NASA's Earth Science Data Systems Program

Program Executive for Earth Science Data Systems
Earth Science Division (DK)
Science Mission Directorate, NASA Headquarters
February 16, 2016

NASA Strategic Plan 2014

- Objective 2.2: Advance knowledge of Earth as a system to meet the challenges of environmental change, and to improve life on our planet.
  - How is the global Earth system changing? What causes these changes in the Earth system? How will Earth's systems change in the future? How can Earth system science provide societal benefits?
  - NASA's Earth science programs shape an **interdisciplinary view of Earth**, exploring the **interaction** among the **atmosphere**, **oceans**, **ice sheets**, **land surface interior**, and **life itself**, which enables scientists to measure **global** climate changes and to inform decisions by Government, organizations, and people in the United States and around the world. **We make the data collected and results generated by our missions accessible to other agencies and organizations to improve the products and services they provide…**

Major Components of the Earth Science Data Systems Program

- Earth Observing System Data and Information System (EOSDIS)
  - Core systems for processing, ingesting and archiving data for the Earth Science Division
- Competitively Selected Programs
  - Making Earth System Data Records for Use in Research Environments (MEaSUREs)
  - Advancing Collaborative Connections for Earth System Science (ACCESS)
- International and Interagency Coordination and Development
  - CEOS Working Group on Information Systems and Services (WGISS)
  - Office of Science and Technology Policy (OSTP) Climate Data Initiative
  - NASA-European Space Agency (ESA) Bilateral
  - Group on Earth Observation (GEO)/USGEO

EARTH SCIENCE DATA OPERATIONS

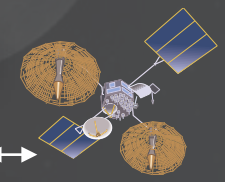
MISSION OPERATIONS

DATA ACQUISITION

EOS Spacecraft

Direct Broadcast (DB)

Direct Broadcast/ Direct Readout Stations

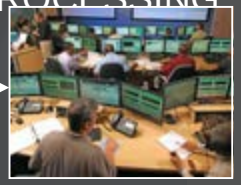


Tracking and Data Relay Satellite (TDRS)

FLIGHT OPERATIONS, DATA CAPTURE, INITIAL PROCESSING

White Sands Complex (WSC)

EOS Polar Ground Stations



EOS Data Operations System (EDOS) Data Processing

EOS Operations Center (EOC) Mission Control

DATA TRANSPORT TO DATA CENTERS/SP

SCIENCE OPERAT

SCIENCE DATA PROCESSING, DISTRIBUTION AN
DATA MANAGEMENT, DATA ACCESS
INTEROPERABLE DATA,
ARCHIVE, AND DISTRIBUTION

EOSDIS Data Centers

Instrument Teams and Science Investigator-led Processing Systems (SIPSs)

Infrastructure (Search, Order, Distribution)

- Research
- Education
- Value-Added Providers
- Interagency Data Centers
- Earth System Models
- International Partners
- Decision Support Systems

NASA INTEGRATED SERVICES NETWORK

NASA's Earth Observing System Data and Information System

- Initiated in 1990
  - In operation since 1994 with mature metadata for "heritage" datasets
  - In operation since 1997 supporting EOS instrument datasets starting with the Tropical Rainfall Measuring Mission
- Manages data from several types of sources – **satellite missions**, **aircraft investigations**, **in situ activities** and, **Principal Investigator-led dataset generation**
- Designed to receive, process (reprocess), distribute and archive terabytes of science data per day
- A **scalable public archive** of environmental data that supports global earth science research (~15PB currently)
  - Open Application Program Interfaces (APIs) allow many other value-added services to access NASA's vast Earth Science collection
  - Interoperates with data archives of other agencies and countries
- Provides a distributed information framework supporting a broad user community
- **Open Data Policy** (since 1997)
  - Data are openly available to all and free of charge except where governed by international agreements

Earth Science Data and Information Policy

- NASA commits to the **full and open sharing of Earth science data** obtained from NASA Earth observing satellites, sub-orbital platforms and field campaigns with all users **as soon as such data become available**.

- There will be **no period of exclusive access** to NASA Earth science data. Following a post-launch checkout period, all data will be made available to the user community. Any variation in access will result solely from user capability, equipment, and connectivity.

- NASA will make available all **NASA-generated standard products** along with the **source code** for algorithm software, **coefficients**, and **ancillary data** used to generate these products.

- All NASA Earth science missions, projects, and grants and cooperative agreements shall include data management plans to facilitate the implementation of these data principles.

- NASA will enforce a **principle of non-discriminatory data access so that all users will be treated equally**. For data products supplied from an international partner or another agency, NASA will restrict access only to the extent required by the appropriate Memorandum of Understanding (MOU).

- **http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/**

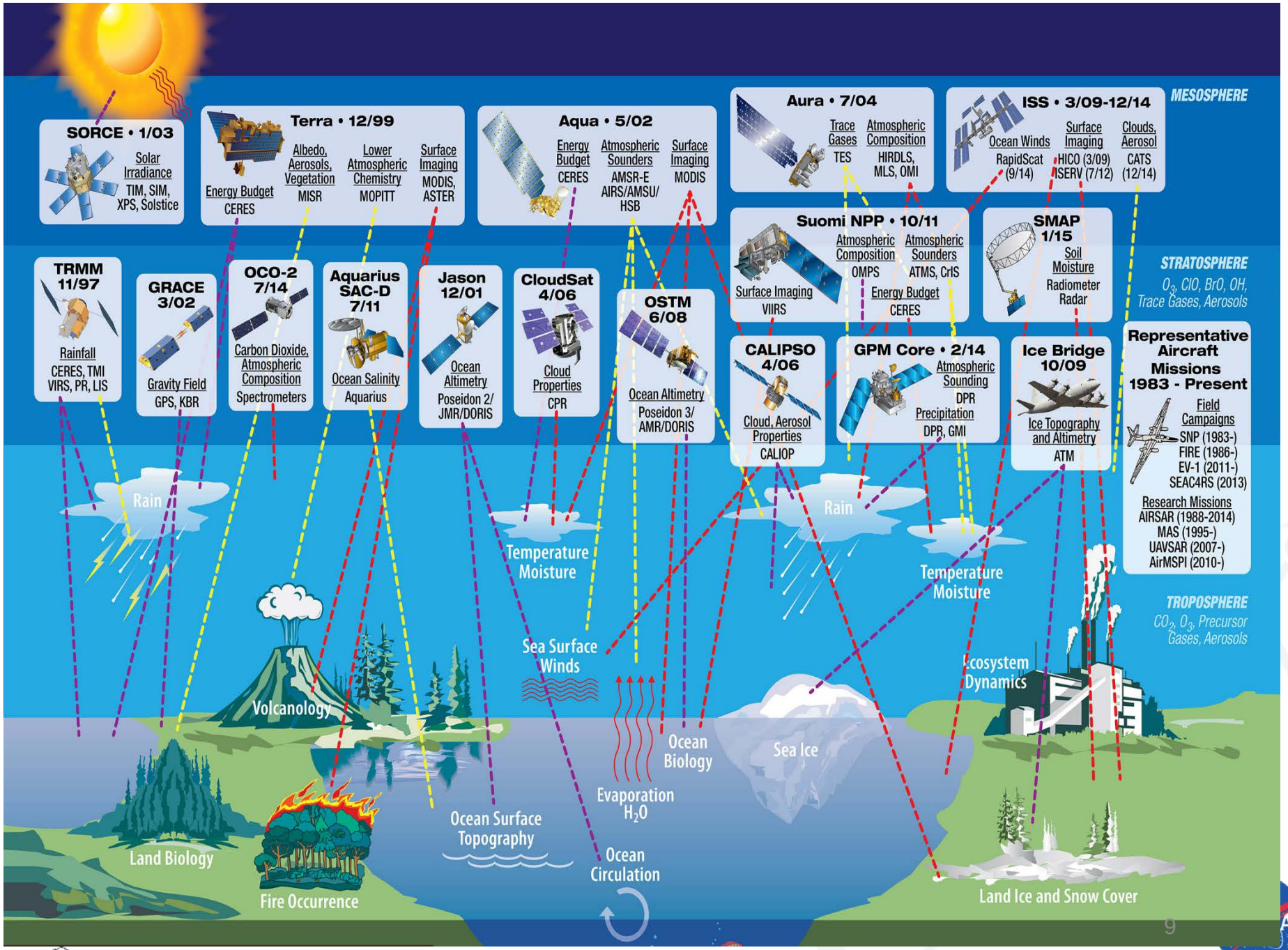
Extensive Data Collection "Volume"

- EOSDIS data collection includes over ~9200 data types
  - Land
    - » Cover & Usage
    - » Surface temperature
    - » Soil moisture
    - » Surface topography
  - Atmosphere
    - » Winds & Precipitation
    - » Aerosols & Clouds
    - » Temperature & Humidity
    - » Solar radiation
  - Ocean Dynamics
    - » Surface temperature
    - » Surface wind fields & Heat flux
    - » Surface topography
    - » Ocean color
  - Cryosphere
    - » Sea/Land Ice & Snow Cover

- Human Dimensions
  - » Population & Land Use
  - » Human & Environmental Health
  - » Ecosystems

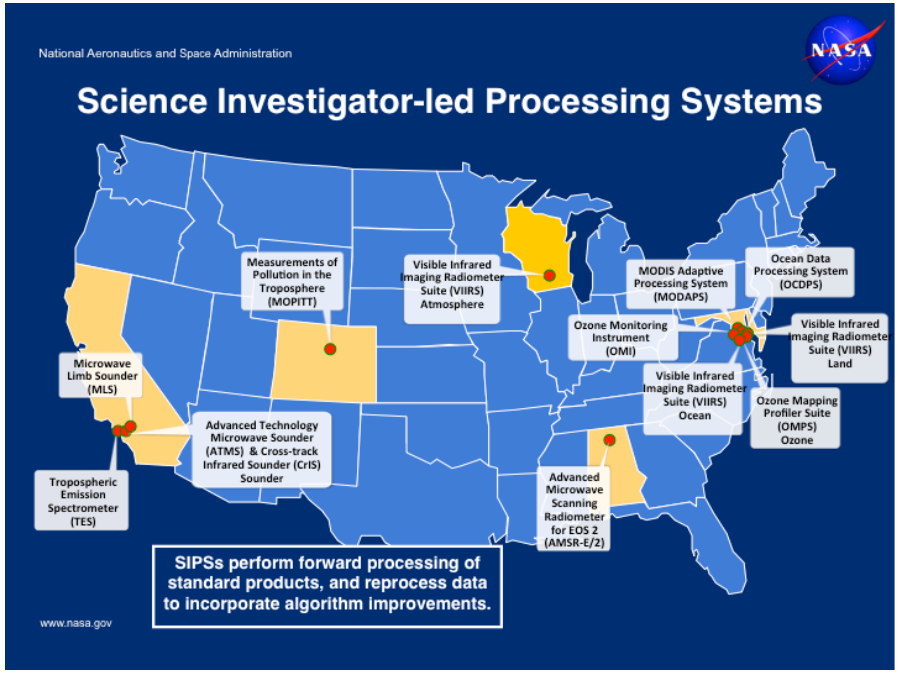
Data Sources – “Variety”

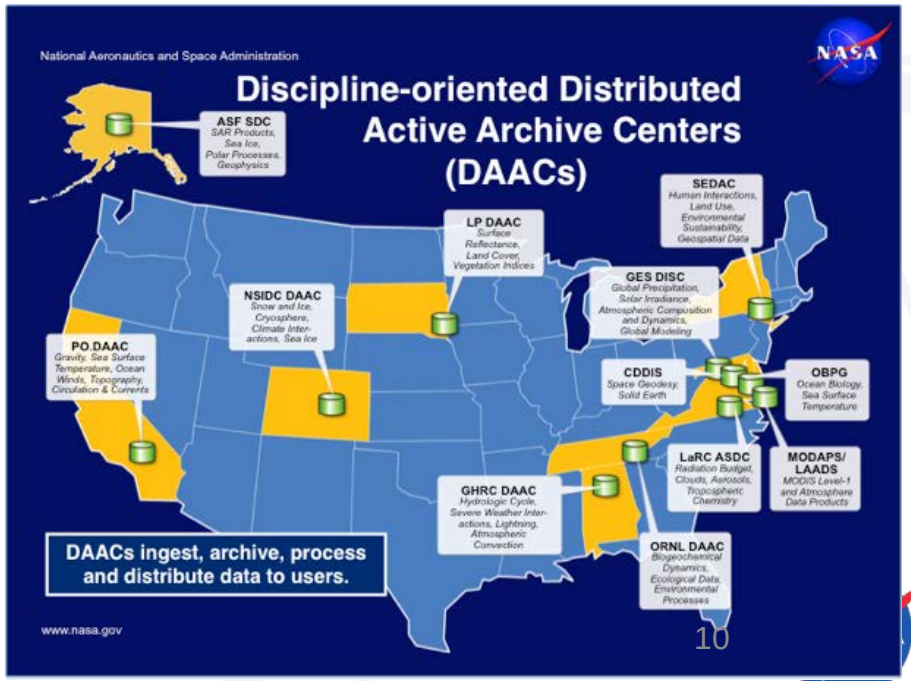
Type	Example Missions
Satellite/on-orbit Missions	Terra, Aqua, Aura, Suomi-NPP, SORCE, GPM, TRMM, GRACE, CloudSat, CALIPSO, Aquarius, etc.
Airborne missions	IceBridge, Earth Ventures (5+ missions), UAVSAR, etc.
In Situ Measurement missions	Field campaigns on land (e.g., LBA-ECO) and in the ocean (e.g., SPURS)
Applications support	Near-real time creation and distribution of selected products for applications communities
Earth Science Research support	Research products from ROSES efforts like MEaSUREs. This also includes data from older, heritage missions (prior to EOS Program) that the DAACs rescue – e.g., Nimbus, SeaSat


SORCE • 1/03
Solar Irradiance
TIM, SIM, XPS, Solstice
Terra • 12/99
Energy Budget
CERES
Albedo, Aerosols, Vegetation
MISR
Lower Atmospheric Chemistry
MOPITT
Surface Imaging
MODIS, ASTER
Aqua • 5/02
Energy Budget
CERES
Atmospheric Sounders
AMSR-E AIRS/AMSU/ HSB
Surface Imaging
MODIS
Aura • 7/04
Trace Gases
TES
Atmospheric Composition
HIRDLS, MLS, OMI
ISS • 3/09-12/14
Ocean Winds
RapidScat (9/14)
Surface Imaging
HICO (3/09) ISERV (7/12)
Clouds, Aerosol
CATS (12/14)
MESOSPHERE
TRMM 11/97
Rainfall
CERES, TMI VIRS, PR, LIS
GRACE 3/02
Gravity Field
GPS, KBR
OCO-2 7/14
Carbon Dioxide, Atmospheric Composition
Spectrometers
Aquarius SAC-D 7/11
Ocean Salinity
Aquarius
Jason 12/01
Ocean Altimetry
Poseidon 2/ JMR/DORIS
CloudSat 4/06
Cloud Properties
CPR
OSTM 6/08
Ocean Altimetry
Poseidon 3/ AMR/DORIS
Suomi NPP • 10/11
Surface Imaging
VIIRS
Atmospheric Composition
OMPS
Atmospheric Sounders
ATMS, CrIS
Energy Budget
CERES
SMAP 1/15
Soil Moisture
Radiometer Radar
STRATOSPHERE
O_3, ClO, BrO, OH, Trace Gases, Aerosols
CALIPSO 4/06
Cloud, Aerosol Properties
CALIOP
GPM Core • 2/14
Atmospheric Sounding
DPR
Precipitation
DPR, GMI
Ice Bridge 10/09
Ice Topography and Altimetry
ATM
Representative Aircraft Missions 1983 - Present
Field Campaigns
SNP (1983-)
FIRE (1986-)
EV-1 (2011-)
SEAC4RS (2013)
Research Missions
AIRSAR (1988-2014)
MAS (1995-)
UAVSAR (2007-)
AirMSPI (2010-)
Rain
Temperature Moisture
Rain
Temperature Moisture
TROPOSPHERE
CO_2, O_3, Precursor Gases, Aerosols
Sea Surface Winds
Volcanology
Ecosystem Dynamics
Ocean Biology
Sea Ice
Evaporation H_2O
Land Biology
Ocean Surface Topography
Ocean Circulation
Fire Occurrence
Land Ice and Snow Cover

NASA'S EOSDIS

- Earth Science mission data are **processed** by Science Investigator-led Processing Systems (SIPS) designed for missions and measurements
- Stewardship of Earth Science Data is conducted by Distributed Active Archive Centers (DAACs) that provide **knowledgeable curation** and **science-discipline-based support**
- NASA provides **high bandwidth** network connectivity to support production data flows and community access to data, including access to **near real time data**
- NASA develop tools for users to obtain ***needed*** data/information while minimizing burden associated with unwanted data
- NASA engages with multiple US agency efforts to facilitate **use** of data **by broadest possible community** with minimal effort and maximal consistency with other data sources





EARTH SCIENCE DATA SYSTEMS

Science Investigator-Led Processing Systems (SIPS)

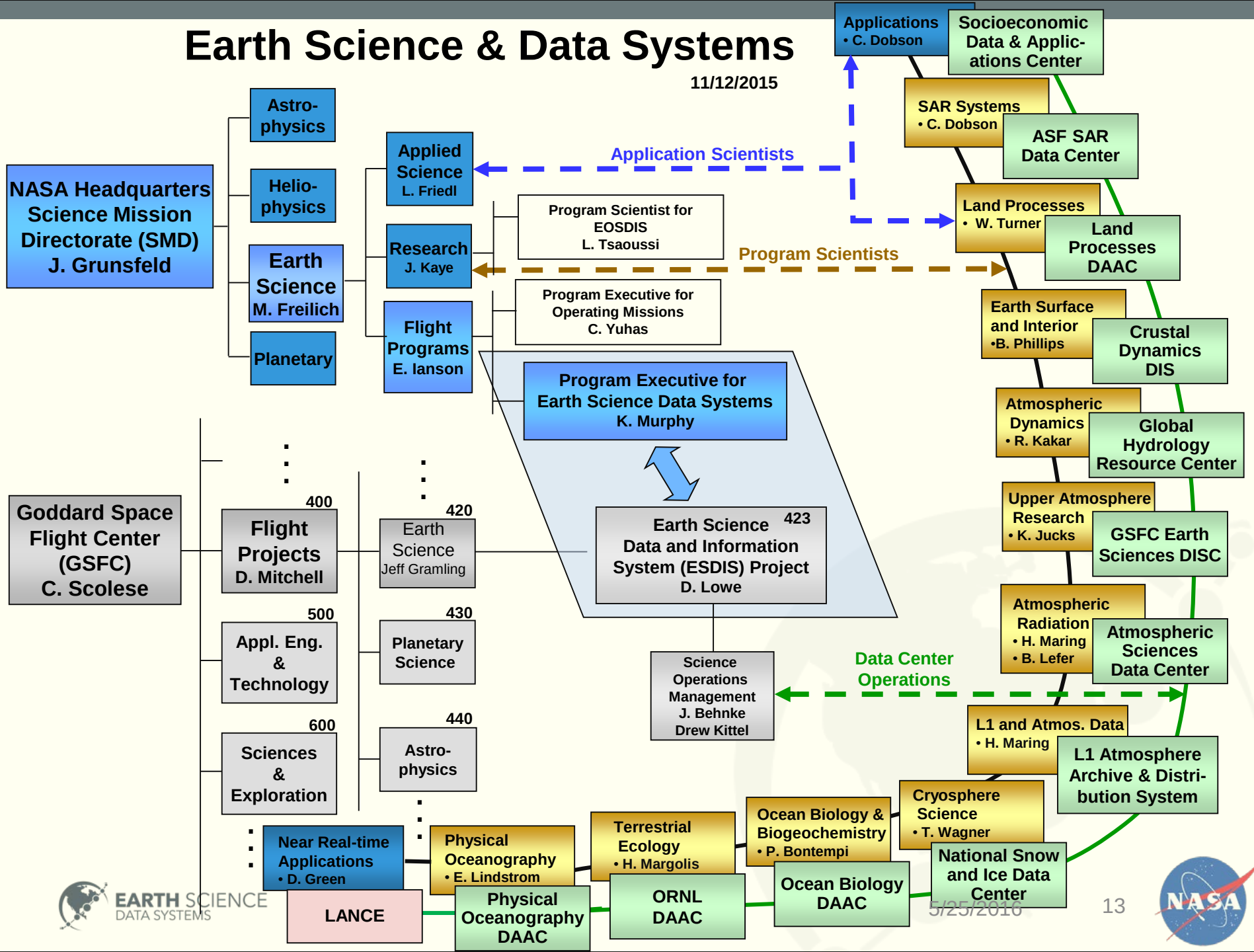
- Data processing system to implement Science Team algorithms/software for production of standard NASA products (L1, L2, L3).
- Work with Science Team members to obtain enhanced, refined, or alternately-developed near real-time algorithms for application and operation usage to meet the needs of NASA's near real-time user community
- Ensure that products meet all Earth Science Data System standards and include appropriate ISO 19115 metadata content, OGC
- Apply cal/val routines and changes to lookup and ancillary data as necessary
- Plan and coordinate resources for re-processing campaigns
- Support quality assessment of the products
- Support special processing requests from the Science Team within scope of the SIPS resources (e.g. field campaigns)
- Transfer products and appropriate documentation on a timely basis to DAACs for public distribution

Science Discipline Based Distributed Architecture

- DAACs are located at host organizations that are widely recognized by the science community for their expertise and heritage of experience in the relevant science disciplines.
  - DAACs have a substantial user base that advocate for data, tools and services that enable cutting edge science
- Each DAAC has a User Working Group composed of leaders representing users within their science disciplines
  - Provide guidance in defining DAAC's science goals and data management priorities;
  - Recommend addition (or deletion) of data sets/products in the DAAC holdings
  - Assess and provide feedback on the DAAC's support to the user community needs.
  - Provide recommendations that are specific to the unique requirements of their science disciplines
- Each DAAC has an assigned ESD Program Scientist

Earth Science & Data Systems

11/12/2015



ESDIS Project Manages the Coordination of EOSDIS Activities

- ESDIS develops and applies standard policies and practices across the DAACs
  - These policies and practices enable interoperability of data sets across multiple disparate science domains with significantly different analysis techniques.
- ESDIS avoids duplication of effort
  - Most ancillary data needed for processing comes from external sources. The GSFC DAAC acquires most of the ancillary data and distributes it to the other DAACs.
- ESDIS coordinates across the DAACs to improve efficiency:
  - Weekly teleconferences with DAACs to share information and coordinate activities;
  - Annual meetings with DAAC Managers and DAAC System Engineers to promote collaboration.
- ESDIS manages the Earth Science Data Systems Working Groups:
  - Bring together DAACs, SIPSs, and peer-review-selected PI-led data system projects (MEaSUREs and ACCESS) to share information and collaborate on projects.
  - These collaborative efforts help to leverage experience and investments across the EOSDIS elements, and avoid duplication of effort.

EOSDIS Infrastructure

- **Earthdata:** The EOSDIS website https://earthdata.nasa.gov will increase visibility to the interdisciplinary use of data and demonstrate how data are used.

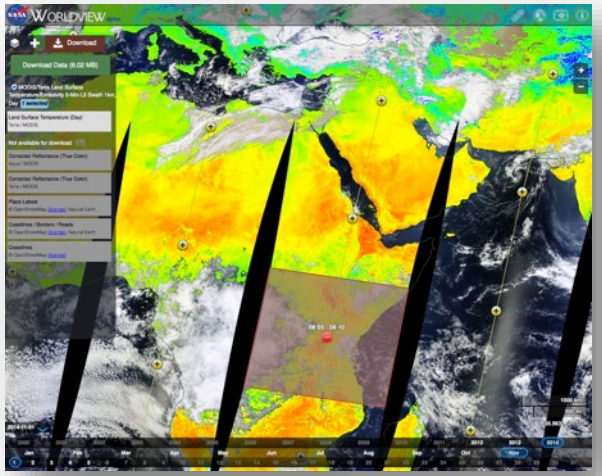
- High Performance Data Search and Discovery
  - **Common Metadata Repository (CMR):** Provide sub-second search and discovery services across the Sentinel and other EOSDIS holdings.
  - **Earthdata Search Client:** Data search and order tool https://search.earthdata.nasa.gov

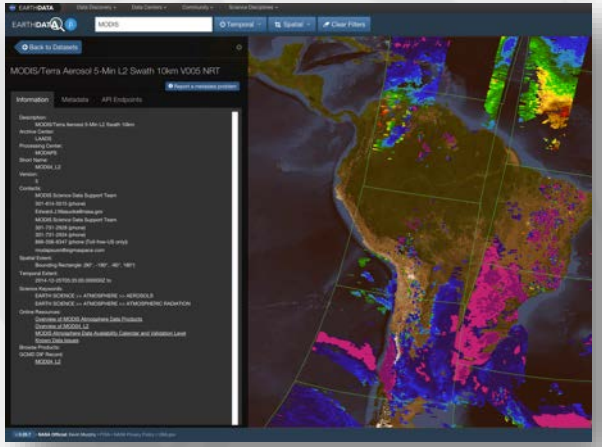
- Imagery and Data Visualization Tools
  - **Global Imagery Browse Services (GIBS)**: full resolution imagery in a community standards-based set of imagery services
  - **Worldview**: highly responsive interface to explore GIBS imagery and download the underlying data granules https://earthdata.nasa.gov/labs/worldview/
  - **Giovanni**: Quick-start exploratory data visualization and analysis tool

- **EOSDIS Metrics System (EMS):** collects and reports on data ingest, archive, and distribution metrics across EOSDIS

- **Earthdata Infrastructure (EDI DevOps):** platform for requirement management, code development, testing and deployment to operations

- **User Support Tool (UST):** user relationship management and issue resolution (Kayako)





Understanding User Needs and Assessing Performance

- DAAC User Working Groups – Provide assessments and recommendations based on unique DAAC mission requirements

- DAAC Customer Satisfaction
  - Annual Online survey of all DAAC users to evaluate satisfaction and measure performance
  - Performed by CFI Group, the American Customer Satisfaction Index (ACSI) is the #1 national indicator of customer satisfaction for more than 225 companies and 130 Federal programs

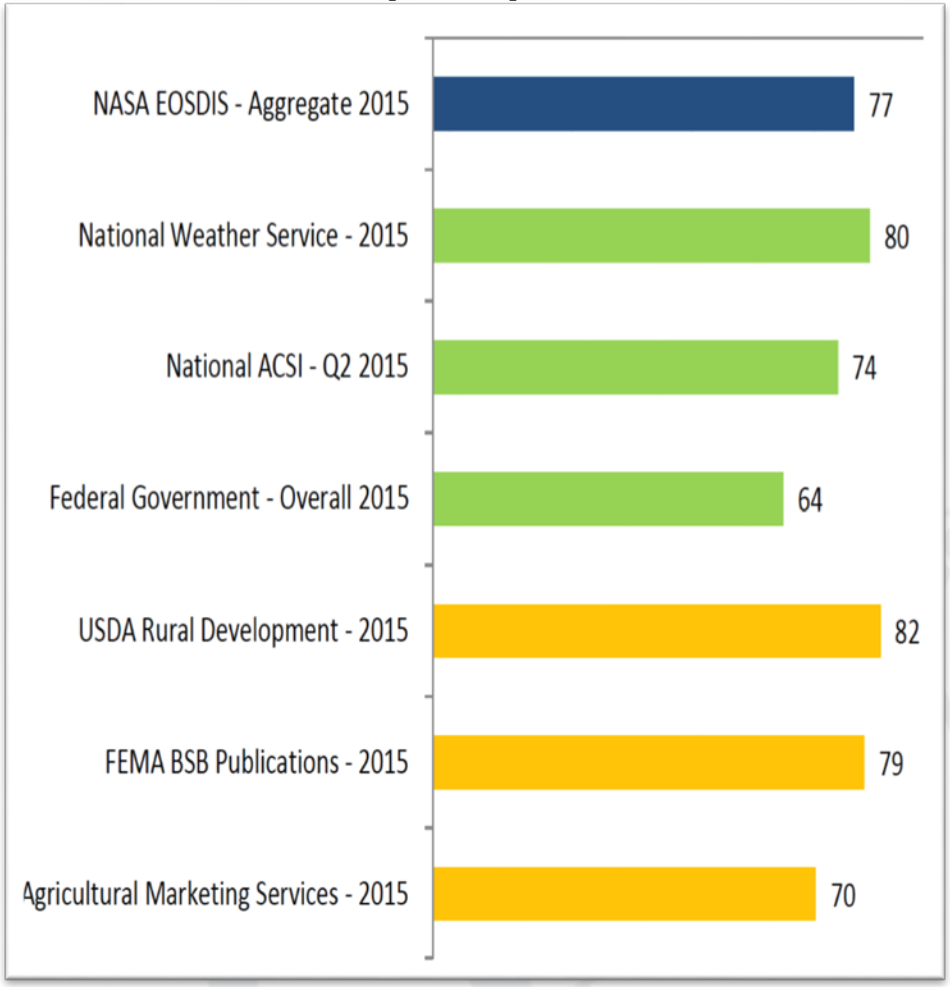
- EOSDIS Metrics System – collects complex metrics on ingest, archive and distribution for evaluation of system performance.
  - Enables ESDIS to characterize use of the EOSDIS, and report to NASA Headquarters and OMB.

- User Services Working Group – DAAC User Services personnel work together to best service science communities
  - User feedback – via Kayako
  - Personal interaction with users

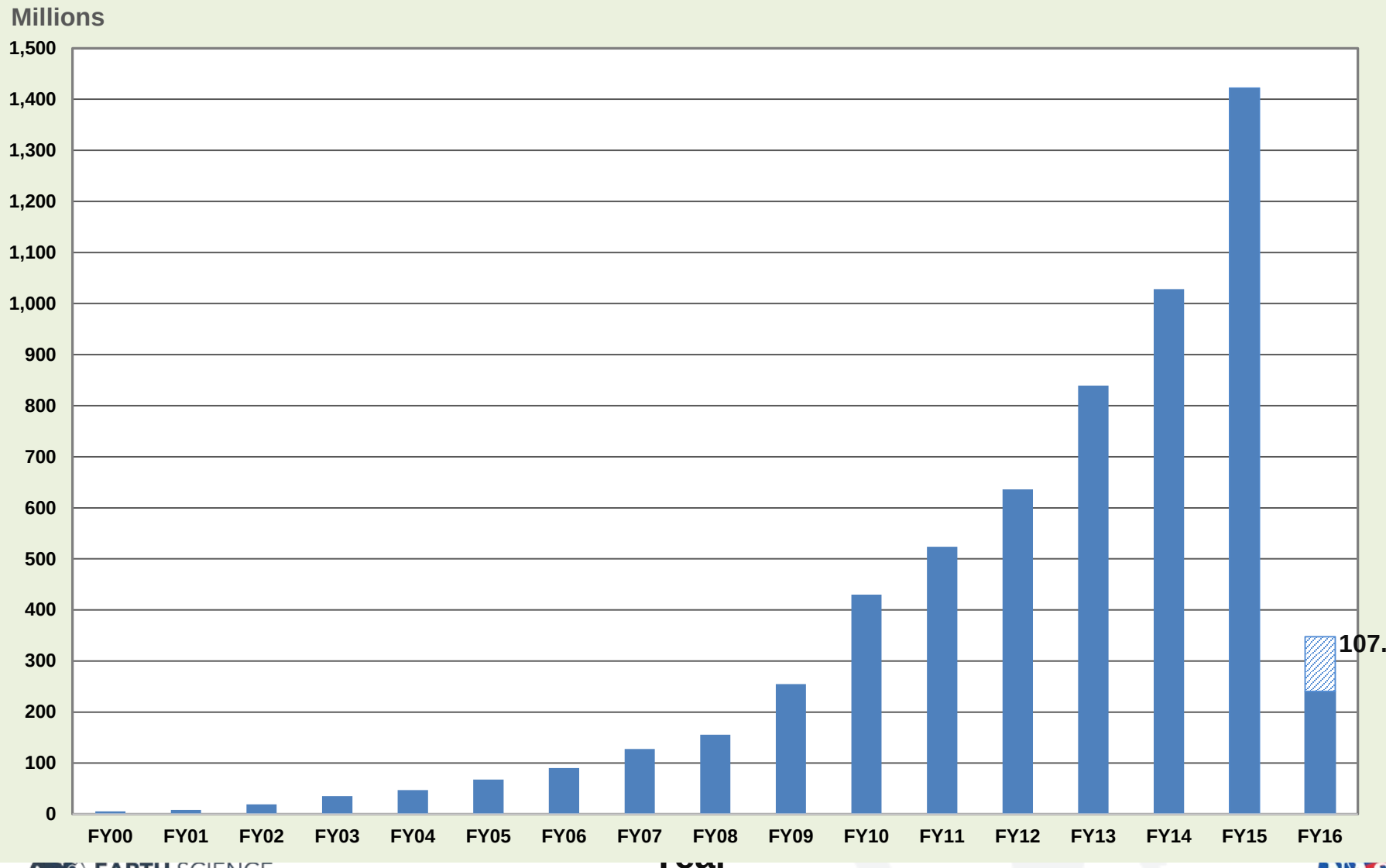
EOSDIS Metrics

Preliminary EOSDIS FY2015 Metrics	
Unique Data Products	9,462
Distinct Users of EOSDIS Data and Services	2.6 M
Web Site Visits of 1 Minute or more	2.4 M
Average Daily Archive Growth	16 TB/day
Total Archive Volume (as of Sept. 30, 2014)	14.6 PB
End User Distribution Products	1.42 B
End User Average Daily Distribution Volume	32.1 TB/day

American Consumer Satisfaction Index (ACSI) FY2015



EOSDIS Products Delivered: FY00 – Dec.'15



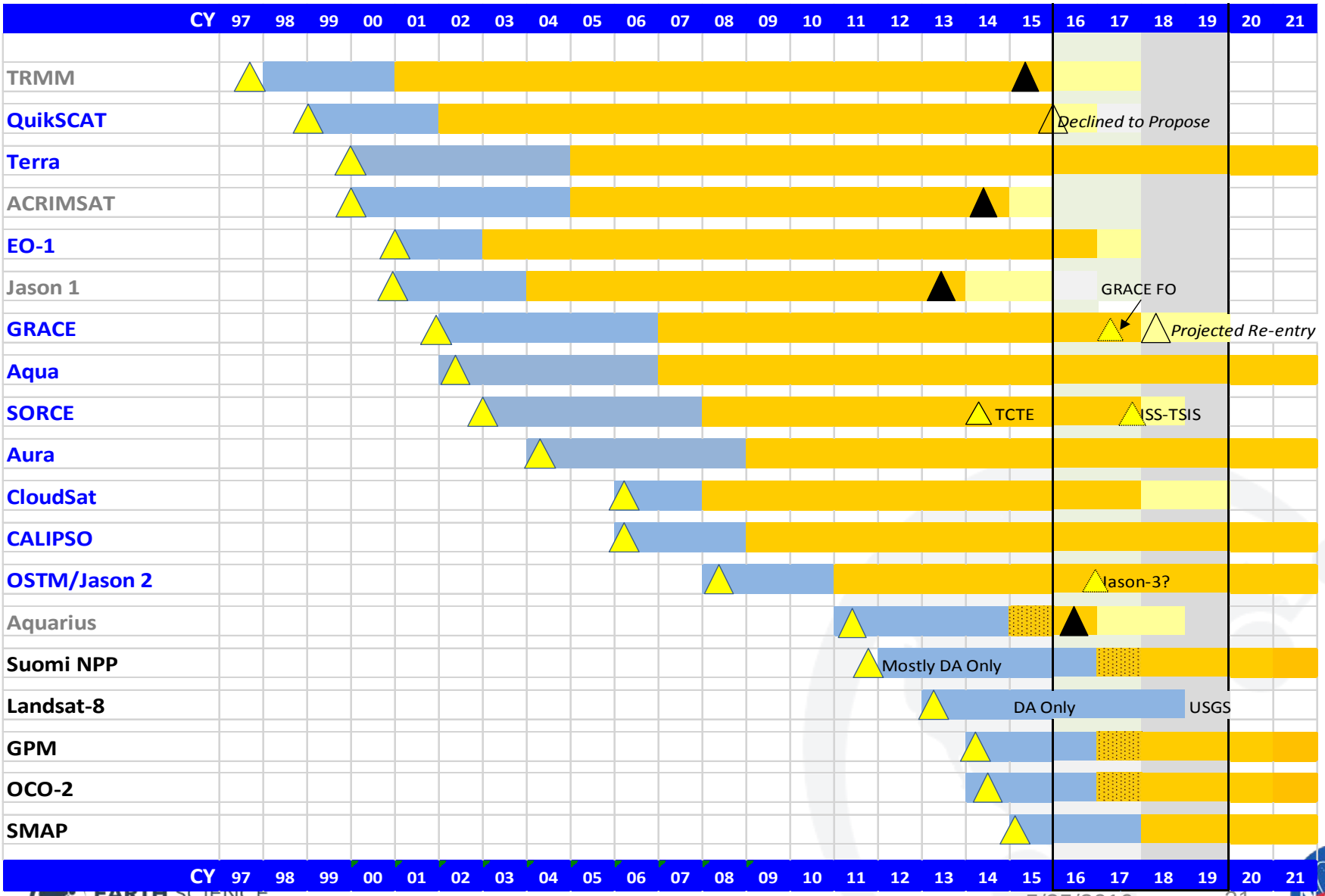
https://worldview.earthdata.nasa.gov/

DEMO

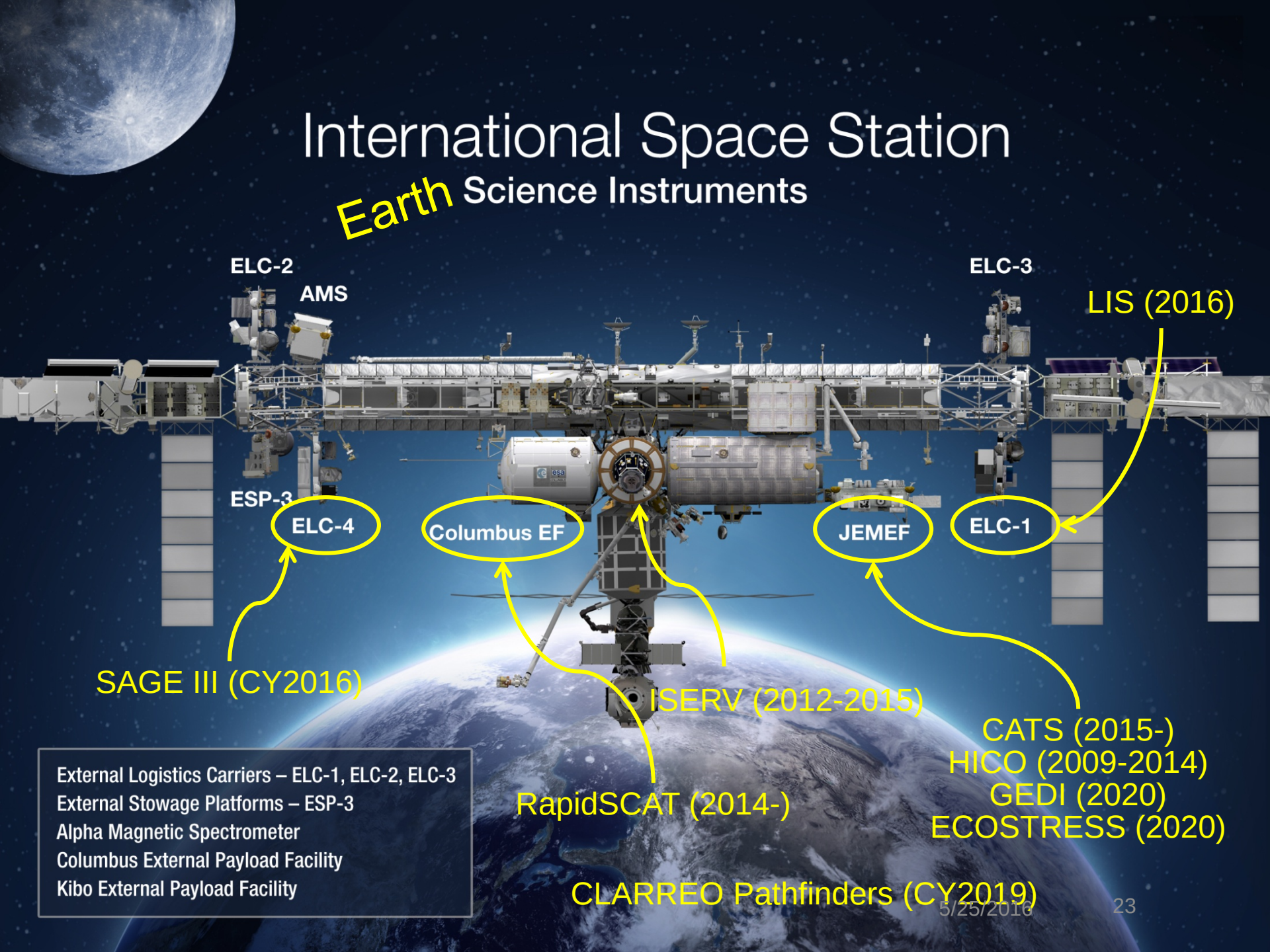
Acronym List

- CALIPSO - Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
- DAACS - Distributed Active Archive Centers
- GPM - Global Precipitation Measurement
- GRACE - Gravity Recovery and Climate Experiment
- ISS - International Space Station
- LBA-ECO - Large-Scale Biosphere-Atmosphere Experiment in Amazonia-Ecology
- NPP - National Polar-orbiting Partnership
- OCO-2 - Orbiting Carbon Observatory-2
- OSTM - Ocean Surface Topography Mission
- ROSES - Research Opportunities in Space and Earth Sciences
- SAC-D – Satélite de Aplicaciones Científicas-D/Satellite for Scientific Applications-D
- SMAP - Soil Moisture Active Passive
- SORCE - Solar Radiation and Climate Experiment
- SPURS - Salinity Processes in the Upper Ocean Regional Study
- TRMM - Tropical Rainfall Measuring Mission
- UAVSAR - Uninhabited Aerial Vehicle Synthetic Aperture Radar

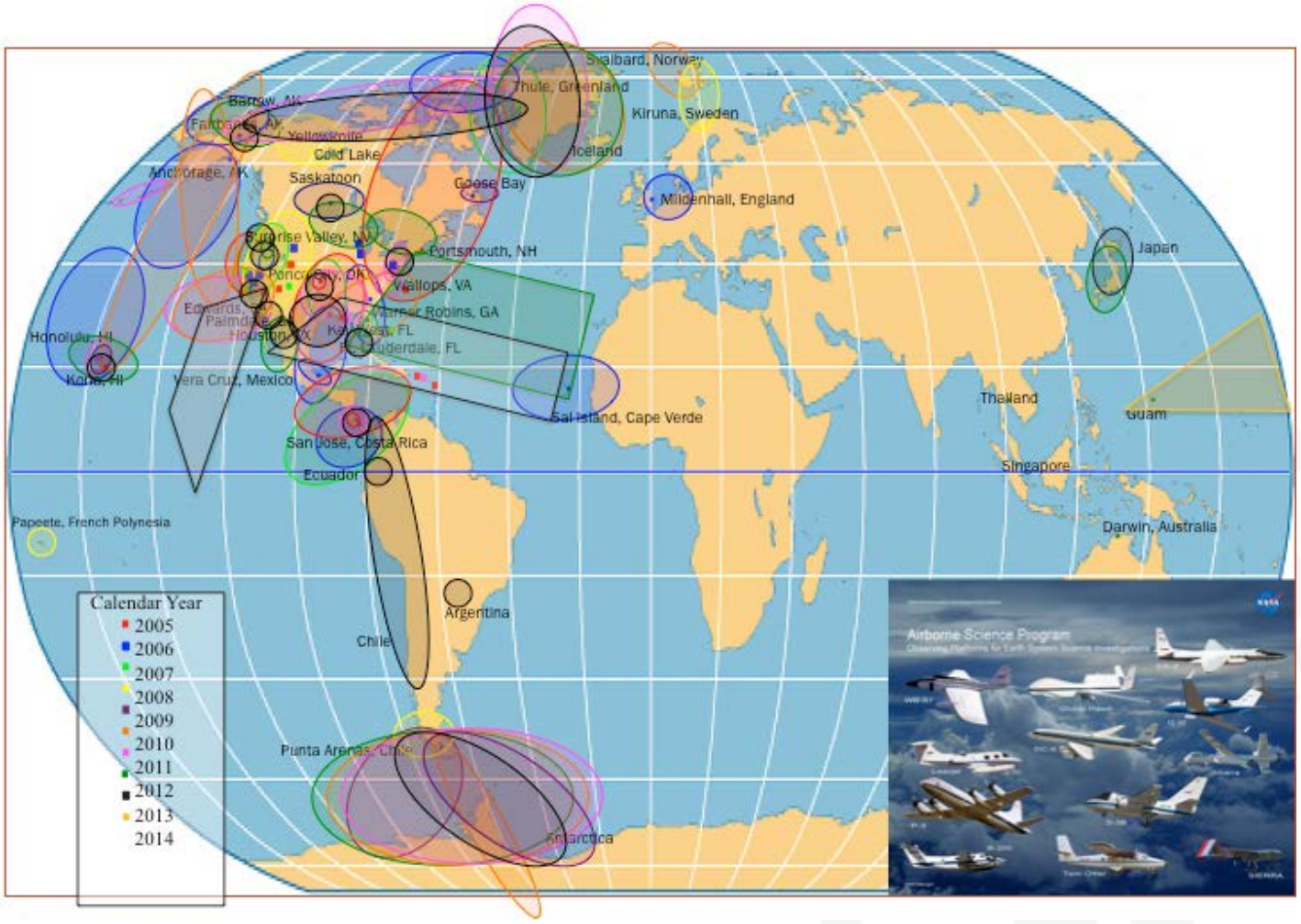
2015 Senior Review: Funded Mission Extensions



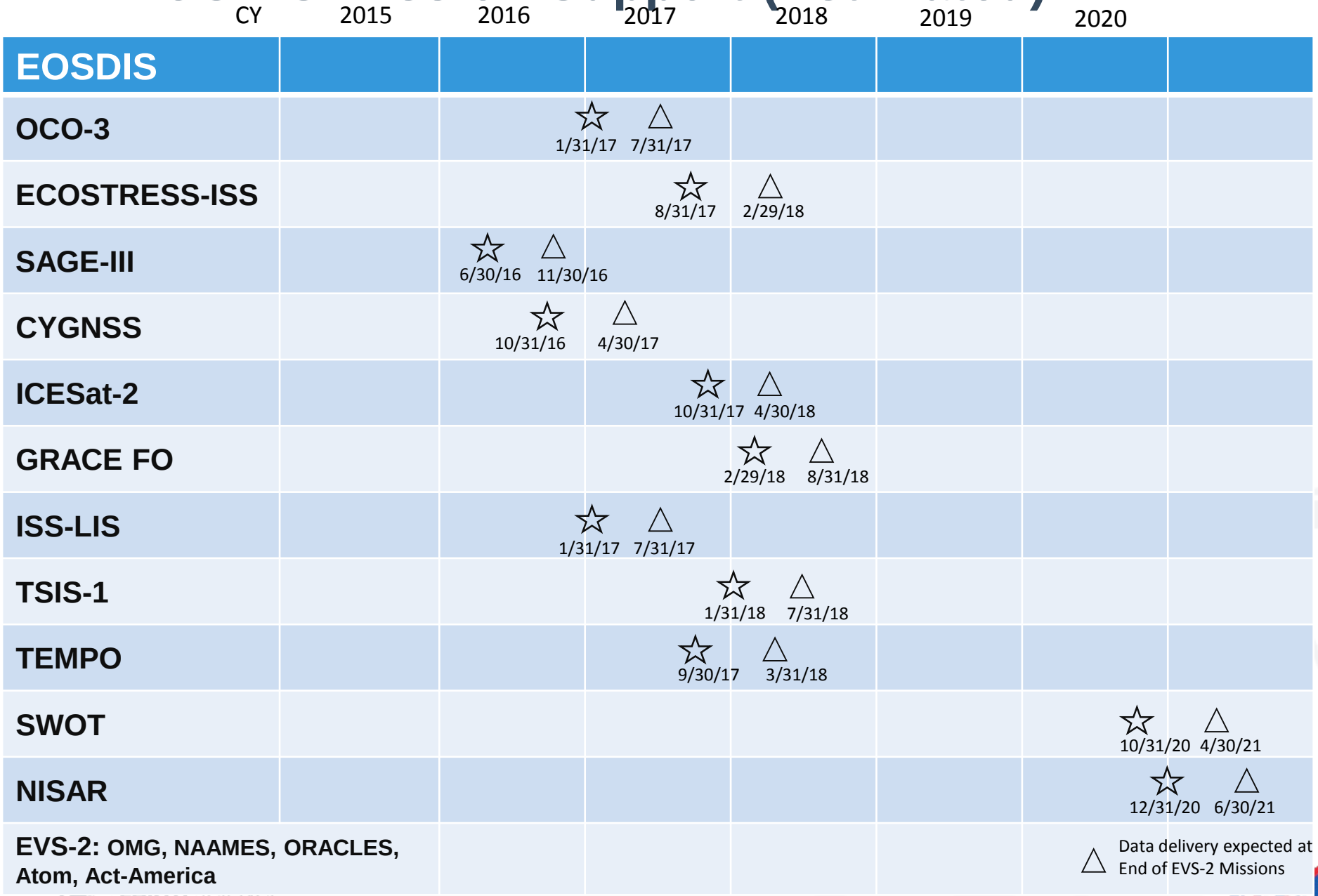

Formulation
Implementation
Primary Ops
Extended Ops
Sentinel-6A/B
Earth Science Instruments on ISS:
RapidScat, CATS,
LIS, SAGE III (on ISS), TSIS-1, OCO-3,
ECOSTRESS,
GEDI, CLARREO-PF
Landsat 9
PACE
NI-SAR
SWOT
TEMPO
JPSS-2 (NOAA)
RBI, OMPS-Limb
GRACE-FO (2)
ICESat-2
CYGNSS
ISS
SORCE,
TCTE (NOAA)
NISTAR, EPIC
(NOAA'S DSCOVR)
QuikSCAT
EO-1
Landsat 7
(USGS)
SMAP
Terra
Suomi NPP
(NOAA)
Aqua
Landsat 8
(USGS)
CloudSat
CALIPSO
GPM
Aura
GRACE (2)
OSTM/Jason 2
(NOAA)
OCO-2


International Space Station
Earth Science Instruments
ELC-2
AMS
ELC-3
LIS (2016)
ESP-3
ELC-4
Columbus EF
JEMEF
ELC-1
SAGE III (CY2016)
ISERV (2012-2015)
CATS (2015-)
HICO (2009-2014)
GEDI (2020)
ECOSTRESS (2020)
RapidSCAT (2014-)
CLARREO Pathfinders (CY2019)
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

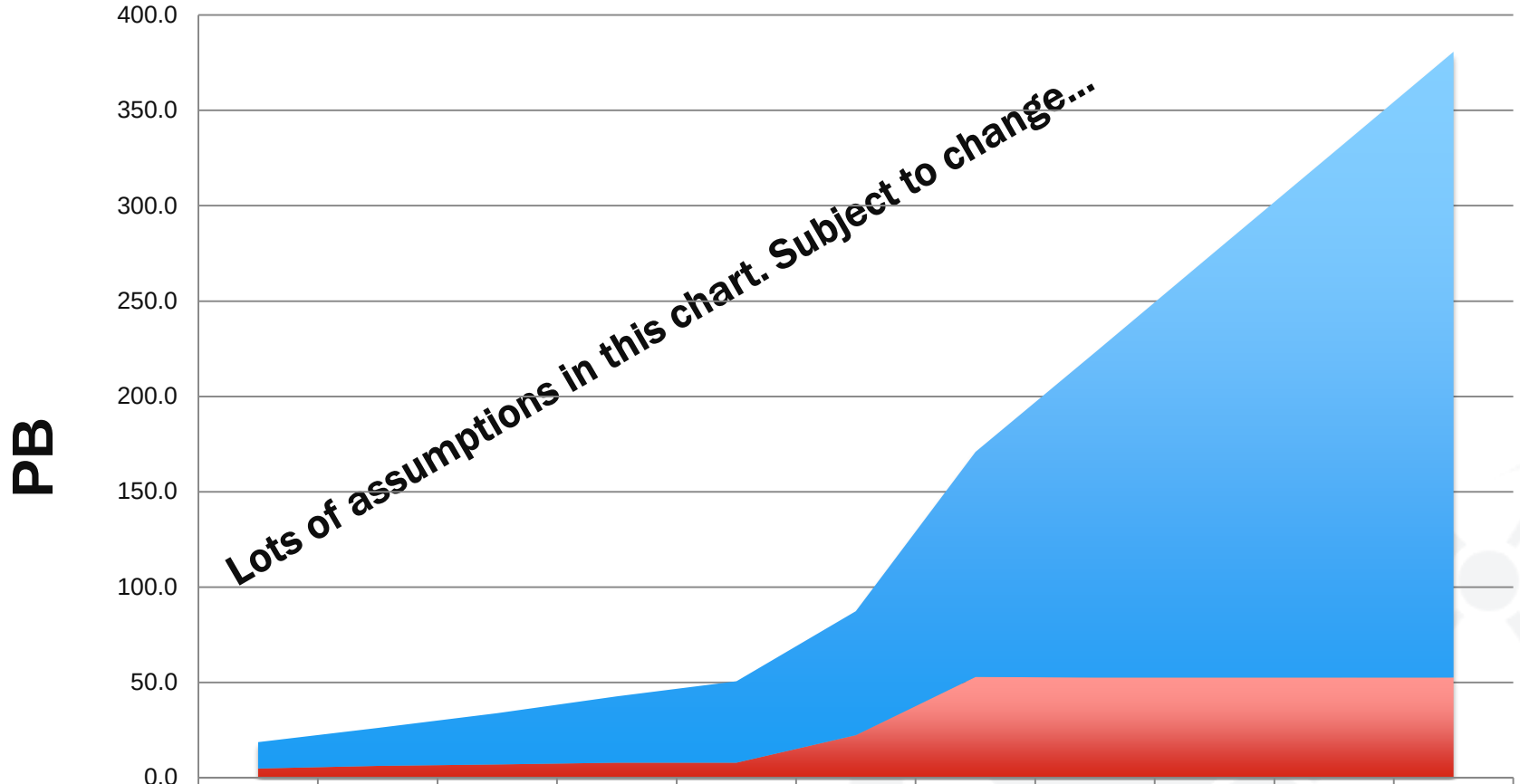
Airborne Science Program 2005-2014



EOSDIS Mission Support (Estimated)



EOSDIS Archive Growth *Estimate* (Prime + Extended)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Cumulative Archive Size (PB)	13.8	20.0	27.0	34.8	42.7	65.0	118.0	170.5	223.1	275.6	328.2
Archive Growth Rate (PB)	4.9	6.2	7.0	7.9	7.9	22.4	52.9	52.6	52.6	52.6	52.6