

# 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



- 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.

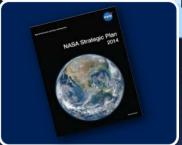
# Technology Portfolio Supports Missions National Aeronautics and Space Administration



#### **National Science and Technology Priorities**







**NASA Mission Requirements Driven** 

**External** Technology Priorities & Partnerships Top Down Driven Strategic Guidance



#### **Technology Portfolio**



**ARMD** 







**Human Exploration** HEOMD

**Cross Cutting STMD** 

Science **SMD** 

**Technology** 

National Aeronautics and Space Administration



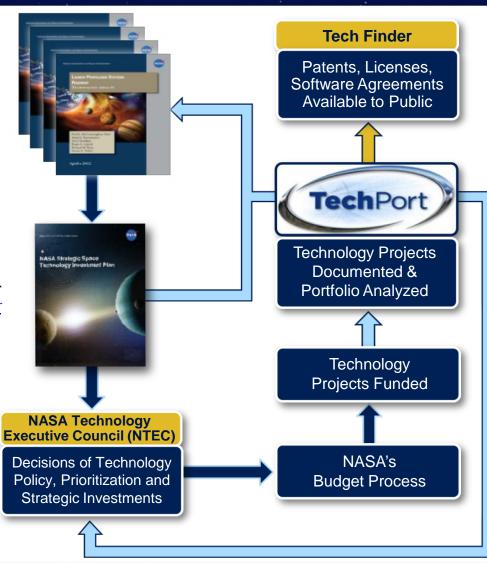
<u>Roadmaps</u> – A set of documents that consider a wide range of needed technologies and development pathways for the next 20 years. The roadmaps focus on "applied research" and "development" activities.

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

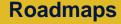
Strategic Technology Investment Plan (STIP) – An actionable plan that lays out the strategy for developing the technologies essential to the pursuit of NASA"s mission and achievement of National goals. This plan provides the prioritization and guiding principles of investment for the technologies identified in the roadmaps. <a href="http://www.nasa.gov/pdf/726166main\_SSTIP\_02\_06\_13\_FINAL\_hires=TAGGED.pdf">http://www.nasa.gov/pdf/726166main\_SSTIP\_02\_06\_13\_FINAL\_hires=TAGGED.pdf</a>

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

<u>TechPort</u> – 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.







What We Could Do

**SSTIP** (Priorities)

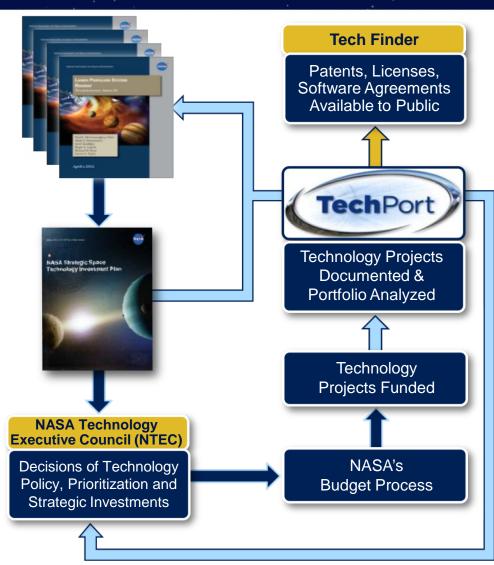
What We Should Do

**NTEC and Budget Process** 

What We Will Do

**TechPort** 

What We Are Doing



# Roadmaps: Why an Update Now?

National Aeronautics and Space Administration





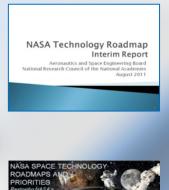
#### **FY 2010**

# 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** 

**Strategic Technology Investment Plan Update** 



#### **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

## Will Consider:

- New priorities
- Current investments
- Unmet needs
- Partnerships & more

#### **Expanded Scope:**

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





### National Aeronautics and Space Administration



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

What Does Update Mean?

Reflects Changing 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 <u>Thrust Areas</u> 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



Incremental steps to steadily build, test, refine, and qualify capabilities that lead to affordable flight elements and a deep space capability.

Mars: Ultimate human destination in the next decades

# **Planetary Exploration**

- Mars
- Solar System

# **Exploring Other Worlds**

- Low-Gravity Bodies
- Full-Capability Near-Earth Asteroid **Missions**
- Lunar Surface
- Phobos/Deimos

High Thrust In-Space Propulsion Needed

# **Asteroids**

Into the Solar System

- Interplanetary Space
- Initial Near-Earth Asteroid Missions **Extending Reach Beyond LEO**

Surface Capabilities Needed

International **Space Station** 

- Translunar Space
- Geostationary Orbit
- High-Earth Orbit

Lunar Flyby & Orbit

# **Initial Exploration Missions**

Orion

- International Space Station
- Space Launch System

Moon

- **Ground Systems Development & Operations** Commercial Spaceflight Development

**Space Launch System** 130 metric ton configuration

20140311-Rev 29

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

NASA Technology Priorities

**National Aeronautics and Space Administration** 

**Extending Reach Beyond LEO** 

Crewed Mission to Surface

Entry, Descent and Landing

Earth; 10.99 km/s; Mars, 14 km/s



**Directorates - Decadals** Mission

**2014 Roadmap Development Process** 

**Investment Plan** 

 Mission Class • Design Reference Missions (DRM) Type Capability • Capability Performance Goal • Capability State of the Art (SOA) • Capability Performance Gap • Technology Performance Goal Technology State of the Art (SOA) Technology Gap • Technology Candidates • Current Investments • Unmet Needs (Technology Investment Gap) • Stakeholder Priorities / Possible Partnerships

**Aeronautics Equivalent Terms** Mission Class = Aeronautics Thrust DRM = Research Theme **Technical Challenge** Technical Work (Technologies)

# Roadmap Document General Format

National Aeronautics and Space Administration



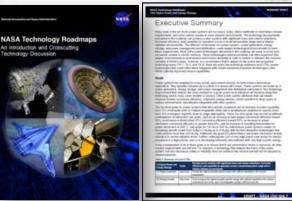
#### 16 Sections

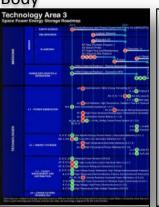
- Introductory/Crosscutting Section (Includes Index)
- 15 Technical Areas

#### 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





TA3	1: P	ower Generation	
generators, for	cross asset for seet florid dis	constructed and healestings on profusional ways, calciusing prosessing representative from the construction, and find ones. This construct destinate for cartillate of section, the matter construction of section constructions and section constructions are section, common with an enables construct, one and no energy construction and one or profuse of the construction of the construction of the section of the s	
Sub-Goal			
specific power parametry diver- possible from specific power	with nation or by the ten a rober straty of a finance product of t	gar space govern generation to the language in to provide that highest provides and declarable in the common separational The establishing on the coupleting and shall not of the among system flood. For a comple, the maximum reporting primary glacinosis with the applica of the appears of the lattice is soon that our. The regions is detailed by the Casade effecting a particular and the maximum for marked flood primaryle, satelling the maximum hand appears are the marked flood primaryle, satelling the maximum hand appears are	
		a distance in sold by the effect of sciency substitute on the photocolistic calls. But I	
percentage of the second secon	n comment die 1 dependen, a na official (1)	coming relations and their can drive becoming privale models of three or officers or this extension to the contract of the organization to the first street in the organization of all and a result for organization of the organi	
Section to Manches to Milhir special many r Section S12 Person	n comment die 1 dependen, a na official (1)	among relations and their call drive technology disvolutionaris in different relation a larger power generalism variables that much the requestionals of all of and corter records; registry power generative technologies that are authory	
percentage of the second secon	n nimero de ecceptura, a ecceptura (). Selectura () () () () () () () ()	acting invarious and their call this has been being the playments in different to a change prompt generation confident of unable the components of all and content encourage register primer generation for financing in that are arriving 1 had brack disposition. Experience particularly financial for global prompting primer prompting actions for content of the content forms for global prompting primer ground primer pr	
Minches III Minches III Milh's spen Minches I and I beause S1 Peers	n námeré de recopiase, p m of Leon's 1 Sale fonds	soming reference and their coll data belowing development in deflivered many a simple prime grained markets that are self-self-self-self-self-self-self-self-	
Appellance Con- table of the space of the con- mittee of the con- mittee of the con- pillance of the con- table of	Control of the contro	soming reference self their cost than believing development in difference may be a language regular point or self-their language regular believing and or self-their language primer generalities for finding as that an a directly find a language primer generalities for finding as find as a directly find a language finding and burstless and a language finding and burstless finding and a language finding and burstless finding and a language finding and burstless finding and a language finding and a language finding and finding and a language finding and a language finding and finding and a language finding and a language finding finding and a language finding and a language finding finding and a language finding and a language finding	
Appellance Con- table of the space of the con- mittee of the con- mittee of the con- pillance of the con- table of	A CAMPAN AND AND AND AND AND AND AND AND AND A	and the second of the control of the	
Street Street Con-	Section of the sectio	and the second of the second o	
Street Street Con-	A comment of the comm	ment proteins and the size that is because the environment. In the size of the	

Technology Candidate Snapshots

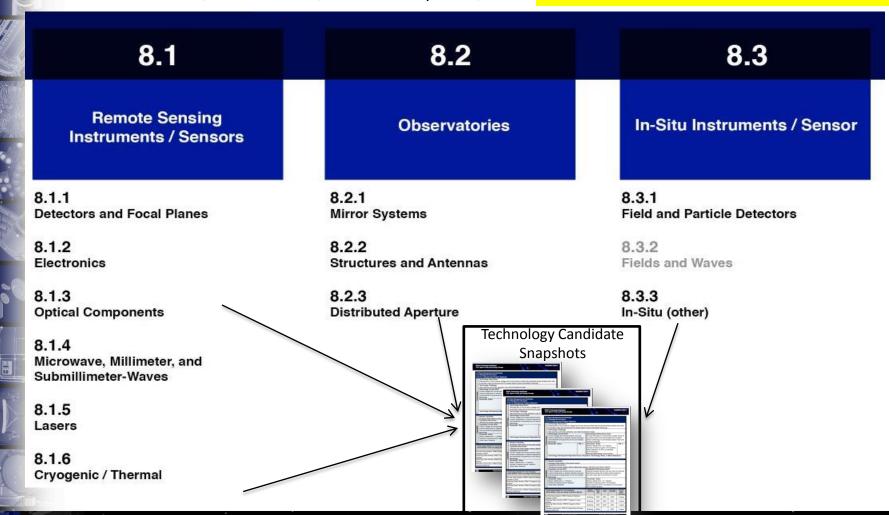
100	Canada Co.	-			-1		
		-		****	-		
All Francis	-	Notice .		-		-	
15177.	- 1	wer Services					
		reasons belongs and person between bidsel grid-sound accommod to press public profession and baselin nor		date desi	444		
2	BASA Face						
188	-				N		
100		magnetic per Stationals					ш
6 "	THE P	homsed Power Sansons	_		-	_	
		And framewood from the latest through					
10	lli T	of Free Management and Hutchiston	_			_	
15	H I	1327 Advanced Power Services					
122	8	Transporters of ten drawns to hape and normal St. Arthrifts 3. (SS), SS), Architecture? St. Arters (Arthrid	manual february	-	ion de los	and strategy	4mi 14m
	ш	Nachronage Chamberger The assumes any free species out on any series	-				
1	II. I	National Color SAS	Total Control	widely to	on to a		n phose to
		and handwidth and parently 40 Kin one adultion	Designed task	indege to	so te	refor before	
120	- 1	minings.	Some re	retria			
100	t l	Process Name (MC)	Parameter.	Fiftee	rii.i ee	-	THE Y
120		Parameter Make 196. 1	-	Foliar months	France of	orden.	
Tomas Control		Mining Southware Squares (for St	Parameter of Parameter of Parameter of	William Million In II	inite to Parame Liberal		
110	-	Parameter State  Parameter State  Various of Transporter Specialists Samuel  Banker Specialis	Parameter of the control of the cont	William Million In II	inite to Parame Liberal		
200	- Canada	Personal Value No. 1  Various Development Squarder Upon St.  Various Development Squarder Upon St.  Various Squarder  Va	Francis III	Filter or to a size to a size to size to si si si si si si si si si si si si si si si si si si s	inite to	netra metro Serie Series	
200	- Company	Manager Febru 96, 1  Various Pales 1 106, 1  Various Pales 1 106, 1  Walter Francisco Administrator Caper 106  Walter Francisco Administrator Caper 106  Walter Francisco Administrator Administrator Caper 106  Walter Francisco Administrator Administrator Caper 106  Walter Francisco	Parameter of the control of the cont	Fisher or	Libera de la companya		THE Y
200	22	Manager Value 96, 1 Varieties Value 196, 1	Parameter of the last of the l	Wilder on the control of the control	Land	Total Section	THE Y
200	12 Et	Manager Value PR. 1  Valuesce Value PR. 1  Valuesce Value PR. 1  Valuesce Value Valu		Fisher or control of the control of	Liberal States	Total Control	THE Y
200	Transfer of the second	Photosoph Villes  Talmining Shedurane Saparates (per Si- Sandari Spelles)  Sandari Spelles  Sandari Sandari Sandari Sandari  Sandari Sandari Sandari Sandari  Sandari Sandari Sandari  Sandari Sandari Sandari  Sandari Sandari Sandari  Sandari Sandari Sandari  Sandari Sandari Sandari  Sandari Sandari Sandari  Sandari Sandari  Sandari Sandari  Sandari Sandari  Sand	Personal Paris of Par	Vision in the second se	Liberal States	TOTAL CONTRACTOR OF THE PROPERTY OF THE PROPER	THE Y
200	10 10	Photography (September 1990) 1982 (1 September 1990) 1	Parameter Communication of the	Vision on the state of the stat	Liberal States	TOTAL CONTRACTOR OF THE PROPERTY OF THE PROPER	THE Y
200	10 10	Statement Visial MR 1 Takening Statement Spreaded (Jan. 30 Takening Statement Spreaded (Jan. 30 Takening Statement Spreaded (Jan. 30 Takening Spreaded (Jan.	Parameter Communication of the	Figure 10 and 10		Man Ann	- N. Y
200	10 10	Community State of the	Parameter Parame	Figure 10 and 10		A CONTROL OF THE PARTY OF THE P	700
200	10 10	Street, Street	Parameter Communication of the	Figure 10 and 10		Man Ann	- N. Y

~40+ pages



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

Each TA Includes a Similar TABS Outline





Level 2 TABS Name Y.Z Level 3 TABS Name

#### X.Y.Z.# Technology Name

#### **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

#### Technology Performance Goal:

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

#### Parameter, Value:

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

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

The

#### Technology Development Dependent Upon:

List of dependencies, including other technologies and basic science.

#### 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

## **New Section Contents**

- 1. Technology Roadmap Overview
- Technology Roadmap <u>Development</u> Process
- 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

- 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.
- of the 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.

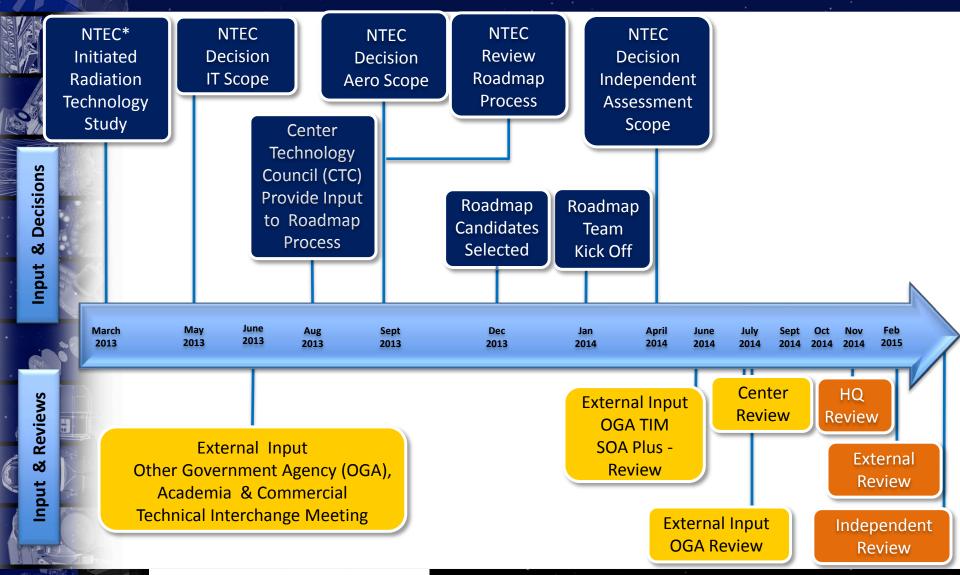
ТА

3.2.7, 15.3.2.8

# Roadmap Update Overview

National Aeronautics and Space Administration

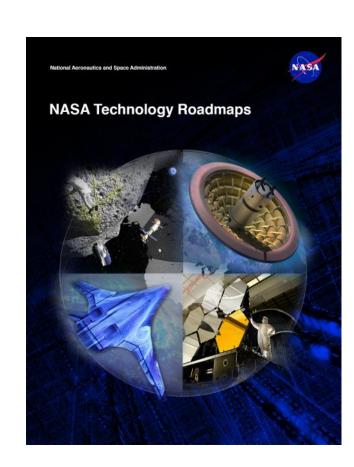




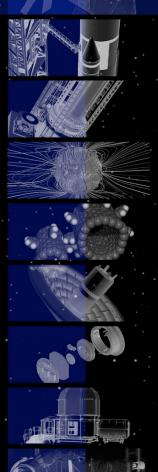


## Conclusion

- 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.
- NASA is in the process of updating of the NASA Technology Roadmaps
  - Public will be provided the opportunity to review and comment on Roadmaps.
- 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 manage the Agency-level technology portfolio.







Back Up





## **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.

ncluded

**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.

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).

<sup>\*\*</sup> Can be downloaded at: http://www.whitehouse.gov/omb/circulars\_a11\_current\_year\_a11\_toc



	2011 NRC Recommendations	Final FY12 Roadmaps	SSTIP	FY14 Roadmap Process	Other
	Technology Development Priorities		✓		
	Advanced Stirling Radioisotope Generators		1	✓	
	Cryogenic Storage and Handling		✓	✓	
	Systems Analysis		1	1	HEOMD Systems Analysis
	Managing the Progression of Technologies to Higher Technology Readiness Levels	✓	✓		
	Foundational Technology Base		✓		10% low TRL
0	Cooperative Development of New Technologies		✓		SSTIP
	Measure Technology Transition				Mission use agreements
	Industry Access to NASA Data		✓		TechPort
	NASA Investments in Commercial Space Technology		✓		
4	Crosscutting Technologies			✓	
A	TA Breakdown Structure Recommendations	<b>√</b>		✓	



## 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





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 <u>Agency's integrated technology</u> <u>data source</u>, sharing the latest accomplishments and new and exciting technology projects from all of NASA's Mission Directorates, Centers and facilities.



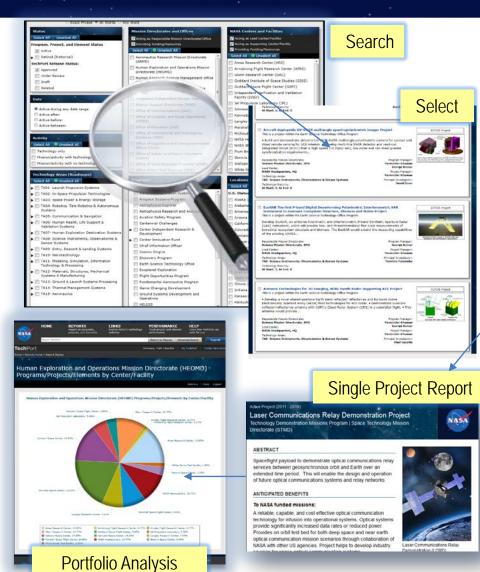
## Introduction to TechPort

#### 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



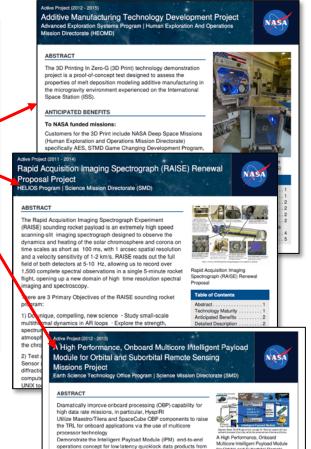


TechPort provides the capability to generate standard and custom reports.

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







airborne vehicles

parameters, and algorithms

Multi-tiered onboard data processing chain

Direct download of Level 2 (L2) data products with atmospheric
correction and geocorrection based on user selected location.

Anticipated Benefits