



NASA Earth Science Division Status and Decadal Survey Thoughts Michael H. Freilich

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## Earth Science Program Overall Strategy



Maintain a **balanced program** that:

- advances Earth System Science
- delivers societal benefit through applications development and capacity building
- provides essential global spaceborne measurements supporting science and "operations"
- develops and demonstrates technologies for next-generation measurements, and
- complements and is coordinated with activities of other agencies and international partners

## NASA's Earth Science Division









#### **Applied Sciences**













A REAL PROPERTY AND INCOME.

#### Technology





## Non-Flight Budgets: 2007-2013





## On-Orbit Flight Missions – Partnerships



#### Missions in Formulation & Development







**OCO-2** July 2014 Global CO<sub>2</sub>



**SMAP** Nov 2014 w/CSA Soil Moist., Frz/Thaw

#### **On the ISS**



**GPM** Feb 2014 w/JAXA **Global Precipitation** 



SWOT 2020 w/CNES; Sea surface & Fresh water height, 94<sup>th</sup> AMS Meeting, 5 February 2014, Atlanta, GA



**ICESat-2** 2017 Ice Dynamics, ecosystem structure



**GRACE FO** Aug 2017 w/GFZ; Global Mass & Water Variation

RapidSCAT, Jul 2014 Wind Scatterometry CATS, Fall 2014 Aerosols SAGE III, Aug 2015 **Ozone & Trace Gases** LIS, 2016 Lightning Mapper



**CYGNSS** Oct 2016 Cyclone Evolution, Air-Sea Interactions in Extreme Storms 6



# International Space Station

ELC-2 AMS

ESP-3

ELC-4

Columbus EF

SAGE III (2014)

External Logistics Carriers – ELC-1, ELC-2, ELC-3 External Stowage Platforms – ESP-3 Alpha Magnetic Spectrometer Columbus External Payload Facility Kibo External Payload Facility

RapidSCAT (2014)

SFRV

CATS (2014) HICO (2009) OCO-3 (2017)

ELC-3

ELC-1

JEMEF

LIS (2016)

## Earth Science Budget: FY14 Request/Appropriation



### Realities



- Decadal Survey recommendations will not be the definitive word on the ESD program scope
  - Earth observation from space is important, thus Administration, Congress have specific equities
  - ESD will be directed to implement sustained measurements in support of NOAA, USGS – ambiguity regarding requirements/capabilities/risks
- ESD budget will not increase substantially, and may decrease
- Mission costs, schedules, can *only* be pre-defined/controlled in competitively selected, cost/schedule-constrained, programs (e.g., Venture-Class) – not in directed, systematic, missions
  - Directed missions to NASA Centers are essential to the Agency
- Venture-Class is now an integral part of ESD culture
- Named-mission backlog from 1<sup>st</sup> Decadal Survey is substantial

## Useful Inputs from Decadal Survey



- Recommend the target budgetary balance between Flight, Non-Flight
- In the Non-Flight portion of the program, recommend the target balance between R&A, Applied Science, and Technology elements
- In the Flight portion of the program, recommend the target budgetary balance between systematic/directed, and cost/schedule-constrained competed, mission programs

o Is there a maximum acceptable mission cost ("Flagships")?

 $_{\odot}$  Should ESD spin up other Venture-like programs, with different caps?

- Flight mission architecture/approach recommendations

   Engineering investments in common s/c? "Small-sats/constellations"?
- Provide decision principles for balancing new measurements and time series extensions of existing data sets
  - ESD budget will **NOT** increase
  - Other agencies will NOT transition measurements from ESD
  - How to account for international missions/programs, some long-term?
- Revisit priorities of named missions from 1<sup>st</sup> Decadal Survey
- Change scope(s) of R&A, Applied Sciences, Technology programs?<sup>11</sup>



#### Venture-Class

- Science-driven, PI-led, competitively selected, cost- and scheduleconstrained, regularly solicited – Venture-Class is a *high-priority Decadal Survey Recommendation*
- Complement the systematic missions, provide flexibility to accommodate scientific advances and new implementation approaches
- All ongoing and planned investigations, solicitations, and selections are on track and fully funded





**Suborbital** 

**Small-sat/Missions** 

Instruments

#### Earth Venture Mission-1 Selection CYGNSS (CYclone Global Navigation Satellite System)

- CYGNSS is a pathfinder to using small satellite constellations
- 8 microsatellite (18 kg each) dense sampling constellation
- GPS reflectometry to measure ocean surface winds in hurricane eyewalls and core in all precipitating conditions
- To improve understanding of hurricane development and intensity at landfall

PI: Chris Ruf, University of Michigan Instrument Development: Surrey Satellite Technology US Spacecraft: SwRI Project Management: SwRI Orbit requirements: Low Earth Orbit 35° inclination, 500 km altitude





#### Earth Venture Instrument-1 Selection Tropospheric Emissions: Monitoring of Pollution

- TEMPO is a pathfinder to using hosted commercial payloads from GEO
- Tropospheric pollution observations from Geostationary Orbit
  - Ozone, NO<sub>2</sub>, SO<sub>2</sub>, aerosols, CH<sub>2</sub>O, others.
- Forms a global Air Quality constellation in GEO with EU/GEMS Sentinel 4 and Korean GEO observations.
- EPA and NOAA researchers are part of the science team.

PI: Kelly Chance, Smithsonian Astrophysical Observatory Instrument Development: Ball Aerospace Project Management: LaRC Orbit requirements: Geostationary Orbit. Hosted on a commercial communication satellite



#### NASA/ESD Applied Sciences Program

#### • Applications

 Enables identification of applications early in satellite mission lifecycle and facilitates effective ways to integrate end-user needs into satellite mission planning and throughout the mission lifecycle

#### • Capacity Building

 Builds U.S. and developing countries' capacity, including human, scientific, technological, institutional, and resource capabilities, to enhance the ability to make decisions informed by Earth science data and models

## NASA/ESD Applied Sciences Program

#### **Applications Themes**

















Oceans



Health

Water Disasters

Ecosystems

Agriculture Clir

Climate

Energy

Weather

nteractive Web GIS: Web Fire Mapp rs and Agus GFIMS **Global Fire Information** Management System lert Services: Fire Email Added EOS Data Services nerations System Image Subsets de Fire Data MODIS anid Reservesse Active Fire Product Burned Area Product

USDA/NOAA managed weekly U.S. Drought Monitor now using NASA GRACE data as part of analysis in creation of national and state-level maps..

United Nation's system now using data from NASA's Terra and Aqua satellites to identify fires and send alerts to remote areas via SMS and text messages.



#### Earth Science Technology Office (ESTO) Opportunities



The Earth Science Technology Office is a targeted, science-driven, competed, and actively managed technology program. The investment elements include:



Instrument Incubator Program (IIP) robust new instruments and measurement techniques 17 new projects added in FY14 (total funding approximately \$71M over 3 years)

#### Advanced Component Technologies (ACT)



development of critical components and subsystems for instruments and platforms 15 new projects added in FY11 (total funding approximately \$16M over 3 years)



Advanced Information Systems Technology (AIST) innovative on-orbit and ground capabilities for communication, processing, and management of remotely sensed data and the efficient generation of data products 18 new projects added in FY12 (total funding approximately \$23M over 3-4 years)



In-Space Validation of Earth Science Technologies (InVEST) on-orbit technology validation and risk reduction for small instruments and instrument systems that could not otherwise be fully tested on the ground or airborne systems *First 4 projects added in FY13 (total funding ~\$13M over 3 years)* 

The current portfolio of active investments supports all of the 2007 NRC Decadal Survey mission concepts. 65% directly support Tier 1 and 2 missions, ~ 15% support Tier 3 missions, and the remainder are crosscutting. 94<sup>th</sup> AMS Meeting, 5 February 2014, Atlanta, GA

## NASA Earth Science



Formulation