

# The Problem

- The US civilian environmental satellite constellation provides essential observations that serve weather forecasting, climate science, environmental monitoring, and basic Earth science.
- The NASA, NOAA and USGS satellite programs are inflexible, overly risk-averse and therefore costly, through the mid-2020's.

*“Gentlemen, we have run out of money. Now we have to think.”  
Sir Winston Churchill*

# Notional Observational Requirements

Must conform to  
Climate Standards  
Earth Science

Observations	Current status and plan; or, potential instrument/mission	US Agency	Type
<b>I: Operational Weather</b>			
Visible and infrared imagery	VIIRS on NPP, JPSS-1	NOAA	OW
Infrared sounding	CrIS on NPP, JPSS-1, JPSS-2	NOAA	OW
Microwave sounding	ATMS on NPP, JPSS-1, JPSS-2	NOAA	OW
Other microwave in LEO afternoon orbit	AMSR on Japanese GCOM	NOAA	OW
Various geostationary measurements*	GOES	NOAA	OW
<b>II: Climate and land imaging</b>			
Solar irradiance	SORCE; TSIS	NASA/NOAA	CL
Ozone	OMPS-Nadir and -Limb	NASA/NOAA	CL
Land imagery	Landsat-8; LI	NASA/USGS	CL
Ice (Gravity)	GRACE (E); GRACE follow-on (RC)	NASA	CL
Earth radiation budget	CERES, RBI	NASA/NOAA	CL
<b>III: Earth Science/Inst. Dev</b>			
Precipitation	Radar: TRMM; GPM	NASA	ES>CL
Sea-surface winds	Scatterometry: QuikScat follow-on	NASA	ES>CL
Cloud composition and extent	Cloudsat; CALIPSO; ACE	NASA	ES>CL
Ocean altimetry	Jason-2; Jason-3	NOAA	ES>CL
Atmospheric chemistry	SAGE; SAGE-III on ISS	NASA	ES>CL
Ice	IceSAT; (Ice Bridge); IceSat-2	NASA	ES
Aerosol	Polarimetry: APS (SAGE-III?)	NASA	ES
Carbon monitoring	OCO-2; ASCENDS	NASA	ES
Soil moisture	SMAP	NASA	ES
Ocean salinity	Aquarius	NASA	ES
Absolute radiance	CLARREO	NASA	ES
Earth deformation	SAR (Lidar?)	NASA	ES
Vegetation canopy, winds	Lidar	NASA	ES
Temp and humidity profiles	GPS/RO: COSMIC; COSMIC-2	NOAA	ID>OW
Hyperspectral	EO-1: HypSPIRI	NASA	ID>ES

**Key:**

**OW** = Operational weather  
**CL** = Climate and land surface imaging  
**ES** = Earth Science Investigation

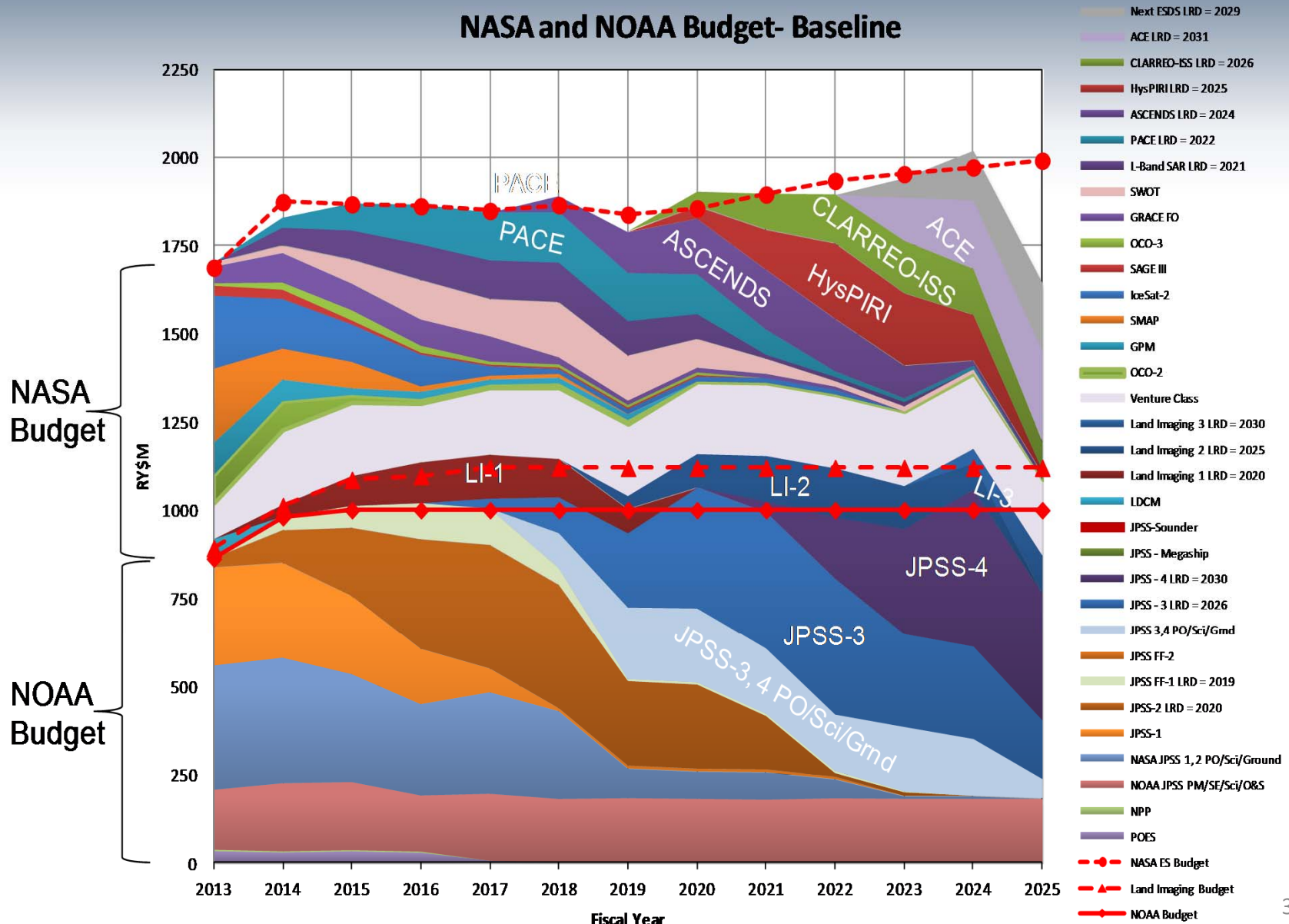
**ID** = Instrument technology development  
**ES>CL** denotes an Earth Science measurement that may evolve into Climate/Environmental monitoring

\* GOES requirements are not addressed in this paper, see section (3)

# Integrated Budget Outlook

FY 14 Presidential Budget

## NASA and NOAA Budget- Baseline



## What Should We Do?

- **Set Priorities.**
- **Optimize acquisition.**
- **Reassess program management models.**

# Setting Priorities: A proposed framework



- **I. Operational Weather monitoring and prediction** - The NOAA weather satellites provide vital data for “nowcasts” and for initializing weather prediction models. Gaps in coverage could have immediate serious negative consequences, i.e., risk to life and limb. ***Maintenance of an unbroken data stream is essential for this task.***
- **II. Continuous Climate and land surface imaging** –This data set includes all Group I observations and a large number of additional measurements, amounting to dozens of data products. Halts or large gaps in these data records directly reduce our ability to track climate and environmental change. ***Data continuity is critical for this task.***
- **III. Research Earth science investigations and instrument technology development** –The NRC 2007 Earth science decadal survey prioritizes missions to support science investigations. New sensor technologies are also supported. Some observations may be promoted to Group I or II depending on their proven importance. ***There is no ab initio requirement for data continuity or reliability beyond supporting the immediate science goals.***

# Setting Priorities

## (2) Linkage between the groups

- Linkages and mutual benefits between the 3 groups are very strong. Weather prediction and climate studies use many of the same observations and instruments.
- Required observations for weather and climate overlap, particularly temperature and humidity sounding, and atmospheric and surface imaging (clouds, weather systems, surface temperatures, etc).
- The instruments designed to gather Group I observations (weather) should conform to Group II (climate) requirements, thereby eliminating unnecessary duplication and cost.
- Group I and II instruments must also satisfy two key requirements to be useful for climate studies:
  - Data quality must be at least as good as that from the precursor instrument.
  - Data products must be “backwards-compatible” with the precursor data stream.

# Setting Priorities

## (3) Building consensus

- An expanded Earth Science Decadal Survey (NASA, NOAA, USGS) is the obvious venue for setting priorities.
- Funding allocation and risk posture:
  - Acceptance of the framework does not mean that agency funds are reallocated nor does it dictate closer coordination among the agencies than is currently required.
  - This framework does not imply a redistribution of funds between the Groups, but it does imply very different levels of reliability, redundancy and risk-tolerance should be assigned to each Group.

**Many more missions could be executed within a given resource envelope if a tiered risk posture were adopted.**

# Acquisition

- Aligning priorities, risk tolerance, cost and mission class

	Class B	Class C	Class D
Mission Complexity	High to Medium	Medium to Low	Medium to Low
Acceptable Risk	Low	Medium	High
Mission Assurance	Comprehensive	Scaled	Limited
Redundancy	Comprehensive	Selected	Single-string
Testing	Comprehensive	Selected	Focused
Potential Savings Relative to Class B	N/A	15-20%	30%-40%

Group I

Group II


Group III



# Acquisition (2)

- **Hardware acquisition: “Block Buys”**
  - Savings of ~60% for spacecraft and for instruments.
  - Two obvious opportunities: JPSS spacecraft (2, 3, 4) and the next block of Landsat spacecraft (10, 11, 12).
  - Incentivize inter-agency block buys.
  - A study is needed to map out the opportunities.
- **Spacecraft accommodations**
  - Most environmental spacecraft are under-manifested (mass, power...)
  - Design spacecraft buses to use available launcher throw-weight to accommodate additional instruments.
  - Incentivize programs to accommodate additional payloads.

# Management Models

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- **Inter-agency consortium (e.g., NPOESS)**
  - **Reimbursable funding, layered management model (e.g., JPSS)**
  - **Reimbursable funding, integrated management model (e.g., GOES-R)**
  - **Agency partner model (e.g., Landsat)**

# Recommendation 1: Set Priorities

- The next Earth Science Decadal Survey should include weather, climate, land imaging, and Earth science requirements.
  - Weather data requirements should be defined to also satisfy climate data requirements.
- The output of the decadal survey should be an integrated prioritized national plan.
  - Joint agency measurement definition teams would then define requirements for acquisition plans.

# Recommendation 2: Optimize Acquisition

- **Aligning priorities, risk tolerance, cost and mission class.**
  - Assess the impact of making most Group II and almost all Group III missions Class D by default.
  - Assess the impact of converting all Earth Venture instruments and missions to Class D by default with raised Class D budget ceilings to ~ \$90M and \$250M.
  - Assess the benefits and risks of executing some decadal survey candidate missions as Class D.
  - Incentivize migration to a lower mission Class.
  - Assess current Decadal missions for lower cost implementation.
- **Investigating spacecraft and instrument block buys:**
  - A cross-agency study should identify block buy opportunities.
- **Optimizing spacecraft accommodations.**
  - Load-up spacecraft with instruments to capacity.

## Recommendation 3: *Reassess program management models*

- A team should study the management schemes in use across the inter-agency programs and seek to find simpler models.

# Next

**Key Action: Prepare Statement of Task for tri-agency NRC Decadal Survey that addresses Group I, II, and III observations.**

**Assess tiered risk framework**

**Other Actions:**

- Assess acquisition models
- Determine appropriate program management models