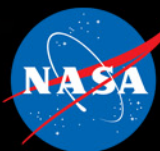




Enabling Exploration: NASA's Technology Needs

Carol W. Carroll
Deputy Director of Science
NASA Ames Research Center



University of Oregon
January 27, 2012



SPACE EXPLORATION: THE NEXT STEPS

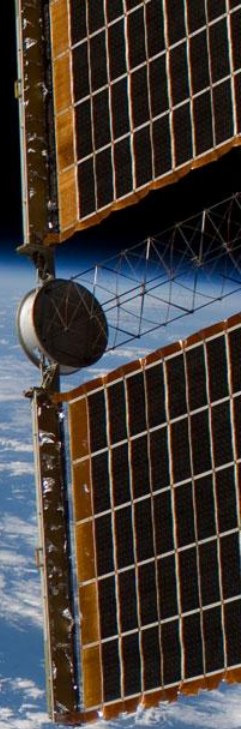


The end of an era July 21, 2011:
30 years of Space Shuttle Exploration

NASA is changing its approach to Space Exploration

Strategy:

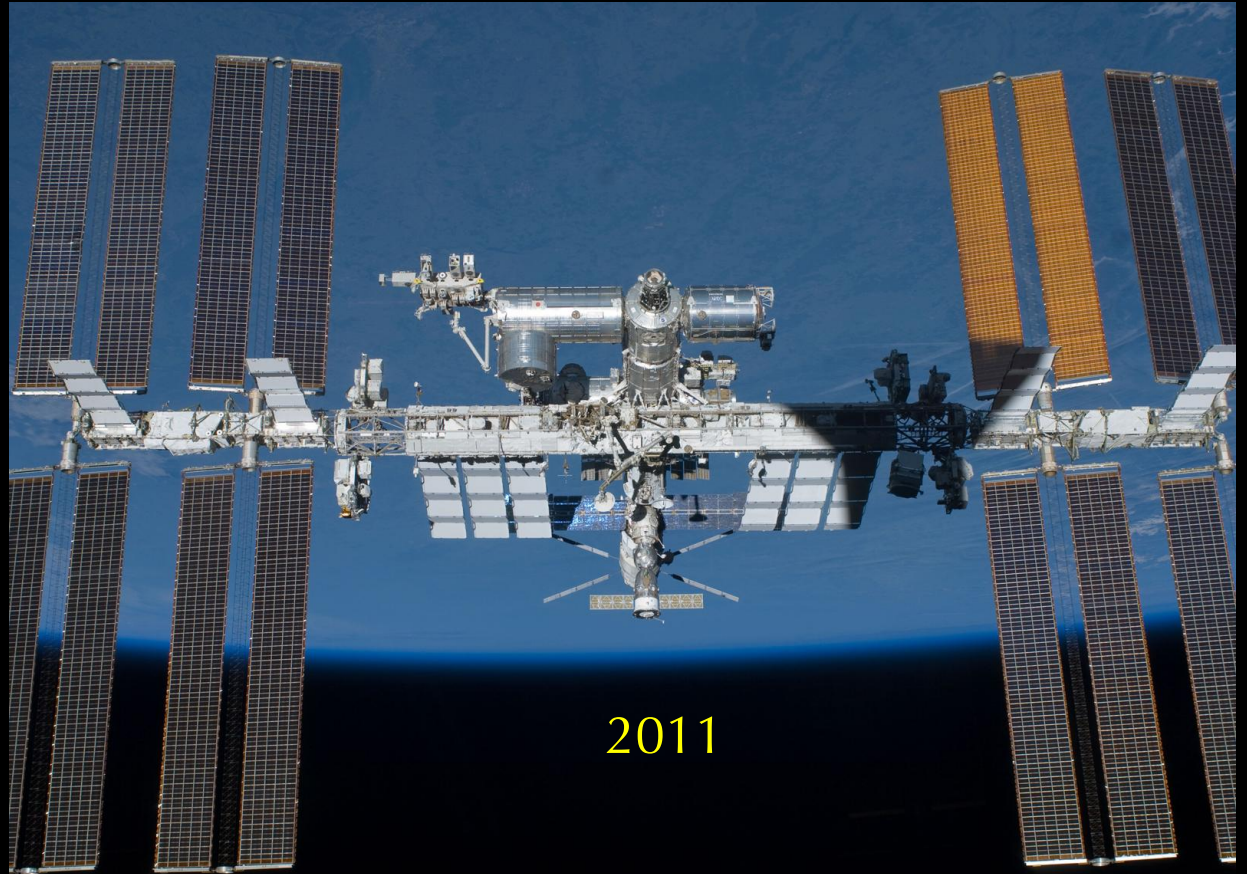
- ✧ Use the International Space Station as a research lab and test bed for new technologies
- ✧ Foster a commercial industry to take us to and from low Earth orbit
- ✧ Develop technologies to take humans to an asteroid and eventually to Mars



International Space Station



1998



2011

An incredible orbiting research lab

1.5 billion statute miles +

16 nations

202 astronauts

74 Russian vehicles, 37 space shuttles, two European and two Japanese vehicles

Foster U.S. Industry to Carry People and Cargo to/from Low Earth Orbit



Sierra Nevada
Dream Chaser



Boeing
CST-100



Space-X
Falcon 9 and Dragon



Blue Origin

Space Tourism: non-NASA Ventures

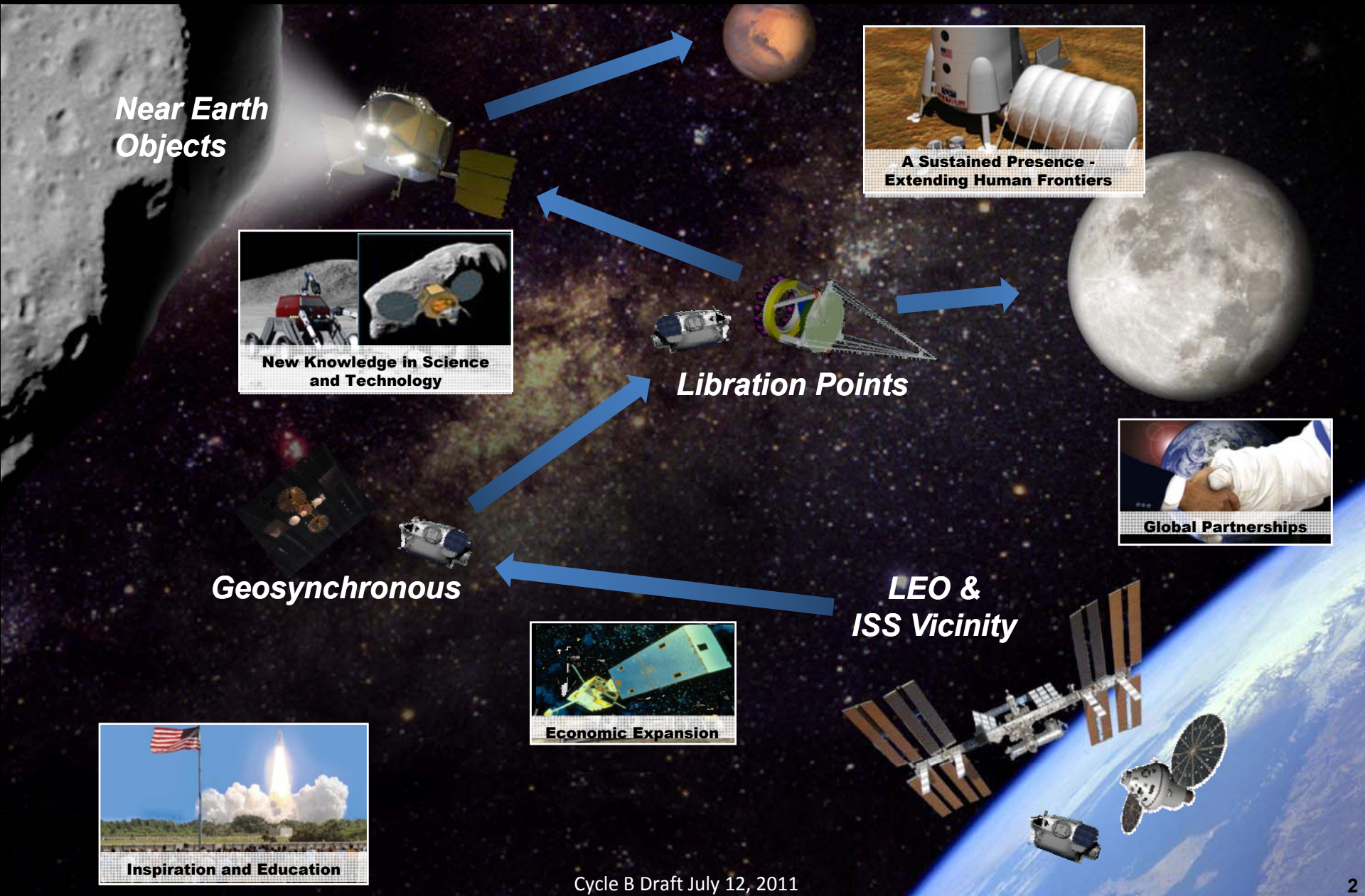


Virgin Galactic



XCOR Aerospace

NASA is Building the Capability to Go Further



Earth's Moon

- 382,500 km / 237,674 mi
- Witness to the birth of the Earth and inner planets
- Has critical resources to sustain humans
- Significant opportunities for commercial and international collaboration

GEOSYNCHRONOUS ORBIT

MID-EARTH ORBIT

LOW EARTH ORBIT

HEO/GEO/Lagrange Points

- Microgravity destinations beyond LEO
- Opportunities for construction, fueling and repair of complex in-space systems
- Excellent locations for advanced space telescopes and Earth

Mars and its Moons

- 54,500,000 km / 33,900,00 mi
- A premier destination for discovery: Is there life beyond Earth? How did Mars evolve?
- True possibility for extended, even permanent, stays
- Significant opportunities for international collaboration
- Technological driver for space systems

Near Earth Asteroids

- Compelling science questions: How did the Solar System form? Where did Earth's water and organics come from?
- Planetary defense: Understanding and mitigating the threat of impact resources
- Excellent stepping stone for Mars

Tomorrow's missions are demanding more ...



More places

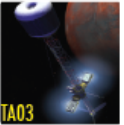
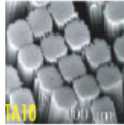
More data processing

More autonomy



WHAT TECHNOLOGIES ARE NEEDED?

14 Technology Areas

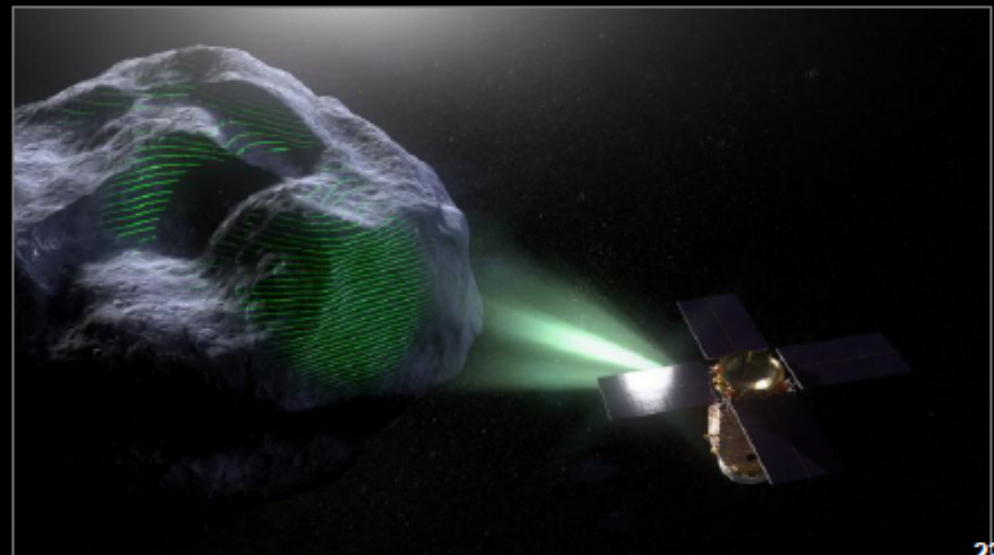
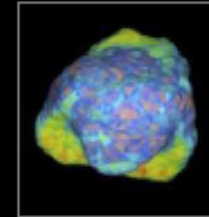
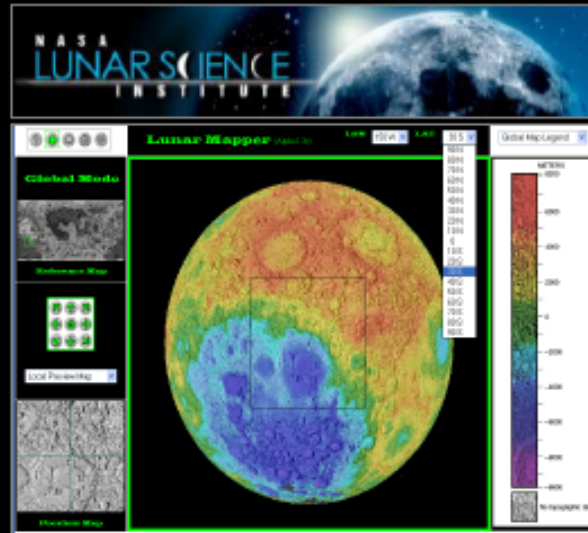
TA01		• Launch Propulsion Systems	TA08		• Science Instruments, Observatories & Sensor Systems
TA02		• In-Space Propulsion Technologies	TA09		• Entry, Descent & Landing Systems
TA03		• Space Power & Energy Storage	TA10		• Nanotechnology
TA04		• Robotics, Tele-robotics & Autonomous Systems	TA11		• Modeling, 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

What new capabilities can be created?

Technology Developments



Robotic Precursor Missions Pave the Way for Future Human Exploration Missions

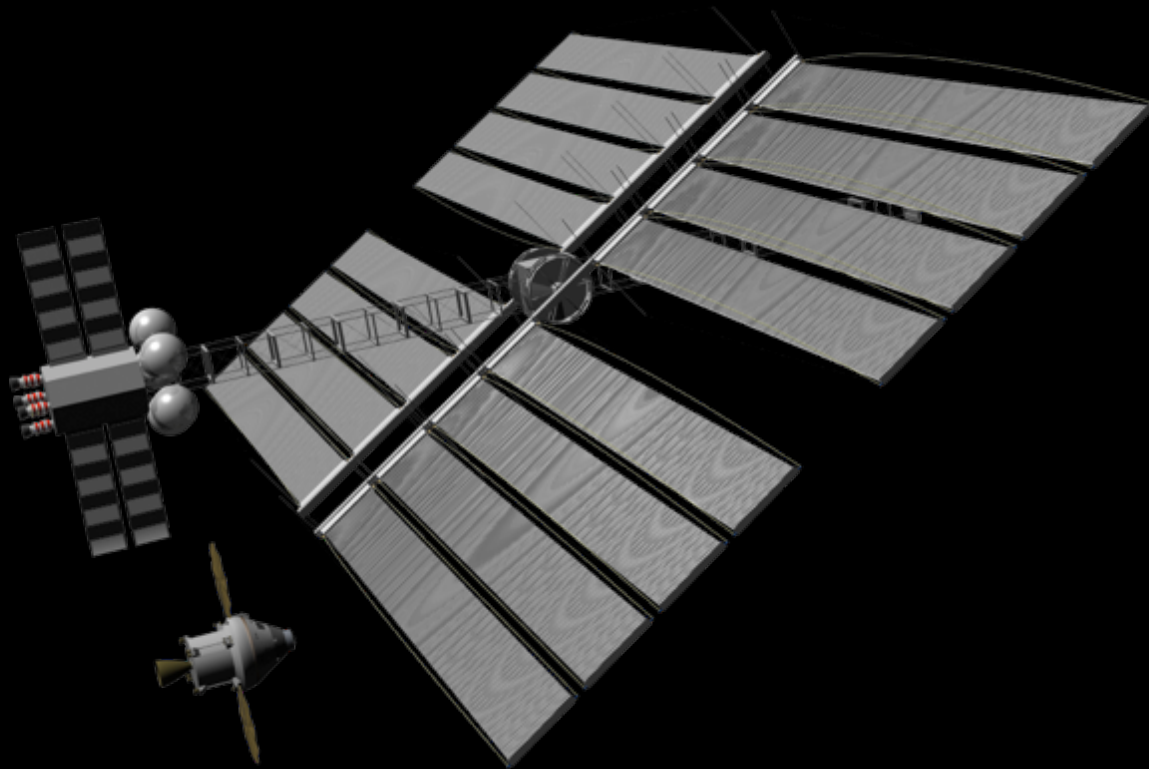


Orion Multi-Purpose Crew Vehicle and Space Launch System



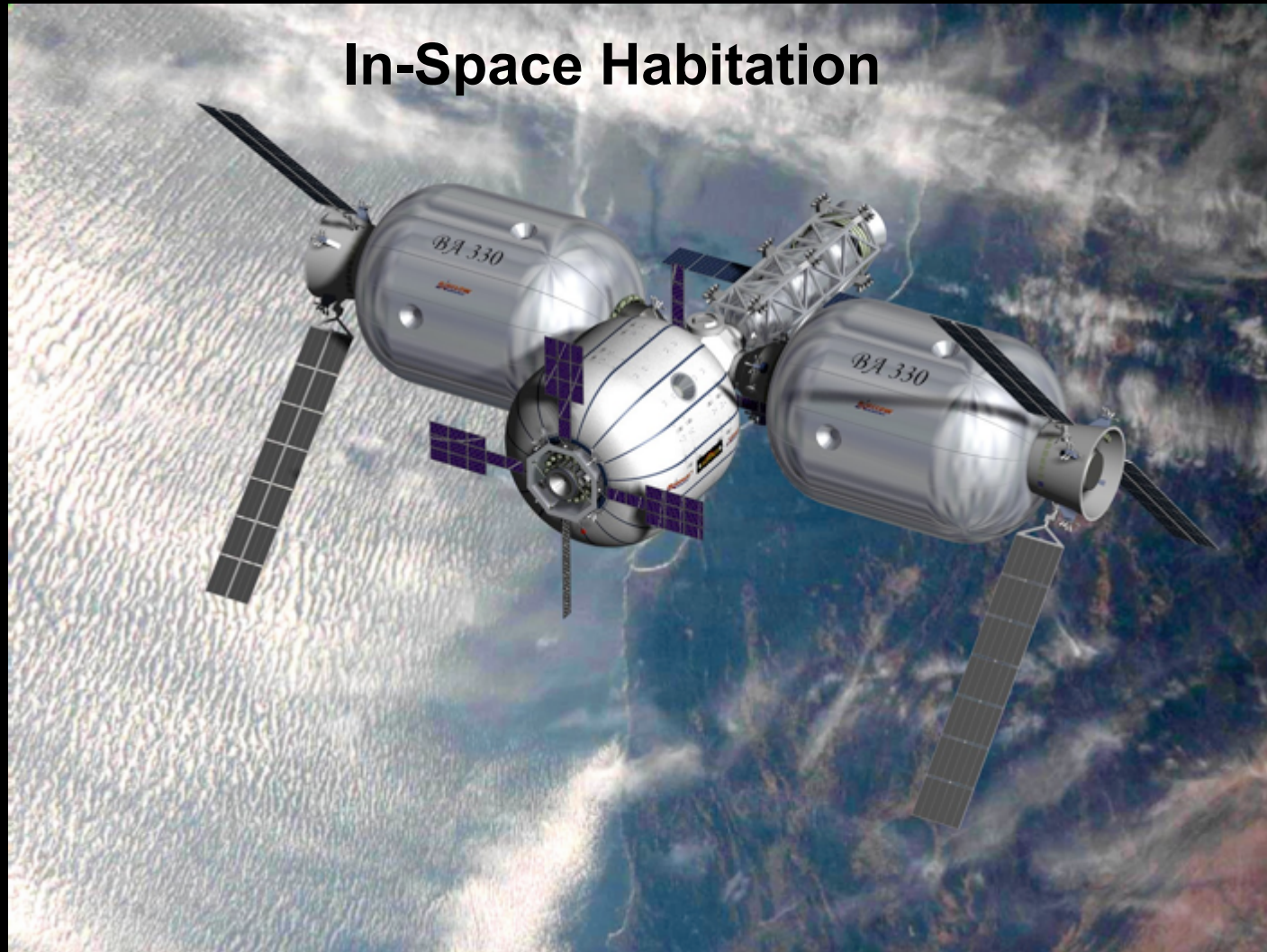


Solar Electric Propulsion





In-Space Habitation



Planetary Transportation System





NASA Ames Overview

Technical Scope:

- Science (Earth-Life-Space))
 - Astrobiology
 - Science Missions
 - Intelligent Systems
 - High End Computing
 - Human System Integration
 - Small Satellites
 - Aviation and Aeronautics
 - Innovative Collaborations
-
- 2400 Employees
 - \$700+ M Annual Budget



Questions?



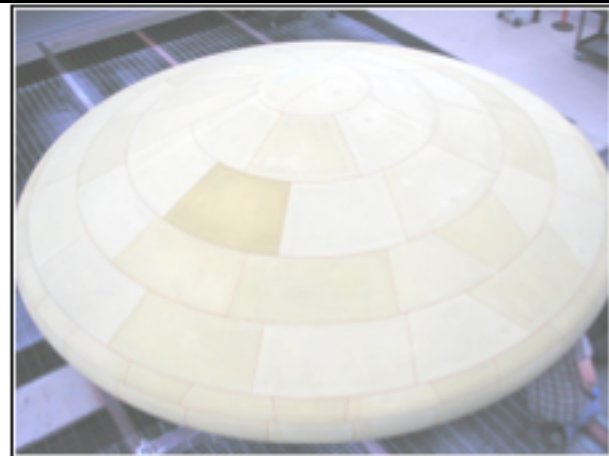


Thermal Protection Systems Research

- **State of the art low density carbon ablators are used for current mission but have challenges**
 - Low strain to failure
 - Brittle char
 - Needs strain isolation pads and gap fillers in tiled configurations



Orion Heat Shield
(5 m diameter)

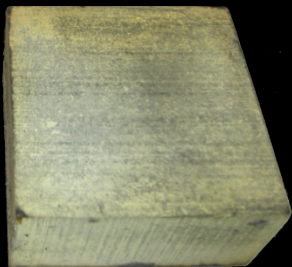


MSL Heat Shield
(4.5 m diameter)

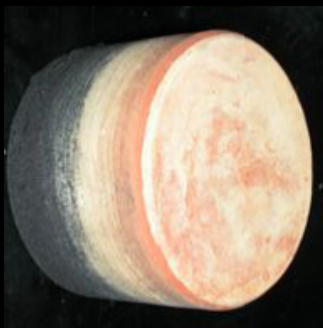


Thermal Protection Materials Research at Ames

Rigid Ablators

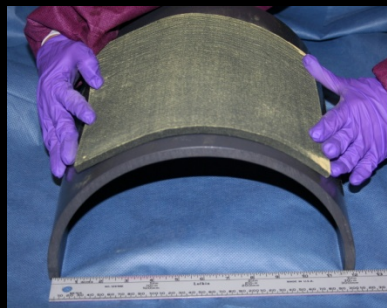


Advanced PICA-like ablators



Graded Ablators

Conformable Ablators



Conformable PICA

Flexible Ablators

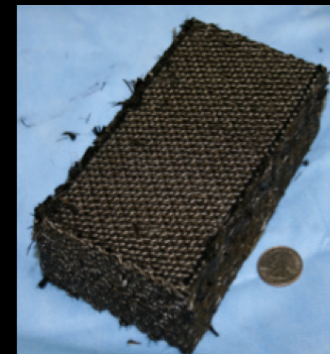


Flexible PICA

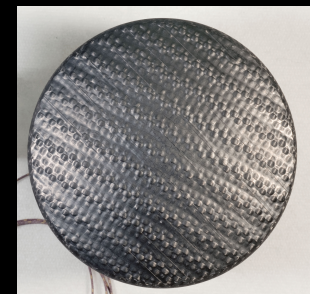


Flexible SIRCA

Woven TPS



Mid density TPS



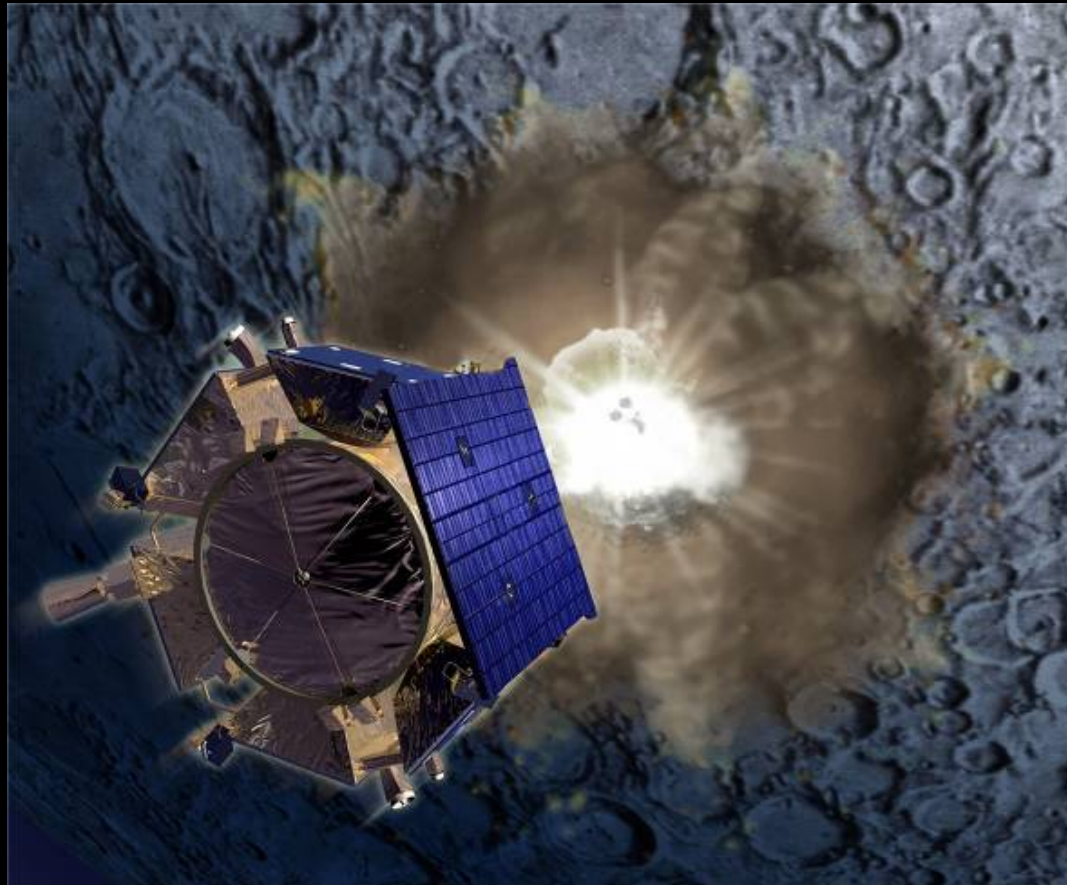
Carbon phenolic replacement



SCIENCE HIGHLIGHTS

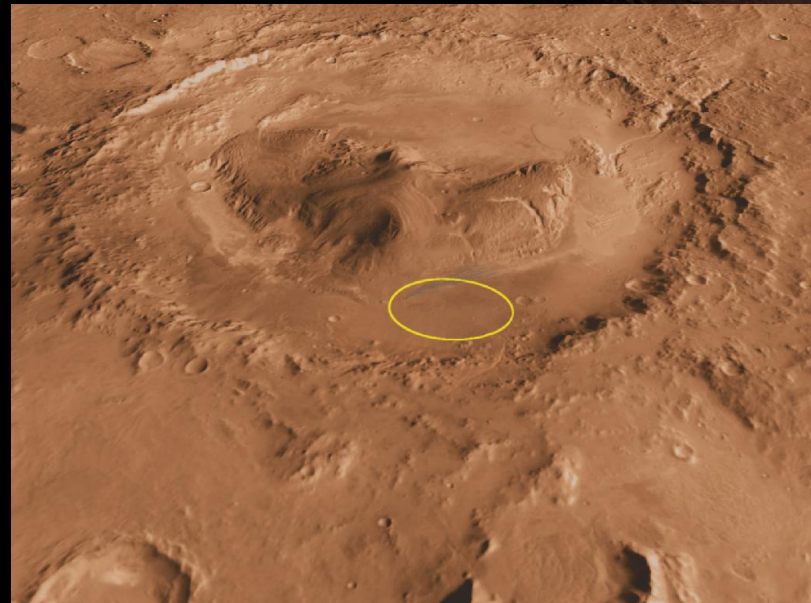


Water on the Moon - LCROSS

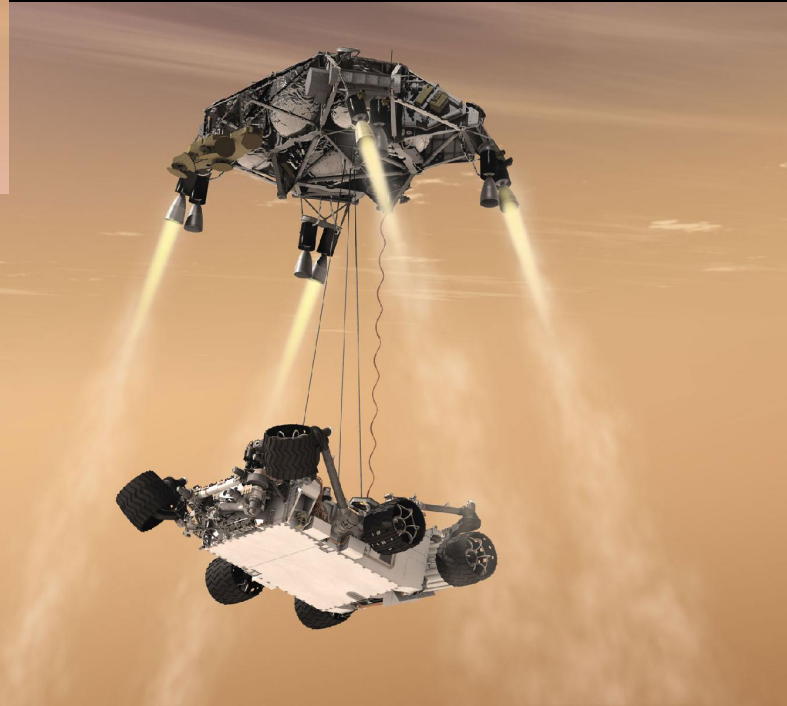
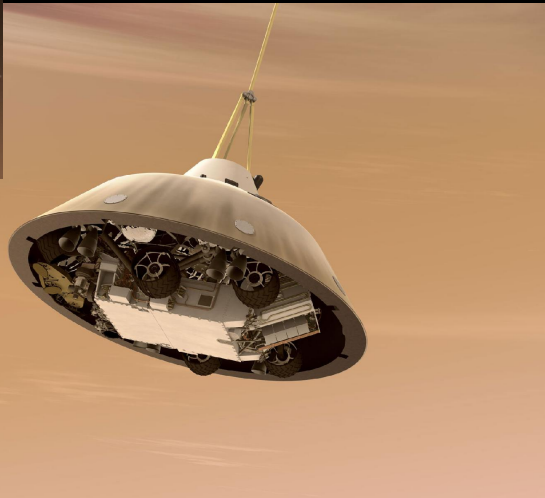
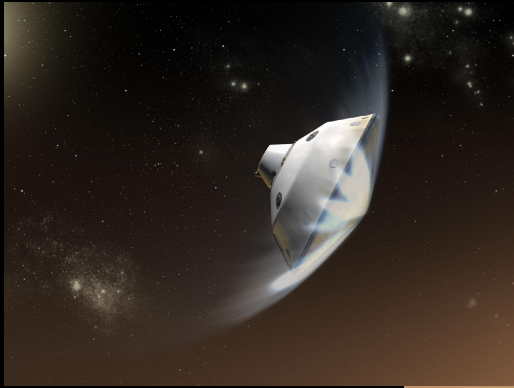


Changed our understanding of the
moon

Destination Mars: Gale Crater

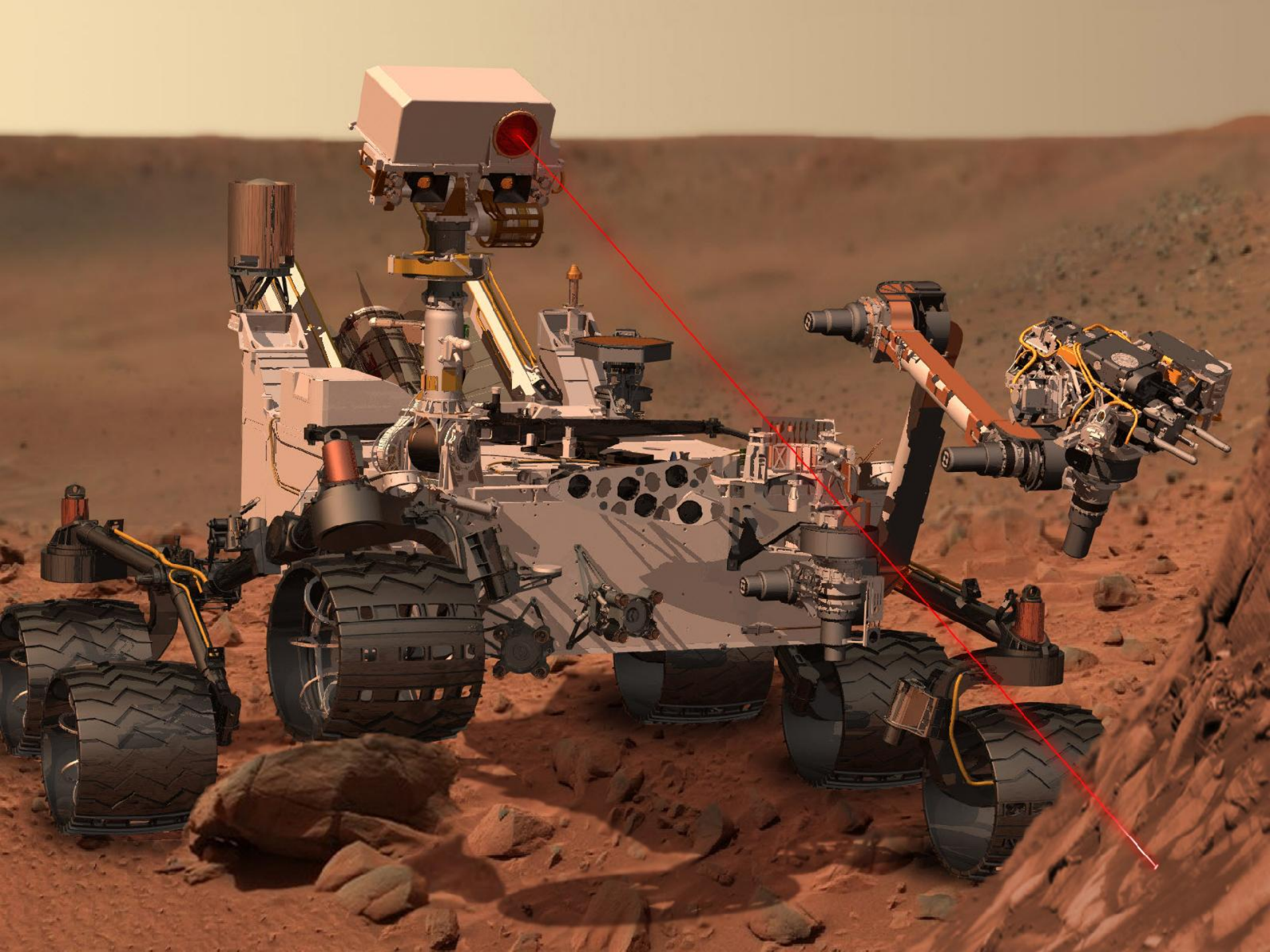


New Landing System: Mars Sky Crane



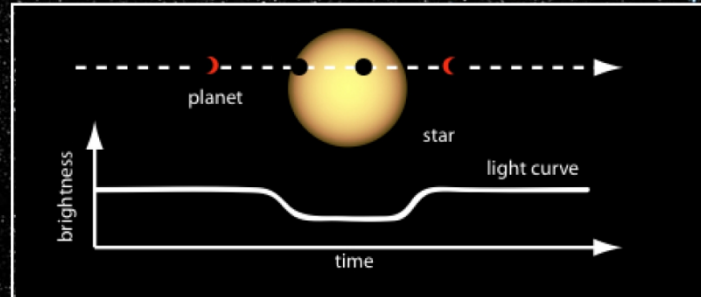
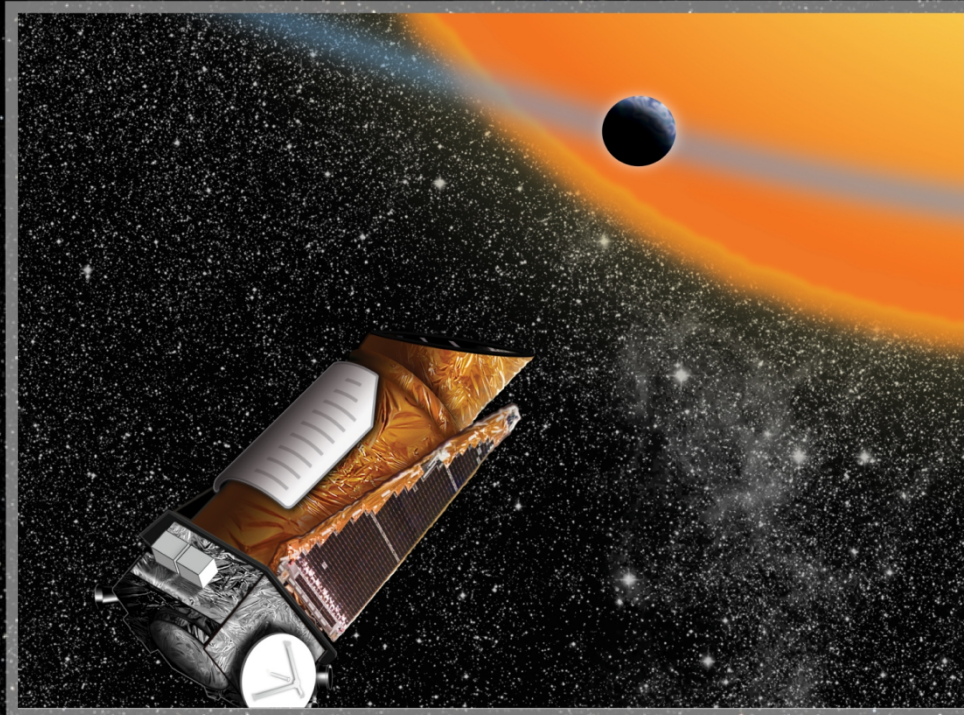
Curiosity – The Next Mars Rover

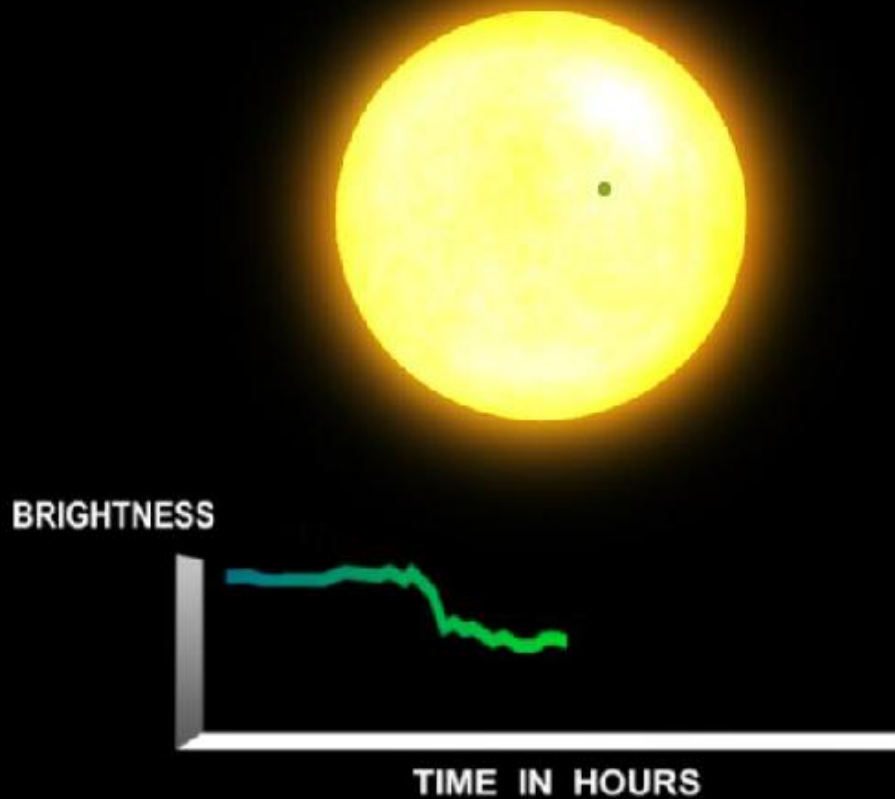




Kepler Mission

*The determination of the frequency of Earth-size & larger planets
in and near the habitable zone of solar-like stars*



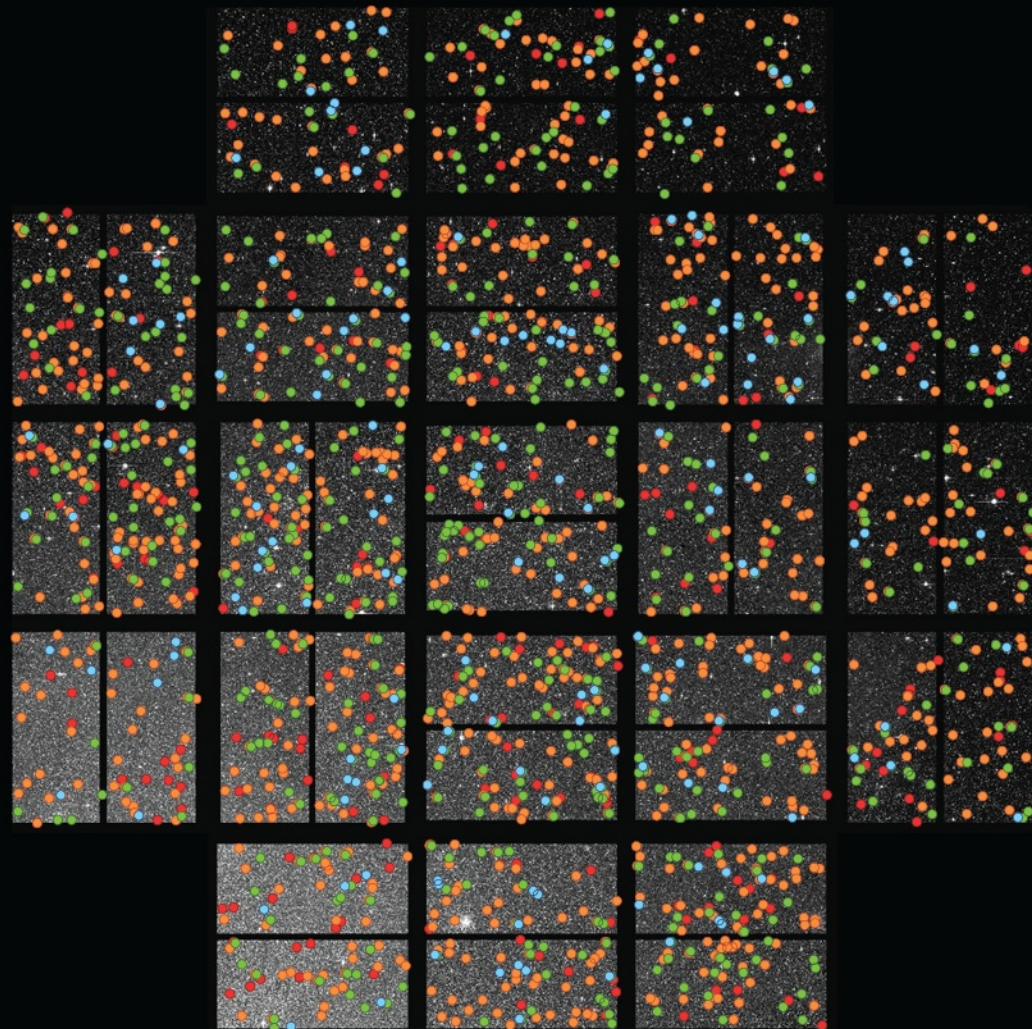


Kepler uses light curves to detect new planets

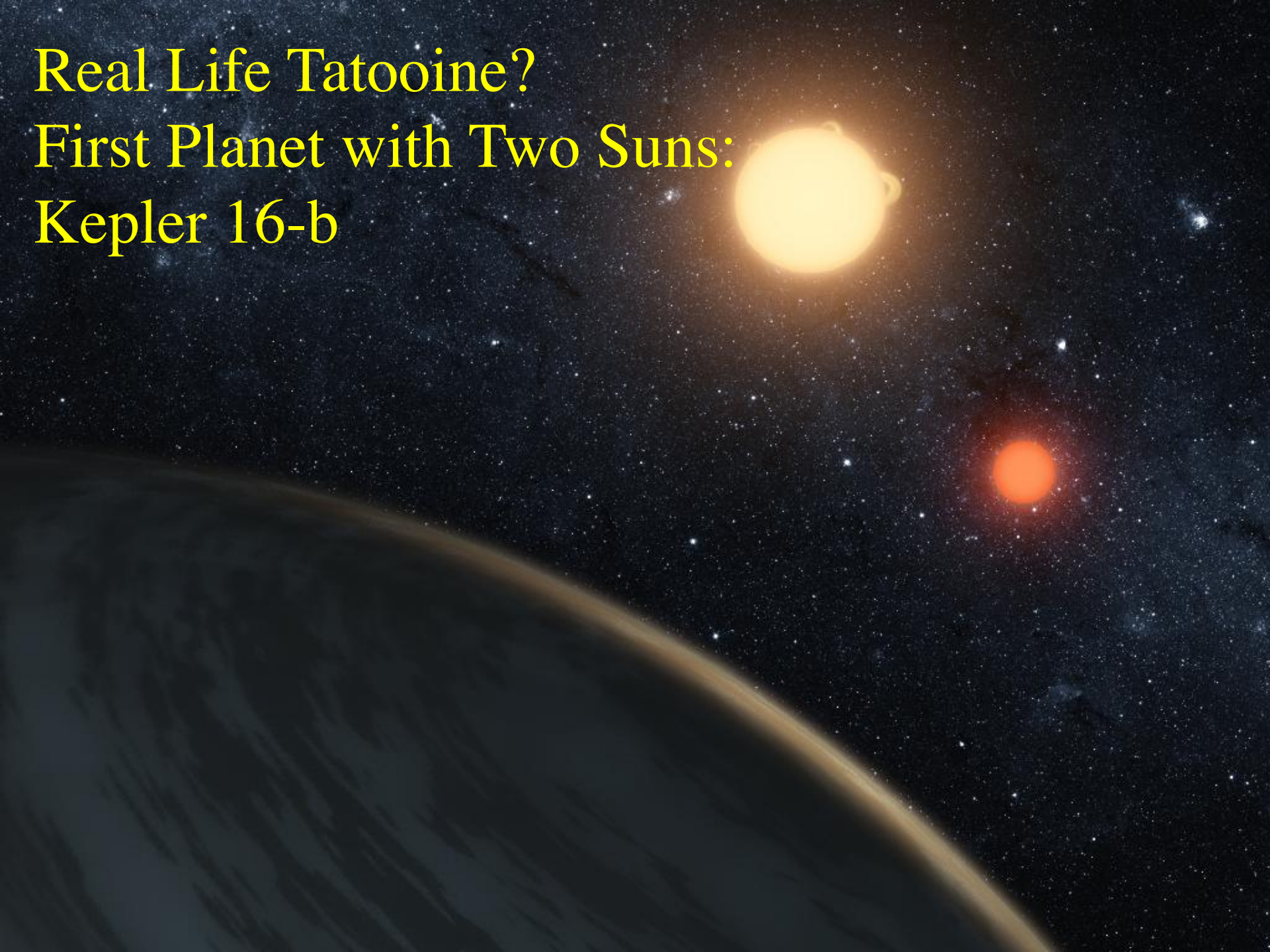
Locations of Kepler Planet Candidates

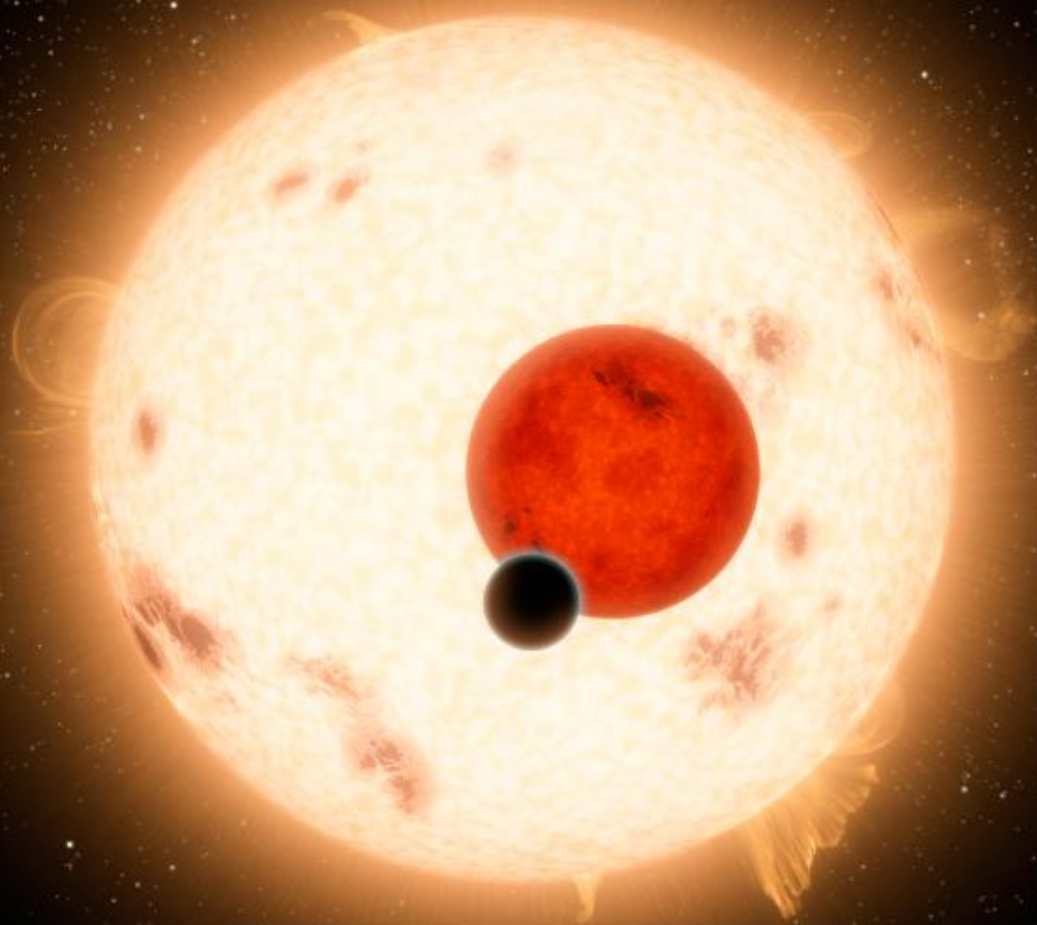
As of December 5, 2011

- Earth-size
- Super-Earth size
1.25 - 2.0 Earth-size
- Neptune-size
2.0 - 6.0 Earth-size
- Giant-planet size
6.0 - 22 Earth-size



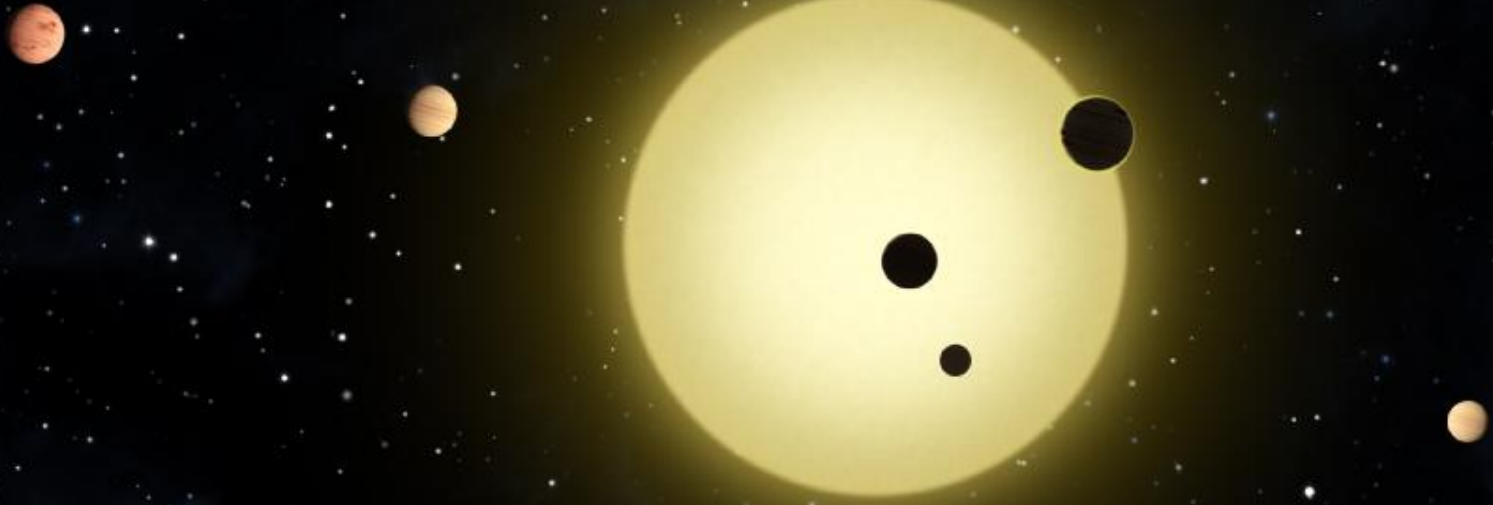
Real Life Tatooine?
First Planet with Two Suns:
Kepler 16-b

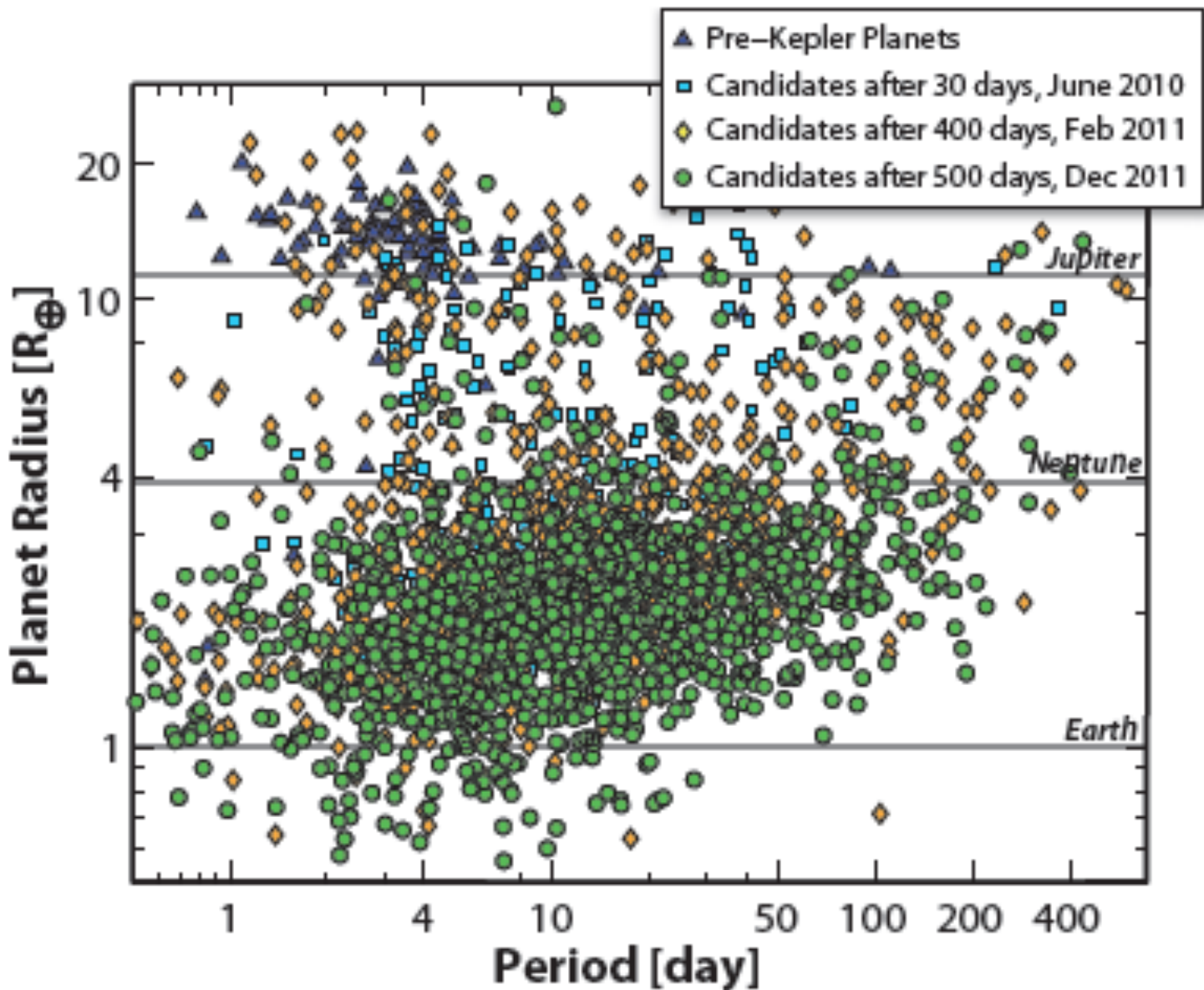




Another View of the “Tatooine” Planet: Kepler 16-b

Out of this world Solar System orbiting Kepler 11





Looking Towards the Future



- **ISS will be the centerpiece of human spaceflight activities until at least 2020**
- **Research and technology breakthroughs aboard ISS will facilitate travel to destinations beyond low Earth orbit**
- **Destinations for human exploration remain ambitious: the Moon, asteroids and Mars**
- **Continue to undertake world-class science missions to observe our planet, reach destinations throughout the solar system and peer even deeper into the universe**
- **Advance aeronautics research to create a safer, more environmentally friendly and efficient air travel network for the Next Generation Air Transportation System**
- **Continue to inspire the next generation of scientists, engineers and astronauts by focusing on STEM education initiatives**





Student Opportunities: Many student internship, fellowship, and post-doc opportunities across NASA



<http://intern.nasa.gov>

<http://eap.usra.edu>

<http://nasa.orau.org/postdoc>



Questions?

