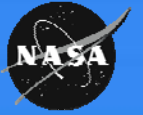


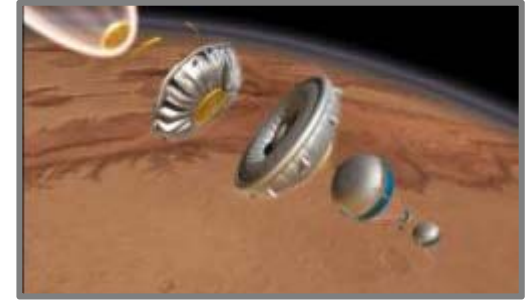
# **Office of the Chief Technologist The State of the Agency NASA Alumni League**

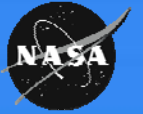
Michael Gazarik, Ph.D.  
NASA Deputy Chief Technologist  
March 4, 2011

# Space Technology: Investments in Our Future

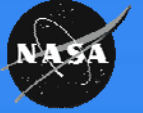


- **Through NASA, America Continues to Dream Big:** NASA's future aeronautics, science and exploration missions are grand in scope and bold in stature.
- **Enabling Our Future in Space:** By investing in high payoff, disruptive technology that industry cannot tackle today, *Space Technology* matures the technology required for NASA's future missions in science and exploration while proving the capabilities and lowering the cost of other government agencies and commercial space activities.
- **NASA at the Cutting Edge:** Pushing the boundaries of aerospace and taking informed-risk, *Space Technology* allows NASA and our Nation will remain at the cutting-edge.
- **Technological leadership is the "Space Race" of the 21<sup>st</sup> Century:** NASA's *Space Technology* investments will stimulate the economy and build our Nation's global economic competitiveness through the creation of new products and services, new business and industries, and high-quality, sustainable jobs.
- **NASA makes a difference in our lives everyday:** Knowledge provided by weather and navigational spacecraft, efficiency improvements in both ground and air transportation, biomedical applications including blood-flow monitoring devices, pacemakers, and lasik eye surgery, as well as the protective armor that keeps our military, firefighters and police safe all benefitted from our nation's investments in aerospace technology. By investing in *Space Technology*, NASA will continue to make a difference in the world around us.



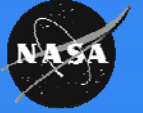


- **Space Technology is a budget line in the FY 2012 request for NASA**
  - Consists of technology development and innovation projects that are broadly applicable to the Agency's future missions in science and exploration while providing space technologies that can improve the capabilities and lower the cost of other government agencies and commercial space activities
  - Includes Partnerships, Innovation and Emerging Space (PI&ES), Strategic Integration (SI), Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR), Crosscutting Space Technology and Exploration Technology
  - The President's FY 2012 NASA Space Technology budget request is \$1,024 million, a modest increase from the amounts authorized for this suite of programs for FY 2012 in the NASA Authorization Act of 2010, consistent with the Administration's plans to "win the future" by investing in research, technology, and innovation
  - Managed by Office of the Chief Technologist (OCT)
- **OCT has chosen to manage technology development through the formation of three divisions**
  - Early Stage Innovation
  - Game Changing Technology
  - Crosscutting Capability Demonstrations
- **Space Technology builds on the success of NASA's Innovative Partnerships Program (IPP)**
  - In FY 2011, IPP was integrated into Office of the Chief Technologist and the IPP budget integrated into the Space Technology Program
- **Formulation of the Space Technology program is complete**
  - Formally approved by Administrator at July 29 Acquisition Strategy Planning meeting



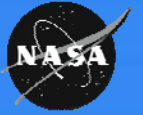
## Space Technology shall:

- Advance broadly-applicable technology to produce technology products for which there are multiple customers.
- Advance exploration-specific technologies to infuse into NASA's future human exploration missions that provide the long-range, critical Exploration-specific technologies required to conduct future human exploration missions beyond low Earth orbit with reduced risk and life cycle cost.
- Employ a portfolio approach over the Technology Readiness Level spectrum.
- Competitively select research by academia, industry, and the NASA Centers based on merit.
- Leverage the technology investments of our international, other government agency, academic and industrial partners.
- Establish a deliberative panel of internal and external stakeholders, including industry and other government agencies, to review and advise OCT on technology development priorities through a transparent and balanced process.
- Result in new inventions, new capabilities and the creation of a pipeline of innovators trained to serve future National needs.



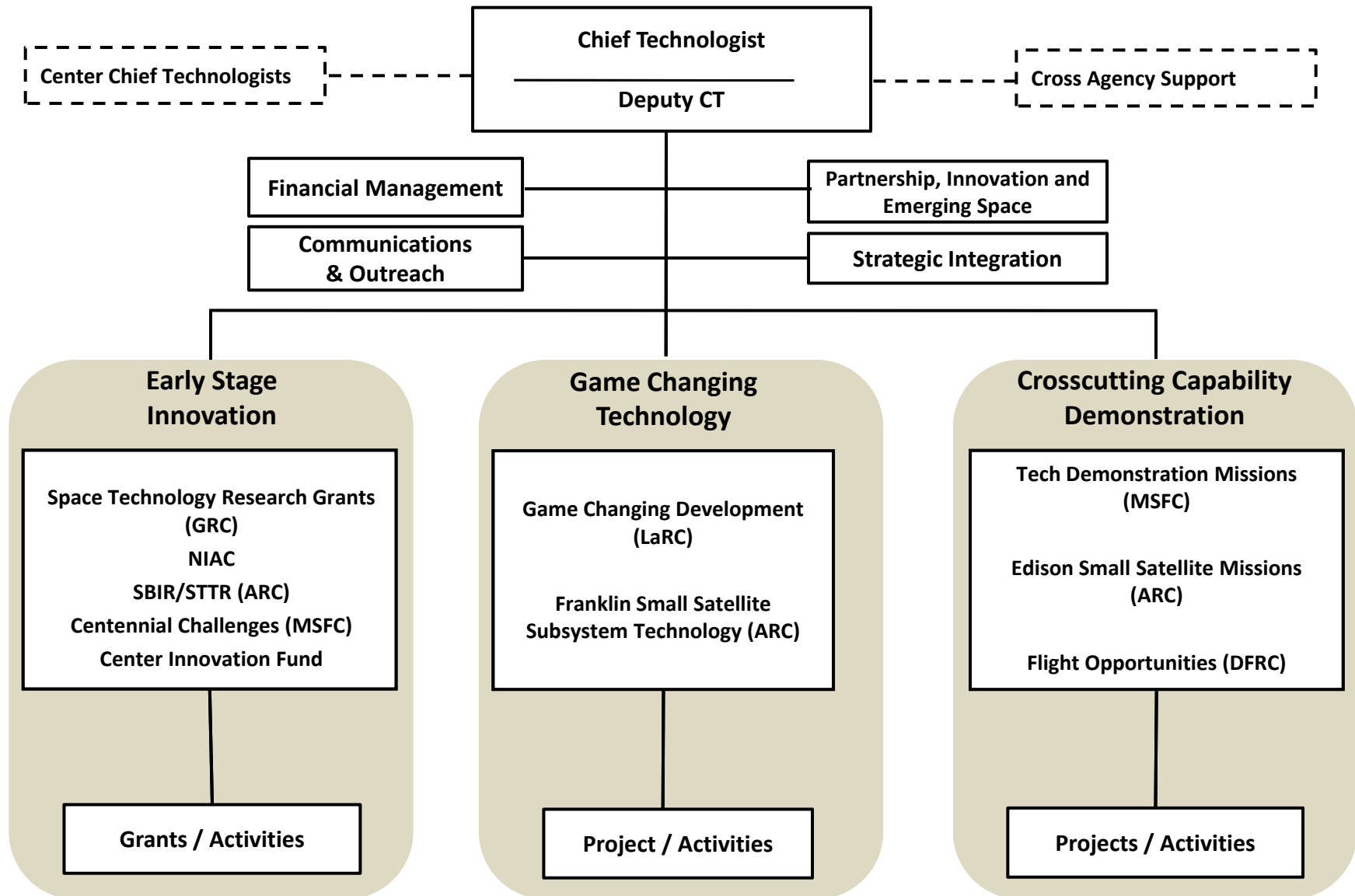
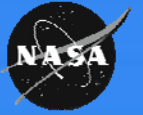
- **Strategic Guidance**
  - Agency Strategic Plan
  - Grand challenges
  - Technology roadmaps
- **Full spectrum of technology programs that provide an infusion path to advance innovative ideas from concept to flight**
- **Competitive peer-review and selection**
  - Competition of ideas building an open community of innovators for the Nation
- **Projectized approach to technology development**
  - Defined start and end dates
  - Project Managers with full authority and responsibility
  - Project focus in selected set of strategically defined capability areas
- **Overarching goal is to reposition NASA on the cutting-edge**
  - Technical rigor
  - Pushing the boundaries
  - Take informed risk and when we fail, fail fast and learn in the process
  - Seek disruptive innovation such that with success the future will no longer be a straight line
  - Foster an emerging commercial space industry

# External Input Has Driven Formulation of the NASA Space Technology Program

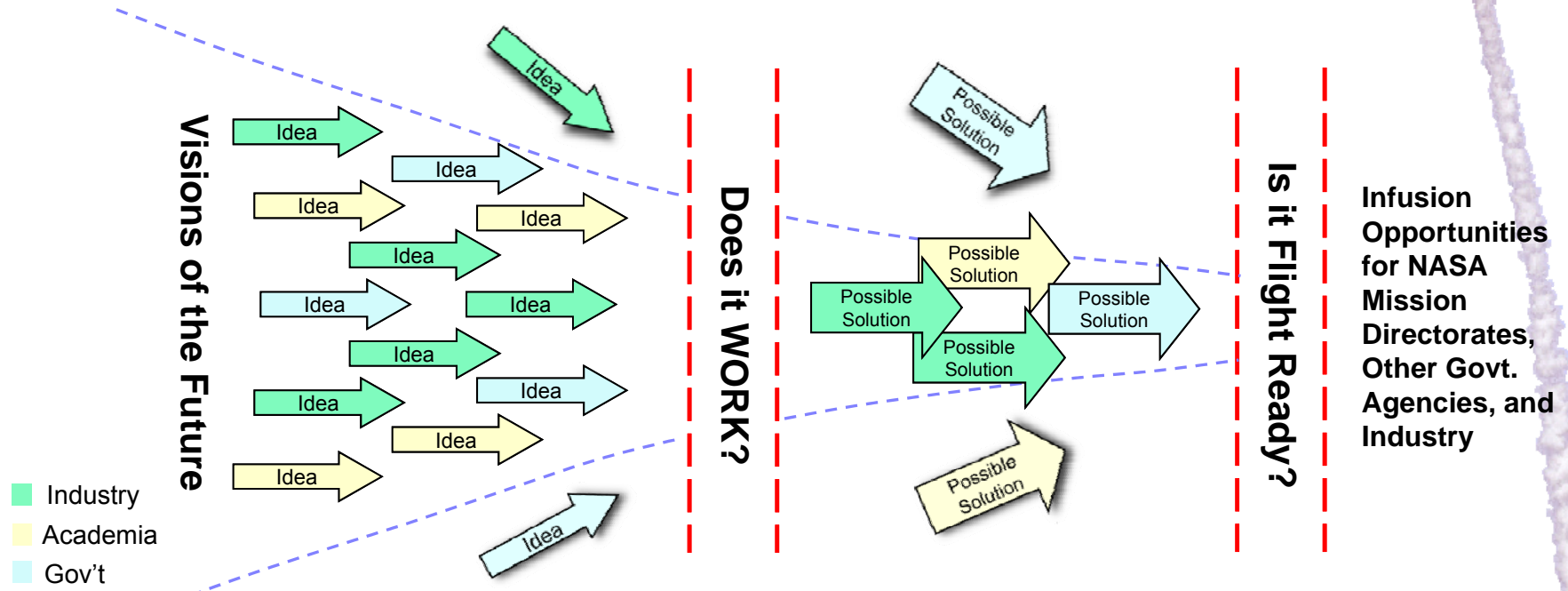
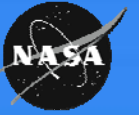


- **NASA Authorization Act of 2008:** *“A robust program of long-term exploration-related research and development will be essential for the success and sustainability of any enduring initiative of human and robotic exploration of the solar system.”*
- **NRC report, A Constrained Space Exploration Technology Program: A Review of NASA’s ETDP, 2008:** *“NASA has created a supporting technology program very closely coupled to the near-term needs of the Constellation Program. This program contains only incremental gains in capability and two programmatic gaps. NASA has effectively suspended research in a number of technology areas traditionally within the agency’s scope. This could have important consequences for those portions of the VSE beyond the initial short-duration lunar missions, including extended human presence on the Moon, human exploration of Mars, and beyond.”*
- **NRC report, America’s Future in Space, 2009:** *“NASA should revitalize its advanced technology development program by establishing a DARPA-like organization within NASA as a priority mission area to support preeminent civil, national security (if dual-use), and commercial space programs.”*
- **NRC report, Fostering Visions for the Future: A Review of the NASA Institute for Advanced Concepts, 2009:** *“To improve the manner in which advanced concepts are infused into its future systems, the committee recommends that NASA consider reestablishing an aeronautics and space systems technology development enterprise. Its purpose would be to provide maturation opportunities and agency expertise for visionary, far-reaching concepts and technologies.”*
- **Augustine Committee, 2009:** *“The Committee strongly believes it is time for NASA to reassume its crucial role of developing new technologies for space. Today, the alternatives available for exploration systems are severely limited because of the lack of a strategic investment in technology development in past decades.”*
- **NRC report, Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research, 2010:** *“To restore the health of the fundamental research laboratories, including their equipment, facilities, and support services, NASA should restore a better funding and leadership balance between long-term fundamental research/technology development and short- term mission-focused applications.”*

# Office of the Chief Technologist Organization



# Space Technology Development Approach



Creative ideas regarding future NASA systems or solutions to national needs.



Prove feasibility of novel, early-stage ideas with potential to revolutionize a future NASA mission and/or fulfill national need.

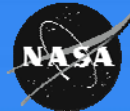


Mature crosscutting capabilities that advance multiple future space missions to flight readiness status

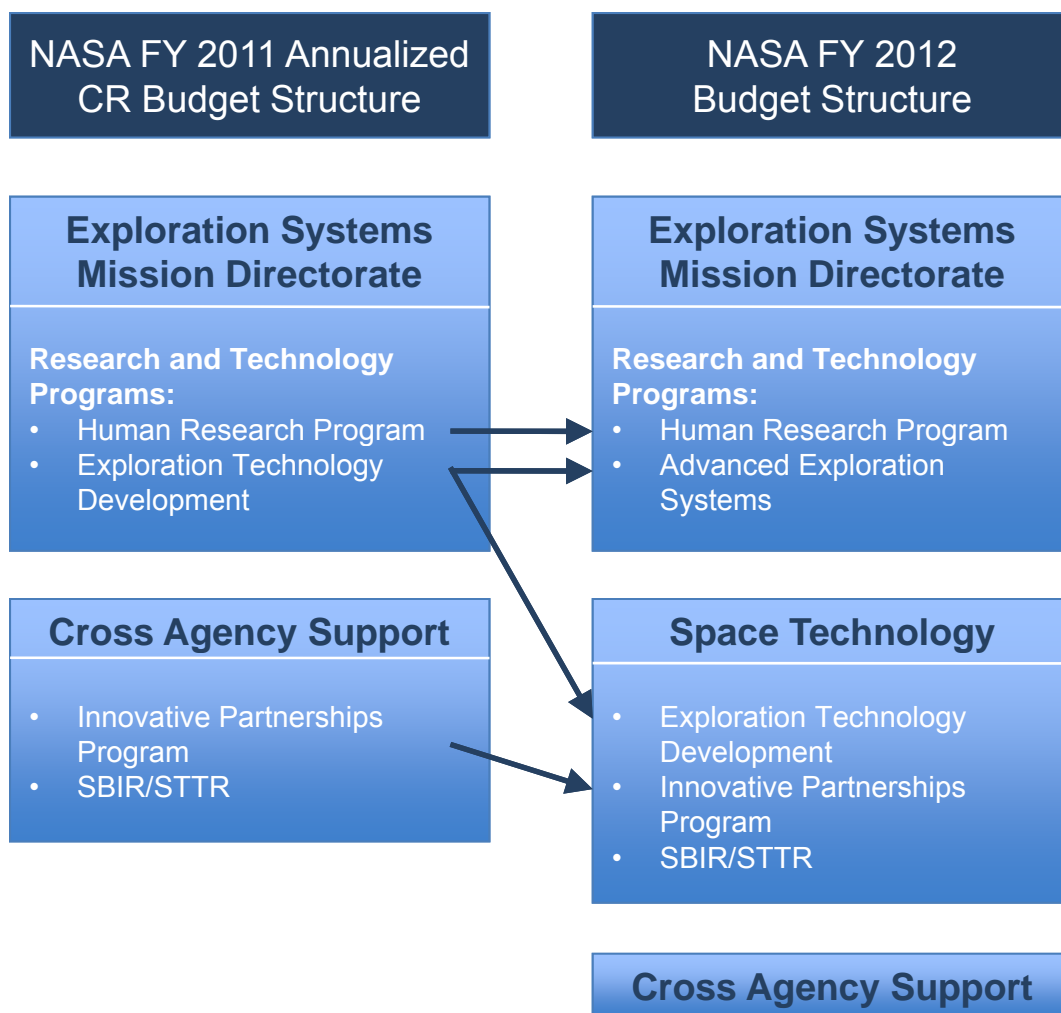




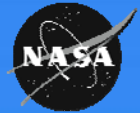
# Exploration Technology Development Move Into Space Technology



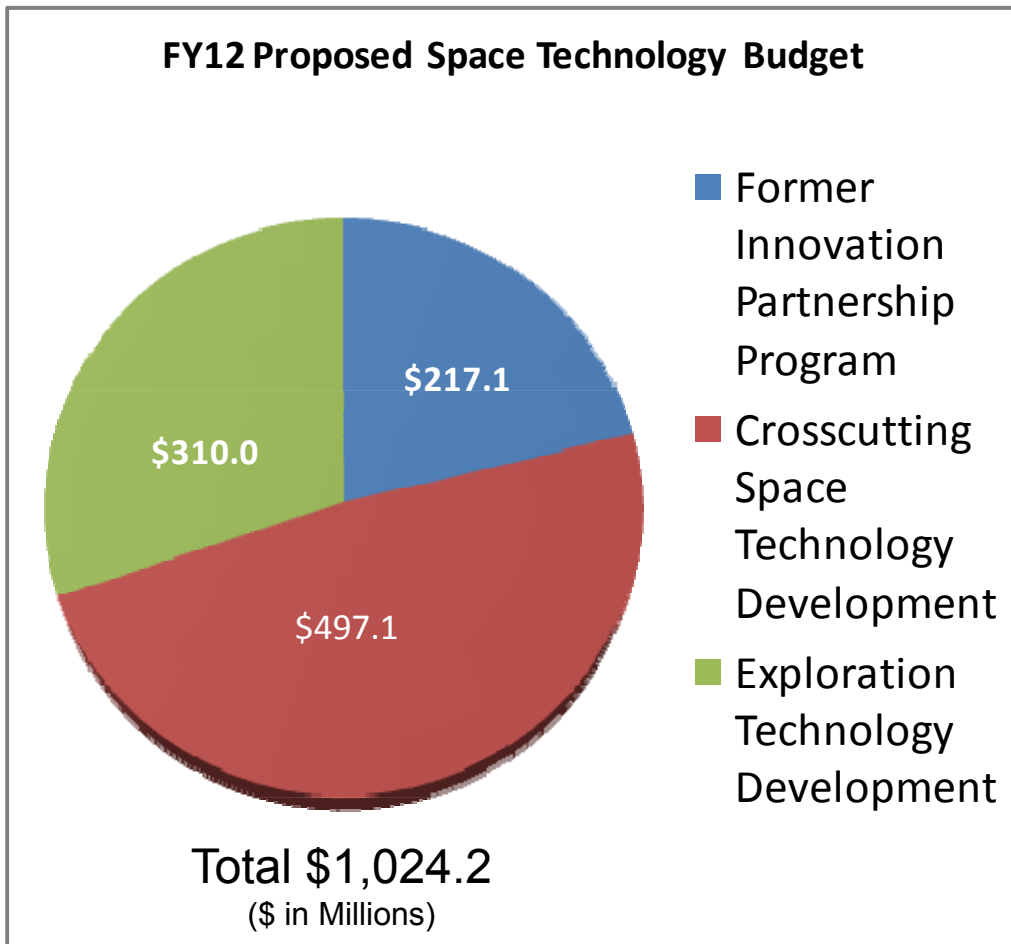
- In FY 2012, a significant portion of the FY 2010 Exploration Technology Development Program as well as the exploration technology activities in planning for FY 2011 will move from ESMD to Space Technology.
- These efforts focus on developing the long-range, Exploration-specific technologies to enable NASA's deep space human exploration future.
- Integrating Exploration technology activities with Space Technology consolidates the management of NASA's space technology programs within an organization focused on technology development and mission infusion, eliminates the potential for overlap had NASA's space technology investments been split among two accounts and creates a robust space technology budget line.
- OCT will manage the Exploration Technology Development (ETD) within its existing divisions and programs: Game Changing Development (GCD) and Technology Demonstration Missions (TDM)
- OCT will work with ESMD in FY 2011 to complete this transition by the start of FY 2012. In FY12, ESMD will provide prioritized requirements and will remain the primary customer for ETD products.



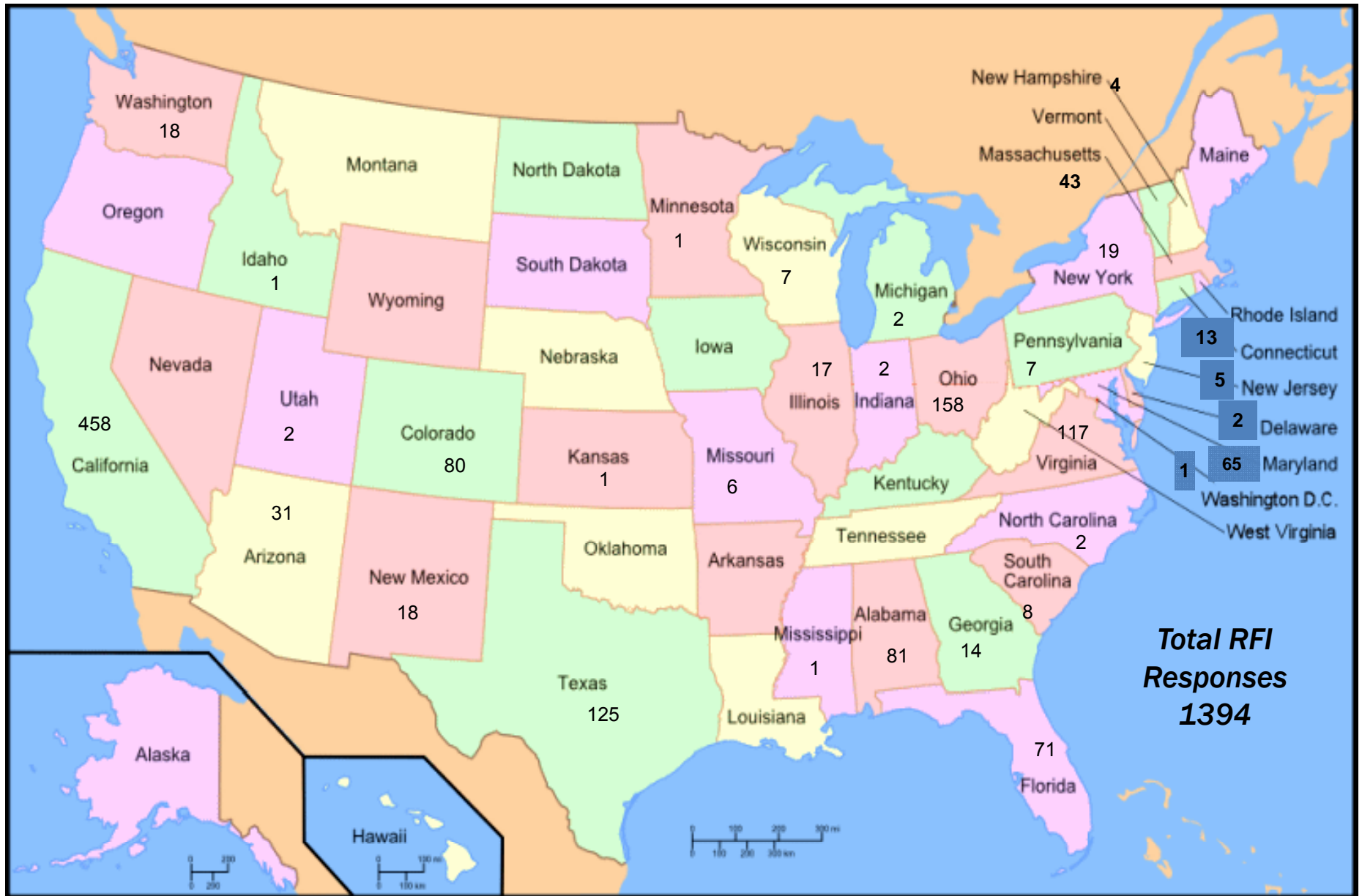
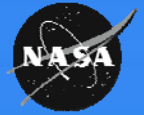
# Proposed FY 2012 Space Technology Budget (Full Cost)



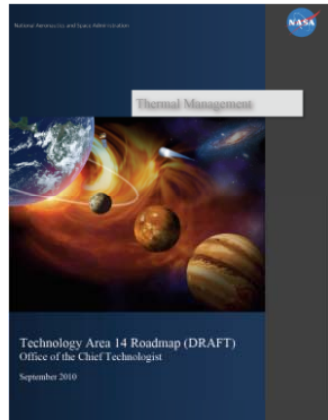
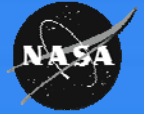
<b><i>FY12 Space Technology (Total) (\$ in Millions)</i></b>	<b>FY 2012 PBR</b>
<b>Space Technology</b>	<b><u>\$1,024.2</u></b>
<b><u>SBIR and STTR</u></b>	\$184.1
<b><u>Partnerships Dev &amp; Strategic Integration</u></b>	\$33.0
<b><u>Crosscutting Space Tech Development</u></b>	\$497.1
<b><u>Exploration Technology Development</u></b>	\$310.0



# Space Technology RFI Responses by State



# Strategic Integration Overview



## Accomplishments

Developed Technology Portion of the Agency Strategic Plan

Defined Space Technology Grand Challenges

Developed 14 Technical Area Draft Roadmaps And Engaged National Research Council To Collect Industry, Academia And National Information To Refine And Prioritize NASA's Technology Needs

Coordinated Mission Directorate Technology Technical Interchange Meetings

Coordinated 5 NASA Technology Executive Council Meetings And 5 Center Technology Council Meetings

Performed 2 Technology Feasibility Studies And Initiated 3 Additional Studies

Chartered 1 Technology Area Working Group

## Future Plans

Develop Agency-Level Technology Policy Directives And Procedural Requirements

Coordinate Monthly Mission Directorate Technology Technical Interchange Meetings

Coordinate Monthly NASA Technology Executive Council Meetings and Center Technology Council Meetings

Develop An Integrated Technology Roadmap And Perform Internal Costing Analysis

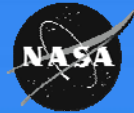
Develop Agency-Wide Technology Portfolio Systems And Initiate Use

Perform Technology Studies As Required

Charter, Manage And Participate In Technology Area Working Groups

Develop Quarterly And Annual Technology Reports

# NASA Space Technology Roadmap Technology Area Breakdown Structure



## NASA Authorization Bill of 2010 (Sept 2010)

“In the development of the national space technology development policy, the President or the President’s designee shall consult widely with academic and industry experts and with other Federal agencies. The Administrator may enter into an arrangement with the National Academy of Sciences to help develop the policy.”

- In order for NASA to more effectively and efficiently develop space technologies moving forward, it is necessary to establish a sustained set of clearly identified and prioritized technology development goals.
- The NASA Space Technology roadmaps, drafted by NASA, and reviewed and vetted for technology investment identification and prioritization by the NRC, will serve NASA as a decadal-like survey, to provide sustained technology investment goals.
- NRC interim findings report release **September 2011**
- NRC final report release **January 2012**

## NASA SPACE TECHNOLOGY ROADMAP TECHNICAL AREA BREAKDOWN STRUCTURE

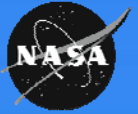
### STR • TABS TECHNOLOGY AREA BREAKDOWN STRUCTURE



TA01		• LAUNCH PROPULSION SYSTEMS	TA08		• SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS
TA02		• IN-SPACE PROPULSION TECHNOLOGIES	TA09		• ENTRY, DESCENT & LANDING SYSTEMS
TA03		• SPACE POWER & ENERGY STORAGE	TA10		• NANOTECHNOLOGY
TA04		• ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS	TA11		• MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING
TA05		• COMMUNICATION & NAVIGATION	TA12		• MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING
TA06		• HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS	TA13		• GROUND & LAUNCH SYSTEMS PROCESSING
TA07		• HUMAN EXPLORATION DESTINATION SYSTEMS	TA14		• THERMAL MANAGEMENT SYSTEMS


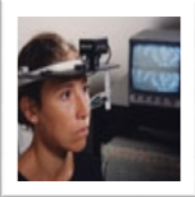

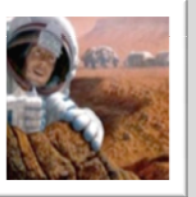



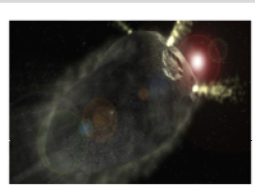



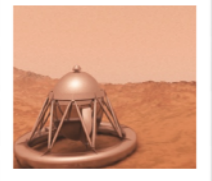
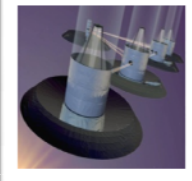
More information at <http://www.nasa.gov/offices/oct/home/roadmaps/index.html>

# Space Technology Grand Challenges



Space Technology Grand Challenges: a set of important space-related problems that must be solved to efficiently and economically achieve our missions.

We will use the Space Technology Grand Challenges with the Space Technology Roadmaps to prioritize our technology portfolio.

<i>Space Technology Grand Challenges</i>				
<b>Expand Human Presence in Space</b>				
				
<u>Economical Space Access</u>	<u>Space Health and Medicine</u>	<u>Telepresence in Space</u>	<u>Space Colonization</u>	
<b>Manage In-Space Resources</b>				
				
<u>Affordable Abundant Power</u>	<u>Space Way Station</u>	<u>Space Debris Hazard Mitigation</u>	<u>Near-Earth Object Detection and Mitigation</u>	
<b>Enable Transformational Space Exploration and Scientific Discovery</b>				
				
<u>Efficient In-Space Transportation</u>	<u>High-Mass Planetary Surface Access</u>	<u>All Access Mobility</u>	<u>Surviving Extreme Space Environments</u>	<u>New Tools of Discovery</u>

More Information at [http://www.nasa.gov/offices/oct/strategic\\_integration/grand\\_challenges\\_detail.html](http://www.nasa.gov/offices/oct/strategic_integration/grand_challenges_detail.html)

## FY 2010 Accomplishments

- Technology Transfer: 300+ Space Act Awards; 290 license agreements; 575 software use agreements; about 80 patents awarded
- Innovation: Funded commercial parabolic flights for 17 projects; 41 Innovation Fund Projects; and infused 68+ technologies into various NASA programs



## FY 2012 Program Plans

### Partnerships

- Transfer and commercialize NASA technology to create jobs, to increase U.S. economic competitiveness, and to save and improve lives every day.
- Leverage resources: a win-win-win for NASA, our partners, and the taxpayer

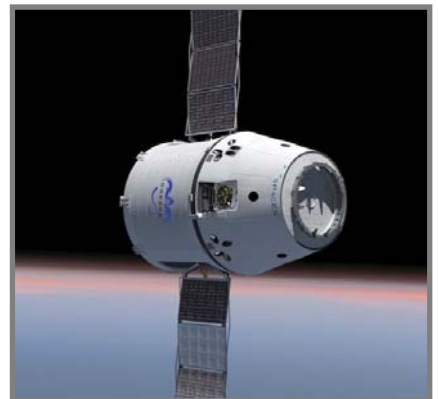
### Innovation

- Explore new models to nurture innovation inside and outside of NASA to accelerate the development of state-of-the-art technology

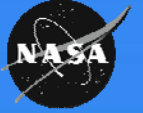


### Emerging Space

- Analyze and facilitate emerging space industry, modeled after how the NACA sparked the growth and success of the world-leading American aviation industry,
- Focus: Targeted sectors include low-cost and reliable access, in-space servicing, space telecom, lunar and asteroid commerce, and microgravity research



# Early Stage Innovation Division



The Early Stage Innovation Division sponsors a wide range of low TRL efforts for advanced space system concept and initial technology development across academia, industry and at the NASA field Centers.

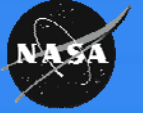


- **Space Technology Research Grants Program** focuses on innovative research in advanced space technology grants & graduate fellowships for student research in space technology
- **NASA Innovative Advanced Concepts (NIAC) Program** focuses on innovative aeronautics and space system concepts for future NASA missions
- **Center Innovation Fund Program** stimulates aerospace creativity and innovation at the NASA field Centers
- **Centennial Challenges Prize Program** addresses key technology needs with new sources of innovation outside the traditional aerospace community
- **Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Program** engages small businesses in our Nation's space enterprise and infuse these products across NASA missions

All Early Stage Innovation selections will be made competitively



# Game Changing Technology Division



- The Game Changing Technology Division focuses on maturing advanced space technologies that may lead to entirely new approaches for the Agency's future space missions and solutions to significant national needs.
- Through ground-based testing and/or laboratory experimentation, the Game Changing Technology Division matures technologies in preparation for potential system level flight demonstration.
- Success is not assured with each investment; however, on the whole and over time, dramatic advances in technology, enabling entirely new NASA missions and potential solutions for a variety of society's technological challenges are expected.



- **Game Changing Development Program** focuses on innovative ideas enabling new capabilities or radically altering our current approaches to space systems
- **Franklin Small Satellite Subsystem Technology Program** enables small satellites to provide game changing capabilities for the space sectors

- The Crosscutting Capability Demonstrations Division focuses on maturation to flight readiness of cross-cutting capabilities that advance multiple future space missions, including flight test projects where in-space demonstration is needed before the capability can transition to direct mission application.
- Matures a small number of technologies that benefit multiple customers to flight readiness status (TRL 7) through Projects that perform relevant environment testing.



- **Edison Small Satellite Demonstration Missions Program** develops and operates a series of NASA-focused small satellite demonstration missions in collaboration with academia and small business
- **Flight Opportunities Program** provides flight opportunities of reduced-gravity environments, brief periods of weightlessness, and high-altitude atmospheric research
- **Technology Demonstration Missions Program** matures, through flight demonstrations, a small number of Agency crosscutting technologies in partnerships with the NASA Mission Directorates, industry, academia and other government agencies

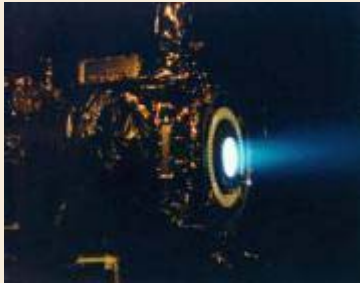
# Solar Electric Propulsion (SEP) - TDM

## GRC Lead



A

STATUS QUO



- Low thrust Ion prop operational
- Med Hall EP thrusters ground tested at vacuum – TRL 5
- Solar power generation is readily available up to 100 kW (ISS)
- Need space EP demo at > 25 kW

### MAIN ACHIEVEMENT:

- Demo high power (> 25 kW), high  $\eta$  (> 50%), med ISP (> 1000s), long duration (> 6 mo), reliable EP
- Couple high power solar array and power mgmt w/ hall EP to prove deep space exploration capability

### HOW IT WORKS:

- 30 kW Array
- High power hall propulsion system
- 15 – 20 mt LEO launch vehicle

### ASSUMPTIONS & LIMITATIONS

- SEP demo to use TRL 6 panels, and TRL 4-5 hall thrusters & power management system
  - Human exploration systems will need 300 kW (~ 5 N) class system
- ### APPROACH:
- Pursuing potential partnership with another government agency

B

- Dramatically expand capability of future space exploration by demonstrating med (ISP > 1000s) and med thrust (~ 1 N)
- Enable future human exploration missions to NEOs, Mars and other deeps space destinations with shorter duration trip times and much lower earth departure mass requirements
- May enable follow-on NEP propulsion

QUANTITATIVE IMPACT

B

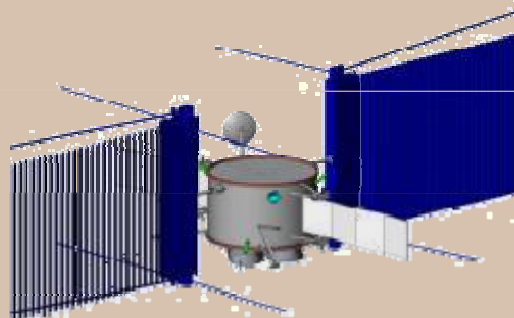
NEW INSIGHT



### Technology Demo to Test

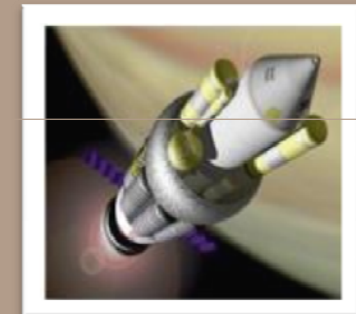
- High Power EP using multiple ~10kW thrusters w/ > 25 kW tot.
- High Voltage, High Power Solar Array w/ stable power mgmt.
- Long duration (> 6 mo) sustained high thrust (>25 kW)

C



D

E



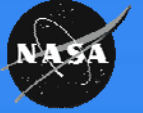
### Efficient In-space Transportation

- Develop systems that provide rapid, efficient and affordable transportation to, from and around space destinations.

END-OF-PHASE GOAL

Demonstrating efficient in-space transportation with a high power solar electric propulsion system

# NASA Space Technology: Part of a Broader National Strategy



- **Space Technology is the central NASA contribution to a revitalized research, technology and innovation agenda for the Nation. These investments will stimulate the economy and build our Nation's global economic competitiveness through the creation of new products and services, new business and industries, and high-quality, sustainable jobs.**
  - A renewed technology emphasis balances NASA's long-standing core competencies of research and technology, spaceflight hardware development, and mission operations.
  - An enhanced technology and innovation focus at NASA responds to the recommendations of multiple external stakeholders.
  - By investing in high payoff, disruptive technology that industry cannot tackle today, Space Technology matures the technology required for NASA's future missions in science and exploration while proving the capabilities and lowering the cost of other government agencies and commercial space activities .
- **Pushing the boundaries of aerospace and taking informed-risk, Space Technology allows NASA and our Nation will remain at the cutting-edge.**
- **In addition to providing a more vital and productive aerospace future, by investing in Space Technology, NASA will continue to make a difference in our lives everyday.**

President Obama, February 3, 2011, at Penn State: *"Innovation is what this country is all about. 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."*