
**Science Committee
Presentation to NAC Plenary
July 16, 2009**

**Jack Burns
Brad Jolliff
Mark Robinson
Byron Tapley
Roy Torbert
Michael Turner
Charles Kennel**

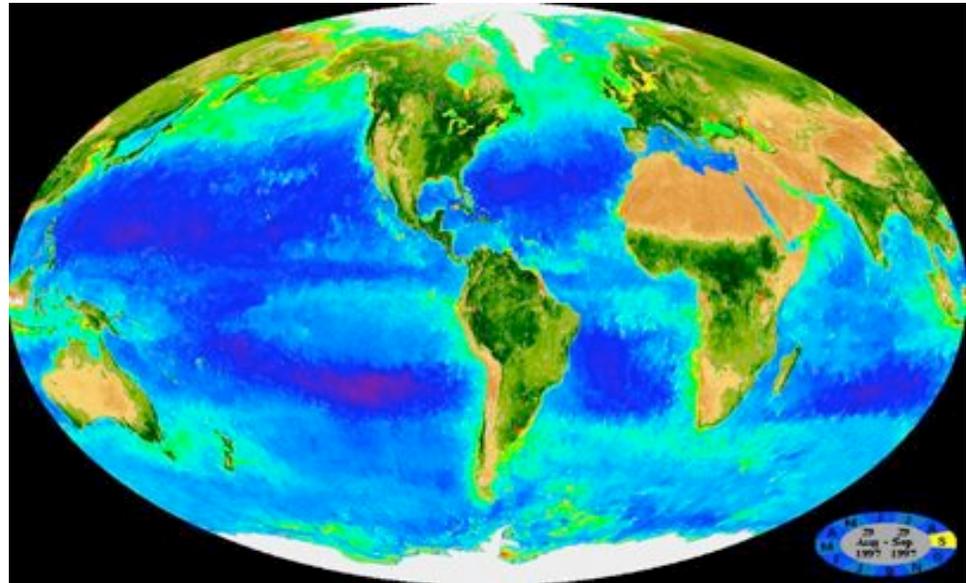
Highlights Since April NAC Meeting

- **NASA / ESA Bilateral**
- **NRC Decadal Survey meetings for Astro and Planetary**
- **HST- SM4**
- **New MSL Challenges**



Topics

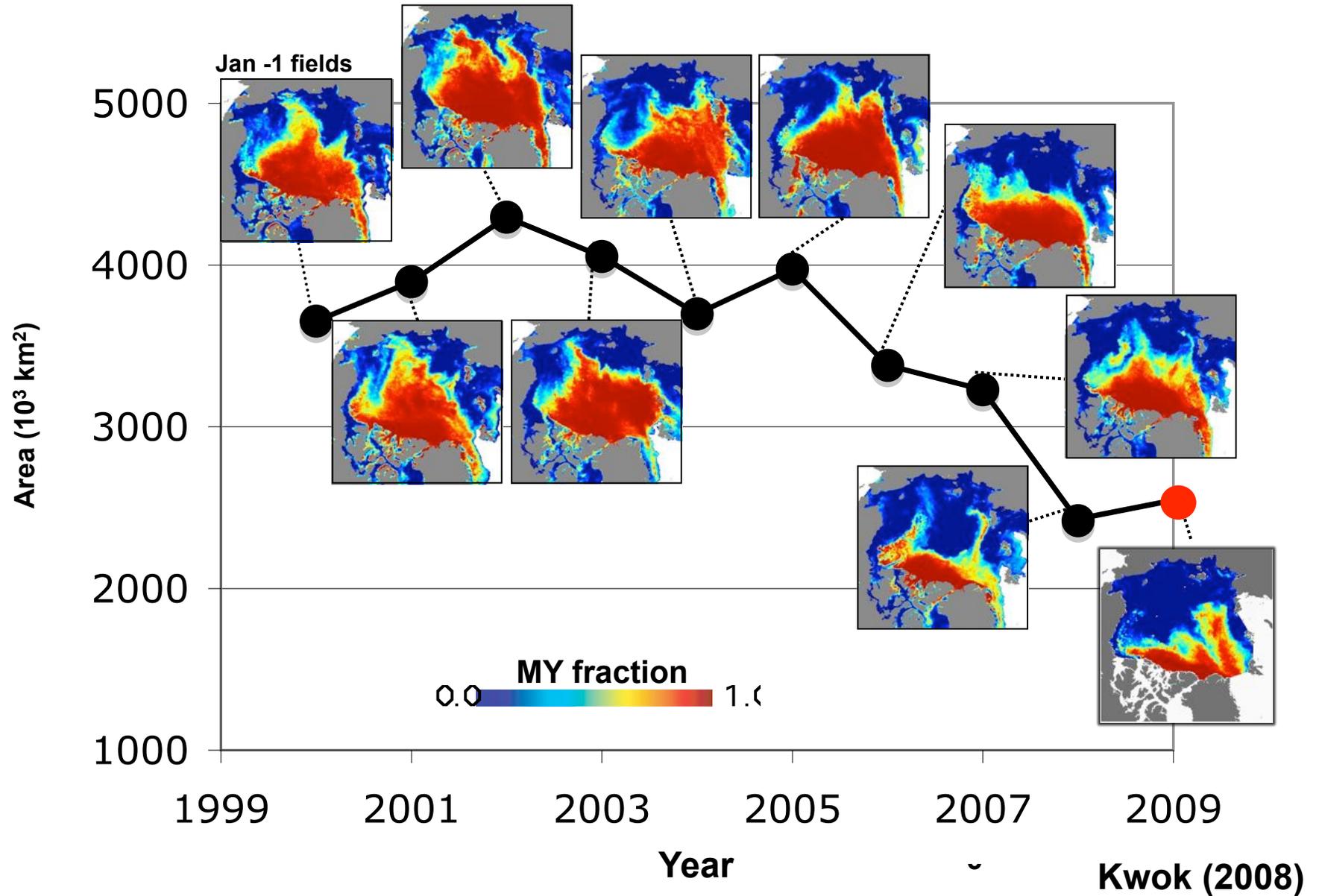
- ***Earth Science***
- **Astrophysics**
- **Planetary Science**
- **Heliophysics**



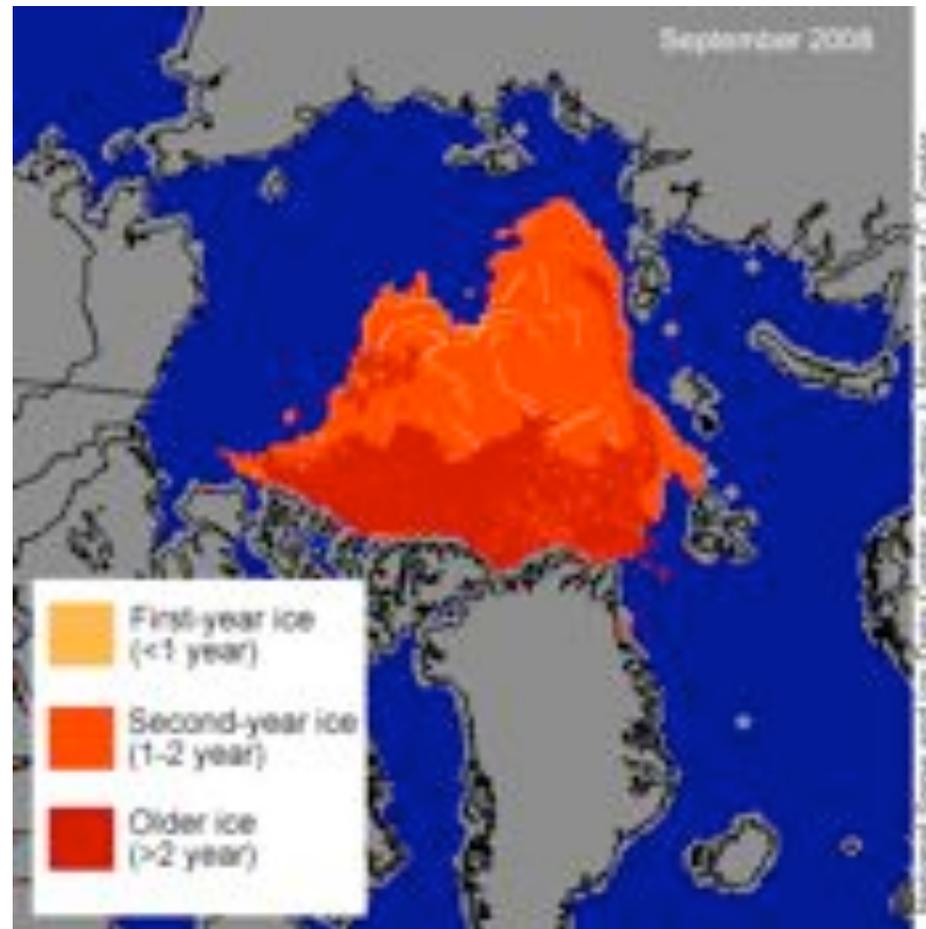
Recommendation SC-09-04 (April 2009)

- **Short title of proposed recommendation:**
Process for identifying non-science requirements and funding for Earth observations.
- **Short Description of Proposed Recommendation:**
 - Recommend NASA work with OSTP and other agencies at the highest levels to define responsibilities and secure funding for Earth observations beyond those recommended by the Decadal Survey to advance Earth System Science.

Decline in multiyear sea ice coverage from QuikSCAT



Annual Variation



Earth Science

- **Complete the 5 “Foundational” Missions**
 - Glory, Aquarius, NPP, LDCM (w/TIRS), GPM Core
- **Replace Orbiting Carbon Observatory**
- **NPOESS**
- **Decadal Survey Response**
 - Venture-class
 - SMAP, ICESAT-II
 - DESDynI, CLARREO

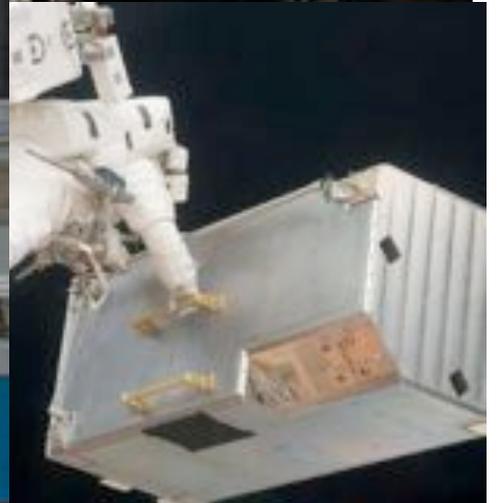
Recommendation

- **Short title of proposed recommendation:**
Extend bilateral cooperation with ESA to include Earth Science
- **Short Description of Proposed Recommendation:**
 - **Recommend that NASA collaborate with ESA to plan coordinated Earth science, applications and observation goals. Based on these goals and plans, identify specific opportunities for coordination of and collaboration on missions, research programs, and for data archival, distribution and exchange policies. The planning should involve corresponding operational agencies where appropriate.**

Topics

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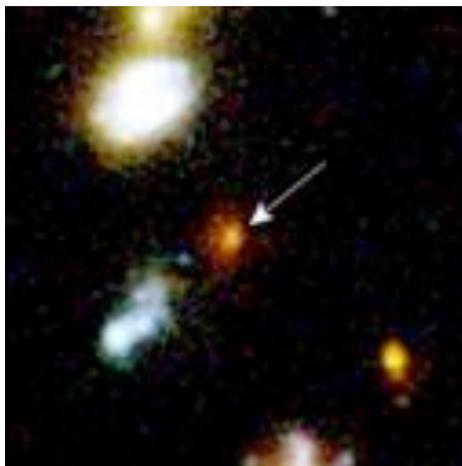


HST SM-4 : Extending Breakthrough Science

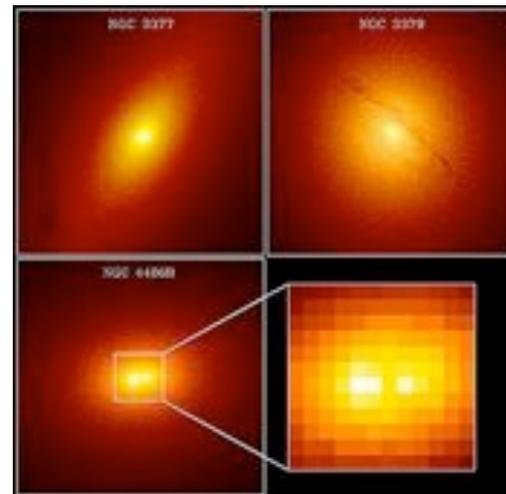


Age of the Universe

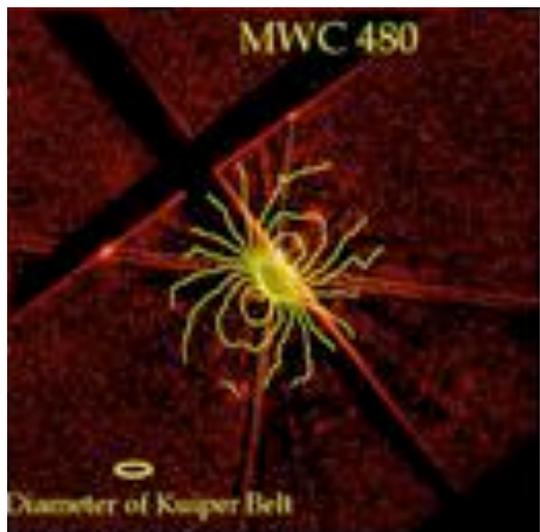
Existence of Dark Energy



Black Holes at Galactic Cores



Planet Formation

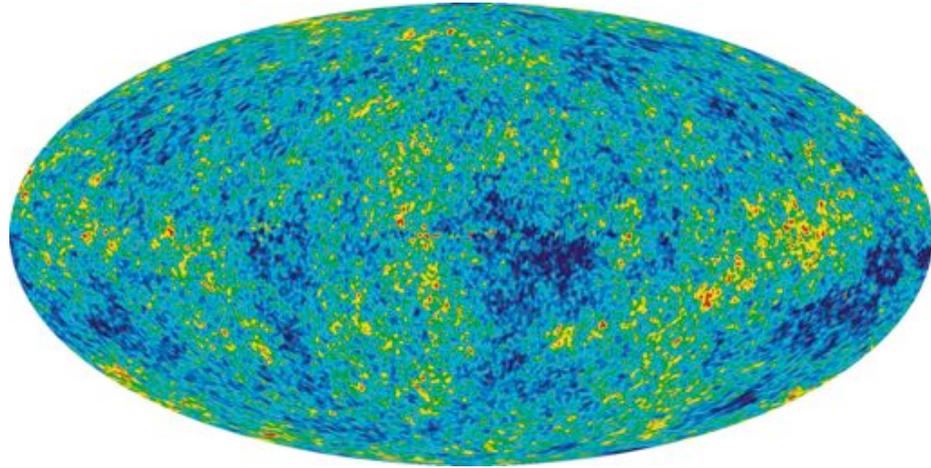


“The scientific success of the new Hubble is yet to be proven, but the outstanding performance of the NASA teams – both the heroic astronauts and the people that support them on the ground – is beyond doubt. This last visit to Hubble shows NASA at its best.” – Astrophysics Subcommittee



First Organic Molecule Found on an Exoplanet

Herschel / Planck (ESA/NASA) Launch May 14



WMAP Cosmic Microwave Temperature Fluctuations

(two coldest things in space: 0.3K)

Planck



Spiral Galaxy M51 ("Whirlpool Galaxy")

Astrophysics

- **The Astrophysics Fleet**
 - The constellation of telescopes in space is the largest ever, spanning the full range of the electromagnetic spectrum
 - May be short lived: the budget envelope for future missions over the next Decade is \$2-4B → rate of future mission deployment is less than the projected rate of decay
 - Hard choices will have to be made in an era of tremendous discovery opportunities
- **Astrophysics Analysis Groups**
 - ExoPAG underway
 - APS is exploring rationale for additional AGs for targeted discipline topics (especially important given limited resources)

Topics

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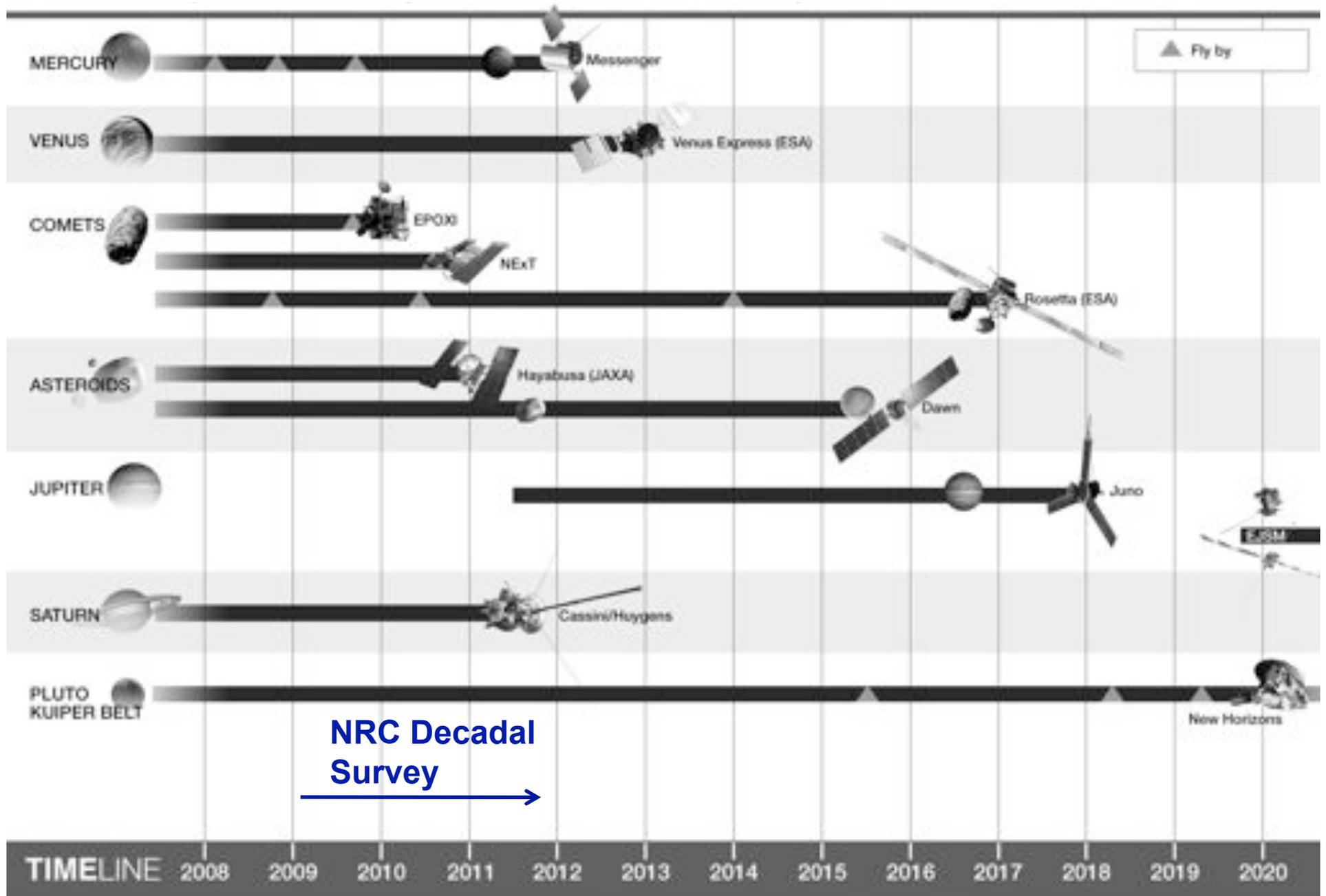


- **Decadal survey progress**
- **On-going missions/highlights**
- **MSL Status and Recommendation**

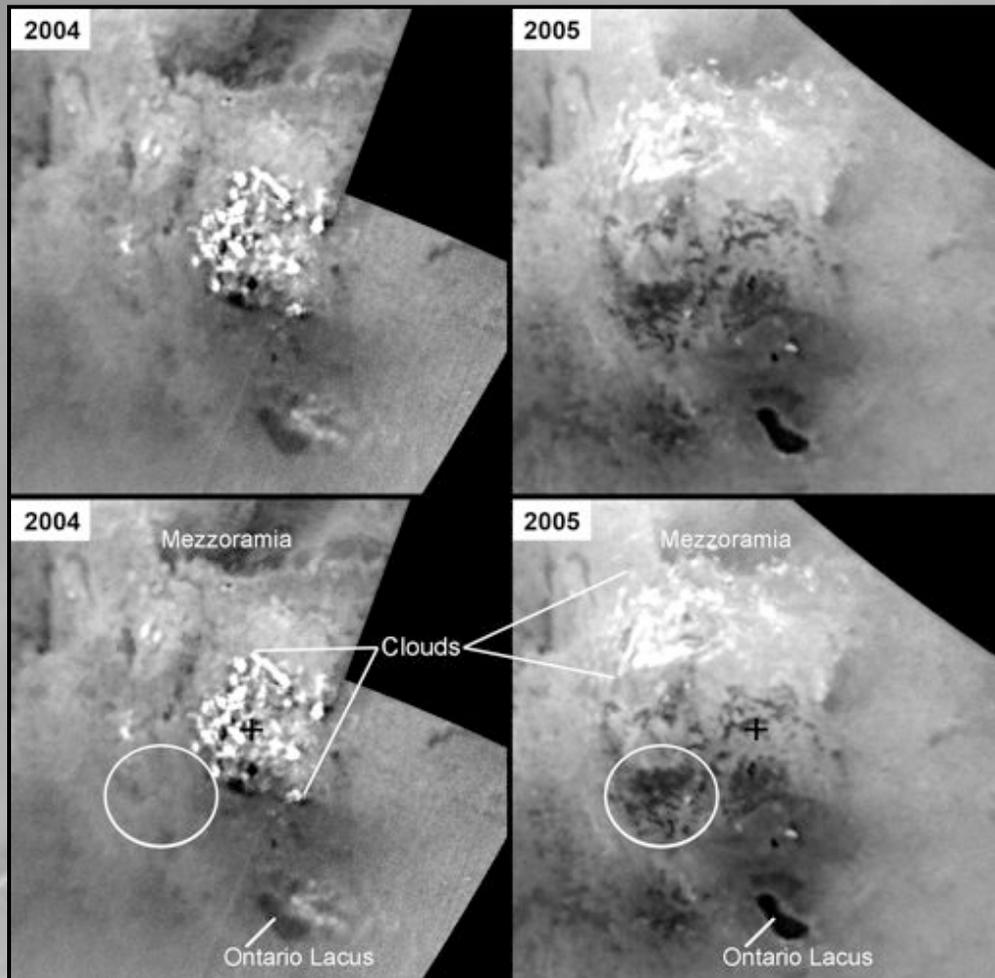
Planetary Science

Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space

Planetary Missions timeline (non-martian, non-lunar)

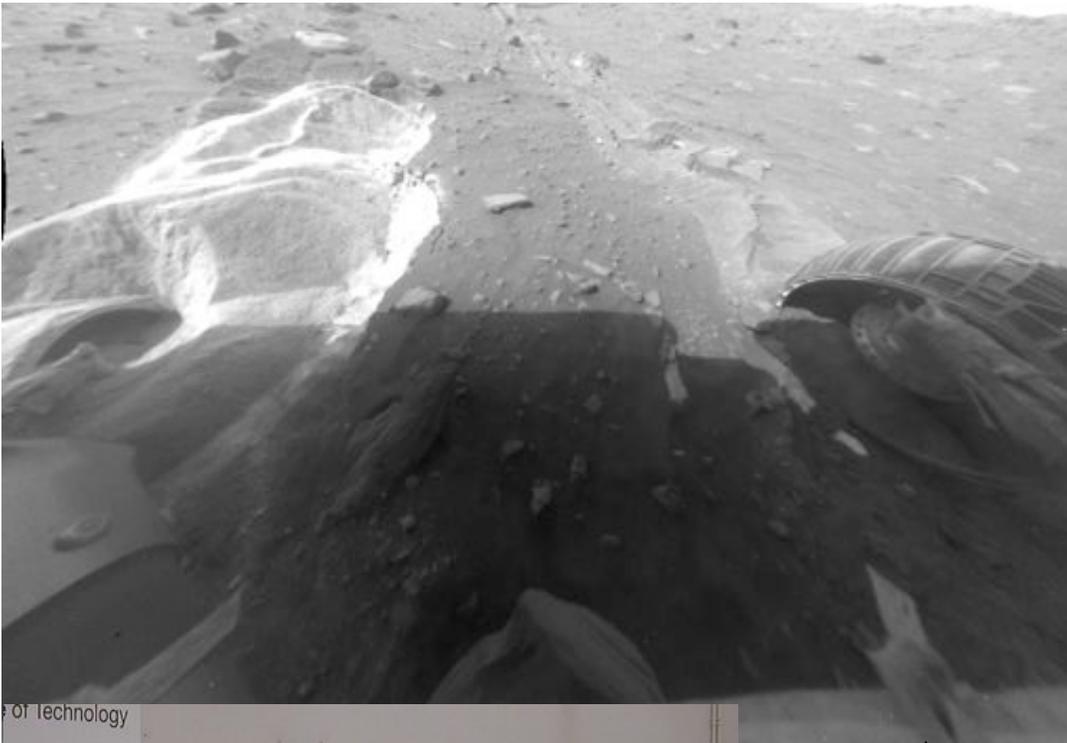


Cassini/Huygens: Titan's Changing Lakes



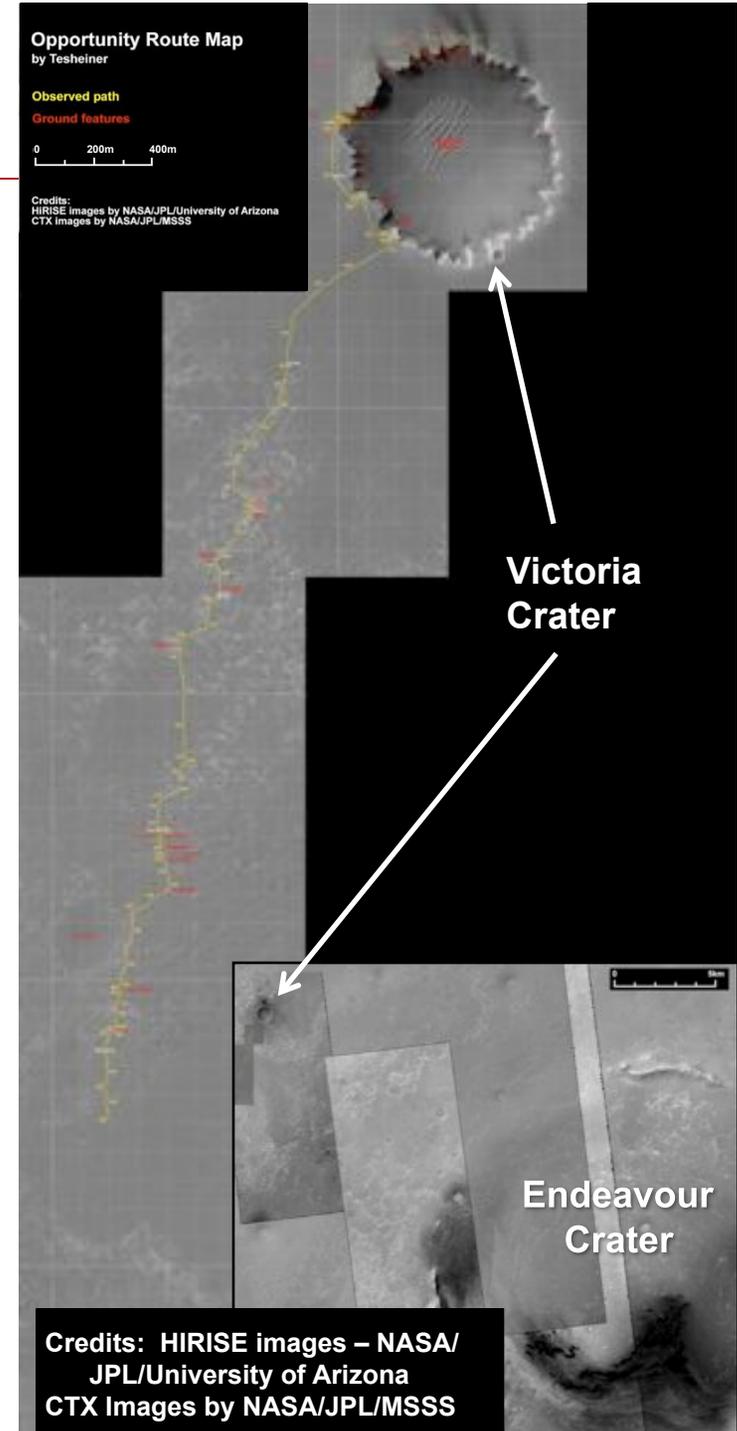
- Recent imaging of Titan affirms the presence of lakes of liquid hydrocarbons in polar regions by capturing changes in the lakes brought on by rainfall.
- Updated Titan map released; included the first near-infrared images of the leading hemisphere portion of Titan's northern "lake district."
- Combined with previous analyses, new observations suggest underground methane reservoirs.

MER: Spirit and Opportunity MRO: HIRISE and CTX



Spirit investigating soft soil in Gusev Crater

Working in the surface system test bed at JPL



Credits: HIRISE images – NASA/JPL/University of Arizona
CTX Images by NASA/JPL/MSSS

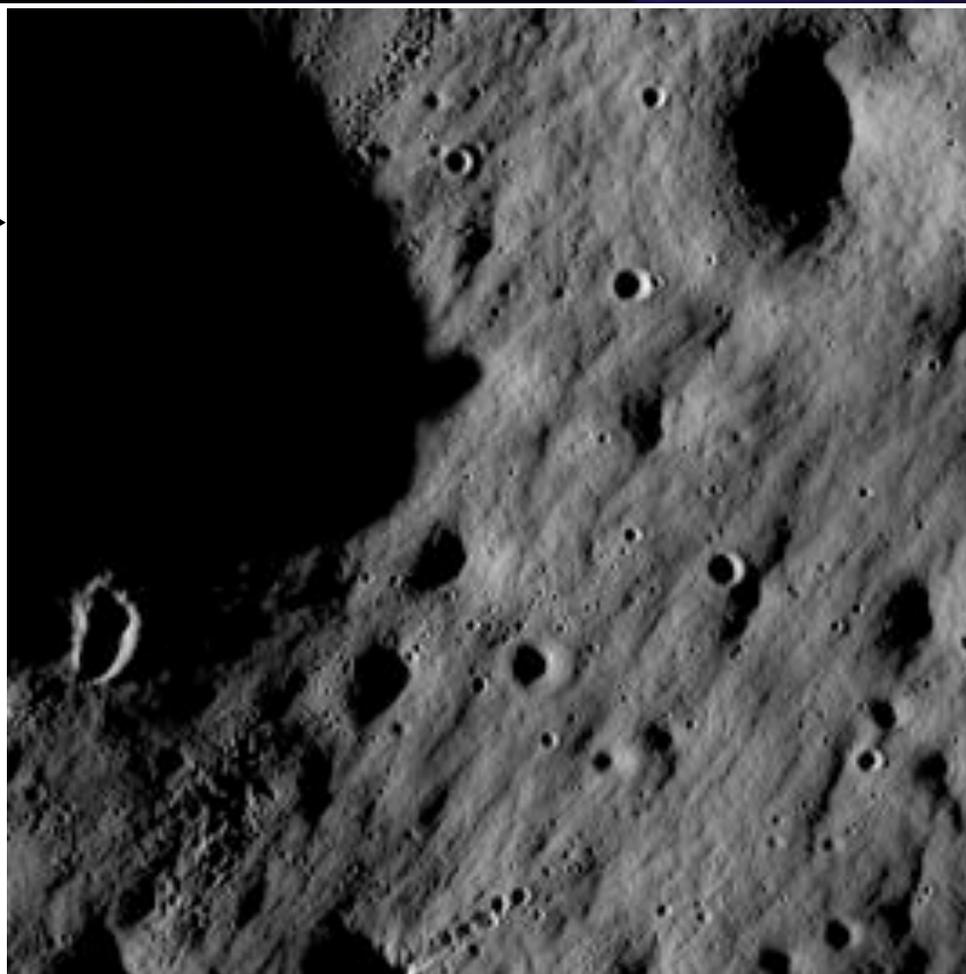


Goddard
Space Flight Center

+ NASA's LRO site

<http://lunar.gsfc.nasa.gov/>

Lunar Reconnaissance Orbiter



Portion of a frame from
the LROC Narrow-Angle
Camera.

Scene is in cratered
region near Mare
Nubium (34.4° South,
 6.0° West)

This frame is 1,400
meters across; 1.4 m/
pixel resolution;
North is down.

Credits: NASA/
Goddard Space Flight
Center/Arizona State
University

exploration science resources commerce



LEAG



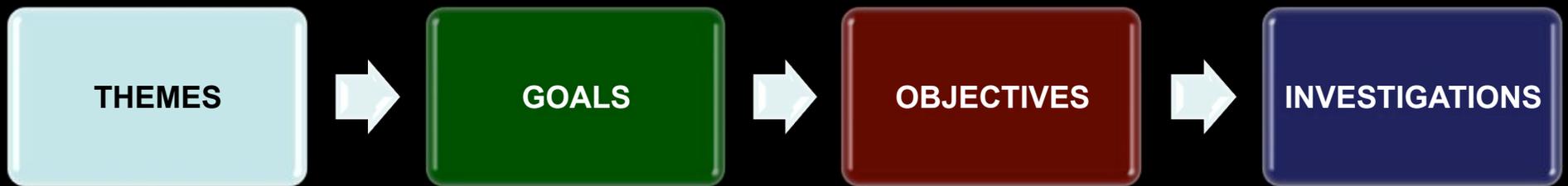
The US Lunar Exploration Analysis Group (LEAG) & the Lunar Exploration Roadmap
Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, & Priorities, 2009

Report to the NAC Science Committee, July 14, 2009



Clive R. Neal
LEAG Chair
University of Notre Dame
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Lunar Exploration Roadmap integrates themes of multiple stakeholders



Science (Sci) Theme: Pursue scientific activities to address fundamental questions about the solar system, the universe, and our place in them

Feed Forward (FF) Theme: Use the Moon to Prepare for Future Missions to Mars and Other Destinations

Sustainability (Sust) Theme: Extend Sustained Human Presence to the Moon to Enable Eventual Settlement

- **Community effort**
- **Input at targeted sessions at conferences**
- **Web site for more detailed input**
- **Sustainability is the key:**
 - **Transition strategy outlined**
 - **Commercial “on ramps” are defined**
 - **International cooperation is critical**

MSL, Current Situation

- **Slip from 2009 launch to 2011 launch**
- **Technical issues remain**
 - actuators, avionics, power
- **A need for additional funds has been identified**
 - cost estimates ranging from \$15M to \$115M
- **SMD Management Review and 'Readiness to Proceed' Review in Fall 2009**

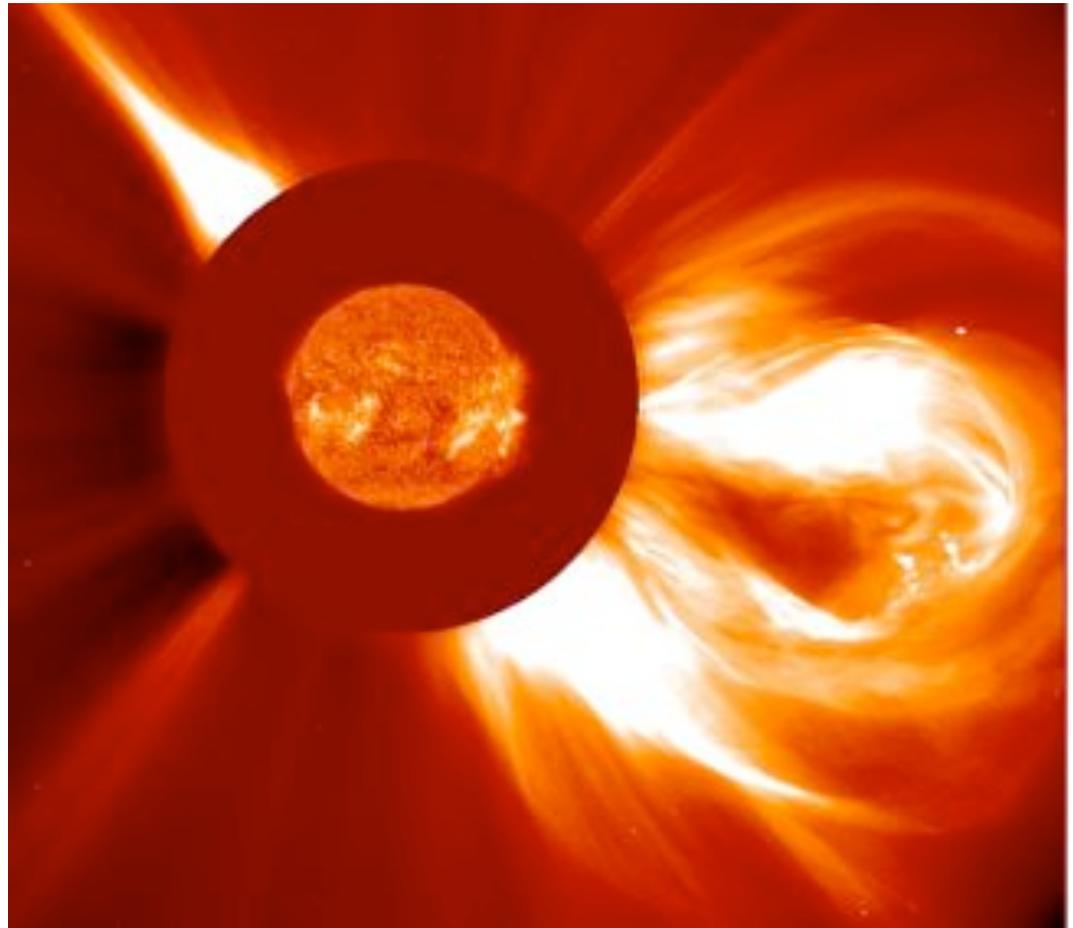


MSL Recommendation

- **Short title of proposed recommendation:**
Managing MSL technical and cost challenges
- **Short Description of Proposed Recommendation:**
 - Recommend no allocation of additional funds for MSL beyond current level, pending planned reviews in Fall 2009
 - Document the lessons learned from MSL history relative to cost growth and technology issues for a large, complex mission

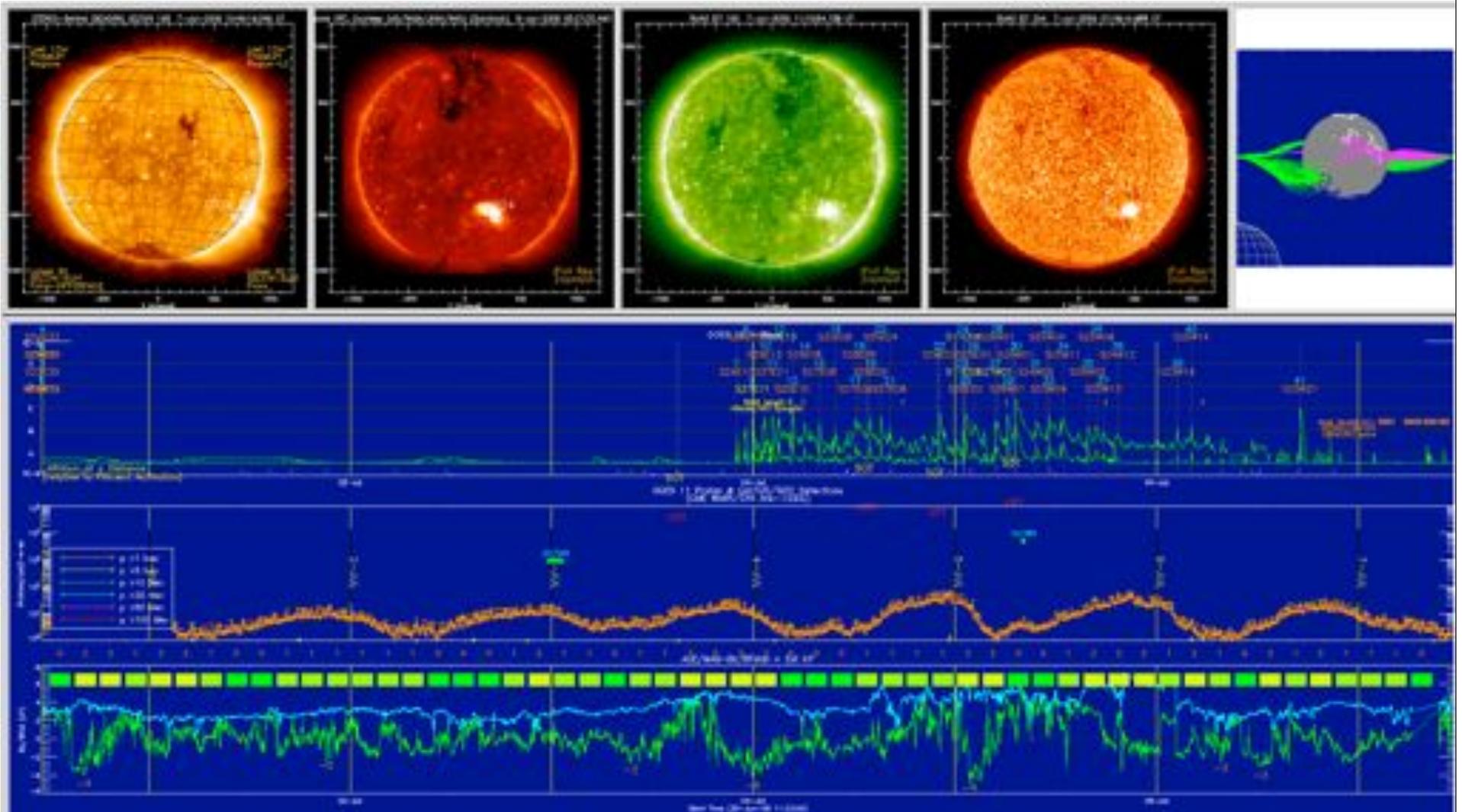
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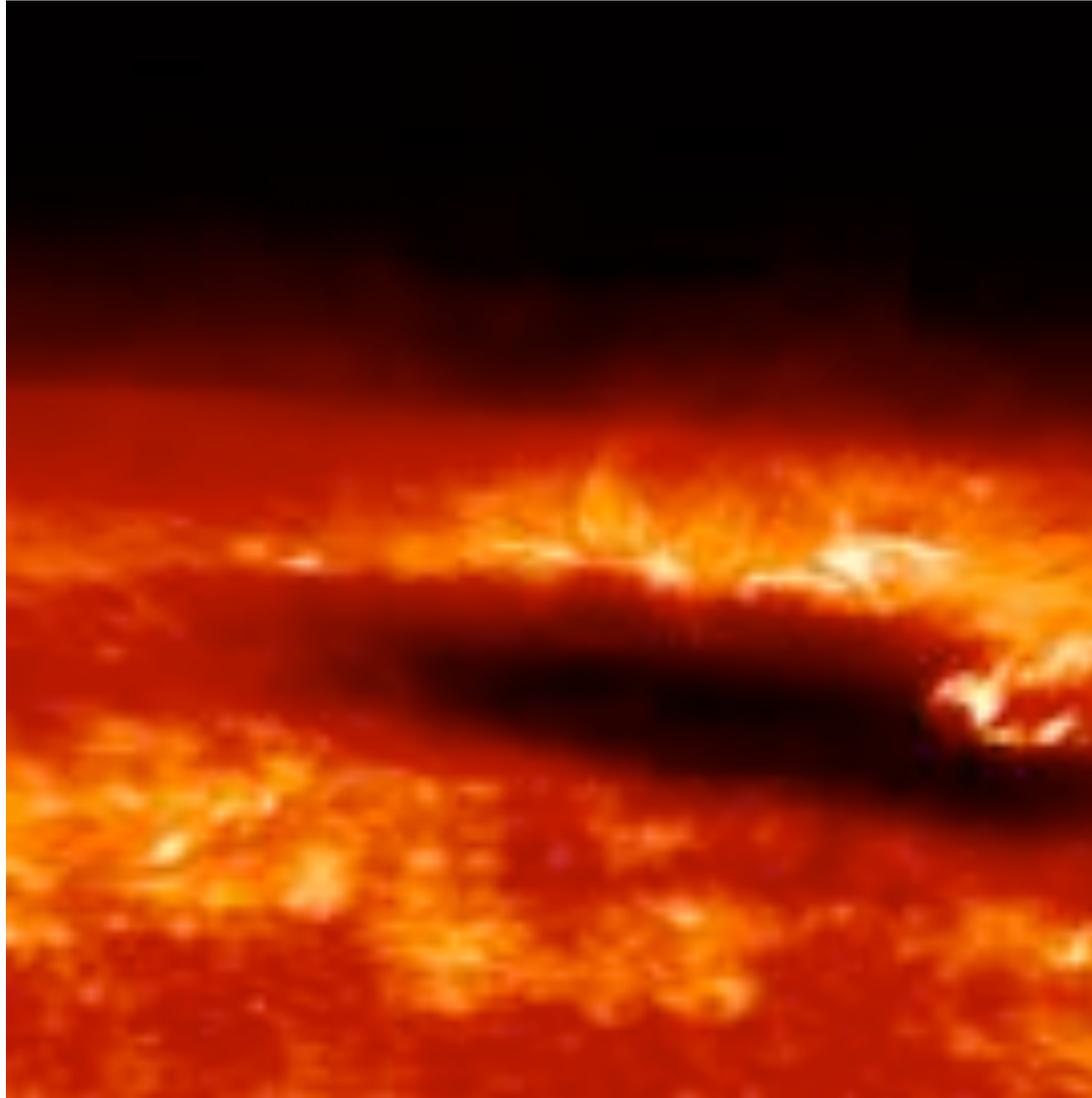


State of the Solar Cycle:

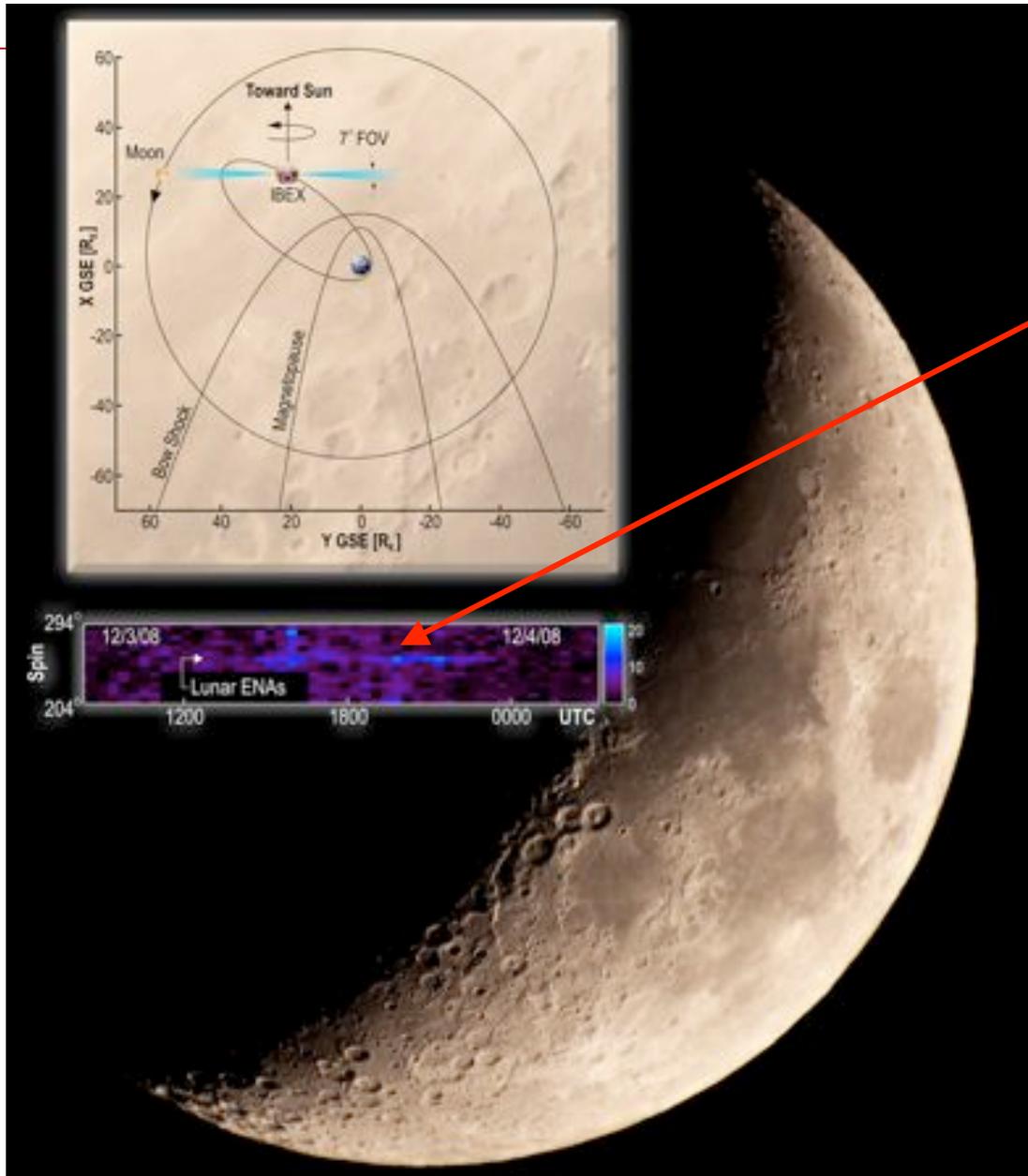
- (a) New cycle polarity groups observed in both hemispheres
- (b) Disk activity sporadically enhanced



Close-up of Sunspot from Hinode



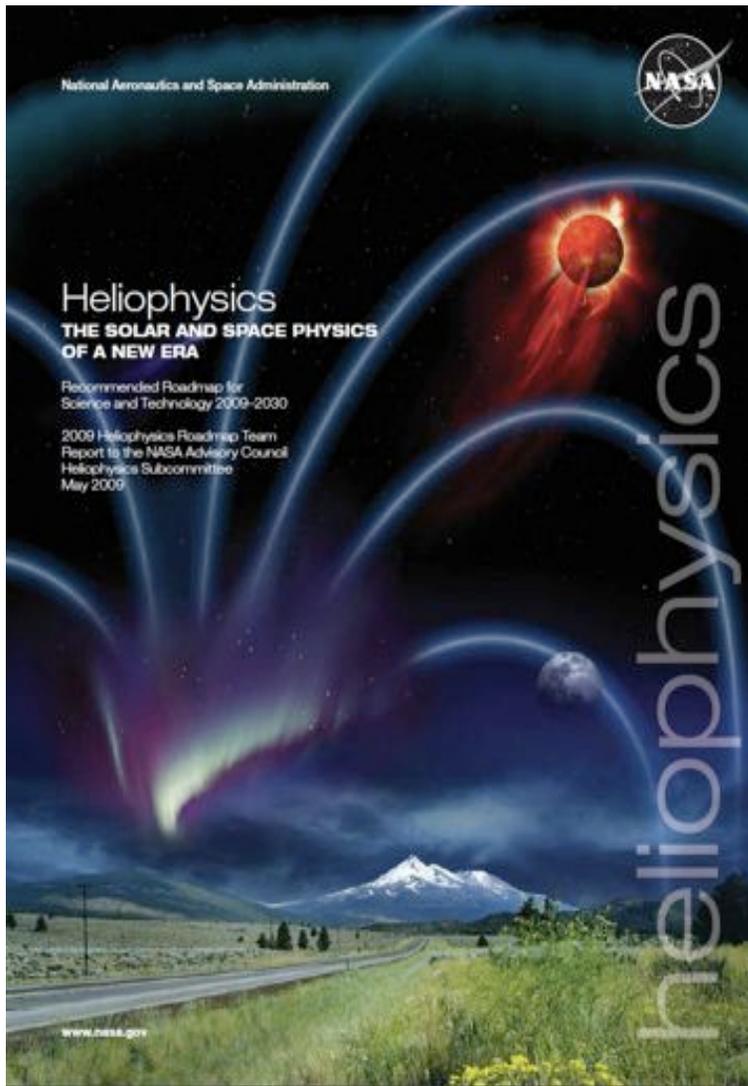
1st IBEX Discovery: ENAs from the Moon!



**Moon moves
through IBEX FoV
for ≈ 10 Hours**

**at the same
Spin Angle**

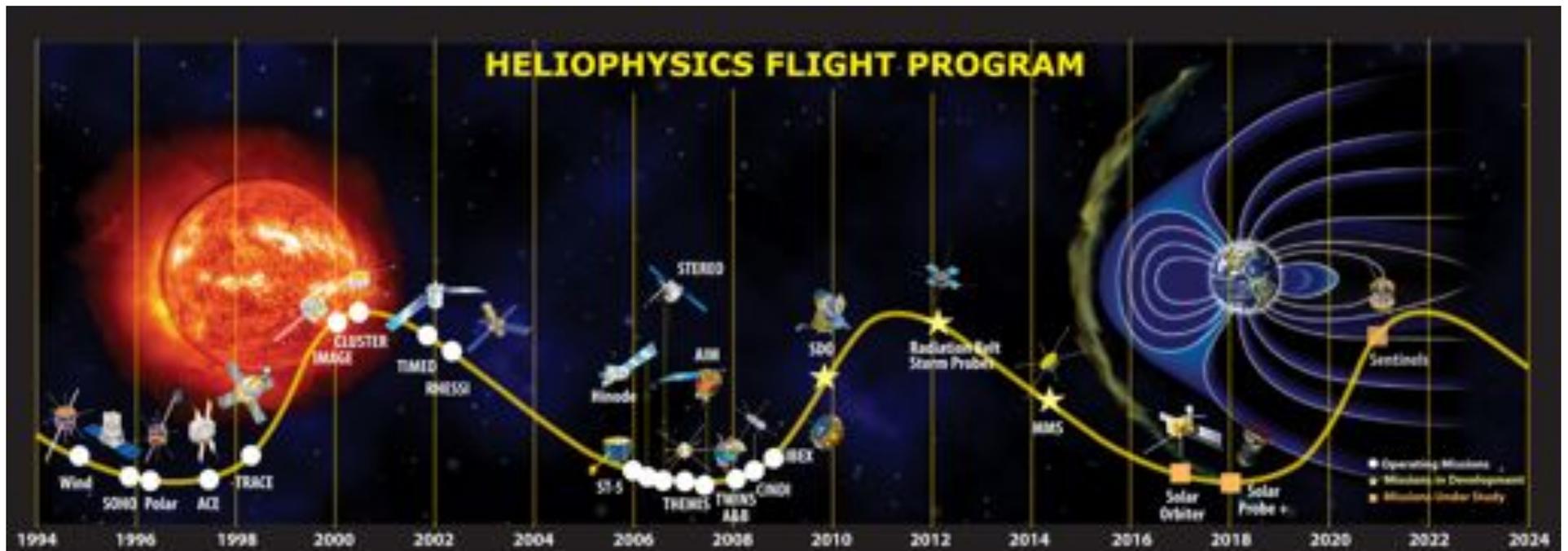
Heliophysics Roadmap



- **The HPS Roadmap process uses innovative approach to define “science targets, ” rather than specific mission architectures.**
- **These science targets allow flexible implementation within the total projected budget envelope.**
- **The Science Committee is intrigued by this approach and encourages SMD to consider how it might be used in future strategic and solicitation planning activities.**

Heliophysics Program

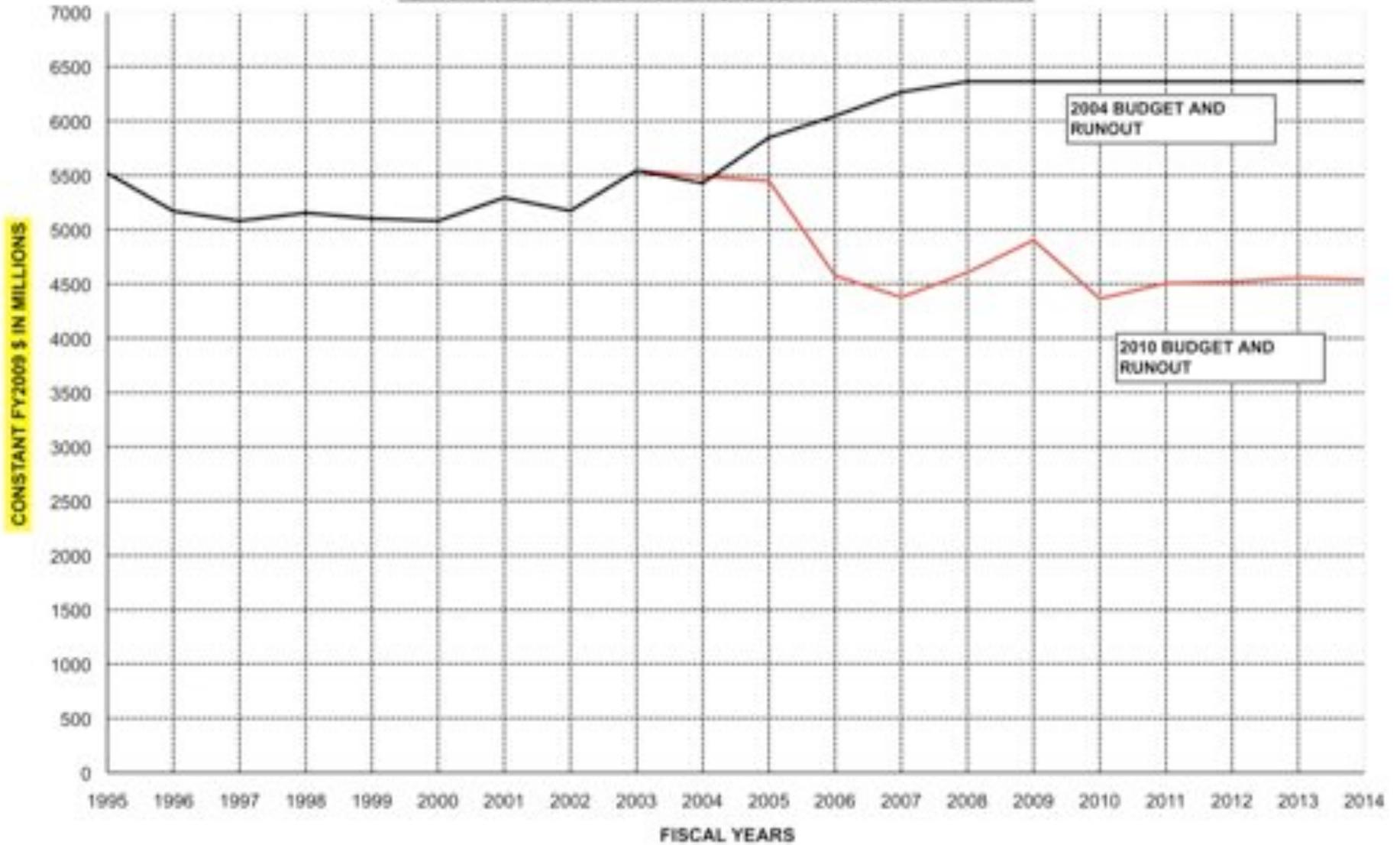
- NASA's Heliophysics Program is well-positioned with its current observing assets, and has a sound planning process for the future.



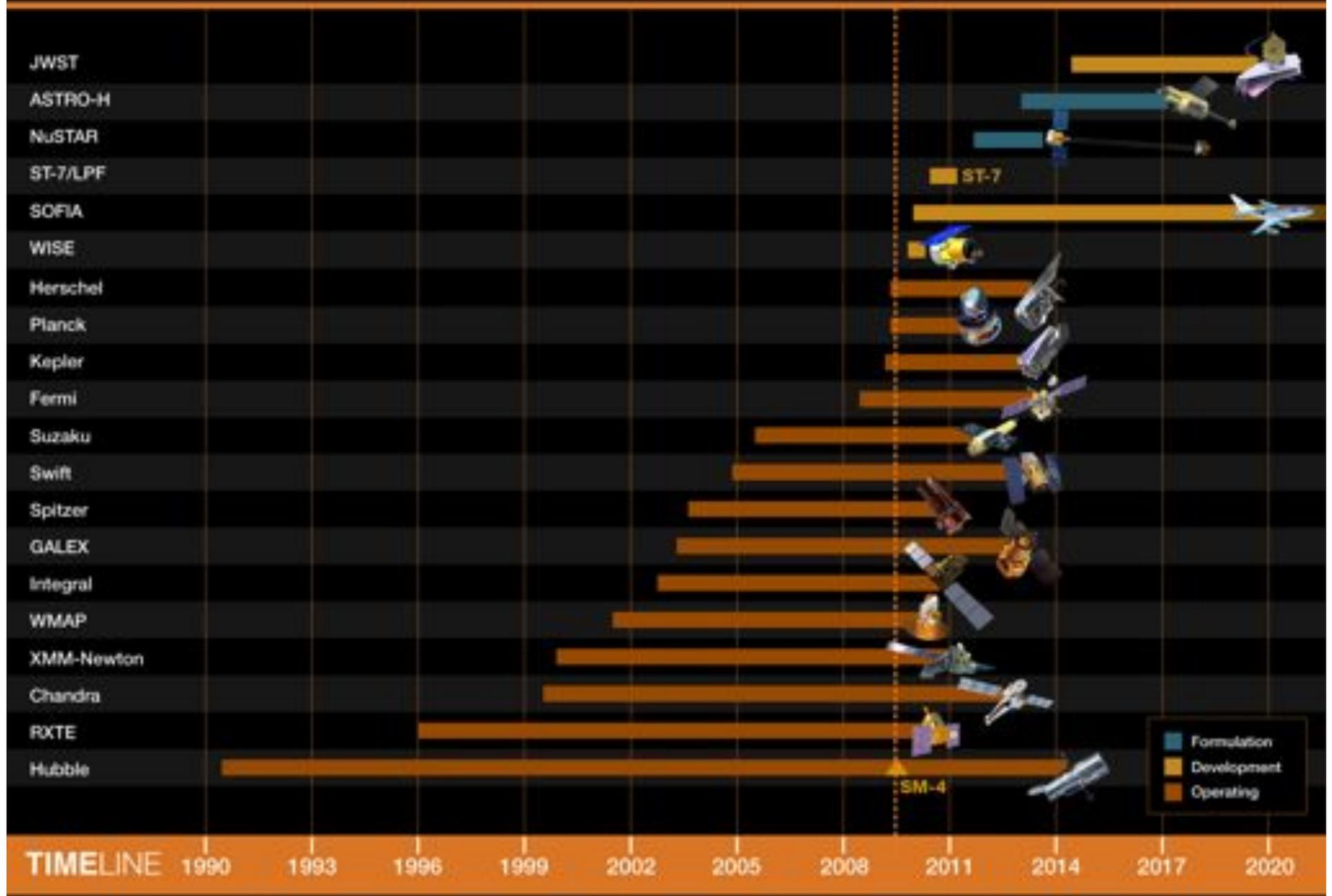
- However, the mission pipeline is thin in the outyears.

UNREALIZED EXPECTATIONS

(FY04 VS. FY10 BUDGETS, NORMALIZED TO INCLUDE ELV'S IN ALL YEARS, TO REMOVE CROSS ENTERPRISE TECHNOLOGY, DEEP SPACE NETWORK AND GROUND NETWORK, AND ADJUST FOR FULL COST ELEMENTS)



Astrophysics Missions timeline



Progress On 2009 Operations Plan

2009 Work Plan Elements	Feb	Apr	Jul	Oct	Comments
Lessons Learned on Large Mission Cost Growth					Recommendation in Feb mtg for NASA compilation of lessons learned – NRC study initiated; due Jan 2010 (<i>actual schedule TBD</i>)
Review Balance in SMD Portfolio					NRC study on Mission-enabling program elements due in mid-2010. Program balance discussion on 4/15 agenda; <i>Reviewed FY10 budget request in July.</i>
Review plans for use of new ELVs for science missions					NAC recommendation in Oct. '08; NASA has requested a Minotaur IV for launch of LADEE
Requirement & Plans for Space Communications					Joint session with SOC in Oct resulted in request for more info. Recommendation for independent <i>space comm study made April NAC meeting.</i>
Advise on Portfolio Mgmt for Advanced Technology					SMD technology investment in 4/15 program balance presentation.
Work with EC on science enabled by or enabling human exploration					Joint session in Feb mtg on Planetary Protection. Joint session with EC & AC on EDL on 4/15. <i>Joint session with EC in July on FY10 Exploration budget impacts on lunar architecture & science</i>
Monitor progress on Earth Science decadal survey implementation					In work by ESS; <i>recommendation in April NAC meeting on high-level coordination with OSTP and other agencies on national Earth observing needs</i>
Monitor and advise NASA on NPOESS evolution & long-term data records					In work by ESS; <i>monitoring current discussions in the Congress on NPOESS management and implementation</i>
Monitor Lunar Science Plan development and LEAG/OSEWG Workshop planning					<i>Reviewed LEAG Lunar Goals Roadmap in July SC meeting; LEAG will hold workshop in conjunction with NLSI workshop in July</i>