



*Johnson Space Center (JSC) Center Director Ellen Ochoa “JSC 2.0
– an envisioned future” May 2013*

*JSC leadership in future exploration is possible because...
we’ve made smart decisions about roles for commercial
.... partners*

Partnerships and the Future of NASA

Presented by:
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Chief Scientist, International Space Station
IAC-15-D3.1.2





American Institute of Aeronautics and Astronautics (AIAA) Executive Director,
Dr. Sandra Magnus

Hearing of the United States House of Representatives Committee on
Science, Space, and Technology (February 27, 2014)

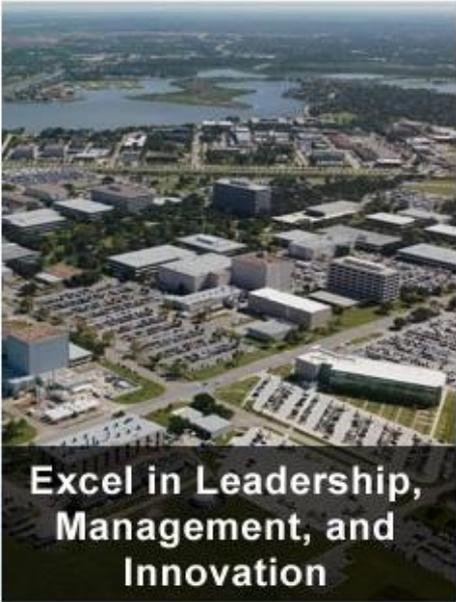
“The role of government is to do the “hard” things; invest in the research and development that industry cannot, and to take on the tasks and push the boundaries that the private sector will not. Our strategy should encompass not only exploration but what we hope to accomplish in low Earth orbit and to encourage an economically viable industry there. We should consider how we want the U.S. to be leveraged for future roles in space, both in commercial and civil, in low Earth orbit and beyond. It should not be an “or,” it should be an “and”. “



Lead Human Exploration



Lead Internationally



Excel in Leadership, Management, and Innovation



Expand Relevance to life on Earth

JSC STRATEGIES SUPPORT EXPLORATION AND COMMERCIALIZATION

Strategy 1.1
Exploit the ISS as a cornerstone of human exploration

Strategy 1.2
Enable the commercialization of LEO

Strategy 1.3
Extend human exploration beyond LEO

Strategy 2.1
Leverage ISS experience to lead international community participation in human space exploration

Strategy 2.2
Guide development of Agency Global Exploration Roadmap

Strategy 2.3
Champion international participation in the development of

Strategy 3.1
Lead through innovative technical and business management practices

Strategy 3.2
Lead by Fully engaging the human spaceflight team

Strategy 4.1
Intertwine JSC in mutually beneficial partnerships to maximize economic and societal impact

Strategy 4.2
Inform, educate and engage all generations to advance human space exploration

Strategy 4.3
Strategically communicate JSC's relevance in terms meaningful to our

Partnership Development is a Key Enabler to Both Current and Future Agency Mission Objectives

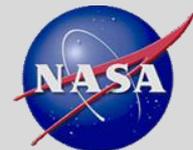


NSG 8-Verticals of NewSpace™

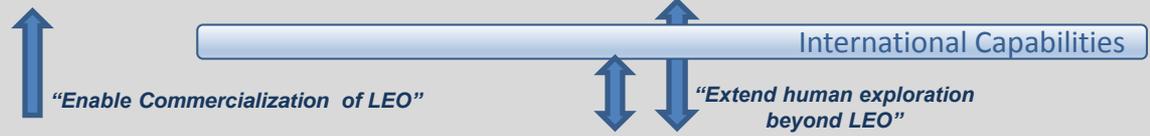


Existing Markets (left) | Potential Markets (right)

Domestic/International Partnerships for the Development of Deep Space Exploration Capabilities



"Mutually Beneficial Partnerships"



EARTH RELIANT
MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

PROVING GROUND
MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS

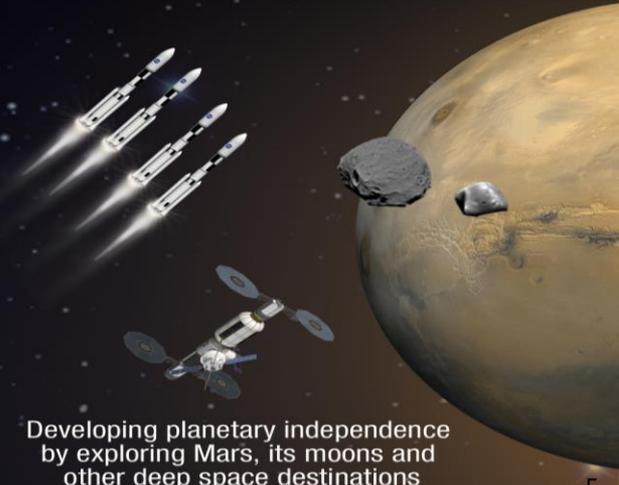
MARS READY
MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS



Mastering fundamentals aboard the International Space Station
U.S. companies provide access to low-Earth orbit



Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit
The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft



Developing planetary independence by exploring Mars, its moons and other deep space destinations

Technology Overlap w/ Commercial Space



NASA's human exploration technology needs are not unique

N-G 8-Verticals of NewSpace™

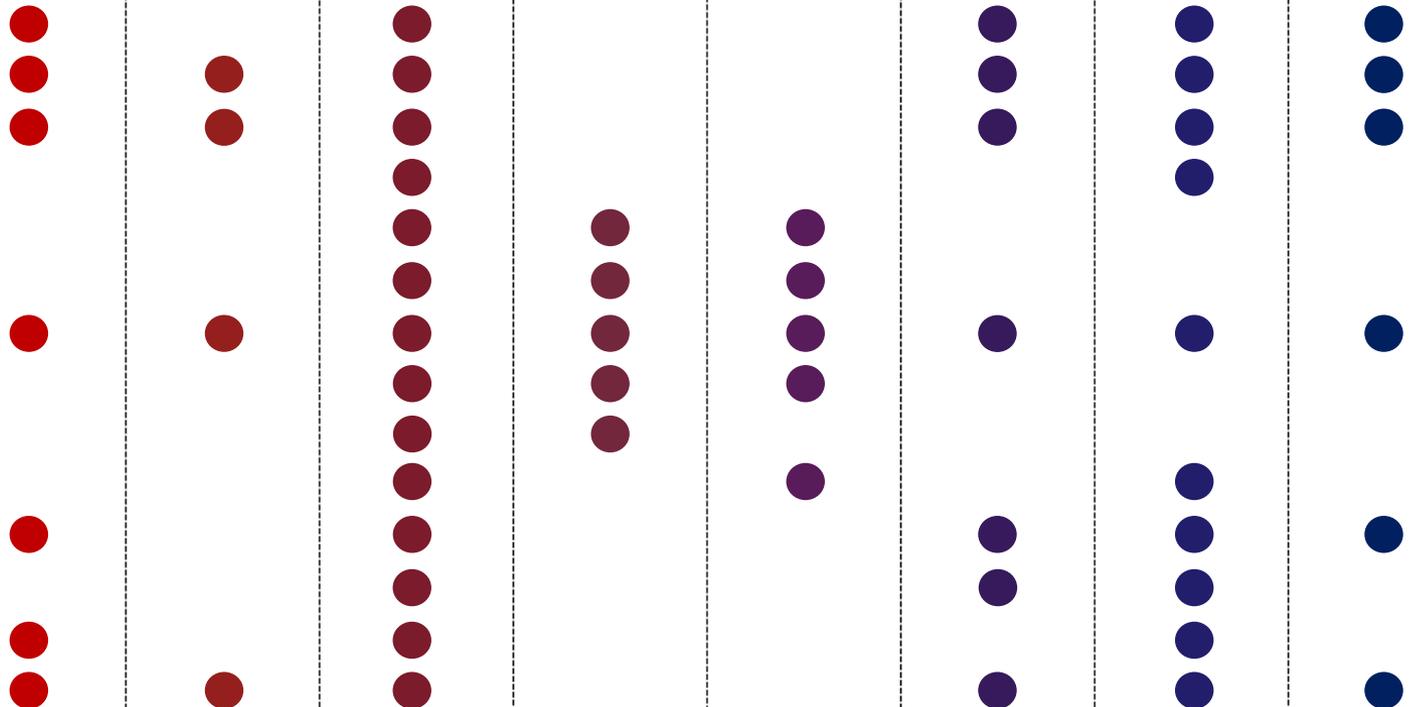
-  Spacecraft
-  Launch Vehicle Providers
-  Human Spaceflight
-  Microgravity Research
-  Spaceland
-  In-Space Services
-  Space Resources
-  Space-Based Energy

Existing Markets

Potential Markets

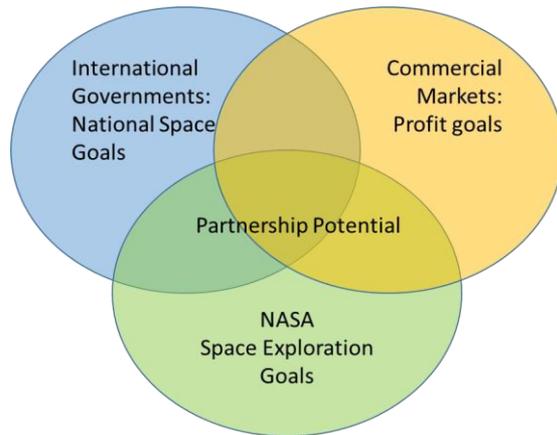
Exploration Technologies & Systems

- Autonomous GN&C
- Advanced Avionics
- Advanced Power Systems
- Entry, Descent, & Landing
- Human Health Systems
- Regenerative ECLSS
- Adv. Lightweight Structures
- Radiation Protection
- Space Suit Technology
- Mobility Systems
- Manipulation Systems
- Dextrous Robotic Systems
- High Efficiency Propulsion
- Energy Production / Storage





- **Key Questions**



- **How can NASA best take advantage of Commercial Space goals that overlap with the human exploration goals of the Agency?**
- **Although the end application may be different, which underlying technologies would advance both beyond LEO exploration as well as Commercial Space markets?**
- **Which capabilities does NASA want to own and further develop? Which capabilities are better suited for commercialization with NASA as a buyer?**

Two-Pronged Strategic Approach

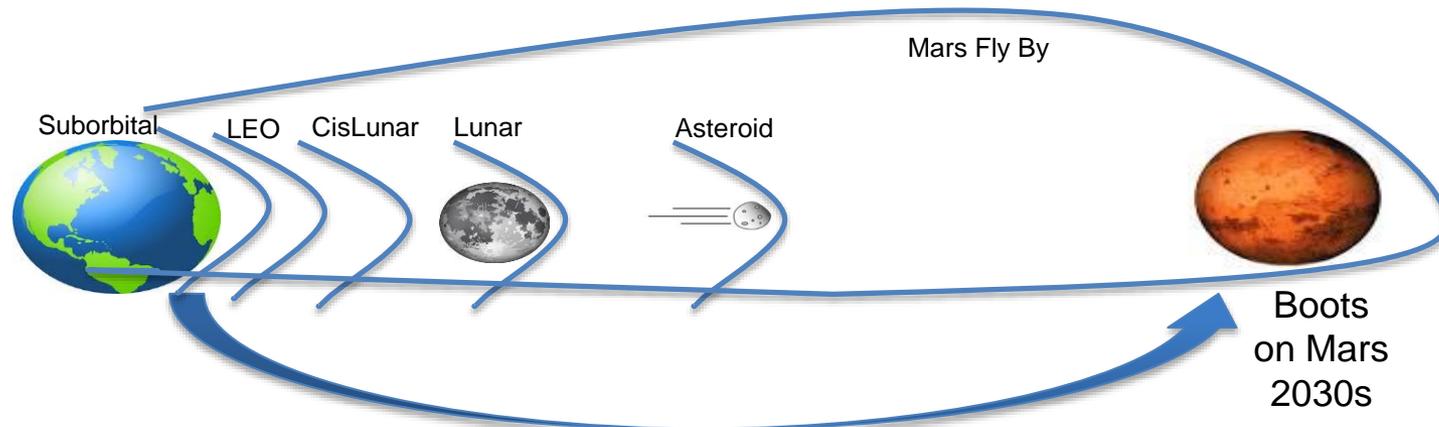


1) Close existing Mars mission technology gaps

- Co-develop new technologies for Mars mission to reduce the time and NASA funding required
- If it reduces total lifecycle costs, purchase capabilities / services in newly established commercial markets to free up NASA resources for beyond LEO
- Through support of Commercial Space Company LEO success, leverage commercial flight opportunities to perform risk reduction / tech demo activities

2) Maximize relevancy for future Mars mission

- Begin working with industry now to identify new market opportunities and sow the early seeds of market adoption as NASA begins to push the envelope of beyond LEO exploration



Technology Development

Enabling Systems

Integrated Demonstrations

Exploration Elements/Capabilities

Missions/Destinations

- AR&D
- Deep Space Nav
- Adv. Comm (C&DH)
- Modular Instru.
- Common Core Flight SW
- Pwr Gen
- Pwr Storage – Adv. Chem Bat & Fuel Cell
- Pwr Dist. – AI wires

- Autonomous GN&C
- Adv. Avionics
- Adv. Pwr Sys



Int. S/C Demo



Spacecraft



>20 day Lunar vicinity

- Hi Speed Heatshield
- Multiphysics Model
- Parachutes/Adv. Dec. Sys
- EDL GN&C

- EDL
- Human Health Sys



Hab Demo



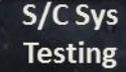
Habitat Sys

- Air Revitalization
- Water Reclamation
- Waste Recycling
- Composites
- Inflatable Techs
- Multifunctional Struc

- Regen ECLSS
- Adv. Lwt Struc
- Radiation Protection



Space Suit Tech



S/C Sys Testing



EVA



>100 day Cis-Lunar

- Multi-layer textiles
- Water Membrane Evaporator
- Rapid Cycle Amine Swing bed
- Variable Regulator
- PLSS

- Mobility Sys
- Manipulation Sys
- Dexterous Sys



Human/Rob. Sys



Robotic Exp. Sys

- SAFER / Rovers
- Robotic Arms
- Robonaut

- Hi Efficiency (ISP)
- Energy Prod/Stor



SEP Demo



Advanced In-space Prop



>600 day Mars

- Green Propellant
- Propellant-less Engines
- Cryo Storage
- Solar Array Perf
- Nuclear Sys



ISS



Surface Sys

Partnership Example: R2



In 2014, Robonaut 2 (R2) was selected as the NASA Government Invention of the Year. R2 was co-developed with General Motors through a *Space Act Agreement*. One of the technologies resulting from R2 was a robotic glove that is a grasp assist device. The robotic glove can help astronauts reduce hand fatigue during spacewalks. It can also help factory workers grip tools longer with less discomfort and fewer stress injuries.

<http://spaceref.com/nasa-hack-space/robonaut-2-receives-nasa-government-invention-of-the-year.html>

Partnership Example: ATK Space Systems Division

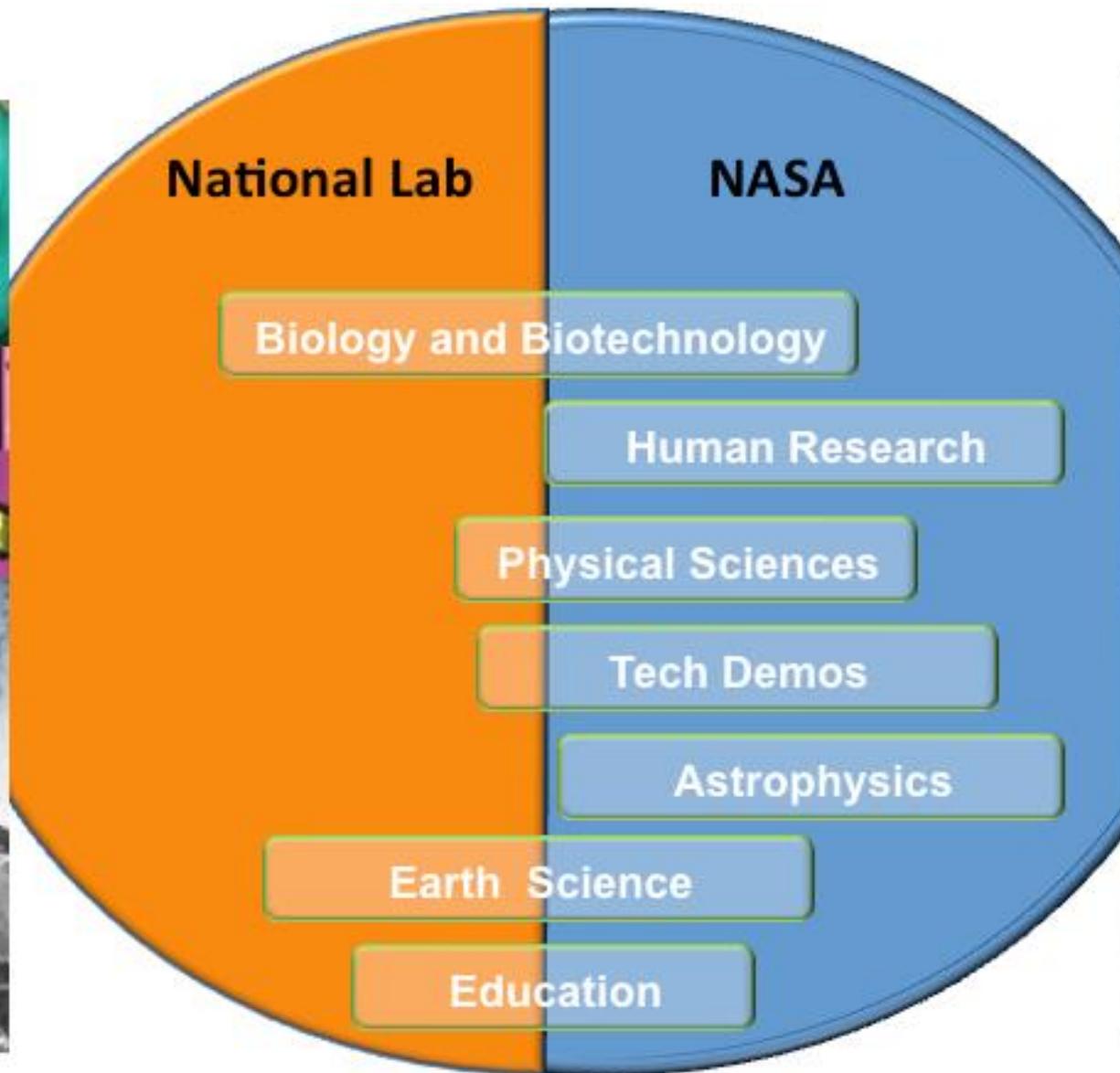


- In 2014, ATK and NASA signed a space act agreement to collaborate on technologies and new product development that meets the near term needs of the emerging satellite transport and space logistics industry.

<http://www.parabolicarc.com/2014/12/24/atk-nasa-collaborate-space-logistics-transportation/>



ISS Utilization



ISS Today: Partnerships



- **Non-Traditional**

- Earth Knowledge Acquired by Middle School Students (EarthKAM)
 - NASA education program that enables thousands of students to photograph and examine Earth from a space crew's perspective. EarthKAM has had participation by over 40 countries, including Argentina, Columbia, Dominican Republic, Kenya, and India.
- Amateur Radio on ISS (ARISS) –
 - Utilizes ham (amateur) radios to increase student interest in space exploration by allowing them to talk directly with crewmembers living and working aboard the ISS. ISS Ham Radio has had participation by over 40 countries, including Senegal, Brazil, Hungary, Ireland, Thailand and Turkey.

- **Inter-agency**

- Bilateral cooperation between NASA and the Department of Energy (DOE) on the Alpha Magnetic Spectrometer (AMS)
 - Science objective is to search for anti-matter from cosmic source
 - By July 2012, AMS had recorded over 18 billion cosmic ray events

- **Cooperative Agreement with Center for the Advancement of Science in Space (CASIS) for National Lab non-NASA uses of ISS**

JSC Partnership Strategy Summary



- Space Act Agreements are a primary tool, with proven beneficial results, utilized by the Johnson Space Center to enable its Partnership Strategy
 - The Johnson Space Center currently has 383 active space act agreements with 188 Partners, 28 of which are Commercial Space companies.
- Building on the success of COTS, NASA/JSC is beginning to strategically engage commercial partners in its' exploration plans. JSC goal is to:
 - Engage in existing and potential Commercial Space markets to advance both human spaceflight technologies and relevancy
 - Identify and leverage international participation in the development of human space exploration capabilities
 - Be selective and prioritize partnerships based on established criteria weighing “opportunity vs. risk” (includes financial, technical, relevancy)
 - Leverage commercial objectives and actively pursue larger, more strategic partnerships for risk reduction and integrated technology demonstration purposes
 - Work with industry to identify and enable new markets that can be beneficial or perhaps even disruptive to human space exploration