

NASA Strategic Roadmaps

Briefing to Exploration of Mars Strategic Roadmap Committee

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- What is a NASA strategic roadmap?
- Why is NASA doing strategic roadmaps and how will we use them?
- What should they contain?
- An example of the concept
- What is the schedule?

Strategic Roadmap Definition

- **Strategic Roadmap:** A coordinated and comprehensive longitudinal strategy, with key achievements, options, and decision points identified, that provides a foundation for NASA's long-term priorities and investments
- There will be a roadmap for each Agency-level Objective
 - 13 roadmaps respond to 18 objectives
 - Consistent contents and structure to simplify integration
- NASA is also developing a set of 15 “Capability Roadmaps”
 - Based on Aldridge Commission recommendations
 - Iterate to ensure consistency with Strategic Roadmaps as they develop

Strategic Roadmaps (1 of 2)

1. Undertake robotic and human exploration of the Moon to further science, and to develop and test new approaches, technologies, and systems to enable and support sustained human and robotic exploration of Mars and more distant destinations. First robotic mission no later than 2008.
Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than the year 2020.
2. Conduct robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration.
Conduct human expeditions to Mars after acquiring adequate knowledge about the planet using robotic missions, and after successfully demonstrating sustained human exploration missions to the Moon.
3. Conduct robotic exploration across the solar system for scientific purposes and to support human exploration. In particular, explore Jupiter's moons, asteroids, and other bodies to search for evidence of life, to understand the history of the solar system, and to search for resources.
4. Conduct advanced telescope searches for Earth-like planets and habitable environments around other stars.
5. Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit. First test flight to be by the end of this decade with operational capability for human exploration no later than 2014.
6. Focus research and use of the International Space Station on supporting space exploration goals, with emphasis on understanding how the space environment affects human health and capabilities, and developing countermeasures.

Strategic Roadmaps (2 of 2)

7. Return the Space Shuttle to flight and focus its use on completion of the International Space Station (ISS), complete assembly of the ISS, and retire the Shuttle as soon as assembly of the ISS is completed, planned for the end of this decade. Conduct ISS activities consistent with U.S. obligations to Station partners.
8. Explore the Universe to understand its origin, structure, evolution, and destiny.
9. Conduct a program of research and technology development to advance Earth observation from space, improve scientific understanding, and demonstrate new technologies with the potential to improve future operational systems.
10. Explore the Sun-Earth system to understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that will be experienced by human explorers, and demonstrate technologies that can improve future operational Earth observation systems.
11. Provide advanced aeronautical technologies to meet the challenges of next-generation systems in aviation, for civilian and scientific purposes, in our atmosphere and in the atmospheres of other worlds.
12. Use NASA missions and other activities to inspire and motivate the nation's students and teachers, to engage and educate the public, and to advance the scientific and technological capabilities of the nation.
13. Develop a comprehensive national plan for utilization of nuclear systems for the advancement of space science and exploration.

Strategic Roadmaps

Roadmap	Tri - Chairs		
	Directorate	Center	External
1. Robotic and human lunar expeditions	Steidle/Readdy	Howell	T. Stafford
2. Sustained, long-term robotic and human exploration of Mars	Diaz	Elachi	T. Young
3. Sustained program of solar system exploration	Figueroa	Hubbard	J. Lunine
4. Advanced telescope searches for Earth-like planets and habitable environments	Asrar	Bleichman	A. Burrows
5. Develop an exploration transportation system	Steidle	Kennedy	C. Bolden
6. Complete assembly of the International Space Station and focus utilization	Uhran	Cabana	T. Betterton
7. Safely transition from Space Shuttle to new exploration-focused launch systems*	<i>Deferred*</i>	<i>Deferred*</i>	<i>Deferred*</i>
8. Explore the origin, evolution, structure, and destiny of the Universe	Kinney	White	K. Flanagan
9. Determine how living Earth system is affected by internal dynamics, and understand implications for life	Figueroa	Evans	C. Kennel
10. Explore Sun-Earth system to understand effects on Earth and implications for human exploration	Diaz	Einaudi	T. Killeen
11. Transform air transportation and enable the next generation of atmospheric vehicles	Hertz	N/A	J. Jamieson
12. Educate students and public, and expand national technical skills and capabilities	Loston	Earls	F. Cordova
13. Comprehensive national plan for utilization of nuclear systems	Steidle	Scolese	J. Ahearne

 = DoD Participation

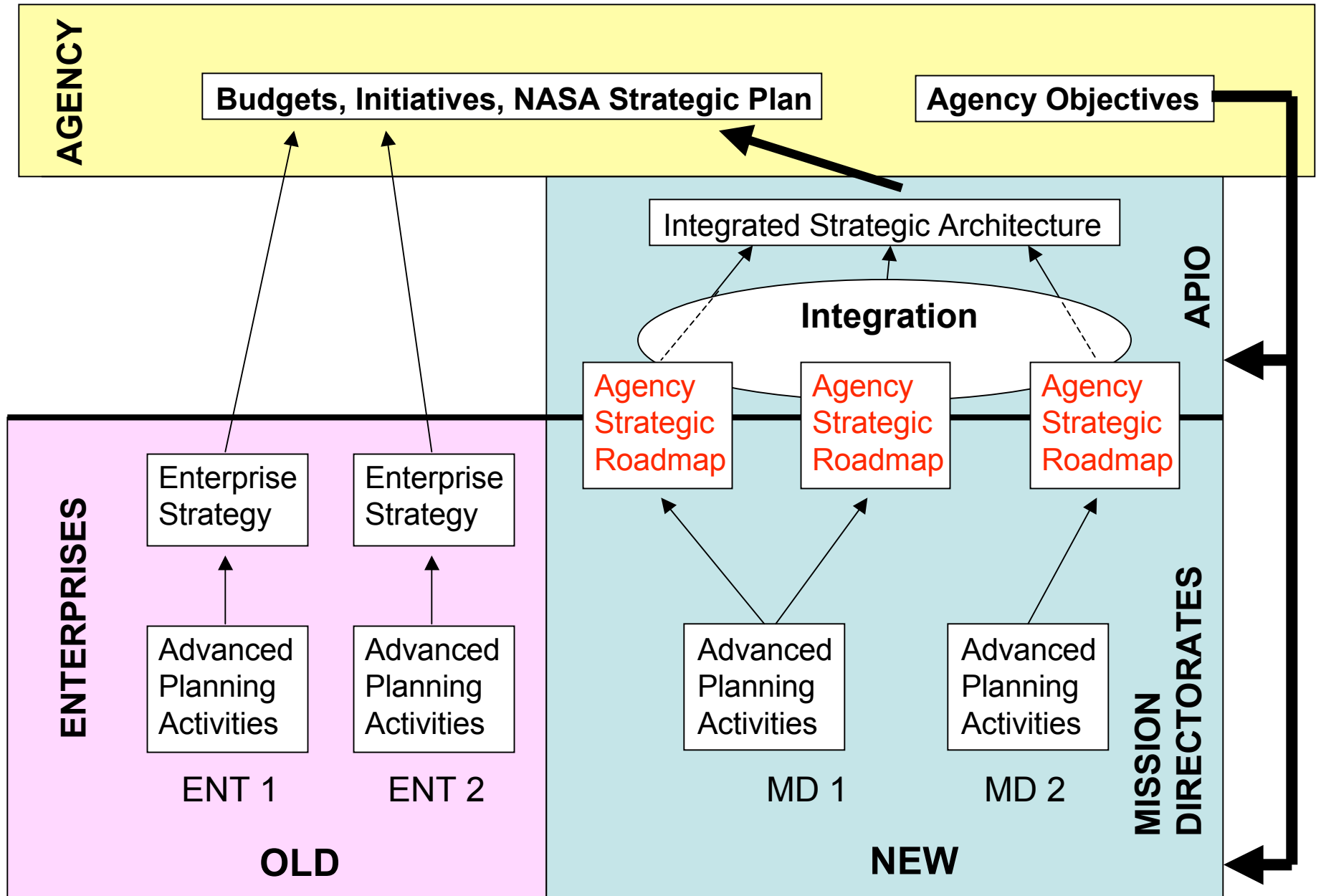
* Leverages off Integrated Space Operations Summit, (ISOS) process until RTF

Why is
NASA doing strategic roadmaps
and how will we use them?

New NASA Advanced Planning Function

- **NASA has transformed the strategic planning process and created several new Agency-level planning and coordination functions**
- **Director for Advanced Planning**
 - Develops input, options, and assessments for Strategic Planning Council
 - **Overall Agency architecture** and requirements flow-down process
 - **Science/exploration/policy strategies** and capability roadmaps (with Directorates)
 - New initiatives and studies of strategic issues
- **Advanced Planning and Integration Office**
 - Provides staff support to above Director for Advanced Planning and Associate Deputy Administrator for Systems Integration
 - **Coordinates development of strategies, roadmaps**, and new initiatives, **working with Mission Directorates and external advisory groups**; manages development of the NASA Strategic Plan

Strategic Planning – Old vs. New



Integration Challenges

- **Achieving this goal will be tough**
 - Each roadmap is different, and there are 13 of them
 - The Capabilities Roadmaps are being developed in parallel with the Strategic Roadmaps
 - Many and varied relationships among the Strategic and Capability Roadmaps
 - Cross-talk between the Strategic Roadmaps, and between the Directorates on a given Roadmap
 - Overlap between some Strategic and Capabilities Roadmaps
 - The schedule is tight!
- **Structure and contents of the roadmaps are being planned to permit integration: *post hoc* won't work**

Roadmap Integration

Roadmaps will be integrated to form a unified NASA strategic architecture

- Individual roadmaps establish priorities, options, and recommended approaches for achieving NASA strategic objectives
 - High-level products developed by discipline experts, managers, visionaries
 - Updates expected every 3-5 years or as discoveries/progress warrants
 - Roadmaps are not implementation plans and are not “funded”
- The Integrated Strategic Architecture will assimilate the roadmaps to provide the following:
 - A framework for Agency-wide decisions and priorities
 - The basis for top-level Agency funding decisions
 - The technical foundation of the Strategic Plan
- Architectural options will be developed and assessed for presentation to the NASA Strategic Planning Council
 - Assess costs and benefits of various options, with feedback to roadmap teams
 - Architectures will identify critical paths of achievements and developments
 - Architecture will be continuously adjusted and used as a tool for Agency management and budget decisions

Path to an Integrated Strategic Architecture

- **Input:** A self-consistent set of strategic and capability roadmaps
 - With identified interdependencies, synergistic science opportunities, and affordable options
- **Process:** Integration team working in parallel with roadmap teams
 - Consists of roadmap coordinators, system engineers, scientists
 - Regular feedback and iteration; co-chairs serve as integration steering group
- **Approach:** Focus on key relationships and synergies among roadmaps
 - Judicious grouping of roadmaps to facilitate integration
 - Identify relationships, priorities, and preferred sequences of events across roadmaps
 - Prepare and assess integrated architecture options
 - Conduct trade studies and supporting analyses as required; high-level assessment of affordability and costs/benefits of options
 - Apply structured systems engineering practices to ensure completeness and traceability

What Should a Roadmap Contain?

Essential Roadmap Elements

- Broad science and exploration goals, priorities, recommended activities or investigations, and a summary of anticipated discoveries and achievements
- Suggested implementation approach and mission sets
- High-level milestones, options, and decision points
- Key dependencies on and relationships to other Strategic Roadmaps
- Identification of required capabilities, facilities, human capital, and infrastructure

Provisional Roadmap Outline

1. Agency Objective Statement
2. Overview of Objectives, Stages, and Pathways Framework
3. Recommended Investigations, Missions, R&D Programs, etc., Aligned with Objectives and Stages/Pathways Framework
4. Summary of Key Program Milestones, Options, and Decision Points

APPENDIXES

1. National Policy Framework and External Constituencies
2. Required Capabilities Mapped to Stages/Pathways Decision Points
 - Technology
 - External Industrial and Academic Capacities
 - Agency Human Capital
 - Applicable Agency Infrastructure
 - Unique Requirements
3. Unique Education and Outreach Opportunities
4. Inter-Roadmap Dependencies
5. External Partnerships
 - USG Agencies
 - International Partners
6. Bibliography of Key Agency Documents and NRC Documents

Some Top Level Core Competency Questions

Human Capital

1. Are there workforce skills or competencies needed that are critical to execute this roadmap?
2. Are there any special Human Capital planning considerations that the team thinks should be highlighted?

Facilities (and other physical infrastructure)

3. Are there critical facilities or other physical infrastructure needed to execute this roadmap that the roadmapping team thinks should be highlighted?

NRC Review

NRC will review the individual roadmaps as they near completion

- Clear and comprehensive support to the 2005 Agency Objectives, including the objectives of the Vision for Space Exploration and the 2003 NASA Vision and Mission statements? Significant gaps?
- Intrinsic merit of the derived objectives and merit of proposed implementing programs in the context of relevant NRC or other external advisory reports?
- Resilience with respect to changing technological capabilities and budgets and agility to take advantage of unforeseen opportunities?
- Important crosscutting opportunities not identified or adequately developed?
- Clear initial priorities and decision rules for making prioritization decisions as implementation proceeds?
- Realism with respect to necessary resources, technologies, and facilities? Presentation of roles and relationships of NASA centers, other federal partners, academia, industry, and international participants?
- Treatment of timelines, relationships between program elements, and schedule realism?

Current plan: The NRC and/or the NASA Advisory Council will review the Integrated Space Architecture when completed

An Example of the
Strategic Roadmap Concept:

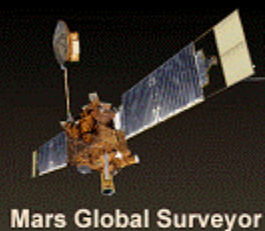
The Mars Pathways Model



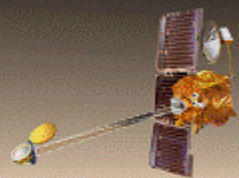
MEP—The Current Decade

Launch Year

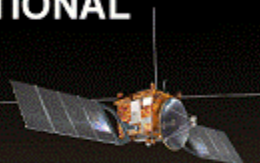
OPERATIONAL



Mars Global Surveyor

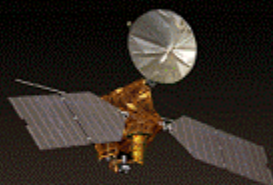


Mars Odyssey



ESA
Mars Express

2005



Mars
Reconnaissance
Orbiter
(Italian SHARAD)

2007

Completed Scout Mission



Phoenix

2009



Mars Telesat

Science pathways
responsive to discovery

Mars Science
Laboratory



...Next Decade

Explore the
Evolution of Mars

Search for
Evidence of Past Life

Search for Present Life

Explore
Hydrothermal
Habitats

Mars
Exploration
Rovers





Mars Potential Next-Decade Pathways

Pathway	Lines of Scientific Inquiry
Search for Evidence of Past Life	<ul style="list-style-type: none">• Science from First Decade missions plus early next-decade missions confirms ancient Mars was wet and warm<ul style="list-style-type: none">• Locating and analyzing water-lain sedimentary rock is primary goal.• Pathway includes search for evidence of past life.
Explore Hydrothermal Habitats	<ul style="list-style-type: none">• Exploration in First Decade discovers hydrothermal deposits (active or fossil)<ul style="list-style-type: none">• Probability of hydrothermal regions being discovered is potentially high.• Hydrothermal habitats are focus of second decade of Mars exploration.• Potential for discovery of evidence of past and present life is greatly improved.
Search for Present Life	<ul style="list-style-type: none">• Commits to search for present life at sites determined to be modern habitats by First Decade missions<ul style="list-style-type: none">• Search for life at active hydrothermal deposits or polar margins.• Path would be taken only following a discovery that revolutionizes our understanding of the potential of Mars to harbor present life.• MSR with mobility is included as the most reliable, validatable means of detecting life.
Explore Evolution of Mars	<ul style="list-style-type: none">• Science of First Decade of Mars exploration does not find evidence of past or present liquid water environments<ul style="list-style-type: none">• Determine the loss mechanisms and sinks for water and CO₂ over time.• Determine why the terrestrial planets evolved differently, much more so than we had thought.• Determining whether the initial conditions on Venus, Earth and Mars were similar or very different.

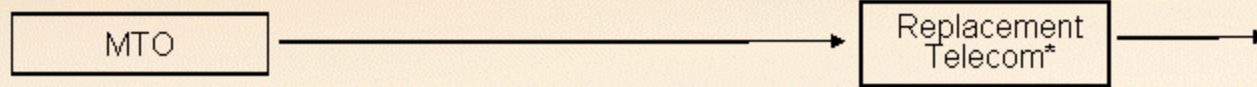




...and Potential Pathway Mission Sequences

Pathway	2009	2011	2013	2016	2018	2020	Notes
Search for Evidence of Past Life	MSL to Moderate Latitude	Scout	MSR	Scout	Astrobiology Field Lab or Deep Drill	Scout	Missions to high-probability past habitat. Mission in '18 influenced by MSL results.
Explore Hydrothermal Habitats	MSL to Hydrothermal Deposit	Scout	Astrobiology Field Laboratory	Scout	Deep Drill	Scout	All core missions sent to active or extinct hydrothermal deposits.
Search for Present Life	MSL to High Latitude or Active Vent	Scout	Scout	MSR	Scout	Deep Drill	Missions to modern habitat. Path has highest risk.
Explore Evolution of Mars	MSL to Moderate Latitude	Scout	MSR	Aeronomy	Network	Scout	Path rests on proof that Mars was never wet.

2005 President's Budget Augmentation		Scout & Mars Testbed		Mars Testbed		Mars Testbed	
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Note: The pathway followed will depend on knowledge and technologies developed this decade.

Schedule

Current Schedule

Key Milestone	Target Date
SPC approval of Strategic Roadmap development plan	August 11, 2004
Co-chairs candidates approved by the Strategic Planning Council	September 3
Co-Chairs signed up	October 8
Complete team formation, assess existing material, finalize SRMP-B, begin work	December
Strategic Roadmap teams mid-term status review	February-March, 2005
Roadmaps submitted for NRC review	April 15
<i>NRC reviews received</i>	<i>June 15</i>
Roadmaps complete	July 31
Integrated Strategic Architecture complete	October 1

BACKUP

NASA Strategic Goals

Goal 1 Implement a sustained and affordable human and robotic program to explore the solar system and beyond

Goal 2 Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations

Goal 3 Develop innovative technologies, knowledge, and infrastructure both to explore and to support decisions about the destinations for human exploration

Goal 4 Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests

Goal 5 Study the Earth system from space and develop new space-based and related capabilities for this purpose

Agency (Level A) Objective X

Level A Objective X

Level B Objective i

Level B Objective ii

Level B Objective iii

etc.

Framework:
Objectives, Pathways,
Programs/Spirals,
Outcomes, and
Decision Criteria

Level B Objective ii for X

Stage/Spiral 3
(not shown)

OUTCOMES

Level C Objectives

Proj
1

Proj
2

Proj
n

**Pathway/
Program 1**
Needed
Capabilities

OUTCOMES

Level C Objectives

Proj
1

Proj
2

Proj
n

**Pathway/
Program n**
Needed
Capabilities

DECISION CRITERIA

Stage/Spiral 2

OUTCOMES

Level C Objectives

Proj
1

Proj
2

Proj
n

Program 1

Stage/Spiral 1
(near term)

etc.

Integration Process Outline



- Form and task the integration team - *starting now*
 - Comprised of roadmap coordinators, senior systems engineers, and scientists with an inter-disciplinary focus
 - Integration team meets regularly and members participate in roadmap meetings
 - Roadmap co-chairs serve as integration steering group
- Group roadmaps to allow focus on *key* relationships and decisions, and to facilitate integration team activities
 - Group 1: Capabilities and knowledge for extending robotic and human presence into the solar system
 - Group 2: Scientific achievements and discoveries of robotic and human exploration
- Identify key roadmap relationships and decisions at *agency strategic* level
 - Track relationships via database - develop tools/process for ongoing use
 - Iterate with roadmap teams to achieve alignment - *a self-consistent set of roadmaps*
 - Engage expert consultants and apply structured systems engineering methodologies
- Synthesize architectures, incorporating affordability analysis and agency priorities, for presentation to Strategic Planning Council
 - Identify key decisions, options, budget issues, gaps, new initiatives

Organization: Integration Elements



Integration lead: Brant Sponberg



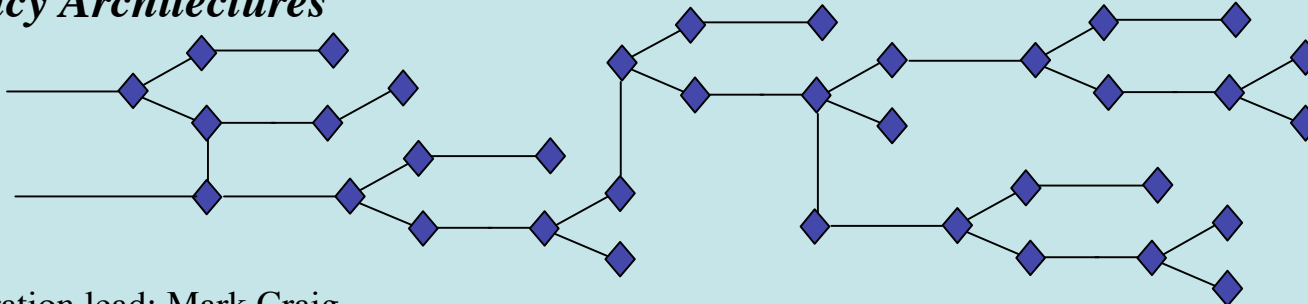
Integration lead: Paul Hertz



*Extending Robotic
and Human Presence*

*Scientific Achievements of
Robotic and Human Exploration*

Agency Architectures



Integration lead: Mark Craig

Top-Level Integration Milestones



- Integration kick-off meetings Jan 2005
- Draft capability roadmaps Feb-Mar
- Initial draft strategic roadmaps (Lunar, Mars, Transp.) Feb 15
- Strategic integration workshop/review Mar 15
- Draft strategic roadmaps (full set) Apr 15
- NRC reviews May-Jun
- Integration steering group review Jul 1
- Roadmaps complete (content) Jul 31
- Architecture option summary to SPC Aug 31
- Roadmap reports complete Oct 1
- Final architectures to SPC for decision Oct 1
- Architecture document/web site published Dec 1
- Agency strategic plan release Jan 23 2006