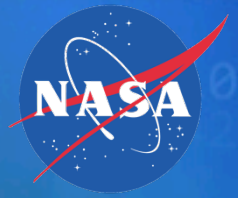
National Aeronautics and Space Administration



Strategic Technology Investment Plan And Technology Roadmaps

FAA COE AST Briefing

October 29, 2013

Faith Chandler
Office of the Chief Technologist

Discussion Topics

- Overview – Office of the Chief Technologist
- Strategic Space Technology Investment Plan (SSTIP)
  - Relates to Technology Portfolio
  - SSTIP Development
  - SSTIP Content Overview
  - SSTIP Governance – NASA Technology Executive
- Opportunities
- What's Next?

NASA - Building Upon Past Excellence….
Creating the Path For the Future

Office of Chief Technologist

- **Technology Strategic Planning, Policy and Requirements**
  - Develop and implement the NASA technology policies, requirements, roadmaps, and strategic technology investment plan to guide Agency technology and innovation activities.

- **Technology Coordination, Councils and Partnerships**
  - Coordinate technology needs across the NASA Mission Directorates and communicate with other Government agencies and the commercial sector to leverage shared priorities, encourage partnerships, and enable the broad use of NASA-developed technologies.
  - Manage NASA Technology Executive Council (NTEC) and Center Technology Council (CTC) to provide Agency-level decisions that address technology priorities & gaps, anticipate future needs, and avoid duplication of effort.

- **TechPort Development and Operation**
  - Provide the capability to make information about NASA's technology investments openly available and accessible to the Agency and the public.

- **Portfolio Tracking and Analysis**
  - Track NASA's technology investments, comparing the portfolio against the strategic technology investment plan and work with stakeholders to make appropriate adjustments.

Office of Chief Technologist

- OCT provides the strategy, leadership, and coordination that guides NASA's technology transfer and commercialization activities

- Managed by OCT, NASA's **Technology Transfer Program** is focused on extending the benefits of NASA's technology investments to have a direct and measurable impact on daily life and provide the greatest benefit to the Nation

Companies featured in recent issues of NASA's *Spinoff* report have used NASA technology to:

- Create more than 14,000 jobs
- Save more than 444,000 lives
- Generate more than $5 billion in revenue
- Save $6.2 billion in costs

Active NASA-Patents	1034
Active NASA–Funded Patents (Non-Govt owned)	1132
All time Total Patents	8345
Technologies available for Licensing	831
Recorded Spinoffs	1,800+

Challenges Working In Space

NASA's Technology Portfolio

National Science and Technology Priorities

Top Down Driven Strategic Guidance

FY2014 UPDATED

2014 EXPANDED

External Technology Priorities & Partnerships

DoD · NRL · FAA · NRO · Space Command · DoE · AFRL · DARPA

Federal Agencies

International Agencies

Commercial Industry

Mission Requirements


ARMD


HEOMD


SMD


SMD


HEOMD


STMD


ARMD


IT

Technology Portfolio

Bottom Up Driven Requirements

What is Technology?

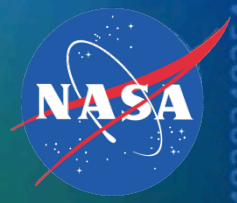
NASA Technology Definition:

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 OMB Circular No. A-11 **Conduct of R&D****	
6.1 Basic Research:	A study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products.
6.2 Applied Research:	Systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.
6.3 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.

Strategic Space Technology Investment Plan (SSTIP)

Strategic Space Technology Investment Plan (SSTIP)



- NASA is moving forward with prioritized technology investments that will support NASA's exploration and science missions, while benefiting other Government agencies and the U.S. aerospace enterprise.

- The plan provides the guidance for NASA's space technology investments during the next four years, within the context of a 20-year horizon.

- This plan will help ensure that NASA develops technologies that enable its 4 goals to:
  - sustain and extend human activities in space,
  - explore the structure, origin, and evolution of the solar system, and search for life past and present,
  - expand our understanding of the Earth and the universe and have a direct and measurable impact on how we work and live, and
  - energize domestic space enterprise and extend benefits of space for the Nation.

"Sparking the imagination and creativity of our people, unleashing new discoveries—that's what America does better than any other country on Earth. That's what we do. We need you to seek breakthroughs and new technologies that we can't even imagine yet." -President Obama.

Roadmap and SSTIP Development

FY 2010
Space Technology Roadmaps

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

- *Revised every 4 years*

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

- *Technology Developments (across full Technology Readiness Level (TRL) spectrum)*
- *Flight Demonstrations*
- *Must accommodate:*
  - *Mission Needs & Commitments*
  - *Push Opportunities*
  - *Affordability*
  - *Technical Progress*
  - *Programmatic Performance*
- *Budgeted annually*

SSTIP Content

Framework

- Goals with capability objectives and technical challenges

4-year Investment Approach

- Three levels of investment
  1. Core
  2. Adjacent
  3. Complementary
- Together these investments:
  - Span the four goals
  - Include pioneering, crosscutting and mission specific technology development
  - Guide future technology expenditures
  - Rapidly produce critical capabilities
  - Seed future innovation

Governance – NASA Technology Executive Council (NTEC)

Principles of Investment and Execution

Core:
- *70% investment*
- *Represent the majority of the NRC's top priority recommendations*
- *Focus on mission specific technologies and 8 critical pioneering and crosscutting areas*
- *Near-term investments necessary to accomplish demanding science and exploration missions*

Adjacent:
- *20% investment*
- *Not part of the Core technologies, but part of NRC's 83 high priorities*
- *Development may take more time*

Complementary:
- *10% investment*
- *Does not include core or adjacent*
- *Does include the remaining technology capabilities in the goals and corresponding Space Technology Roadmaps*
- *Seeds innovation providing some early development in technologies that are not needed immediately*
- *Provide technologies relevant within the 20-year horizon of this strategic plan*

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

SSTIP Content
Technology Investment Framework

- Four goals of Agency Space Technology Investment

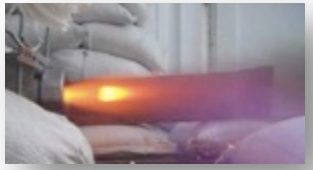
- Each comprises:
  - Strategic investment goal
  - Capability objectives
  - Technical challenges

- Built upon:
  - NASA Space Technology Roadmaps
  - NRC recommendations
  - NASA technology portfolio assessments
  - Survey of stakeholder needs
  - U.S. National Space Policy

GOAL: EXTEND AND SUSTAIN HUMAN PRESENCE AND ACTIVITIES IN SPACE	GOAL: EXPLORE THE STRUCTURE, ORIGIN, AND EVOLUTION OF THE SOLAR SYSTEM, AND SEARCH FOR LIFE PAST AND PRESENT	GOAL: EXPAND UNDERSTANDING OF THE EARTH AND THE UNIVERSE (REMOTE MEASUREMENTS)	GOAL: ENERGIZE DOMESTIC SPACE ENTERPRISE AND EXTEND BENEFITS OF SPACE FOR THE NATION
CAPABILITY OBJECTIVES	CAPABILITY OBJECTIVES	CAPABILITY OBJECTIVES	CAPABILITY OBJECTIVES
1. Achieve improved spacecraft system reliability and performance	1. Achieve improved spacecraft system reliability and performance	1. Achieve improved spacecraft system reliability and performance	1. Achieve improved spacecraft system reliability and performance
2. Enable transportation to, from, and on planetary bodies	2. Enable transportation to, from, and on planetary bodies	2. Enable transportation to space	2. Enable transportation to and from space
3. Sustain human health and performance	3. Enable advanced in-situ measurement and exploration	3. Enable space-based and earth-based observation and analysis	3. Sustain human health and performance
4. Enable payload delivery and human exploration of destinations and planetary bodies		4. Enable large-volume, efficient flight and ground computing and data management	4. Meet the robotic and autonomous navigation needs of space missions
			5. Enable large-volume, efficient flight and ground computing and data management

SSTIP Content
Core Technology Investments

- Core technologies represent 8 focus areas of technology investment that are indispensable for NASA's present and planned future missions
- Core technologies are the central focus of technology investment and will comprise approximately **70%** of the Agency's technology investment of the next 4 years (★ = highest investments now)



Launch and In-space Propulsion ★

Environmental Control and Life Support Systems

High Data-Rate Communications

Space Radiation

Lightweight Space Structures and Materials

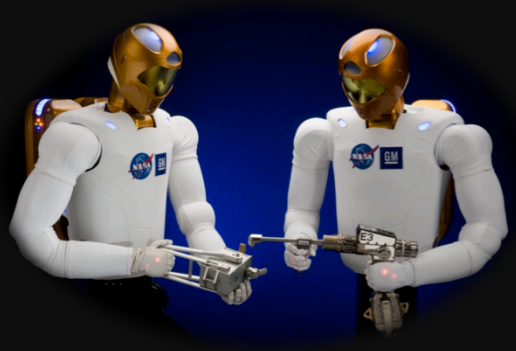
Scientific Instruments and Sensors ★

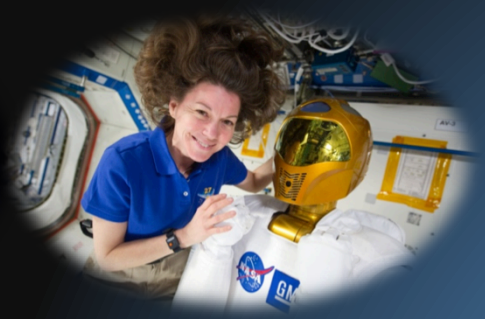
Robotics and Autonomous Systems ★

Entry, Descent, and Landing ★

Evolving Paradigm for Rapid Development of World Class Robots

- Software, Robotics and Simulation Division uses a rapid development model that leverages core technologies
- Typical build cycle lasts 1 year

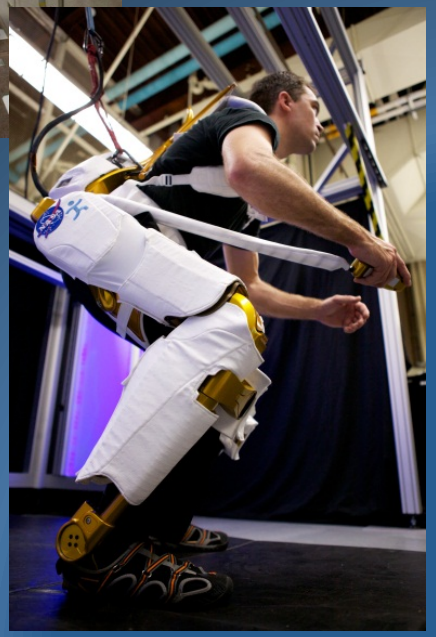






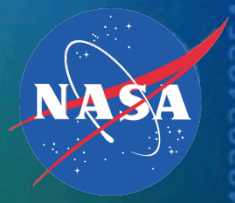
Potential Uses

- Assisted Walking on Earth
- Strength Augmentation
- Rehabilitation
- On Orbit Countermeasures
- On Orbit Dynamometry
  - Assessing muscle strength in space
- Assisted Walking on the Moon or Mars



The Possibilities are Endless!

SSTIP Content
Adjacent Technology Investments



- Adjacent technologies are a significant focus and will comprise **20%** of the Agency's technology investment over the next 4 years
- Though not part of the Core, these technologies are still high-priority and integral to supporting the 4 goals of investment

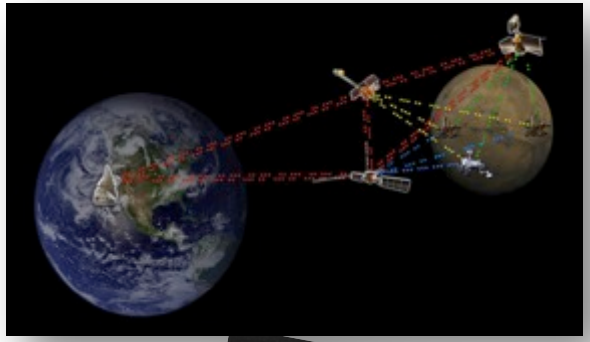
Example Adjacent technologies:

Technology Investment Classification	Associated SSTIP Technical Challenge Area	TABS	Associated NRC High Priorities
Adjacent	Advanced Power Generation, Storage and Transmission; Increased Available Power	3.2	Batteries
Adjacent	Efficient Accurate Navigation, Positioning and Timing	5.4	Timekeeping and Time Distribution
Adjacent	Long Duration Health Effects	6.3	Long Duration Crew Health
Adjacent	Surface Systems	7.4	Smart Habitats; Habitation Evolution
Adjacent	Improved Flight Computers	11.1	Flight Computing; Ground Computing

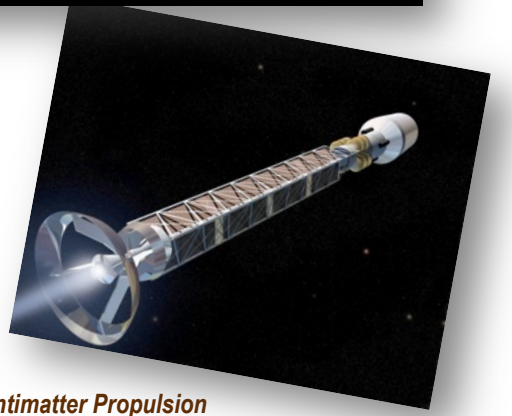
SSTIP Content
Complementary Technology Investments

- Opportunities to invest in future technologies beyond nearer term needs
- Will comprise **10%** of the Agency's technology investment over the next 4 years

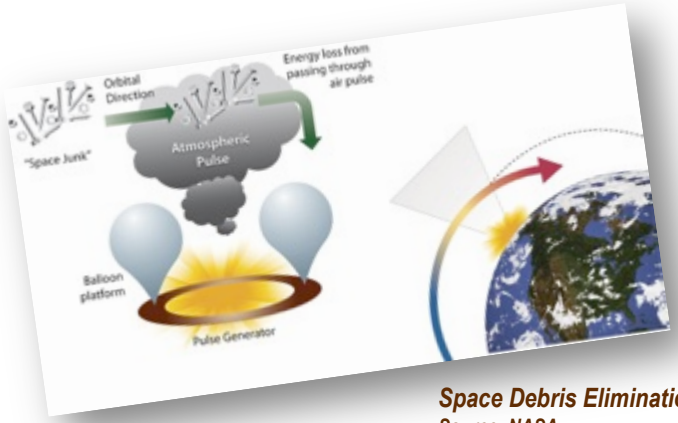
- Examples include:
  - Concepts for mitigating orbital debris
  - Innovative propulsion concepts
  - Ground processing technologies
  - New information technologies



Information Technologies support space exploration
Source: NASA



Antimatter Propulsion
Source: NASA

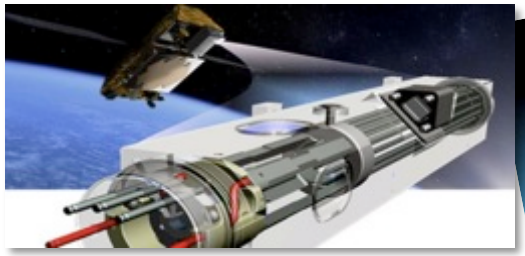


Space Debris Elimination (SpaDE)
Source: NASA

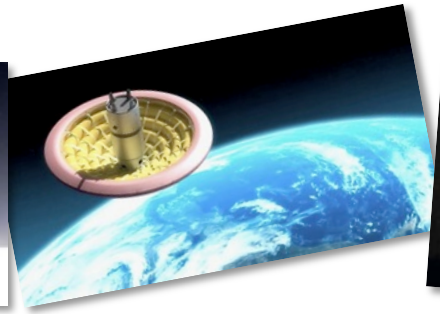
SSTIP Governance and Decision Making

- **NASA Technology Executive Council (NTEC) is the governing body for the SSTIP**.

- NTEC:
  - Evaluates the content and progress of NASA's space technology programs
  - Evaluates the Agency technology portfolio, balance the portfolio, or concur on a variation from the 70% - 20% - 10% approach
  - Makes recommendations on technology gaps, overlaps, and synergies



The Deep Space Atomic Clock
Source: NASA



Hypersonic Inflatable Aerodynamic Decelerator
Source: NASA

Computer simulations derived from data from years of Hubble observations indicate the Andromeda and Milky Way galaxies will collide in 4 billion years, depicted in this artist's rendering.

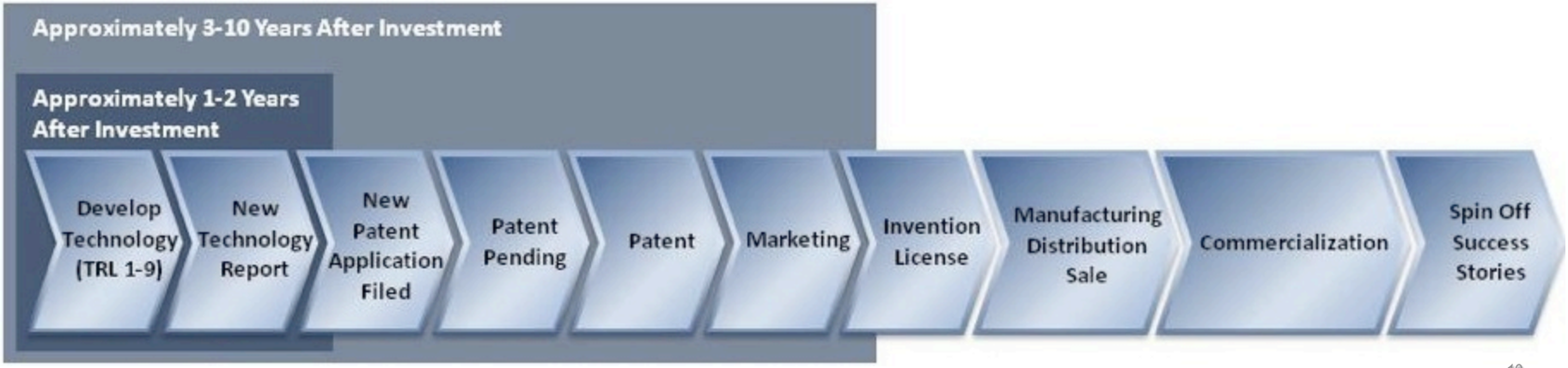
Source: NASA

SSTIP
Principles of Investment and Execution

Principles optimize investments, maintain a balanced portfolio, use developed technologies, and provide transparency to the American public

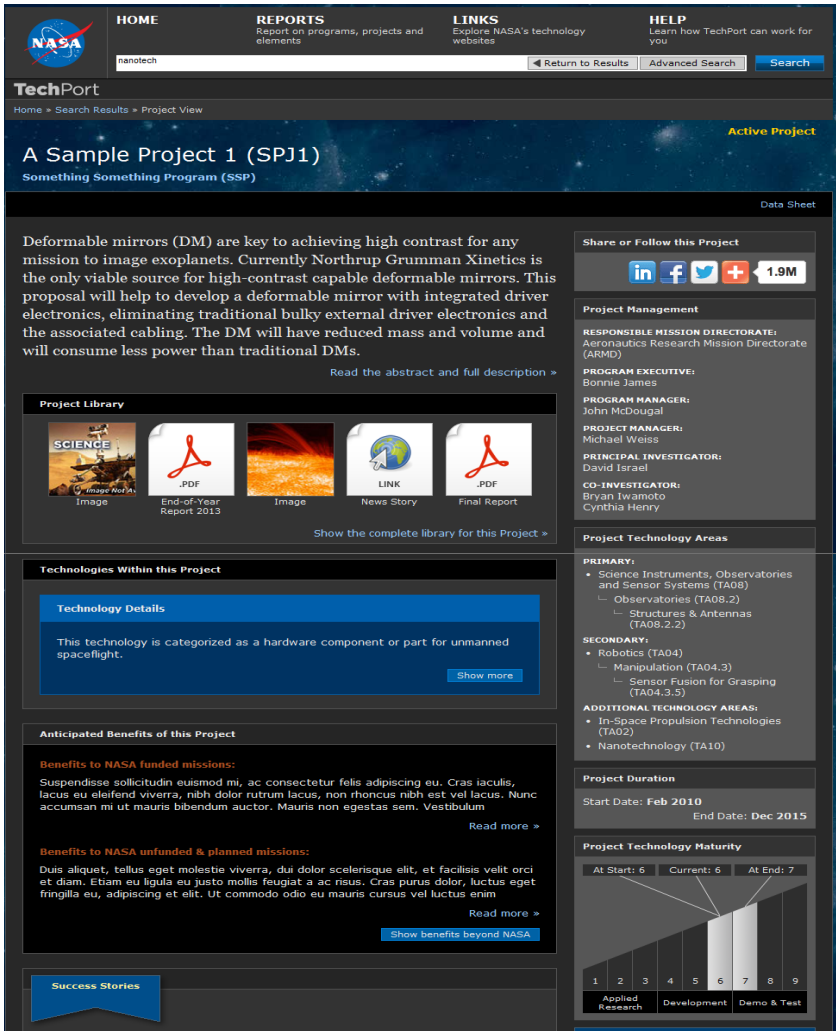
Principles Guide Future Portfolio Investment and Execution

- Achieve the agreed upon balance among investments:
  - Across all 14 Space Technology Areas in the Roadmaps
  - Across all levels of technology readiness
- Ensure developed technologies are infused into Agency missions
- Develop technologies through partnerships and ensure developed technologies are infused throughout the domestic enterprise
- Use a systems engineering approach when planning technology investments
- Reach out to the public and share information about its technology investments



Opportunities

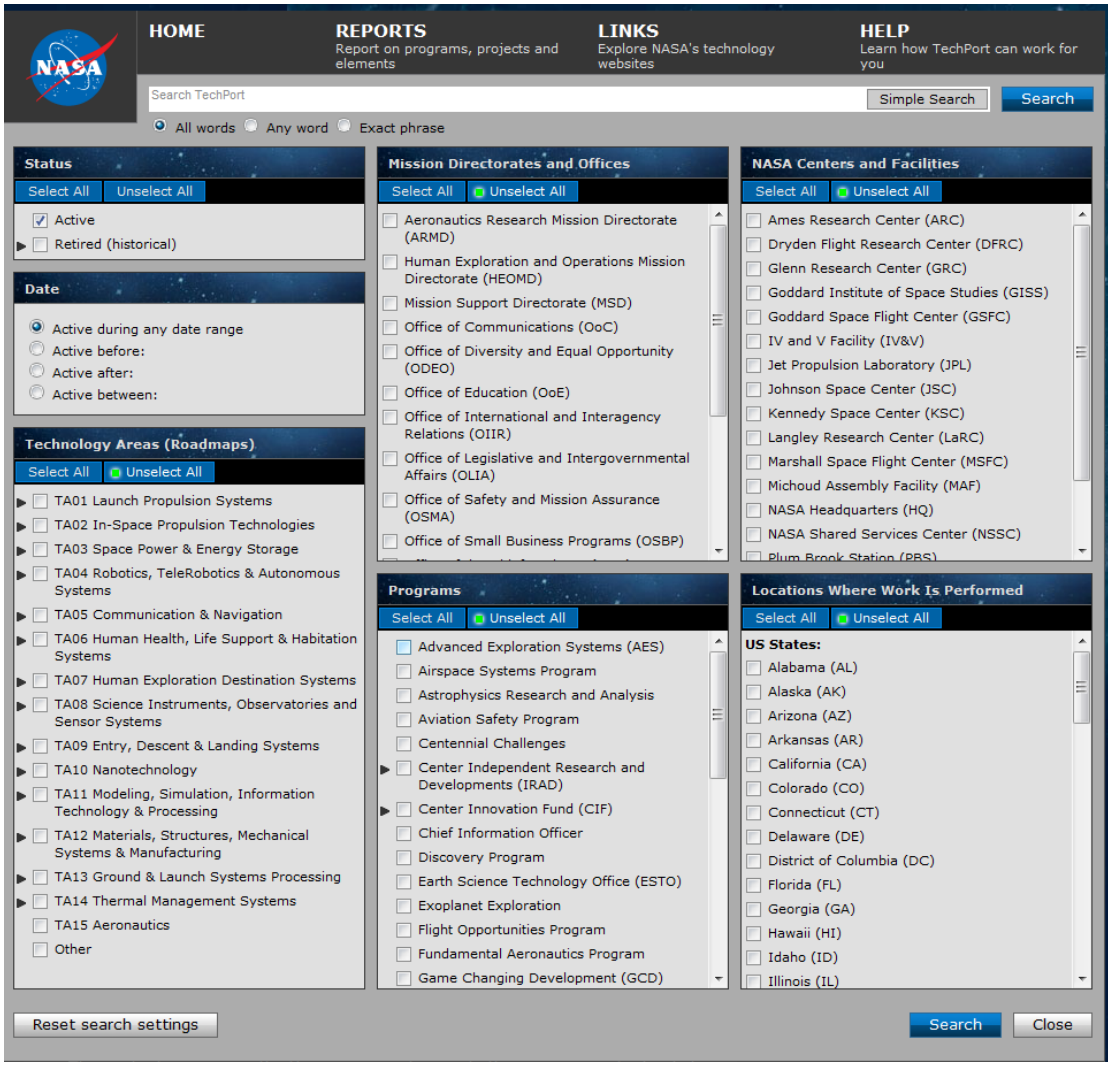
TechPort



The Technology Portfolio System (TechPort) is an integrated, Agency-wide, software system that provides detailed information on individual technology programs and projects throughout NASA.

Portions of TechPort will be publically available soon.

TechPort


HOME
REPORTS
Report on programs, projects and elements
LINKS
Explore NASA's technology websites
HELP
Learn how TechPort can work for you
Search TechPort
Simple Search
Search
All words
Any word
Exact phrase
Status
Select All
Unselect All
Active
Retired (historical)
Date
Active during any date range
Active before:
Active after:
Active between:
Technology Areas (Roadmaps)
Select All
Unselect All
TA01 Launch Propulsion Systems
TA02 In-Space Propulsion Technologies
TA03 Space Power & Energy Storage
TA04 Robotics, TeleRobotics & Autonomous Systems
TA05 Communication & Navigation
TA06 Human Health, Life Support & Habitation Systems
TA07 Human Exploration Destination Systems
TA08 Science Instruments, Observatories and Sensor Systems
TA09 Entry, Descent & Landing Systems
TA10 Nanotechnology
TA11 Modeling, Simulation, Information Technology & Processing
TA12 Materials, Structures, Mechanical Systems & Manufacturing
TA13 Ground & Launch Systems Processing
TA14 Thermal Management Systems
TA15 Aeronautics
Other
Mission Directorates and Offices
Select All
Unselect All
Aeronautics Research Mission Directorate (ARMD)
Human Exploration and Operations Mission Directorate (HEOMD)
Mission Support Directorate (MSD)
Office of Communications (OoC)
Office of Diversity and Equal Opportunity (ODEO)
Office of Education (OoE)
Office of International and Interagency Relations (OIIR)
Office of Legislative and Intergovernmental Affairs (OLIA)
Office of Safety and Mission Assurance (OSMA)
Office of Small Business Programs (OSBP)
NASA Centers and Facilities
Select All
Unselect All
Ames Research Center (ARC)
Dryden Flight Research Center (DFRC)
Glenn Research Center (GRC)
Goddard Institute of Space Studies (GISS)
Goddard Space Flight Center (GSFC)
IV and V Facility (IV&V)
Jet Propulsion Laboratory (JPL)
Johnson Space Center (JSC)
Kennedy Space Center (KSC)
Langley Research Center (LaRC)
Marshall Space Flight Center (MSFC)
Michoud Assembly Facility (MAF)
NASA Headquarters (HQ)
NASA Shared Services Center (NSSC)
Programs
Select All
Unselect All
Advanced Exploration Systems (AES)
Airspace Systems Program
Astrophysics Research and Analysis
Aviation Safety Program
Centennial Challenges
Center Independent Research and Developments (IRAD)
Center Innovation Fund (CIF)
Chief Information Officer
Discovery Program
Earth Science Technology Office (ESTO)
Exoplanet Exploration
Flight Opportunities Program
Fundamental Aeronautics Program
Game Changing Development (GCD)
Locations Where Work Is Performed
Select All
Unselect All
US States:
Alabama (AL)
Alaska (AK)
Arizona (AZ)
Arkansas (AR)
California (CA)
Colorado (CO)
Connecticut (CT)
Delaware (DE)
District of Columbia (DC)
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Search
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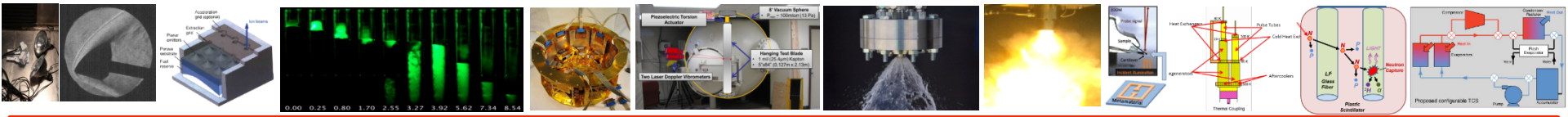
Space Technology Research Grants



- Invest in innovative, groundbreaking, high-risk/high-payoff, low TRL space technology research
- Reinvigorate the pipeline of low TRL technologies and future technological leaders

STRO *Space Technology Research Opportunities*

- One or more NRAs expected annually. Awards are typically grants
- Two workhorse solicitations
  - *Early Career Faculty (ECF)* – support for outstanding faculty early in their careers
  - *Early Stage Innovations (ESI)* – university-led efforts, multiple investigators possible
- Annual award value: ~$200 - $250K, awards initially one year with 1 or 2 renewals possible (depending on solicitation)

http://www.nasa.gov/directorates/spacetech/strg/index.html

NSTRF *NASA Space Technology Research Fellowships*

- Competitive selection of U.S. Citizen / permanent resident graduate students
- Annual solicitation consistent with academic calendar; awards are training grants to U.S. universities
- Selected candidates perform graduate student research on their respective campuses and at NASA Centers and not-for-profit R&D labs
- Annual award value: ~$68K, up to four years of support possible

http://www.nasa.gov/directorates/spacetech/strg/archives_nstrf.html

Center Innovation Fund

Goal: Stimulate and encourage creativity and innovation from within the NASA Centers.

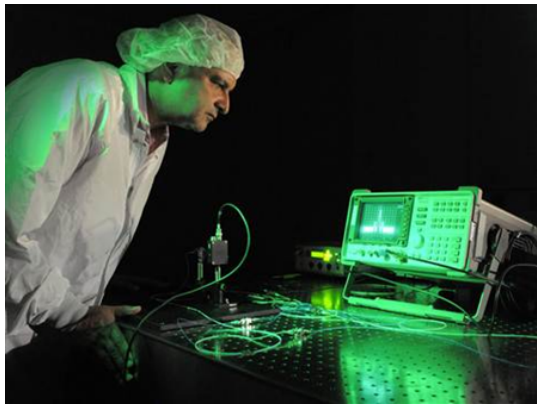
CIF seed funds support:
- New technologies
- Innovative approaches
- Creative ideas
- Leveraging NASA Center talent and capabilities, as well as external partnerships

These funds allow Centers to support low TRL innovative technology initiatives.

HIGHLIGHTS

- In FY 2012, ~180 projects and studies were executed.
- Several of these were picked up by GCD (Woven TPS), or SBIR/STTR for further development.
- CIF is acting as a successful pipeline to the Space Technology programs focusing on higher TRL development.
- In FY 2013, all CIF selections of projects will be completed by the end of May

FY 2014: Center Chief Technologists will select annual awards in alignment with Strategic Space Technology Investment Plan



GSFC: Atom Interferometry for Detection of Gravity Waves

"This project was extremely exciting to be involved with and is just the kind of thing that NASA needs to be doing more of in regards to technology development. It is a good first step to changing the culture of innovation at the center and should definitely be continued."

GSFC: Electrically-controlled extinguishable solid propellant (ESP) thrusters

http://www.nasa.gov/directorates/spacetech/innovation_fund/index.html

What's Next In Technology?

FY2014 Update
Roadmaps and Investment Plan

SSTIP 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

Roadmap Update

Will Consider:
- Updates in Science Decadal Surveys
- Human Exploration Capability Work
- Advancements In Technology

Will Include:
- Capability Needs
- State-of-Art
- Performance Goals
- Technology Challenges & More

Expanded Scope:
- ✓ Aeronautics Technology
- ✓ Information Technology
- ✓ Radiation
- ✓ Space Weather
- ✓ Avionics
- ✓ Orbital Debris

2010 Roadmaps

NASA Teams generated 14 Technical Area Roadmaps That Provided the Foundation for the Space Technology Investment Plan

Excellent products developed by some of NASA's most talented professionals.

We are not starting over!

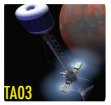
We are enhancing the existing roadmaps to be responsive to:

- Changing needs and priorities
- Advances in technology development
- Needed improvements that will increase the utility and ease of use by NASA and our external stakeholders.

Space Technology Roadmap
14 Technical Areas + Additional Areas

TA01 • LAUNCH PROPULSION SYSTEMS

TA02 • IN-SPACE PROPULSION TECHNOLOGIES



TA03 • SPACE POWER & ENERGY STORAGE

TA04 • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

Autonomous Systems & AI Enhancements

TA05 • COMMUNICATION & NAVIGATION

Avionics Tech Enhancements

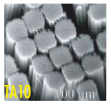
Radiation Tech Enhancements

TA06 • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

TA07 • HUMAN EXPLORATION DESTINATION SYSTEMS

TA08 • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

TA09 • ENTRY, DESCENT & LANDING SYSTEMS



TA10 • NANOTECHNOLOGY

TA11 • MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

Information Technology Section Expanded

Include NITRD and more

TA12 • MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

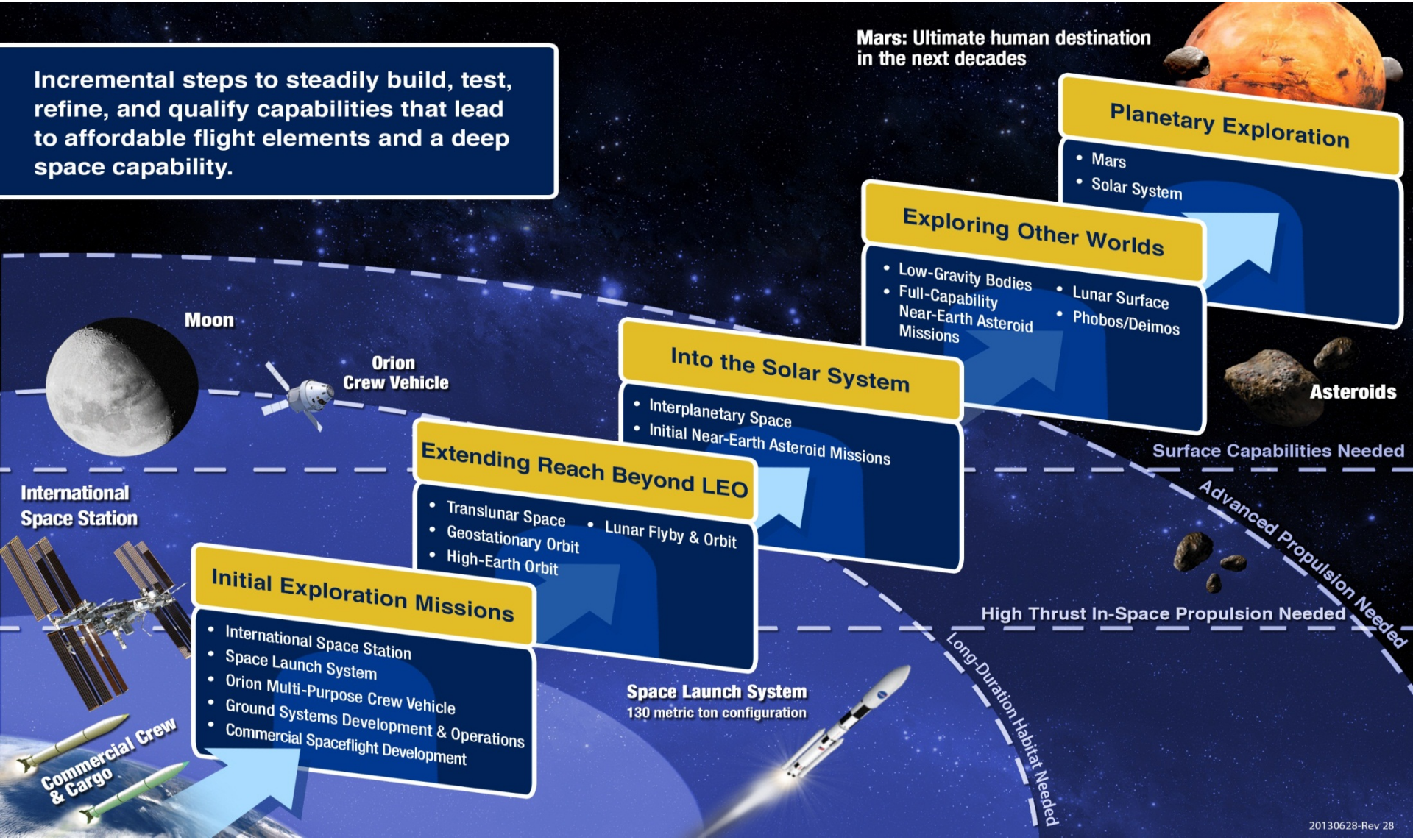
Space Weather Tech

TA13 • GROUND & LAUNCH SYSTEMS PROCESSING

TA14 • THERMAL MANAGEMENT SYSTEMS

TA15 AERONAUTICS

Capability Driven Framework



Technology Investment Plan Update

Collect Information:

*NASA's Current Investments

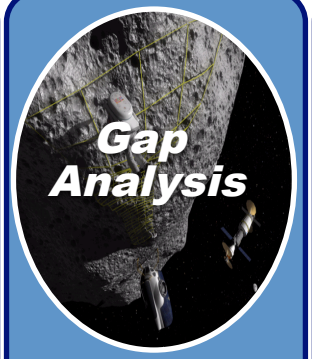
*National Priorities

*NASA MD/Office Needs/Priorities

*Other Government Partnership Priorities

*Commercial Sector Partnership Priorities

*International Partnership Priorities



Identify Unmet Capability Needs

Compare funded investments with:

*US Space Policy

*National Priorities

*NASA's Strategic Plan

*NASA's Needs

*MD/Office Priorities

Establish Criteria

Consider the following:

*All Priorities

*Crosscutting Needs

*NRC Recommendations

*Potential Partnerships

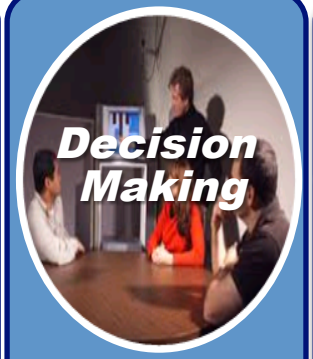
*Benefits

*Capabilities & Facilities

Use Criteria to Rank

Evaluate All Current Investments

Technologies That Address Unmet Capability Needs



Establish Strategy for Core, Adjacent and Complementary:

*Specific Goals

*Top Capability Objectives

*Technology Challenges

*Investment Approach

NTEC Approval

MD/Center Review

NAC Review

LRM Review

A-Suite Review

Final Report

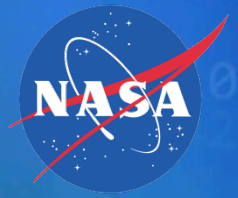
SSTIP - Impact to NASA's Future

Impact to achieving NASA's goals

- The SSTIP provides guidance on NASA's space technology investments
- Using TechPort and other tools, NASA conducts comprehensive data analysis enables understanding of the current technology portfolio
- NTEC uses SSTIP to make integrated Agency-level decisions
- NASA Implements actions that strengthen NASA's position for the future:
  - Optimizes technology investments to maximize technological breakthroughs:
    - Provides depth in key focus areas (core) - launch concepts, in-space propulsion, life seeking missions
    - Ensures breadth across far-term technology areas (adjacent and complementary)
    - **Increases strategic cooperation with other government agencies**
    - Builds stronger ties across industry (consider their priorities & develop crosscutting capabilities)

"Scientists discover the world that exists; Engineers create the world that never was."

Theodore von Karman



Back Up

Asteroid Strategy

To protect our planet, advance exploration capabilities and technologies for human space flight, and learn how to best utilize space resources, the FY14 budget aligns relevant portions of NASA's science, space technology, and human exploration capabilities to cost-effectively meet the President's challenge to send astronauts to an asteroid by 2025 and to Mars in the 2030s.

The FY14 budget aligns relevant portions of NASA's science, space technology, and human exploration capabilities to plan for the mission.

NASA will build on a rich history of engaging citizen scientists, researchers and individual innovators in this quest.

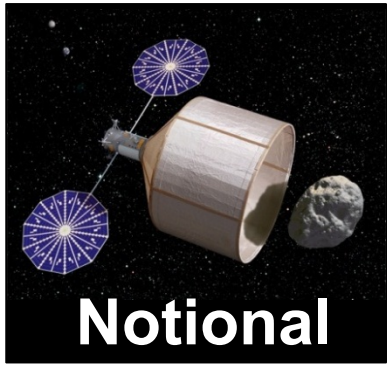
Asteroid Mission Would Consist of Three Main Segments

Identify

Asteroid Identification Segment:

Ground and space based NEA target detection, characterization and selection

Redirect



Asteroid Redirection Segment:

Solar electric propulsion (SEP) based asteroid capture and maneuver to trans-lunar space

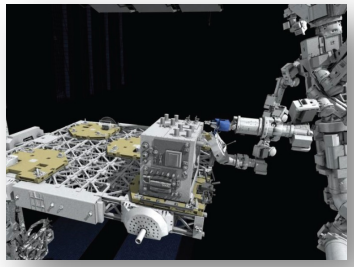
Explore

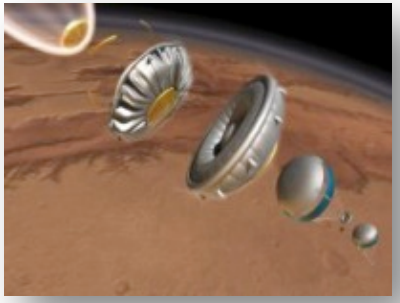
Asteroid Crewed Exploration Segment:

Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid

Goal 1: Extend and Sustain Human Presence and Activities in Space

Autonomous systems such as satellite servicing will advance technologies to achieve improved spacecraft system reliability and performance.





Transportation to planetary bodies will be enabled through entry, descent, and landing (EDL) technologies, such as low density supersonic decelerators.

Every human space mission requires a thorough radiation mitigation plan, using a wide variety of technologies and systems.

GOAL: EXTEND AND SUSTAIN HUMAN PRESENCE AND ACTIVITIES IN SPACE

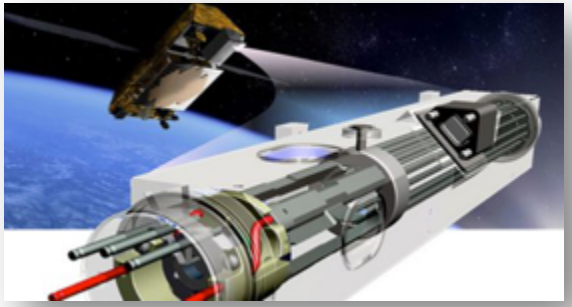
CAPABILITY OBJECTIVES

1. Achieve improved spacecraft system reliability and performance
2. Enable transportation to, from, and on planetary bodies
3. Sustain human health and performance
4. Enable payload delivery and human exploration of destinations and planetary bodies

Goal 2: Explore the Structure, Origin, and Evolution of the Solar System, and Search for Life Past and Present

Exploring the solar system will require high-bandwidth communications to improve spacecraft performance. The Mars Science Laboratory will use high-bandwidth communication technologies as it searches for life past and present.

Deep space atomic clock technologies are necessary for efficient and accurate navigation and enable transportation to and from planetary bodies.



Autonomous robotic technologies allow for maneuvering and manipulation of samples on planetary surfaces, enabling in-situ measurement and exploration.

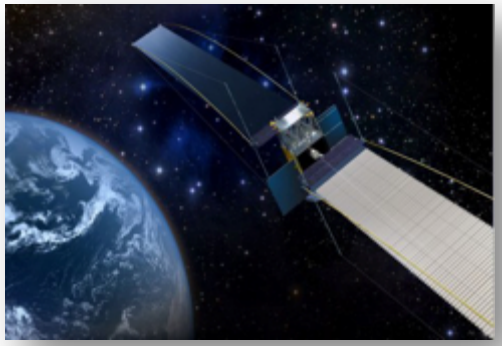
GOAL: EXPLORE THE STRUCTURE, ORIGIN, AND EVOLUTION OF THE SOLAR SYSTEM, AND SEARCH FOR LIFE PAST AND PRESENT

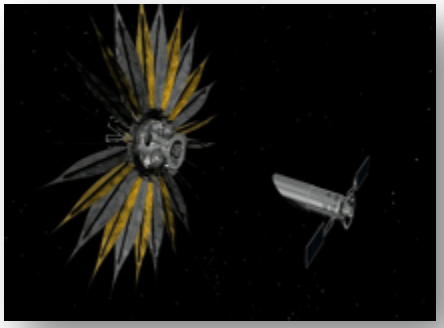
CAPABILITY OBJECTIVES

1. Achieve improved spacecraft system reliability and performance
2. Enable transportation to, from, and on planetary bodies
3. Enable advanced in-situ measurement and exploration

Goal 3: Expand Understanding of the Earth and the Universe (Remote Measurements)

Technologies such as those being advanced for solar electric in-space propulsion will help enable space transportation.





New techniques for using scientific instruments and sensors, like telescopes with a starshade, will enable future space-based observations.

Efficient computing and data management will be enabled by technologies for improving flight computers, such as low-power flight computers for cubesats.

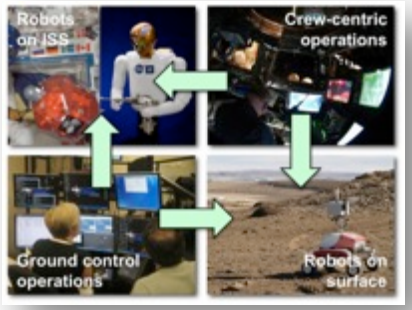
GOAL: EXPAND UNDERSTANDING OF THE EARTH AND THE UNIVERSE (REMOTE MEASUREMENTS)

CAPABILITY OBJECTIVES

1. Achieve improved spacecraft system reliability and performance
2. Enable transportation to space
3. Enable space-based and earth-based observation and analysis
4. Enable large-volume, efficient flight and ground computing and data management

Goal 4: Energize Domestic Space Enterprise and Extend Benefits of Space for the Nation

Technologies for hazard detection and avoidance enable descent and landing on Earth and other planetary bodies.



Advancements in robotic and autonomous technologies will support future on-orbit assembly activities

Autonomous mission operations require high data rates. Technologies to improve computing will extend benefits to domestic space enterprises.

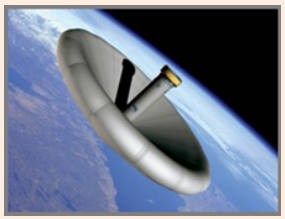
GOAL: ENERGIZE DOMESTIC SPACE ENTERPRISE AND EXTEND BENEFITS OF SPACE FOR THE NATION

CAPABILITY OBJECTIVES

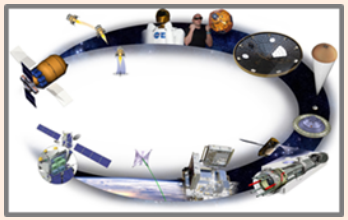
1. Achieve improved spacecraft system reliability and performance
2. Enable transportation to and from space
3. Sustain human health and performance
4. Meet the robotic and autonomous navigation needs of space missions
5. Enable large-volume, efficient flight and ground computing and data management

Space Technology Portfolio

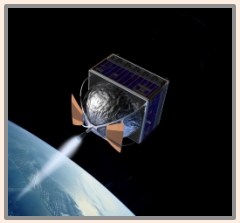
Transformative & Crosscutting Technology Breakthroughs



Game Changing Development (ETD/CSTD)



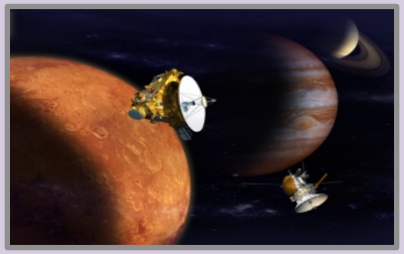
Technology Demonstration Missions (ETD/CSTD)



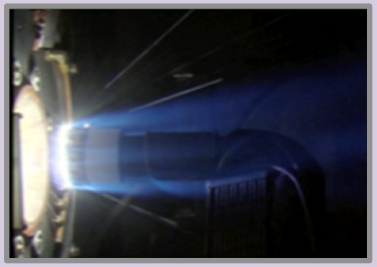
Small Spacecraft Technologies (CSTD)

Pioneering Concepts/ Developing Innovation Community

Space Technology Research Grant (CSTD)



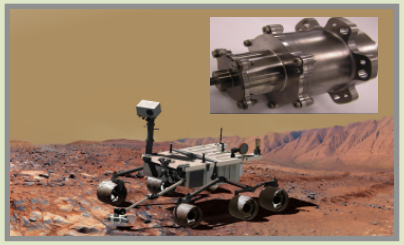
NASA Innovative Advanced Concepts (NIAC) (CSTD)



Center Innovation Fund (CSTD)

Creating Markets & Growing Innovation Economy

Centennial Challenges Prize (CSTD)



Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR)

Flight Opportunities Program (CSTD)

Roadmap Development
Comparison Architecture to Capability Driven

Content Development

2010 Roadmap Development Process

1. Design Reference Missions
2. Architectures
3. Mission Directorate Priorities
4. 14 Technical Areas
5. Technical Challenges
6. Potential Technologies / Paths (Roadmaps)

2014 Roadmap Development Process

Mission Directorates - Decadals

1. Mission Class (Aero Thrust Area) ★
2. Design Reference Missions (Type)
3. Capability
4. Function
5. Parameter
6. Performance Goal ★
7. State of Art (SOA) ★
8. Performance Gap ★
9. Technical Challenges
10. Potential Technologies/ Paths (Roadmaps)

★ = New Content For Some or All of TAs

Capability Driven Helps Align Priorities

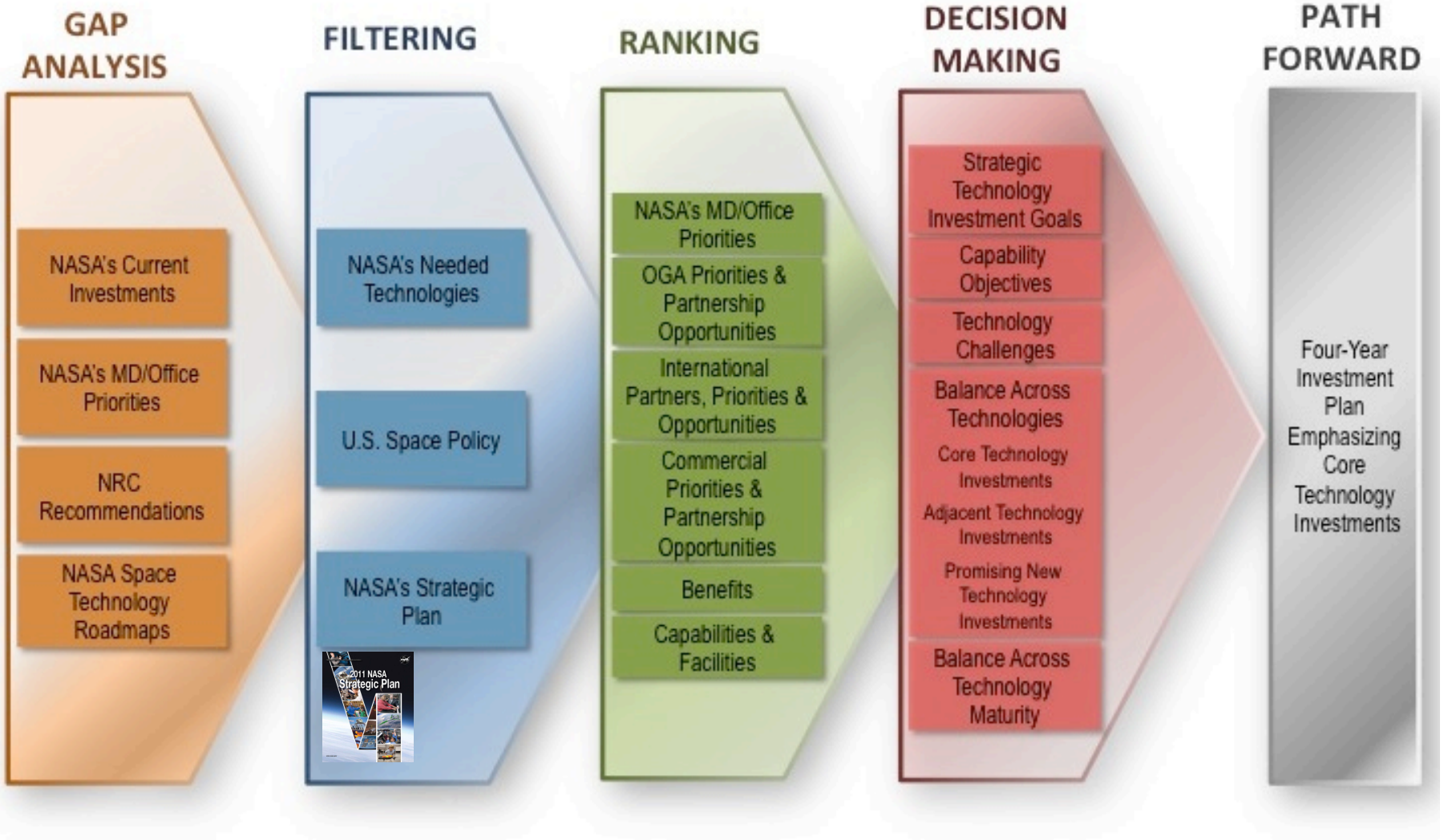
Mission Directorates - Decadals

2014 Roadmap Development Process

Technology Roadmap & Prioritization

1	• Mission Class	Extending Reach Beyond LEO
2	• Design Reference Missions (Type)	Crewed Mission to Surface
3	• Capability	Entry, Descent and Landing
4	• Function	Perform Entry
5	• Parameter	Entry Location and Velocity
6	• Performance Goal	Earth; 10.99 km/s; Mars, 14 km/s
7	• State of Art (SOA)	
8	• Performance Gap	
9	• Technical Challenges	
10	• Potential Technologies/ Paths (Roadmaps)	
11	• Current Investments	
12	• Unmet Needs (Investment Gap)	
13	• Stakeholder Priorities / Possible Partnerships	
14	• NASA Priorities	

Change From 2012 SSTIP Development Process



Science Decadal Surveys

- 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

* **3 of the Decadal surveys are new and can influence the Technology Roadmap updates**