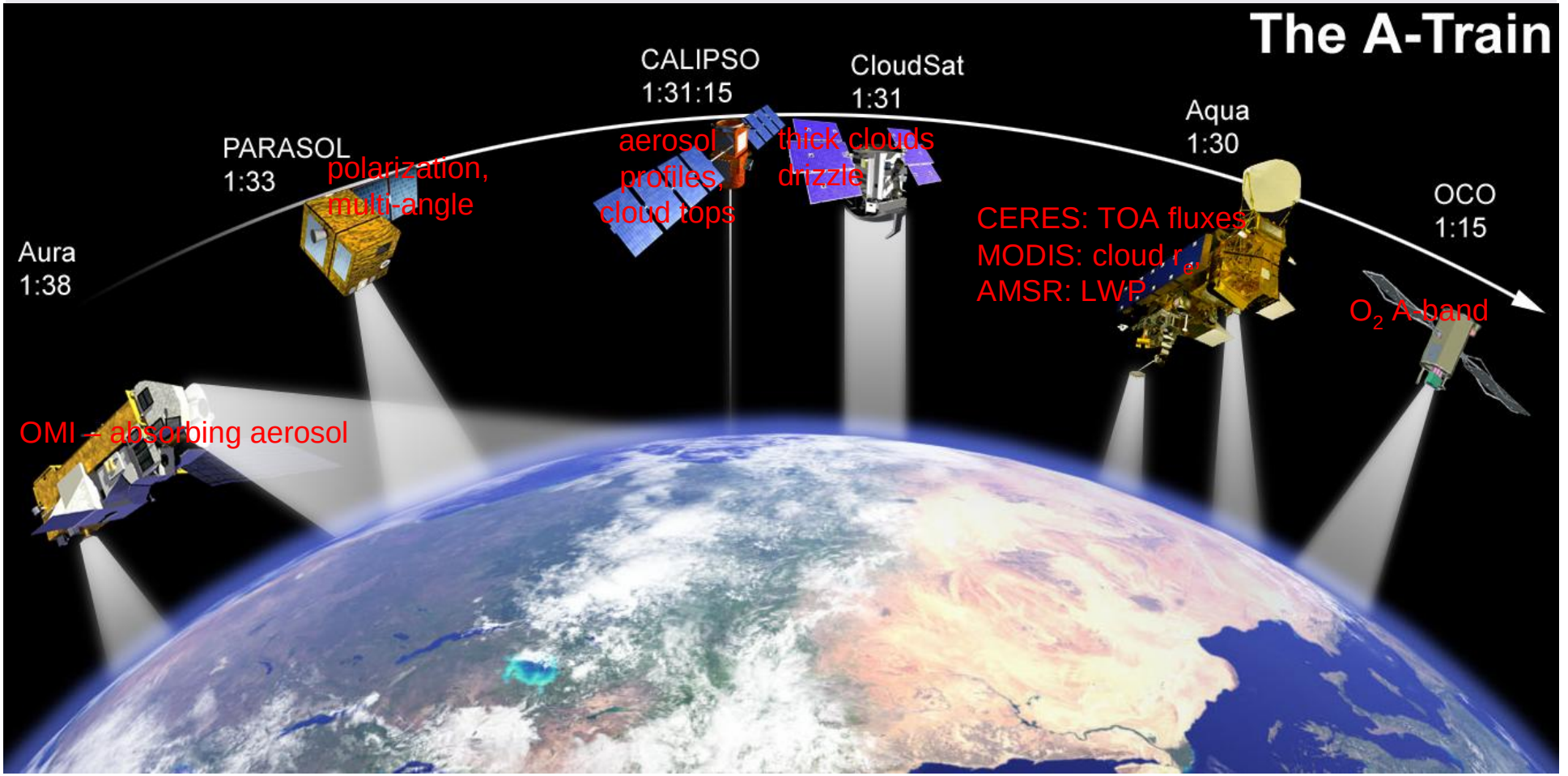
U.S. Commercial Remote Sensing Space Policy: Civil Agency Implementation Plan

December 12, 2003

Implementation Plan Working Group (IPWG)

The "A-Train"

Moving Toward the Future of Integrated Earth Observation



Data System Evolution

NASA has an irreplaceable data set created by the Earth Science Enterprise over the last 15 years. Continuing analysis of this data set is consonant with the three Presidential initiatives:

- 1. Climate Change Research Initiative,
- 2. Global Earth Observation, and
- 3. Vision for Space Exploration.

NASA systems will evolve and support integrated, open and easy access to the data for the purpose of supporting NASA research and shared decision support systems across other federal and state agencies.

NASA is moving from selecting missions-oriented systems to measurements availability to support its research programs and focus areas.

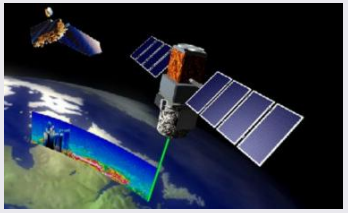
NASA is planning to evolve its EOSDIS over the next several years, and will continue to procure new data systems assets, e.g. REASoNs, to support our Earth-Sun research and science applications

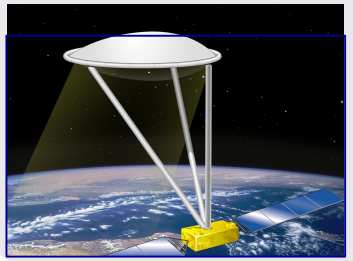
Near-term actions for NASA involving the research community:

- ***Review initial REASoNs in FY05***
- ***Review EOSDIS data products***
- Solicit for additional REASoNs in FY06 via ROSES

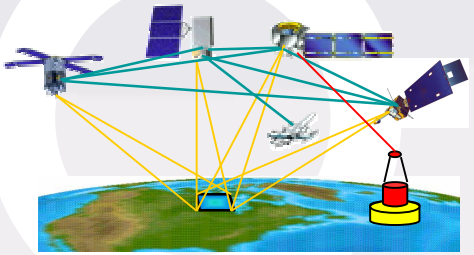
ES Technology Priorities

- **Active Remote Sensing Technologies** to enable atmospheric, cryospheric and earth surface measurements

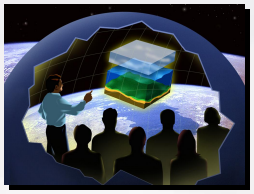




- **Large Deployables** to enable future weather/climate/ natural hazards measurements



- **Intelligent Distributed Systems** using advanced communication, on-board reprogrammable processors, autonomous network control, data compression, high density storage



- **Information Knowledge Capture** through 3-D visualization, holographic memory and seamlessly linked models.

Topics of this Discussion

- Framework Development for ESDRs
  (Review July 2004)
- Planning Challenges
- ESDR Implementation Options / Management
- Invitation for Input

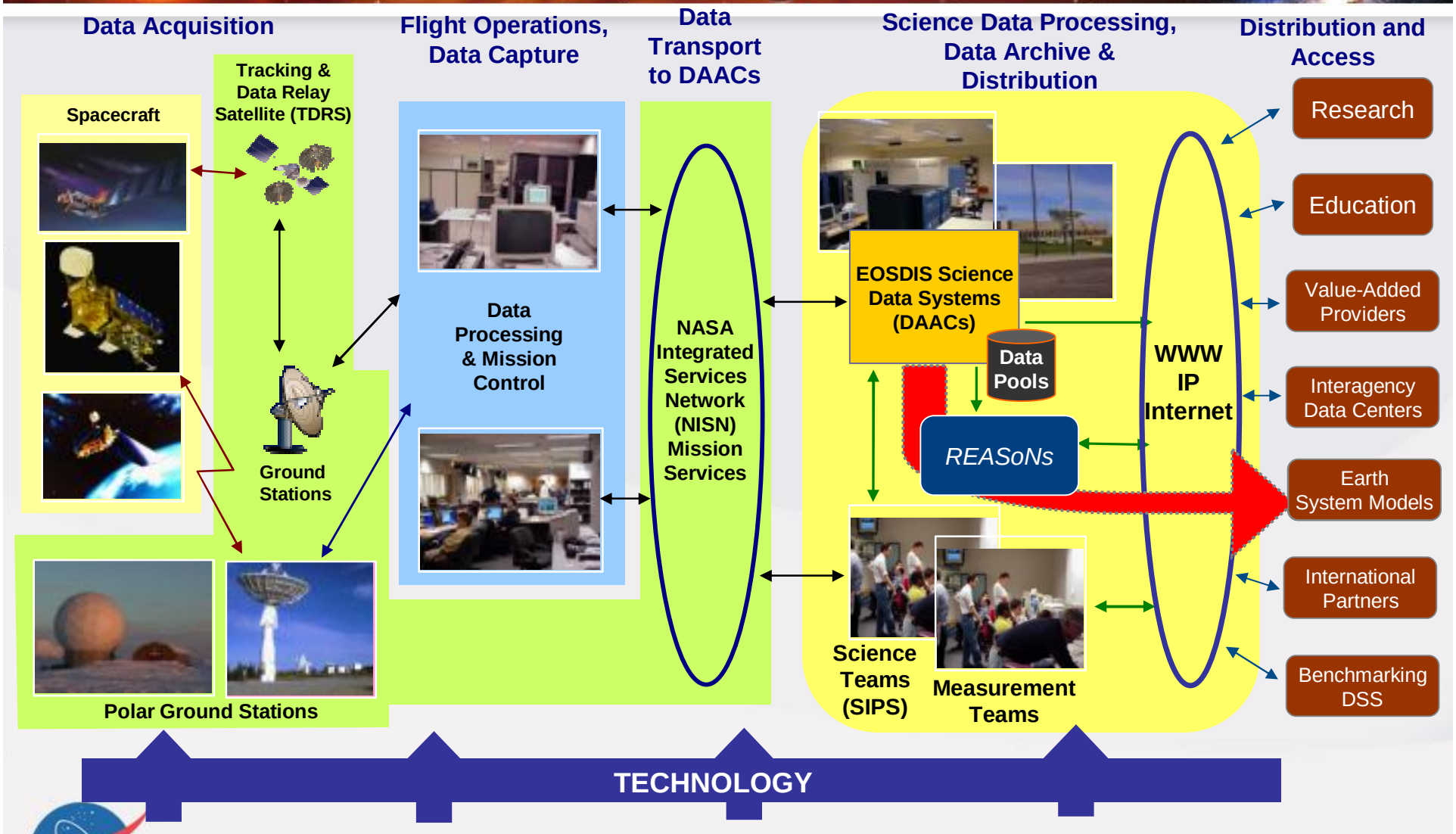
ESDR Implementation Options / Management

It is proposed that NASA implement an ESDR R&A program and use CAN and/or NRA solicitations specific to prototyping and developing and/or delivering NASA ESDRs. Possibly the follow-on to the REASoN program can be targeted to ESDRs.

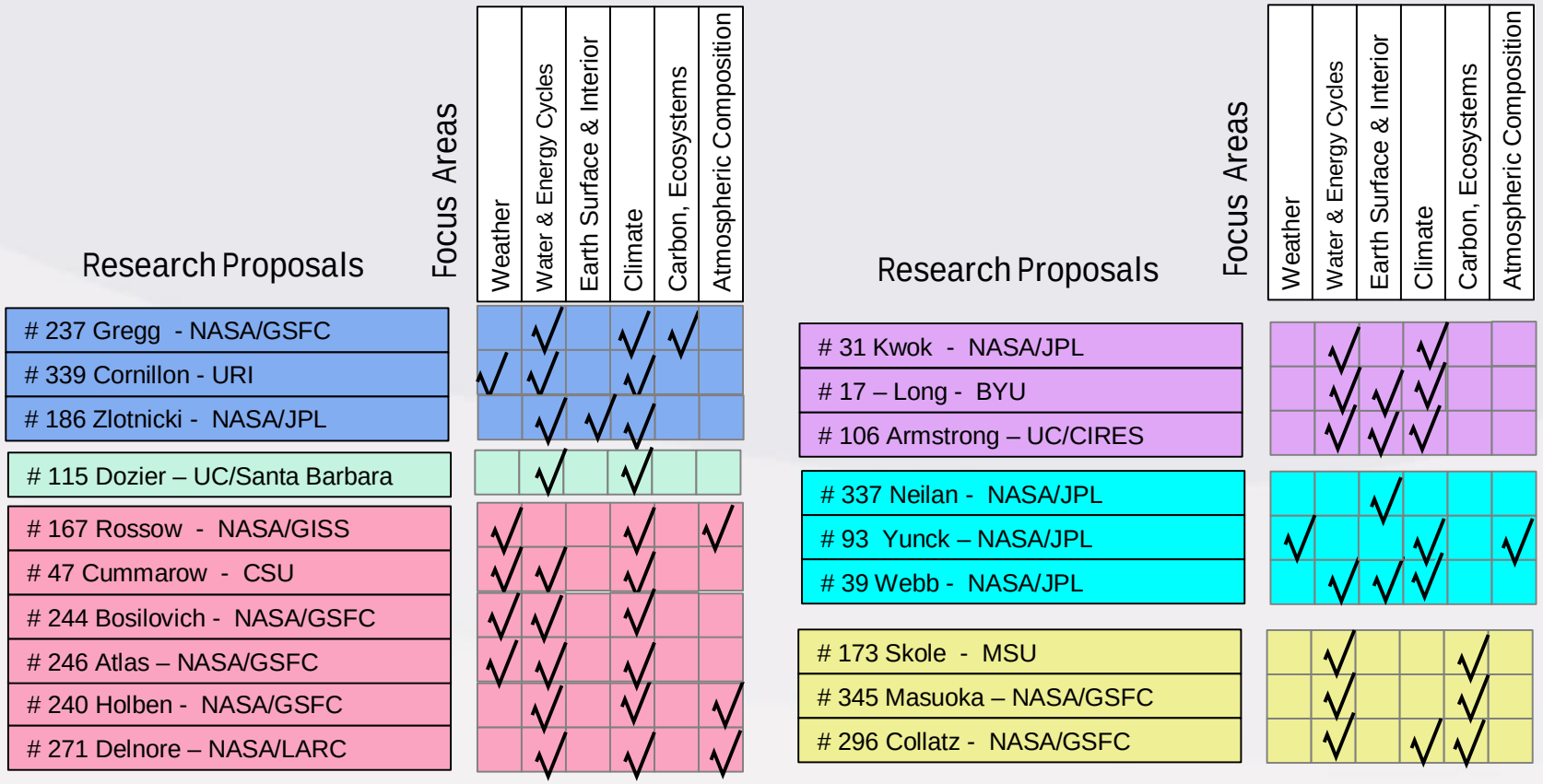
Benefits from utilizing this approach are:

- Allowing for the widest possible community input in ESDR selection, development and evaluation. In addition, participation of the research and modeling communities may be promoted.
- Fostering competition and peer review in relevant science and technology development, while allowing for community teaming.
- Enabling research required to answer requirements and/or quality questions surrounding proposed ESDRs

From Data Acquisition to Information Access



NASA ESE Focus Areas
Selected REASoN Project Traceability



Ocean | Atmosphere | Ice | Hydro | Land | Geodetic

Invitation for Input

- Establish high priority science products, including ESDRs, and articulate their purpose
- Identify scientific challenges for their development and implementation
- Participate in any of the planning efforts, collectively and individually

Back-up

Declaration of Policy and Purpose

The aeronautical and space activities shall be conducted so as to contribute materially to one or more of the following objectives:

The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space;

The improvement of the usefulness, performance, speed… and efficiency of space vehicles;

The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;

The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and **scientific purposes**;

The preservation of the role of the US as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities…

The making available to agencies directly concerned with national defense of discoveries…

Cooperation of the US with other nations…

The most **effective utilization of the scientific and engineering resources of the US,** with close cooperation among all interested agencies of the US in order to avoid unnecessary duplication of effort, facilities, and equipment; and

The preservation of the US preeminent position in aeronautics and space through **research and technology development** …

National Aeronautics & Space Act of 1958

The Act under Sec. 102(b) states "The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities. The Congress further declares that such activities **shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States**, except that activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States…"

Sec. 103 (a) defines the functions of NASA as:

- (1) **plan, direct, and conduct aeronautical and space activities**;
- (2) **arrange for participation by the scientific community in planning** scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations;
- (3) provide for the widest practicable and appropriate **dissemination of information** concerning its activities and the results thereof
- (4) seek and encourage to the maximum extent possible, the fullest commercial use of space; and
- (5) **encourage and provide for Federal Government use of commercially provided space services and hardware**, consistent with the requirements of the Federal Government.

Evolving EOSDIS Elements

Evolve data systems to achieve "**stability with innovation**".

Current Data System Context

- EOSDIS operation volumes include:
  - 2,178 unique data products
  - 4.5TB of daily ingest
  - 2TB of daily distribution
  - Over 2 million distinct users for 2003

Approach to system evolution

- Work with the ESE advisory committee (ESSAAC) to develop a plan for the way forward (plan expected within a year).
- Identify which current systems and functions need to evolve, e.g., bandwidth and storage capacity
- Work with the community (e.g. REASoN) to implement changes

Drivers of Evolving Data & Info Systems

Missions to Measurements

- ESE is moving from mission-based data systems to those that focus on Earth science measurements.
- ESE's DIS will be a resource for science-focused communities enabling research, and will be flexible, scalable and suited for the particular community needs.
- Continue on the pathways for acquiring observations to understand processes and develop Earth system models.

The Advance of Information Technologies

- NASA will remain at the forefront of IT development and will partner with other agencies to ensure the strategic use of IT resources to avoid obsolescence and enable enhanced performance.
- The lowering cost of IT infrastructure enables ESE data systems to take advantage of improving computation, storage and network capabilities.

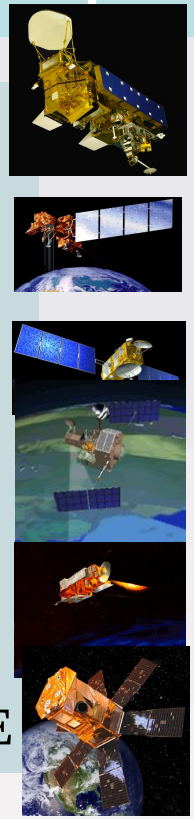
Facilitate the Transition from Research to Operations

- Work with Federal partners to transition operational elements of data systems to other agencies while maintaining core data system functions necessary for conducting NASA ESE mission and goals.

Systematic Measurement Missions

Existing

- Terra, Aqua
- Landsat 7
- TOPEX, Jason
- TRMM
- SeaWinds
- TOMS, OMI
- ACRIMSat/SORCE



Through 2010

- NPOESS Preparatory Project (2005/06)
- LandSat Data Continuity Mission (2005/06)
- Ocean Topography Mission (2006)
- Global Precipitation Mission (2008)
- Ocean Surface Winds (2006)
- Total Column Ozone/Aerosols (2008)
- Solar Irradiance (2006)

- Funded
- Under study/ early formulation
- Contained within NASA budget projections/undergoing preliminary study

Earth-Sun System Division