From the Decadel Survey

Four Major Themes

- *The First Billion Years of Solar System History*.
  This formative period propelled the evolution of Earth and the other planets, including the emergence of life on Earth, yet this epoch in our Solar System's history is poorly known.
- *Volatiles and Organics; The Stuff of Life*.
  Life requires organic materials and volatiles, notably liquid water, originally condensed from the solar nebula and later delivered to the planets by organic-rich cometary and asteroidal debris.
- *The Origin and Evolution of Habitable Worlds*.
  Our concept of the "habitable zone" is being expanded by recent discoveries on Earth and elsewhere in the Solar System. Understanding our planetary neighborhood will help to trace the evolutionary paths of the planets and the fate of our own.
- *Processes; How Planets Work*.
  Understanding the operation of fundamental processes is the firm foundation of planetary science, providing insight to the evolution of worlds within our Solar System, and planets around other stars.

Goals Guiding Solar System Exploration

- Determine how life developed in the solar system, where it may have existed, whether extant life forms exist beyond Earth, and in what ways life modifies planetary environments;
- Understand how physical and chemical processes determine the main characteristics of the planets, and their environments, thereby illuminating the workings of the Earth;
- Learn how the Sun’s retinue of planets originated and evolved;
- Explore the terrestrial space environment to discover what potential hazards to the Earth may exist;
- Discover how the basic laws of physics and chemistry can lead to the diverse phenomena observed in complex systems.
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Decadal Survey Research Areas

- Primitive Bodies: Building Blocks in the Solar System and the Origins of Organic Matter in the Solar System.
- The Inner Solar System: Key to Habitable Worlds.
- Mars: The Evolution of an Earth-like Planet.
- Giant Planets: Keys to Solar System Formation.
- Large Satellites: Active Worlds and Extreme Environments.

* Incorporated 24 White Papers

Twelve Major Questions

The First Billion Years of Solar System History.

1. What processes marked the initial stages of planet and satellite formation?
2. How long did it take the gas giant Jupiter to form, and how was the formation of the ice giants different from that of the gas giants?
3. What was the rate of decrease in the impactor flux throughout the solar system, and how did it affect the timing of the emergence of life?

Volatiles and Organics; The Stuff of Life.

4. What is the history of volatile material, especially water, in our Solar System?
5. What is the nature and history of organic material in our Solar System?
6. What planetary processes affect the evolution of volatiles on planetary bodies?

The Origin and Evolution of Habitable Worlds.

7. Where are the habitable zones for life in our Solar System, and what are the planetary processes responsible for producing and sustaining habitable worlds?
8. Does (or did) life exist beyond the Earth?
9. Why did the terrestrial planets diverge so dramatically in their evolution?
10. What hazards do Solar System objects present to Earth's biosphere?

Processes; How Planets Work.

11. How do the processes that shape the contemporary character of planetary bodies operate and interact?
12. What does our solar system tell us about other solar systems, and vice versa?

Six Continuing Mysteries About Our Solar System

- **The Classes of Bodies in Our Solar System**

There are several distinct classes of objects now recognized in the Solar System, including the terrestrial planets, the gas giants (Jupiter and Saturn), the ice giants (Uranus and Neptune), and the Kuiper Belt Objects (including Pluto). Is this a common feature of planetary systems, and why?

- **The Sharp Contrast Between Sister Planets Earth and Venus**

Although similar in size, mass, composition and solar distance, Venus is hellish while the Earth has life. Did Venus once have an ocean's worth of water? Is the uniqueness of the Earth's moon a factor? What basic factors control climate?

- **The Potential Habitability of Mars, the Most Earth-Like Planet**

Mars is on the threshold of habitability. Massive climate change may have occurred. Was there ever life, and is it there yet, hiding beneath the surface?

- **The Effect that the Asteroids and Comets Have on the Earth**

The small wandering bodies of our Solar System may determine the fate of the Earth. What role have asteroids and comets played in delivering volatiles to Earth, or in punctuating evolution through globally devastating impacts? Do these objects threaten our ultimate fate?

- **Distant Worlds of Fire and Ice, and Possible Life**

Activity abounds on the satellites of the outer Solar System, from Io's fiery volcanoes to Triton's frigid geysers. What is the role of tidal heating? How many of the large icy moons hide subsurface oceans? Are these oceans habitable?

- **What is the Nature of the Kuiper Belt and its Myriad Objects?**

What is the diversity of compositions among Kuiper Belt Objects? How many Pluto-sized or larger Kuiper Belt Objects exist? What is the relationship of Kuiper Belt Objects to comets, Trojans, and Centaurs? How does our Kuiper Belt relate to extrasolar dust disks?

Fundamental Scientific Question	**Most Relevant Missions***
***The First Billion Years of Solar System History*:**	
1. What processes marked the initial stages of planet and satellite formation?	CSSR, KBP
2. How long did it take the gas giant Jupiter to form, and how was the formation of the ice giants different from that of the gas giants?	JPOP, NOP
3. What was the rate of decrease in the impactor flux throughout the Solar System, and how did it affect the timing of the emergence of life?	KBP, SPA-SR
***Volatiles and Organics: The Stuff of Life*:**	
4. What is the history of volatile materials, especially water, in our Solar System?	CSSR, JPOP
5. What is the nature and history of organic material in our Solar System?	Cassini, CSSR, TEX
6. What planetary processes affect the evolution of volatiles on planetary bodies?	MEP, VISE
***The Origin and Evolution of Habitable Worlds*:**	
7. Where are the habitable zones for life in our Solar System, and what are the planetary processes responsible for producing and sustaining habitable worlds?	EGE, MEP
8. Does (or did) life exist beyond the Earth?	ELAN, MSR
9. Why did the terrestrial planets diverge so dramatically in their evolution?	MEP, VISE
10. What hazards do Solar System objects present to Earth's biosphere?	LSST
***Processes: How Planetary Systems Work*:**	
11. How do the processes that shape the contemporary character of planetary bodies operate and interact?	All
12. What does our Solar System tell us about other solar systems, and vice versa?	Cassini, KBP, LSST, JPOP, NOP

TABLE ES.2 Prioritized List of New Flight Missions for the Decade 2003-2013

SOLAR SYSTEM FLIGHT MISSIONS (non-Mars)

Small (< $325 million)

1 Discovery missions at one launch every 18 months Small, innovative, principal-investigator-led exploration missions

2 Cassini Extended Orbiter mission at Saturn

Medium (< $650 million)

1 Kuiper Belt-Pluto Explorer A flyby mission of several Kuiper Belt objects, including Pluto/Charon, to discover their physical nature and understand their
endowment of volatiles

2 South Pole-Aitken Basin Sample Return A mission to return samples from the solar system's deepest crater, which pierces the lunar mantle

3 Jupiter Polar Orbiter with Probes A close-orbiting polar spacecraft equipped
with various instruments and a relay for three probes that make measurements below the 100+ bar level

4 Venus In Situ Explorer A core sample of Venus to be lifted into the atmosphere for compositional analysis; simultaneous atmospheric measurements

5 Comet Surface Sample Return Several pieces of a comet’s surface to be returned to Earth for organic analysis

Large (>$650 million)

1 Europa Geophysical Explorer An orbiter of Jupiter’s ice-encrusted satellite to seek the nature and depth of its ocean

An Integrated Strategy for Solar System Exploration.

Prioritized List of Flight Missions for the Decade 2003 - 2013

Mission List			Science				Tech & Opportunity	
Priority Rank in Cost	Mission Concept Name	Acronym	Could Create New Paradig	Could Change Existing Paradig	Results Will be Pivotal	Will Add to Factual Base	Technical Readiness	Special Opportunities
SOLAR SYSTEM FLIGHT MISSIONS (non-Mars)								
	Small Class							
1	Cassini Extended	CASx	x	xx	xxx	xxx	xxx	xxx
	Medium Class							
1	Kuiper Belt/Pluto	KBP	xxx	xxx	xxx	xxx	xxx	xxx
2	South Pole Aitkin Basin Sample Return	SPA-SR	xx	xx	xxx	xxx	xx	x
3	Jupiter Polar Orbiter with Probes	JPOP	xx	xxx	xxx	xxx	x	
4	Venus In-situ Explorer	VISE	x	xxx	xxx	xxx	x	
5	Comet Surface Sample Return	CSSR	xxx	xxx	xxx	xxx		
	Large Class							
1	Europa Geophysical Explorer	EGE	xxx	xxx	xxx	xxx	xx	
MARS FLIGHT MISSIONS (beyond 2005)								
	Small Class							
1	Mars Scout line	Scout	x	xx	xxx	xxx	xxx	xxx
2	Mars Upper Atmosphere Orbiter	MAO	x	xx	xxx	xxx	xx	xx
	Medium Class							
1	Mars Smart Lander	MSL	x	xx	xxx	xxx	x	xxx
2	Mars Long-lived Lander Network	MLN	xx	xxx	xxx	xxx	x	xx
	Large Class							
1	Mars Sample Return	MSR	xxx	xxx	xxx	xxx		xx
DISCOVERY FLIGHT MISSIONS								
One Launch every 18 months								

Science and technology evaluation codes: xxx = high; xx = medium; x = modest.
Opportunity codes: xxx = approved, operating or celestial mechanics;
xx = international; x = technology opportunity.