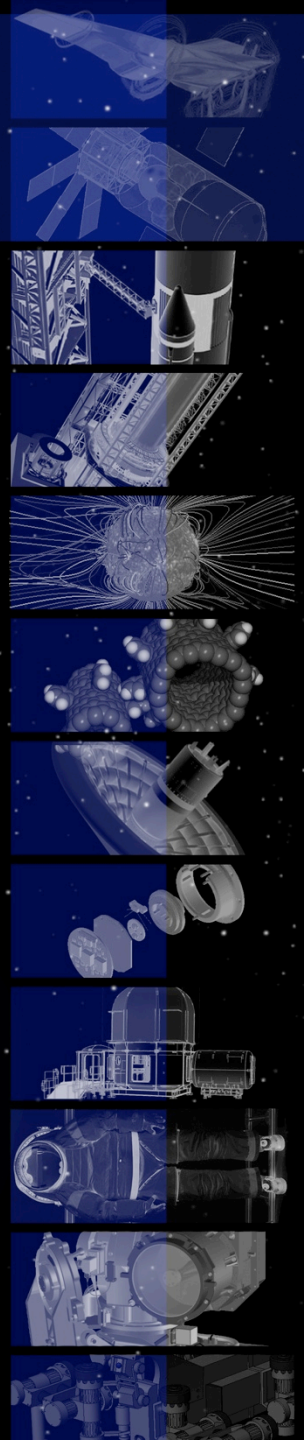


National Aeronautics and Space Administration

NASA Technology Roadmap Update Overview

NASA Advisory Committee Technology, Innovation, and Engineering Committee Meeting
December 4, 2014

Faith Chandler
NASA Office of the Chief Technologist

Bottom Line Up Front

National Aeronautics and Space Administration

1. NASA Technology Roadmaps are a foundational element of NASA's of the Strategic Technology Investment Plan (STIP), an actionable plan that lays out the strategy for developing those technologies essential to the pursuit of NASA's mission and achievement of National goals.

2. NASA in Process of Updating of NASA Technology Roadmaps
   - Process included multiple opportunities for input from those internal and external to NASA.
   - Overall Roadmap technical organization the same - same Technical Area Breakdown Structure (TABs), with minor modifications and addition of TA15: Aeronautics.
   - Expanded to include all NASA-developed technologies including Aeronautics (No longer just Space Technologies).
   - Multiple enhancements included.
   - Public will be provided the opportunity to review and comment on Roadmaps.

3. NASA's technology investments are tracked and analyzed in TechPort, a web-based software system that serves as NASA's integrated technology data source and decision support tool.

4. Together, the roadmaps, the STIP, and TechPort provide NASA the ability to track and manage the Agency-level technology portfolio.

Technology Portfolio Supports Missions

National Aeronautics and Space Administration

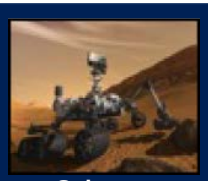
National Science and Technology Priorities

NASA Mission Requirements Driven

External Technology Priorities & Partnerships

Top Down Driven Strategic Guidance

Technology Portfolio



Background: Where Roadmaps Fit In

National Aeronautics and Space Administration

Roadmaps – A set of documents that consider a wide range of needed technologies and development pathways for the next 20 years. The roadmaps focus on "applied research" and "development" activities.

http://www.nasa.gov/offices/oct/home/roadmaps/index.html

Strategic Technology Investment Plan (STIP)– An actionable plan that lays out the strategy for developing the technologies essential to the pursuit of NASA"s mission and achievement of National goals. This plan provides the prioritization and guiding principles of investment for the technologies identified in the roadmaps.

http://www.nasa.gov/pdf/726166main_SSTIP_02_06_13_FINAL_hires=TAGGED.pdf

NASA Technology Executive Council (NTEC) - NASA's senior decision-making body for technology policy, prioritization, and strategic investments.

TechPort – Web-based software system that serves as NASA's integrated authoritative technology data source and decision support tool. Provides information on technology programs and projects.

Tech Finder

Patents, Licenses, Software Agreements Available to Public

TechPort

Technology Projects Documented & Portfolio Analyzed

Technology Projects Funded

NASA's Budget Process

NASA Technology Executive Council (NTEC)

Decisions of Technology Policy, Prioritization and Strategic Investments

Background: Where Roadmaps Fit In

National Aeronautics and Space Administration

Roadmaps

What We Could Do

SSTIP (Priorities)

What We Should Do

NTEC and Budget Process

What We Will Do

TechPort

What We Are Doing

NASA Technology Executive Council (NTEC)

Decisions of Technology Policy, Prioritization and Strategic Investments

NASA's Budget Process

Technology Projects Funded

Technology Projects Documented & Portfolio Analyzed

TechPort

Tech Finder

Patents, Licenses, Software Agreements Available to Public

Roadmaps: Why an Update Now?

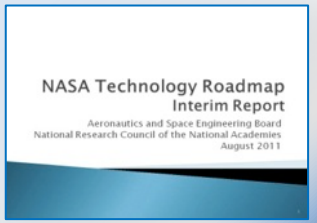
National Aeronautics and Space Administration

FY 2010

Space Technology Roadmaps

- 140 challenges (10 per roadmap)
- 320 technologies
- 20-year horizon

Revised every 4 years, last one 2010



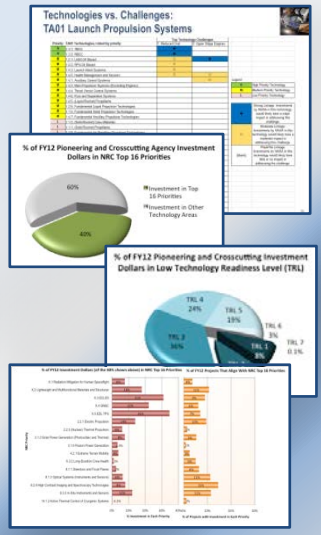
FY 2011

National Research Council (NRC) Study

Prioritization:

- 100 top technical challenges
- 83 high-priority technologies (roadmap-specific)
- 16 highest of high technologies (looking across all roadmaps)

Requested every 4 years



FY 2012

SSTIP Development

Updated ST Roadmaps:

- Incorporate NRC Study Results

Developing a Strategic Space Technology Investment Plan:

- Current investments
- current MD/Office priorities
- Opportunities for partnership
- Gaps vs. current budget and capabilities
- 20-Year horizon with 4-year implementation cadence

Revised every 2 years

FY 2013

Execution

Investment Portfolio

- NASA Technology Executive Council Uses SSTIP to Make Decisions
- Must accommodate:
  - Mission Needs & Commitments
  - Push Opportunities
  - Affordability
  - Technical Progress
  - Programmatic Performance

Budgeted annually

What Does Update Mean? Scope Expanded – All NASA

National Aeronautics and Space Administration

Technology Roadmap Update

Will Consider:
- Updates in Science Decadal surveys
- Human Exploration capability work
- Advancements in technology

Will Include:
- State-of-art
- Capability needs
- Performance goals

Expanded Scope:
- ✓Aeronautics technology
- ✓Autonomous systems
- ✓Avionics
- ✓Information technology
- ✓Orbital debris
- ✓Radiation
- ✓Space weather

Strategic Technology Investment Plan Update

Will Consider:
- New priorities
- Current investments
- Unmet needs
- Partnerships & more

Expanded Scope:
- ✓Aeronautics technology
- ✓Information technology
- ✓Other technologies as influenced by other roadmap updates

What Does Update Mean? Reflects Changing Needs

National Aeronautics and Space Administration

Include updates in new Human Exploration, Science, and Aeronautics mission needs:

- Human Exploration mission classes and design reference missions derived from Capability Driven Framework and Human Spaceflight Architecture studies
- Science mission classes and design reference missions derived from decadals and Science plans
- Aeronautics content from Thrust Areas and Aeronautics Research and Development Plans

NASA relies on the science community to identify and prioritize leading-edge scientific questions and the observations required to answer them. One principal means by which NASA's Science Mission Directorate engages the science community in this task is through the National Research Council (NRC).

2013 – Visions and Voyages for Planetary Science*

2012 – Solar and Space Physics: A Science for a Technological Society*

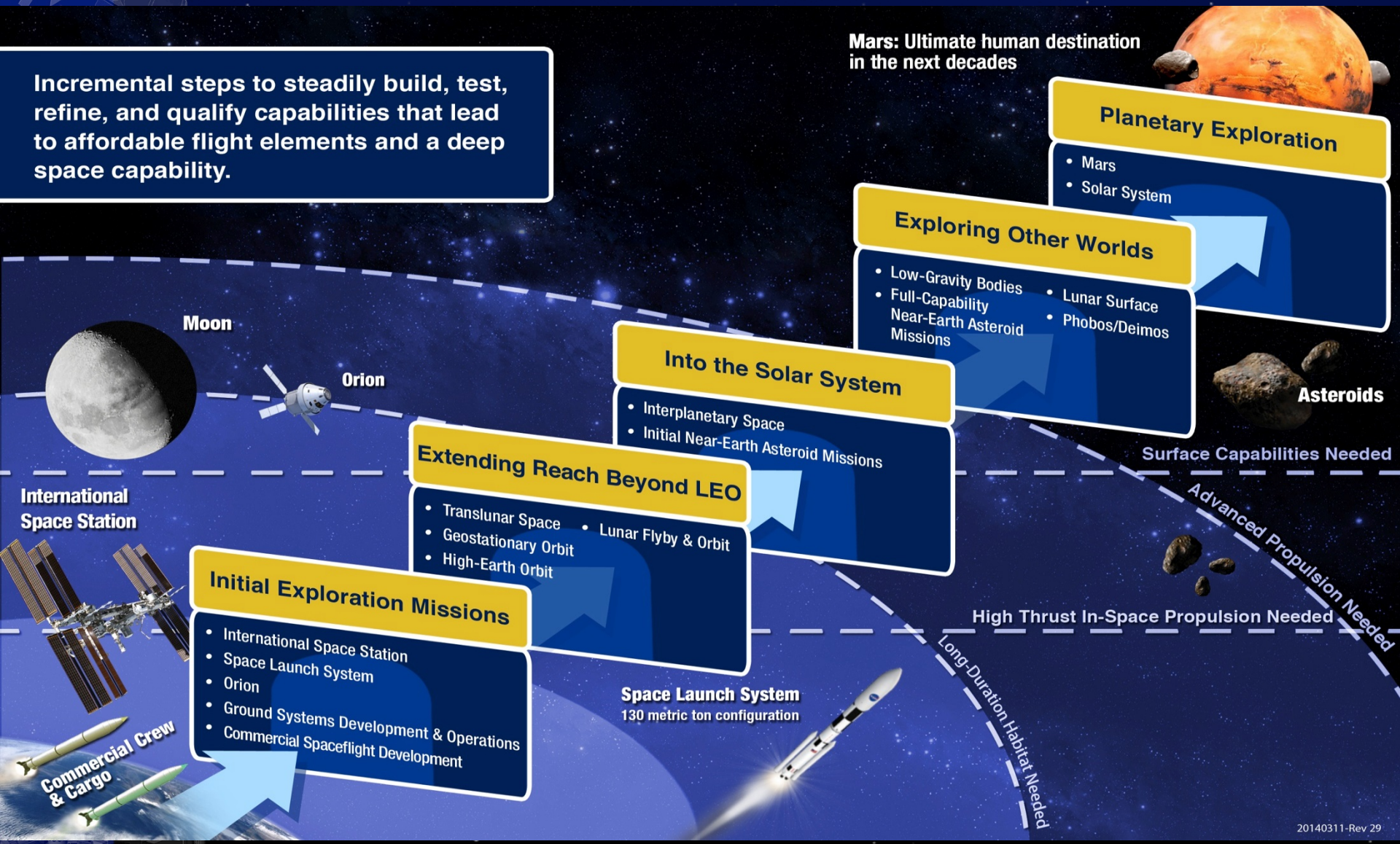
2010 – New Worlds, New Horizons in Astronomy and Astrophysics*

2007 – Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond

* The top three of the Decadal surveys are new and have influenced the Technology Roadmap updates

What Does Update Mean?
Supports NASA's Capability Driven Framework

National Aeronautics and Space Administration



What Does Update Mean? Capability Driven Helps Align Priorities to Our Missions

National Aeronautics and Space Administration

NASA

Mission Directorates - Decadals

2014 Roadmap Development Process

1	• Mission Class	Extending Reach Beyond LEO
2	• Design Reference Missions (DRM) Type	Crewed Mission to Surface
3	• Capability	Entry, Descent and Landing
4	• Capability Performance Goal	Earth; 10.99 km/s; Mars, 14 km/s
5	• Capability State of the Art (SOA)	
6	• Capability Performance Gap	
7	• Technology Performance Goal	
8	•Technology State of the Art (SOA)	
9	• Technology Gap	
10	• Technology Candidates	

Investment Plan

11	• Current Investments
12	• Unmet Needs (Technology Investment Gap)
13	• Stakeholder Priorities / Possible Partnerships
14	• NASA Technology Priorities

<u>Aeronautics Equivalent Terms</u>
Mission Class = Aeronautics Thrust
DRM = Research Theme
Technical Challenge
Technical Work (Technologies)

Roadmap Document General Format

National Aeronautics and Space Administration

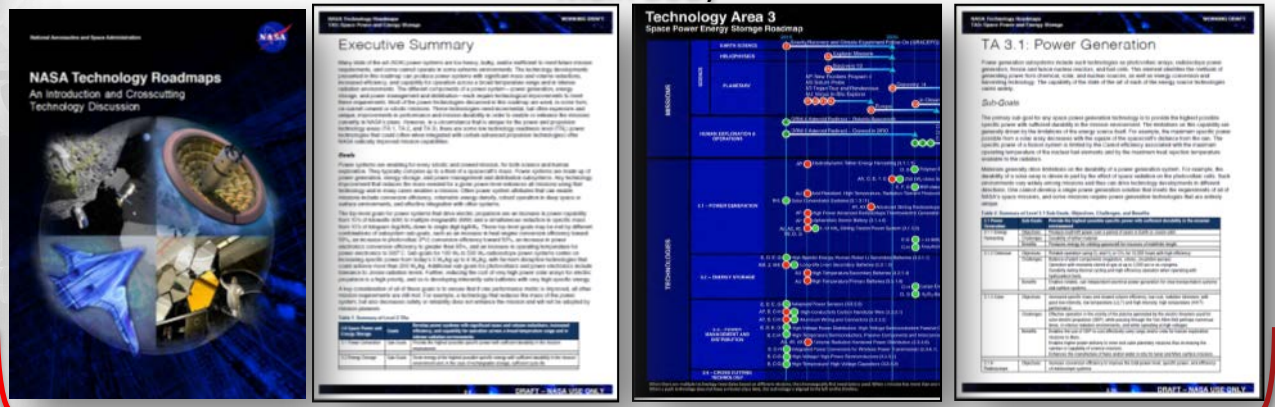
16 Sections

- Introductory/Crosscutting Section (Includes Index)
- 15 Technical Areas

What's New? What's Different

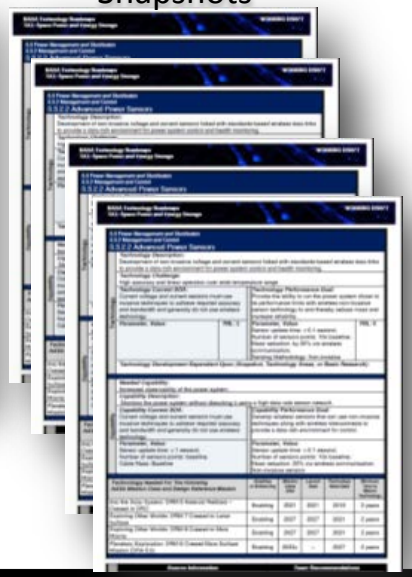
- Overall technical organization the same - Same Technical Area Breakdown Structure (TABS), with minor modifications
  - Content in Same Technical Area (TA)
  - Some New Sub-Tiers
  - More Detail (Snapshots)
  - Includes Pull and Push Technologies
- Standard document format, definitions and graphics
- Introduction, crosscutting section, and index
- Tied to Mission Class and Capability Needs
- Includes SOA and Performance Goals

Main Body



~40+ pages

Technology Candidate Snapshots



Roadmap Document TABS and Snapshots

National Aeronautics and Space Administration

Example Technology Area Breakdown Structure from Science Instruments, Observatories, and Sensor Systems, TA 8

Each TA Includes a Similar TABS Outline

8.1	8.2	8.3
Remote Sensing Instruments / Sensors	**Observatories**	**In-Situ Instruments / Sensor**
8.1.1 Detectors and Focal Planes	8.2.1 Mirror Systems	8.3.1 Field and Particle Detectors
8.1.2 Electronics	8.2.2 Structures and Antennas	8.3.2 Fields and Waves
8.1.3 Optical Components	8.2.3 Distributed Aperture	8.3.3 In-Situ (other)
8.1.4 Microwave, Millimeter, and Submillimeter-Waves		
8.1.5 Lasers		
8.1.6 Cryogenic / Thermal		

Technology Candidate Snapshots

Roadmap Document
Technology Snapshot Overview

National Aeronautics and Space Administration

X.Y Level 2 TABS Name
X.Y.Z Level 3 TABS Name
X.Y.Z.# Technology Name

Technology

Technology Description:
Description of the technology. The description should relate back to the capability.

Technology Challenge:
The top technical issues that impede achieving the capability performance goal.

Technology Current SOA:
The current state of the technology as applied to any environment.

Parameter, Value:
The performance that the technology in can currently provide, as related to the needed capability.

TRL:
Current TRL of the technology with respect to the planned operational environment

Technology Performance Goal:
The 20-year performance goal for this technology with respect to the performance goals identified for the capability need.

Parameter, Value:
The 20-year performance goal for this technology with respect to the performance parameters identified for the capability need.

TRL:
The TRL at PDR or when infused, unless a technology will not finish development by 2035.

Technology Development Dependent Upon:
List of dependencies, including other technologies and basic science.

Capability

Needed Capability:
Brief name for the capability needed to execute the mission

Capability Description:
Description of the capability needed to execute the mission. There should be a linkage between the "Needed Capability" and the DRM/mission class.

Capability Current SOA:
Best available capability that is currently being used to provide the described capability in your mission's environment

Parameter, Value:
The best performance provided in the mission environment associated with the state of the art described.

Capability Performance Goal:
The performance that the capability needs to provide so as to execute the design reference mission(s).

Parameter, Value:
The performance parameters and values that are the key drivers for the development of technologies intended to meet the capability performance goal (need).

Technology Needed For The Following NASA Mission Class and Design Reference Mission	***Enabling or Enhancing***	***Mission Class Date***	***Launch Date***	***Technology Need Date***	**Minimum Time to Mature Technology**
Mission Class: Design Reference Mission					
Mission Class: Design Reference Mission					

Technology Section:
Provides description, challenges, current technology state of the art, performance goal, and dependencies

Capability Section:
Describes the capability need, current capability state of the art, and mission-driven performance goals

Mission Linkage:
Lists Design Reference Missions needing the described capability, and relevant dates

New Introductory and Crosscutting Section

National Aeronautics and Space Administration

New Section Contents

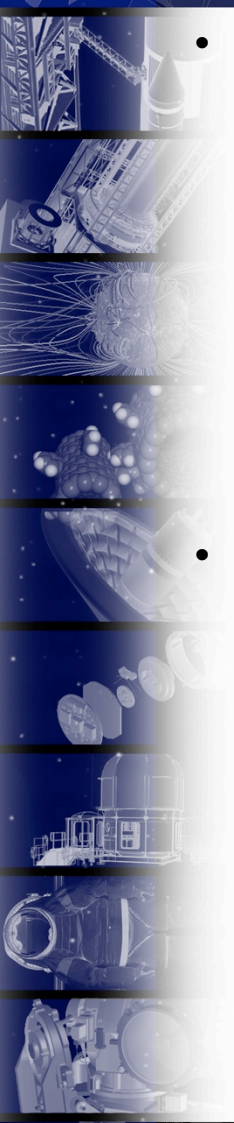
1. Technology Roadmap Overview
2. Technology Roadmap Development Process
3. Technologies that Cross Multiple Technology Areas and Indexes
   a. NASA's broad mission and goals drive the need for technologies that fulfill similar capabilities in many different technology areas
   b. Because of their nature, these technologies do not fit neatly into any one-technology area, but rather are spread across all 15 roadmaps.
   c. The 2014 Technology Roadmaps, therefore, provides extra details on 9 areas

Expanded Areas

1. Autonomous Systems* and Artificial Intelligence
2. Avionics*
3. Extra Vehicular Activity
4. Information Technology*
5. In-Situ Resource Utilization
6. Orbital Debris*
7. Radiation* and Space Weather*
8. Sensors
9. Thermal Protection Systems

EXAMPLE:
Thermal Protection Systems

National Aeronautics and Space Administration



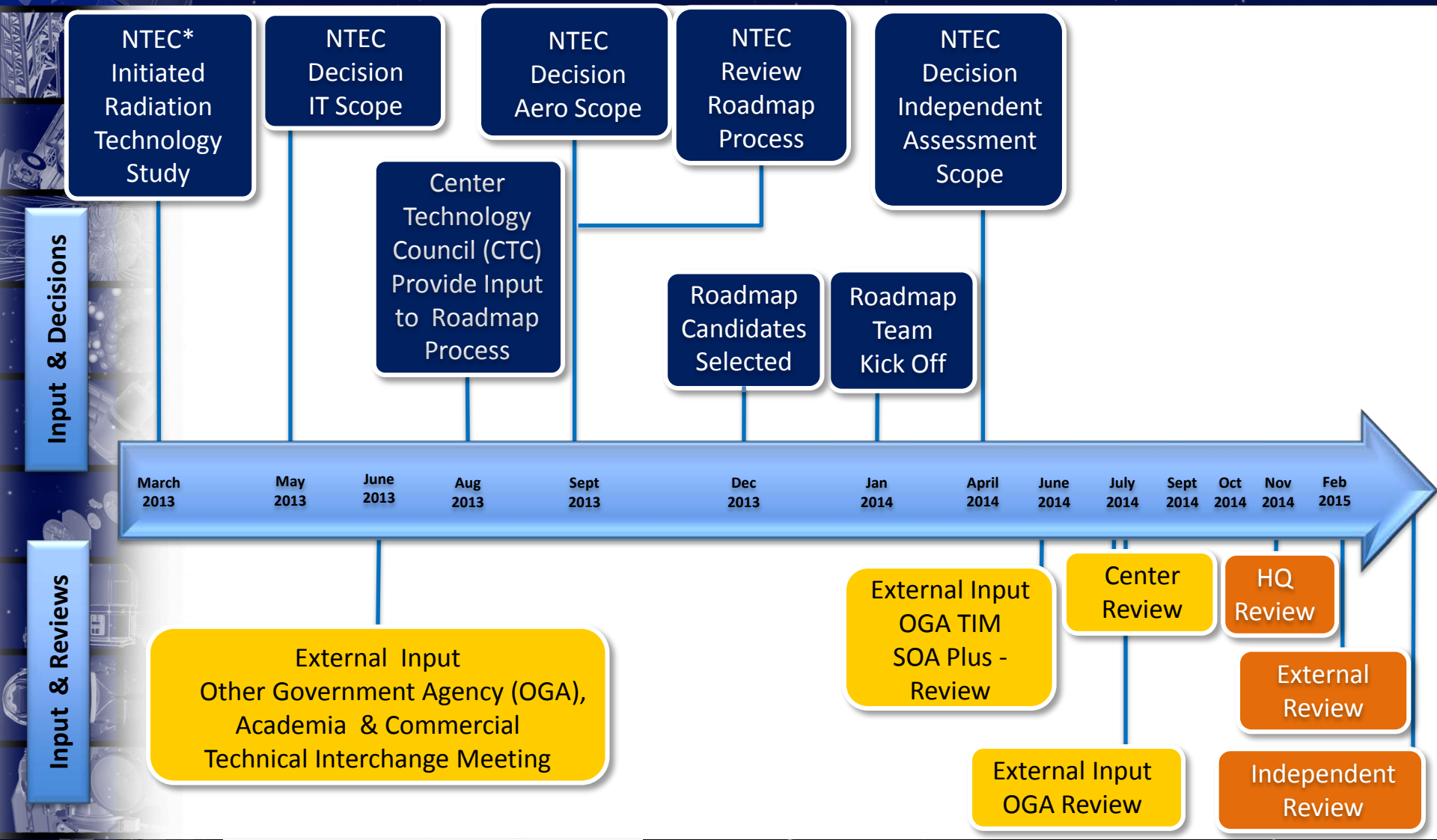
- Thermal Protection Systems (TPS) protect spacecraft from extremely high temperatures and heating during all mission phases, and are very often low-to-no-fault-tolerant, critical systems that constitute a significant mass fraction of spacecraft.

- TPS technologies appear in 10 of the technology areas, as they require exotic materials and structures necessary for reentry and propulsion systems, and require high-temperature sensors and electronics for health monitoring and communication through plasma during reentry.

TA	
	3.2.7, 15.3.2.8

Roadmap Update Overview

National Aeronautics and Space Administration



*NTEC - NASA Technology Executive Council
SOA – State of Art

Conclusion

National Aeronautics and Space Administration

1. NASA Technology Roadmaps are a foundational element of NASA's Strategic Technology Investment Plan (STIP), an actionable plan that lays out the strategy for developing those technologies essential to the pursuit of NASA's mission and achievement of National goals.

2. NASA is in the process of updating of the NASA Technology Roadmaps
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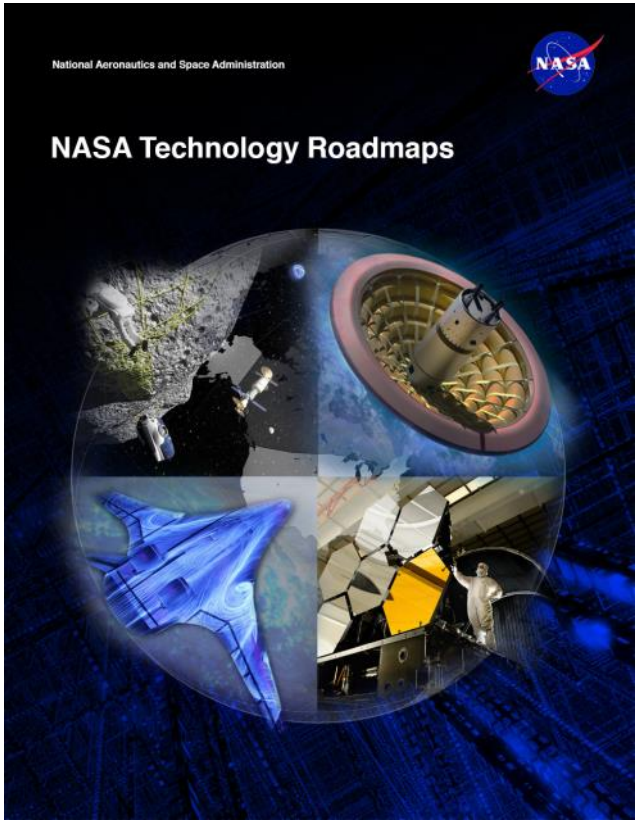
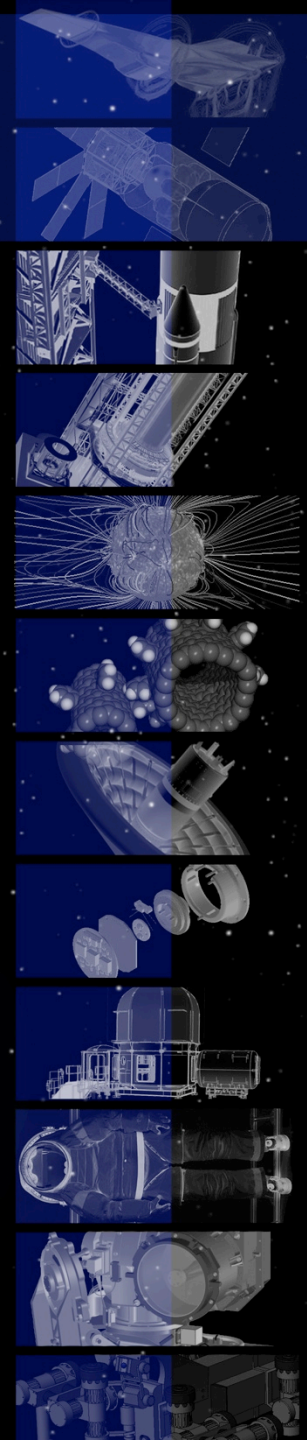


National Aeronautics and Space Administration



Back Up

Technology Definitions

National Aeronautics and Space Administration

NASA Technology Definition:

A solution that arises from applying the disciplines of engineering science to synthesize a device, process, or subsystem to enable a specific capability.

Government-Wide Office of Management and Budget Circular No. A-11 **Conduct of Research and Development****	
Basic Research	Systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. Basic research, however, may include activities with broad applications in mind.
Applied Research	Systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.
Development	Is directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

Technology Included

OMB Analytical Perspectives, Budget of the United States Government, Fiscal Year 2015
NASA Technology Actuals For Applied Research and Development = $7.8B in 2013
(This includes mission-specific technology and development and associated infrastructure).

*** Can be downloaded at: http://www.whitehouse.gov/omb/circulars_a11_current_year_a11_toc*

What Does Update Mean?
Address NRC's Recommendations

National Aeronautics and Space Administration

2011 NRC Recommendations	Final FY12 Roadmaps	SSTIP	FY14 Roadmap Process	Other
Technology Development Priorities		✓		
Advanced Stirling Radioisotope Generators		✓	✓	
Cryogenic Storage and Handling		✓	✓	
Systems Analysis		✓	✓	HEOMD Systems Analysis
Managing the Progression of Technologies to Higher Technology Readiness Levels	✓	✓		
Foundational Technology Base		✓		10% low TRL
Cooperative Development of New Technologies		✓		SSTIP
Measure Technology Transition				Mission use agreements
Industry Access to NASA Data		✓		TechPort
NASA Investments in Commercial Space Technology		✓		
Crosscutting Technologies			✓	
TA Breakdown Structure Recommendations	✓		✓	

SSTIP Development Process

National Aeronautics and Space Administration

GAP ANALYSIS

- NASA's Current Investments
- NASA's MD/Office Priorities
- NRC Recommendations
- NASA Space Technology Roadmaps

FILTERING

- NASA's Needed Technologies
- U.S. Space Policy
- NASA's Strategic Plan

RANKING

- NASA's MD/Office Priorities
- OGA Priorities & Partnership Opportunities
- International Partners, Priorities & Opportunities
- Commercial Priorities & Partnership Opportunities
- Benefits
- Capabilities & Facilities

DECISION MAKING

- Strategic Technology Investment Goals
- Capability Objectives
- Technology Challenges
- Balance Across Technologies
  - Core Technology Investments
  - Adjacent Technology Investments
  - Promising New Technology Investments
- Balance Across Technology Maturity

PATH FORWARD

Four-Year Investment Plan Emphasizing Core Technology Investments

Introduction to TechPort

National Aeronautics and Space Administration

TechPort is a web-based software system.

NASA's TechPort – A window into NASA's pioneering and cross-cutting technology programs and projects.

NASA develops and matures technologies that enable achievement of aeronautics, space exploration, and scientific-discovery missions.

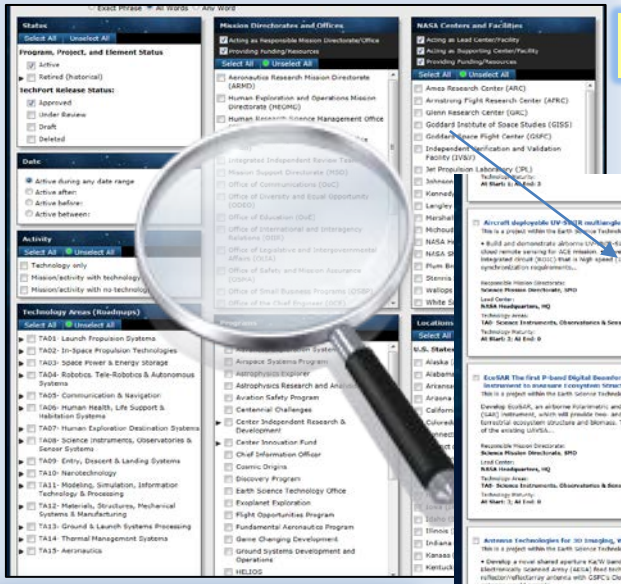
TechPort serves as the Agency's integrated technology data source, sharing the latest accomplishments and new and exciting technology projects from all of NASA's Mission Directorates, Centers and facilities.

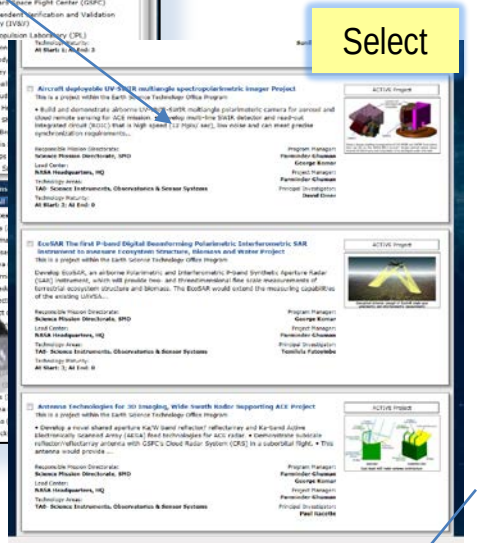
Introduction to TechPort

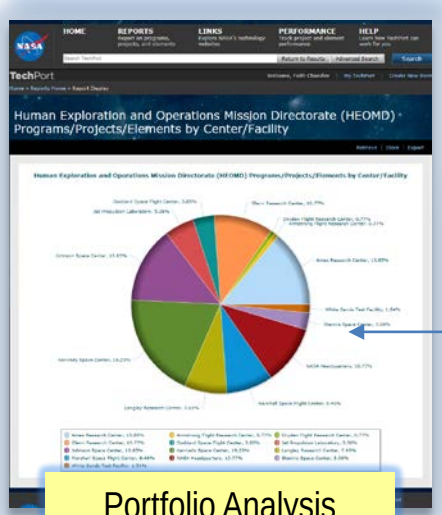
National Aeronautics and Space Administration

TechPort makes a wide range of technology information available, so different users can search and find information relevant to their specific needs.

- ✓ Provides the capability to search and select NASA technology information.
  - Management Team
  - Brief Description
  - Technology Readiness Level (TRL)
  - Anticipated Benefits
  - Realized Benefits
  - Potential Applications
  - Contributing Partners
  - Where Developed
  - NASA Firsts
  - News Stories
  - Social Media Links
  - Track milestones
  - Track technology infusion into NASA missions
- ✓ Provides capability to analyze the Agency technology portfolio and evaluate how NASA's technology portfolio aligns with the Agency's investment strategy.
- ✓ Provides capability to generate reports.

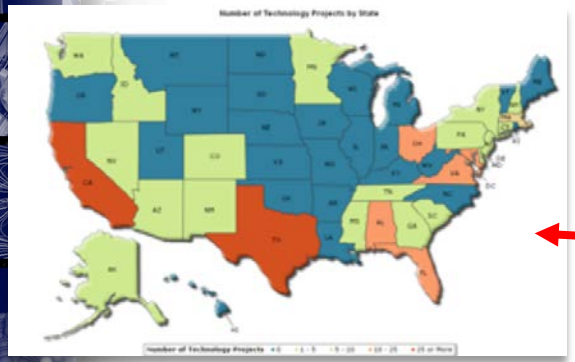


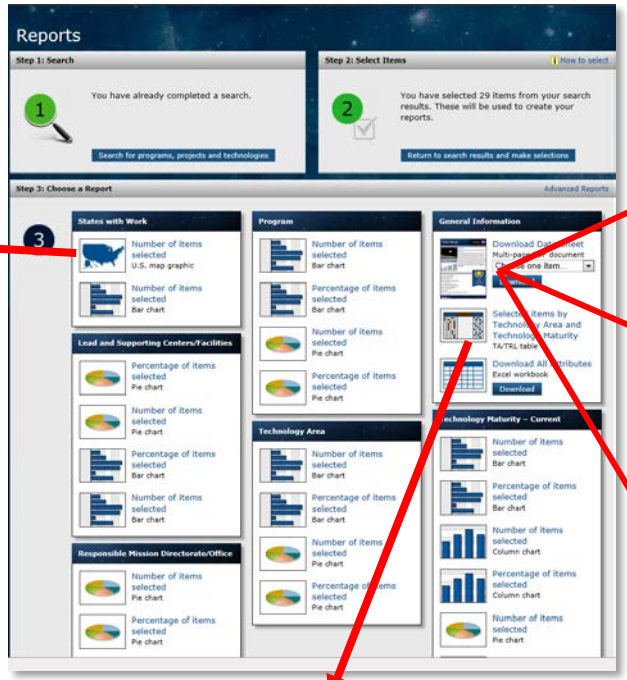


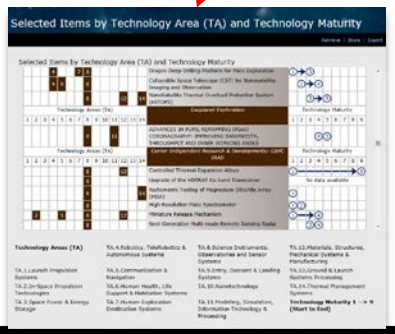


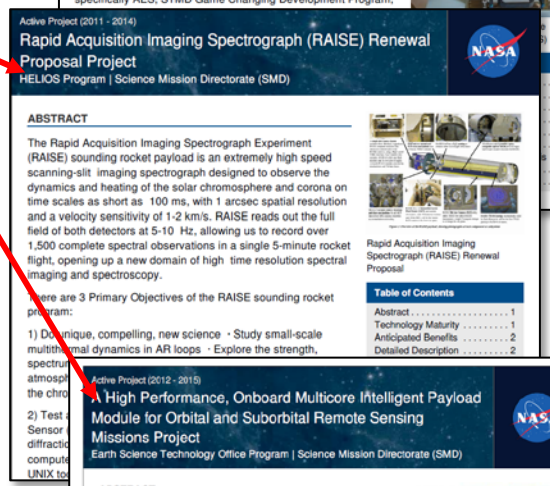
Introduction to TechPort

National Aeronautics and Space Administration









TechPort provides the capability to generate standard and custom reports.

This enables NASA to manage the Agency-level technology portfolio, access gaps and overlaps, and make assessments on balance and prioritization.