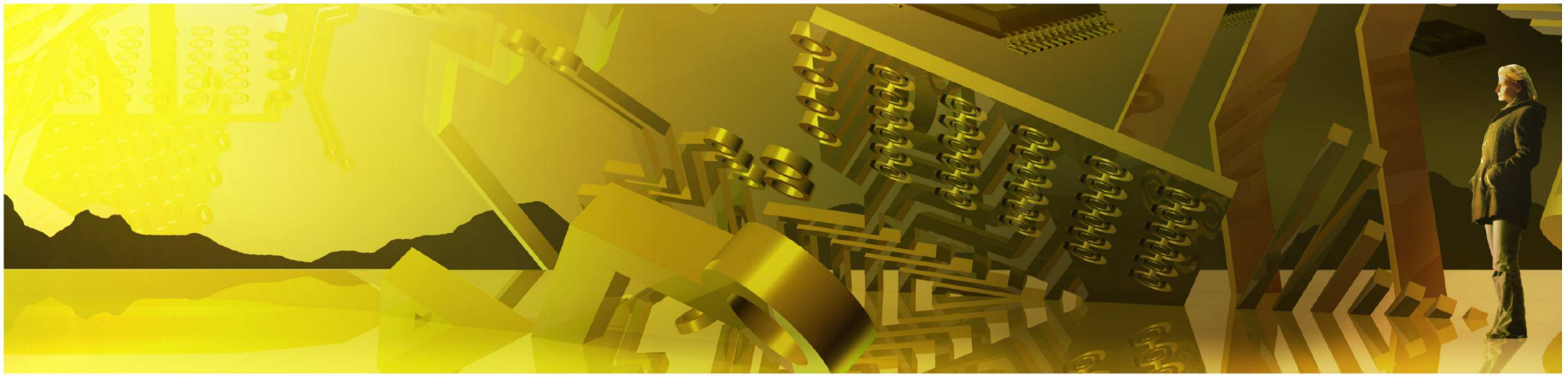
National Aeronautics and Space Administration

INVESTMENTS IN OUR FUTURE: EXPLORING SPACE THROUGH INNOVATION AND TECHNOLOGY



Michael J. Gazarik, Ph.D.
NASA Deputy Chief Technologist

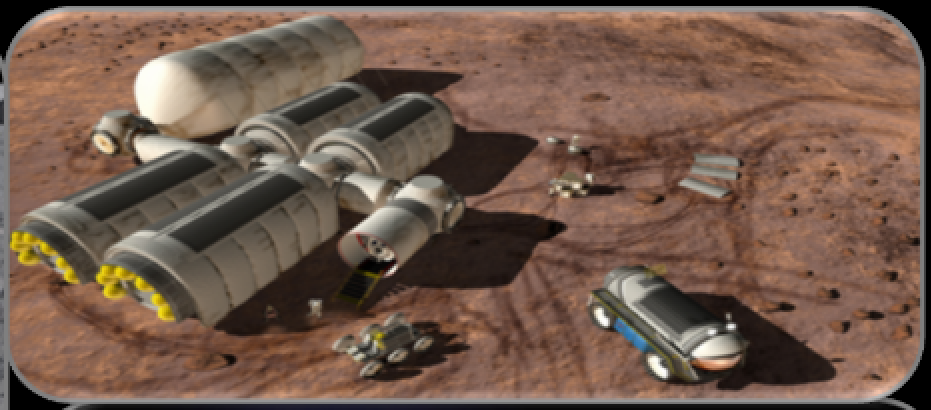
Space Shuttle Symposium

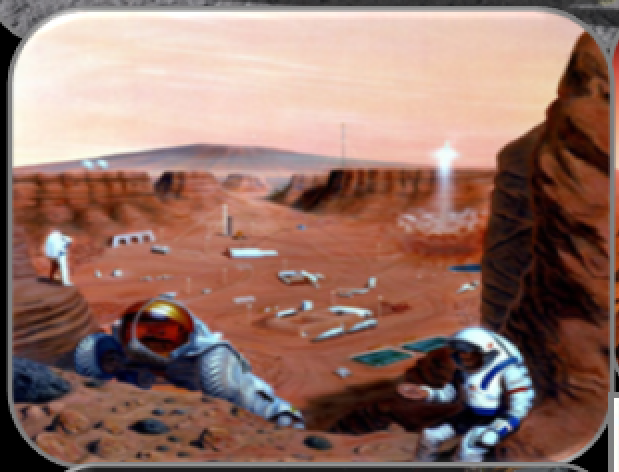
June 8, 2011

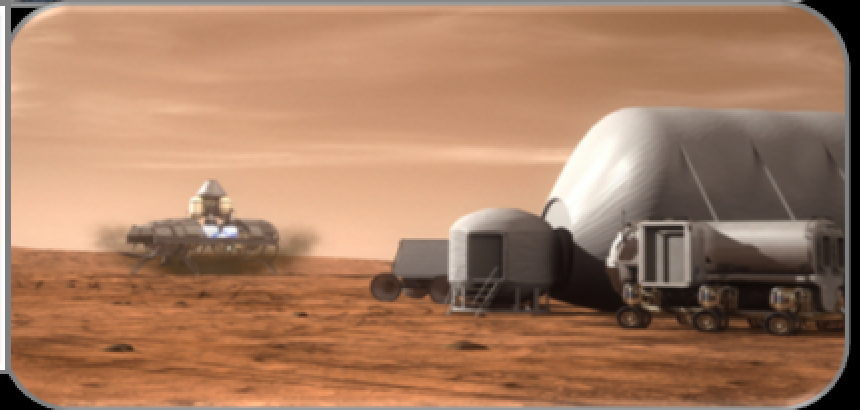
Engle & Truly and the Shuttle Inspire a High School Student

NASA's Grand Achievement Defined Rocket Science

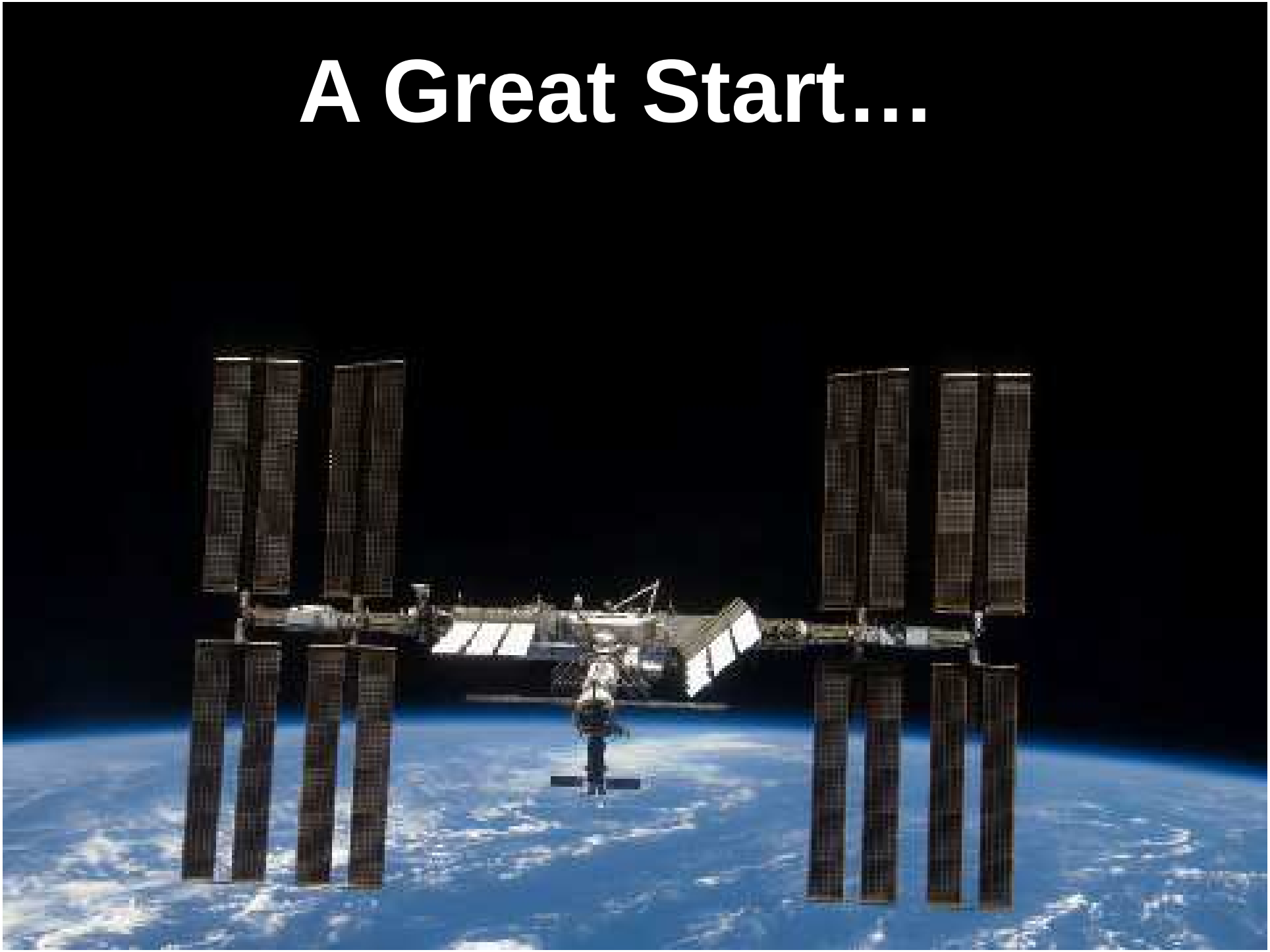
What is the Equivalent of Our Generation's "Space Race"?







A Great Start…



Dual approach to human spaceflight, and invest in research and technology to enable increasingly advanced missions

Commercial Cargo and Crew systems to reach the Space Station

A NASA-built heavy lift rocket and crew capsule to explore the solar system beyond Low Earth Orbit

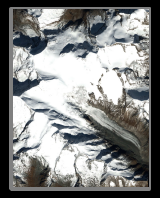
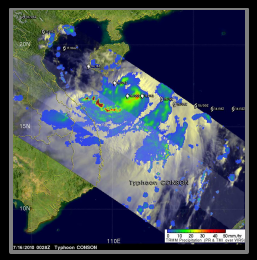
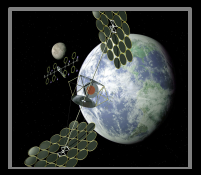
Specific-Purpose Vehicles

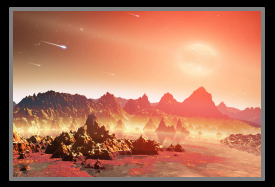
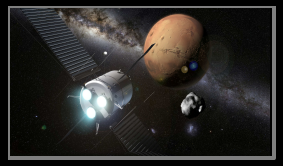
Designed, Built and Tested Today

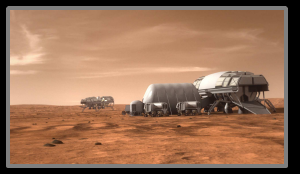
Our Space Exploration Future

9 Game-Changing Civil Space Possibilities Within Our Grasp:

- Quantify Causes, Trends and Effects of Long-Term Earth Climate Change
- Accurately Forecast the Emergence of Major Storms and Natural Disasters
- Develop and Utilize Efficient Space-Based Energy Sources
- Prepare an Asteroid Defense
- Identify Life Elsewhere in our Solar System
- Identify Earth-like Worlds Around Other Stars
- Initiate Interstellar Robotic Exploration
- Achieve Reliable Commercial Low-Earth Orbit Transportation
- Achieve Permanent Human Presence Beyond the Cradle of the Earth

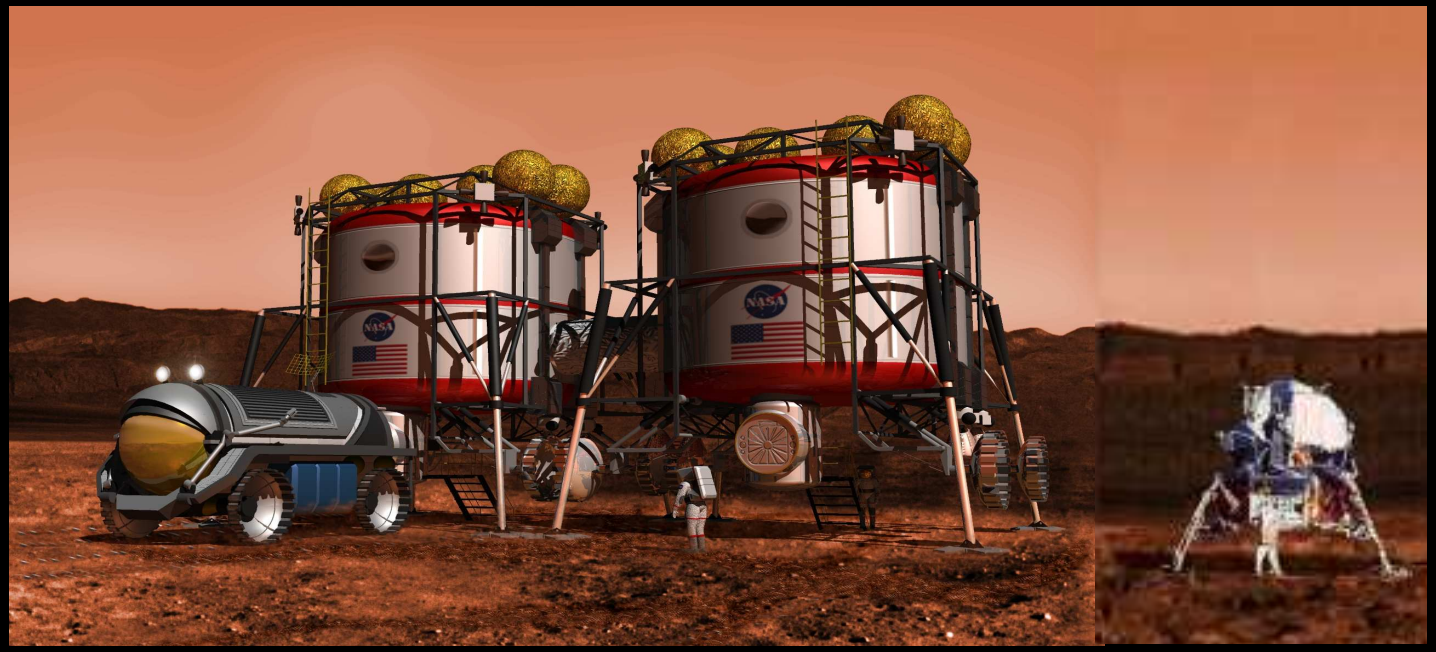






Humans Mars Exploration

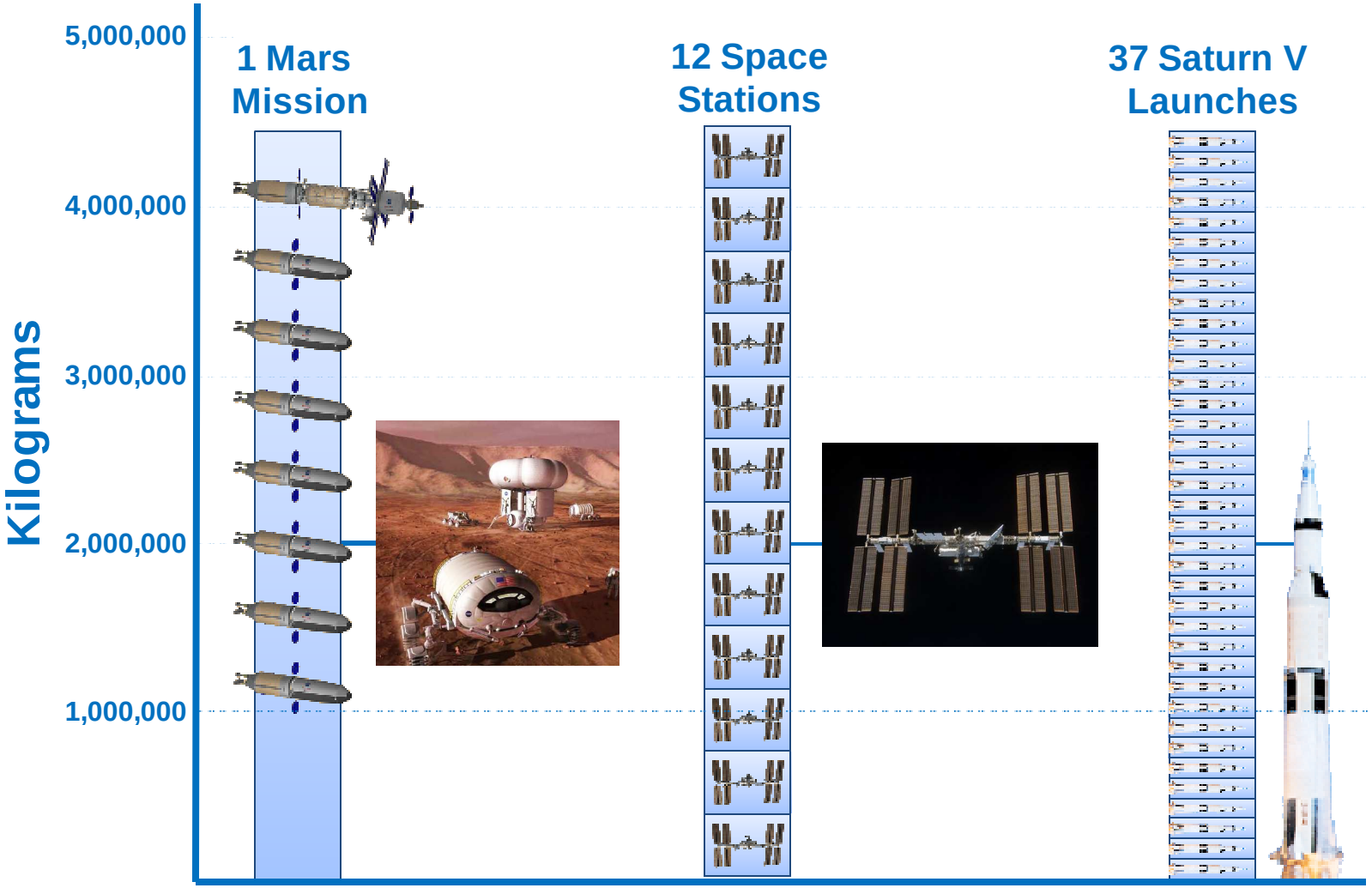
Mars Science Laboratory
1 Metric Ton



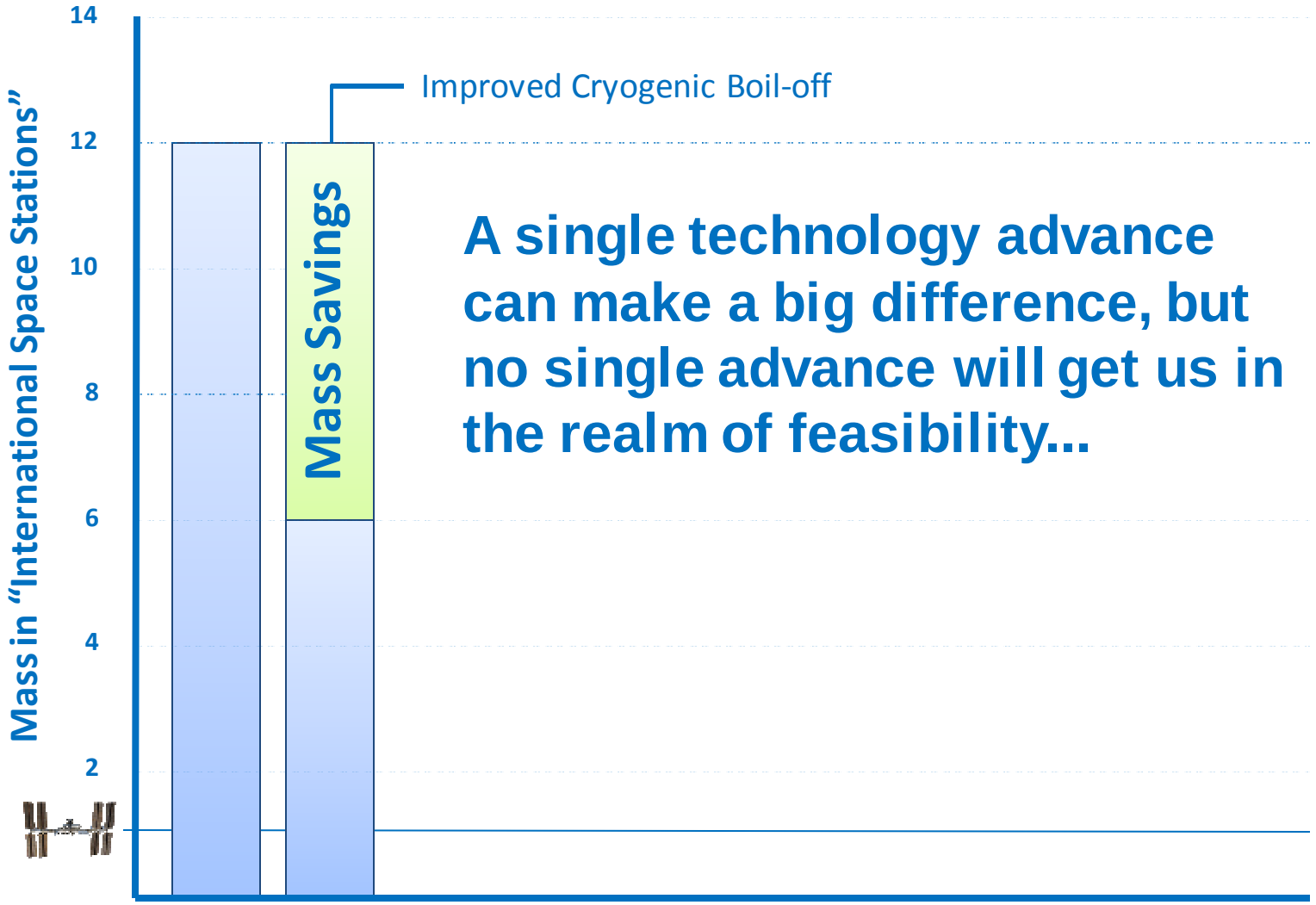
Human Mars Mission
40-100 Metric Ton
Per landing

How Do We Land Something This Big?

Human Mars Exploration
Low Earth Orbit Departure Mass Requirement

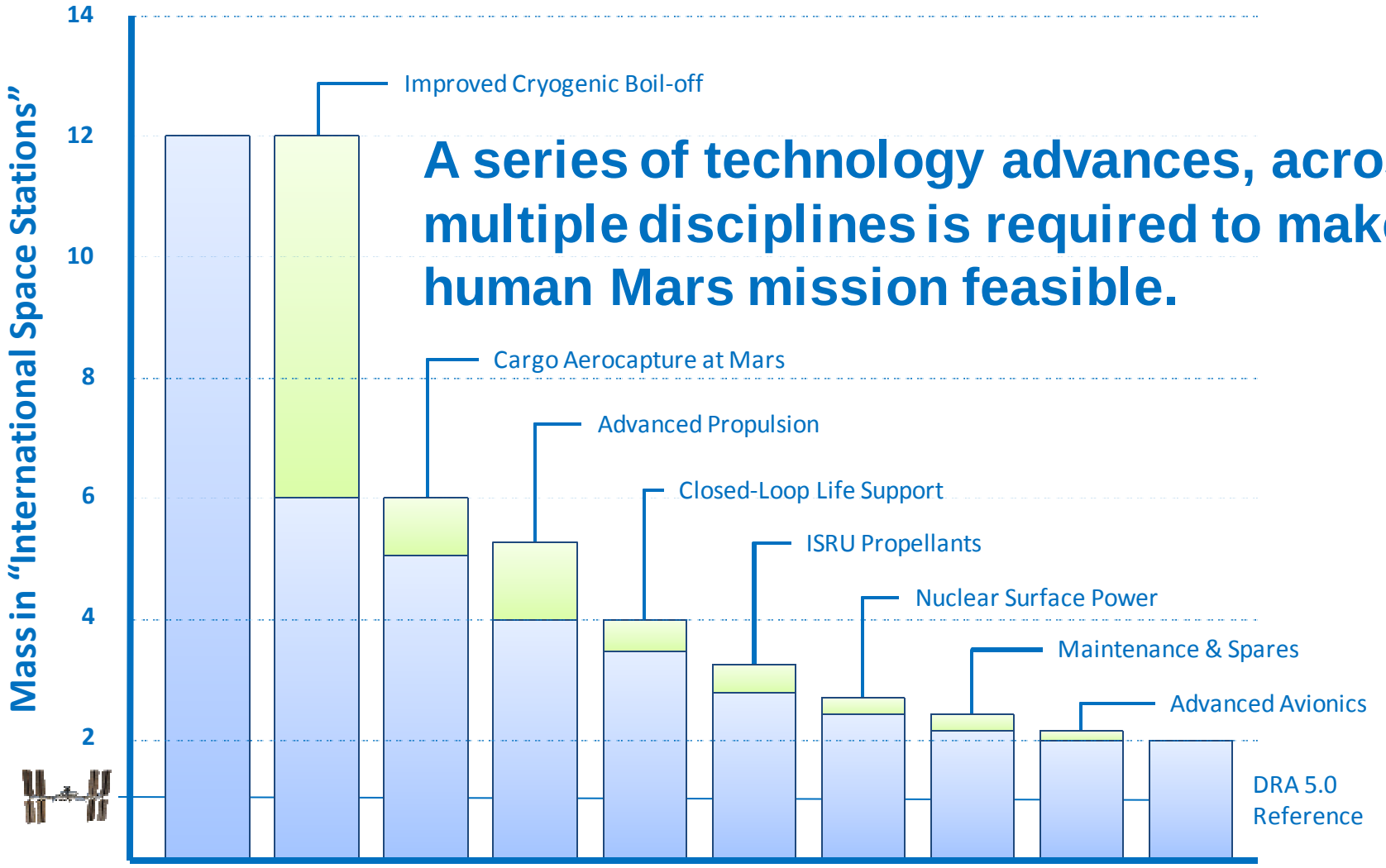


The Impact of Technology Advancement



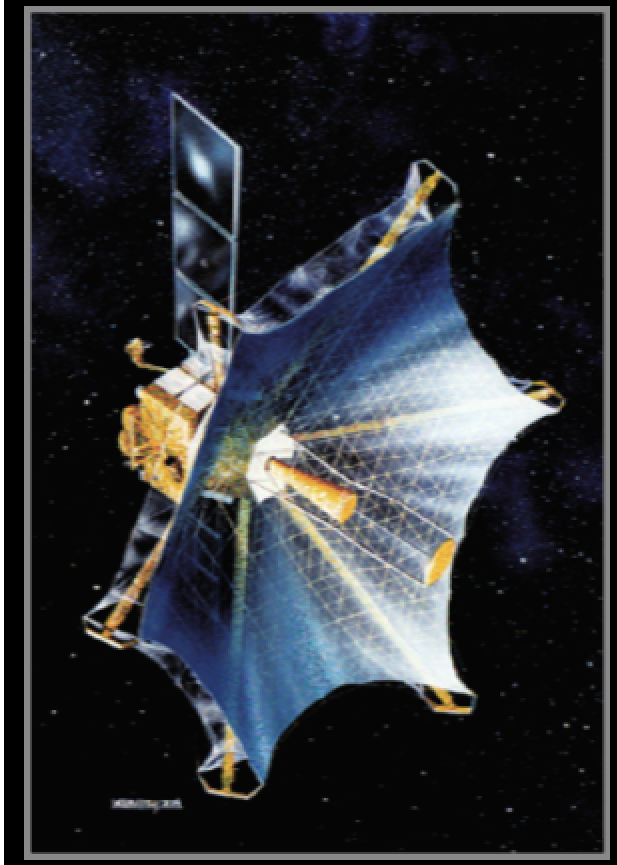
A single technology advance can make a big difference, but no single advance will get us in the realm of feasibility...

The Impact of Technology Advancement



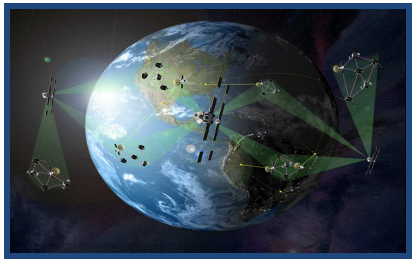
A series of technology advances, across multiple disciplines is required to make a human Mars mission feasible.

Technology-Enabled Approaches to Science



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**
  - 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 aeroscience and taking informed-risk, *Space Technology* allows NASA and our Nation to remain at the cutting-edge.
- **Technological leadership is the "Space Race" of the 21st Century**
- **NASA makes a difference in our lives everyday**
  - Knowledge provided by weather and navigational spacecraft
  - Efficiency improvements in both ground and air transportation
  - Solar- and wind-generated energy
  - Cameras found in many of today's cell phones
  - Improved biomedical applications including advanced medical imaging
  - More nutritious infant formula
  - Protective gear that keeps our military, firefighters and police safe



14

Broad Technology Maturation Coverage

- Space Technology Research Grants

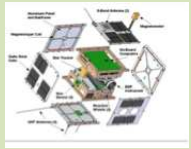
- NASA Innovative Advanced Concepts (NIAC)

- Center Innovation Fund

- Centennial Challenges Prize

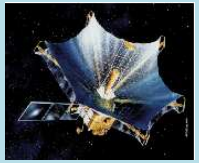
- Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR)

- Game Changing Development

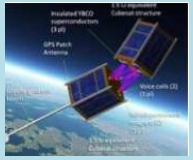


- Franklin Small Satellite Subsystem Technology

- Flight Opportunities



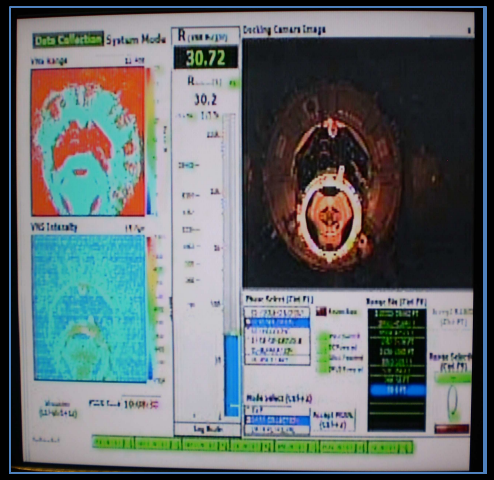
- Technology Demonstration Missions



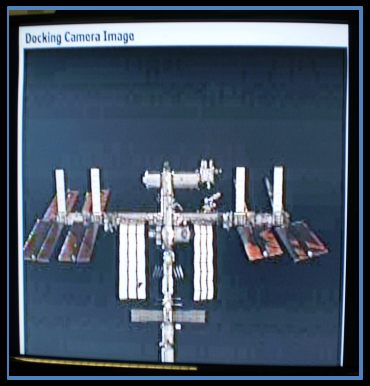
- Edison Small Satellite Demonstration Missions

Hardware…Solve a Problem…Fast

Shuttle Infrared Camera

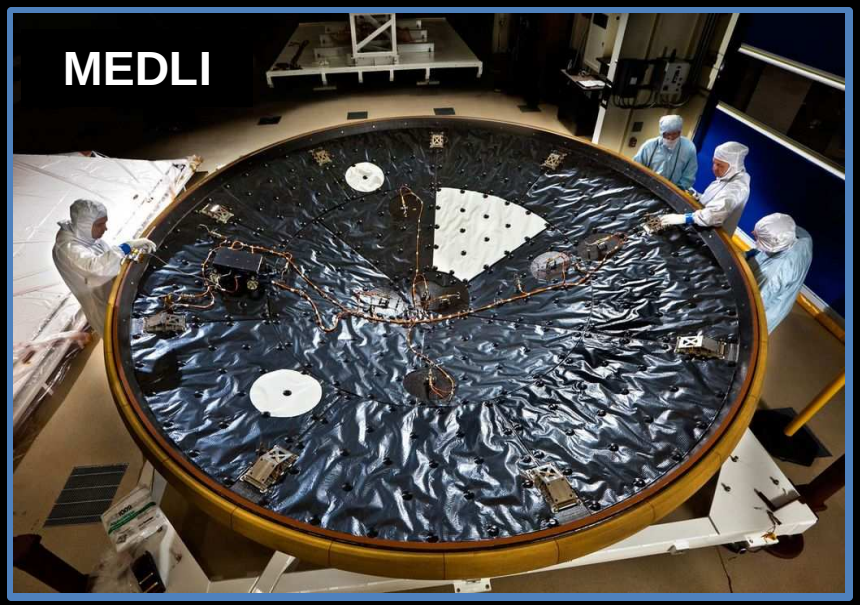


STORRM



ALHAT

MEDLI



Team Support at Mission Control

STS-121 EVA-3 Support at Mission Control, July 12, 2006

Infrared Image of EVA IR Camera Team

LaRC
JSC
GSFC
EVA IR CAMERA

EVA IR Camera Team

www.nasa.gov

Reflection of EVA IR Camera in Piers Sellers' Visor

Risk Posture: Necessary to Accomplish Worthy Goals

- **Risk Posture different for technology development**
- **Failure is an Option – in technology-focused development programs**
    - "Failing Forward" because a technology did not pan out results in increased knowledge and learning
    - How "failure" is treated is key to the success of the Program

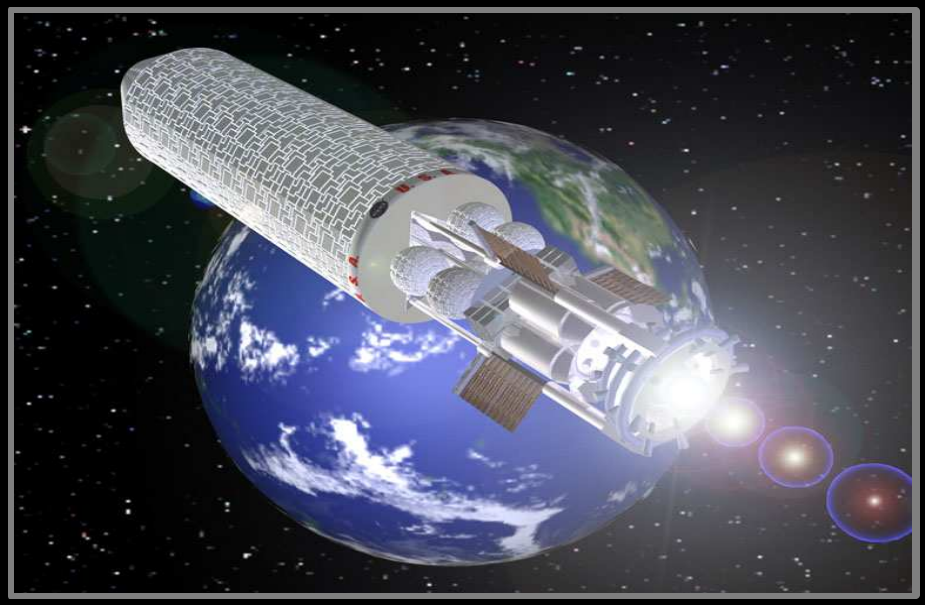
- **Programs focused on technology development afford us the opportunity to take technical risk. Accomplishing something great demands that we do.**

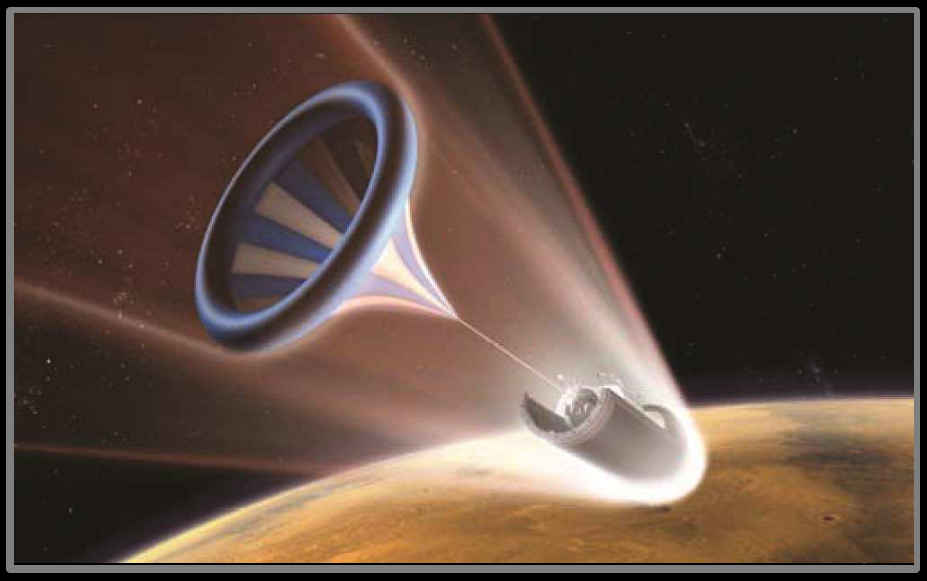
"Risk intolerance is a guarantee of failure to accomplish anything of significance." – Sandia National Laboratories, *Risk, Challenge and Reward in LDRD*

- **Informed Risk-Taking**
    - **Practice of understanding the risk one is taking in implementing a project and managing project resources to best mitigate the integrated risk posture.**

"We cannot shrink from risk.... When you take chances and do stuff that nobody else has ever done…We have to be willing to accept risk. We have to be willing to do daring things." - NASA Administrator Charles Bolden

Technology-Enabled Approaches to Exploration





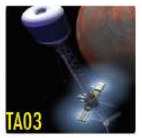
Technical Area Breakdown Structure

TA01 

• LAUNCH PROPULSION SYSTEMS

TA02 

• IN-SPACE PROPULSION TECHNOLOGIES

TA03 

• SPACE POWER & ENERGY STORAGE

TA04 

• ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

TA05 

• COMMUNICATION & NAVIGATION

TA06 

• HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

TA07 

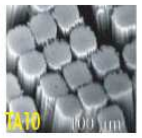
• HUMAN EXPLORATION DESTINATION SYSTEMS

TA08 

• SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

TA09 

• ENTRY, DESCENT & LANDING SYSTEMS

TA10 

• NANOTECHNOLOGY

TA11 

• MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

TA12 

• MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

TA13 

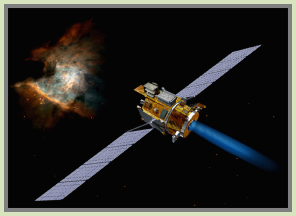
• GROUND & LAUNCH SYSTEMS PROCESSING

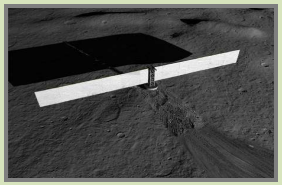
TA14 

• THERMAL MANAGEMENT SYSTEMS

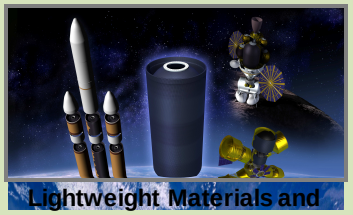
FY12 Space Technology Project Areas

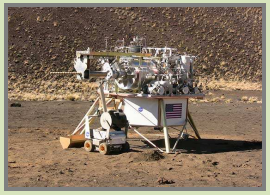
Game Changing Technology

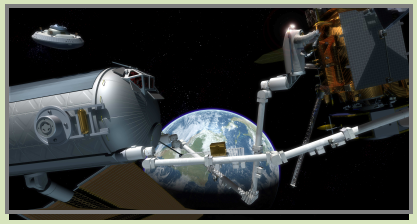

In-Space Propulsion

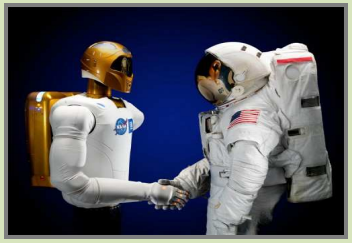

Space Power Generation


Nuclear Systems

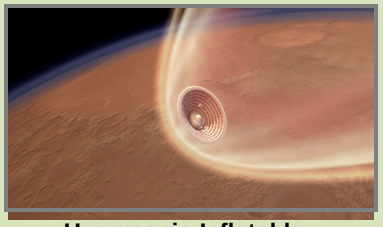

Lightweight Materials and Structures


In-Situ Resource Utilization

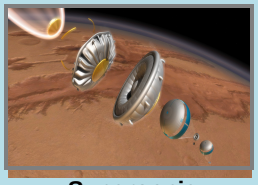

Autonomous Systems

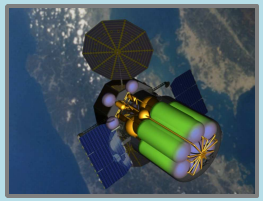

Human-Robotic Systems


Next Generation Life Support


Hypersonic Inflatable Aerodynamic Decelerator

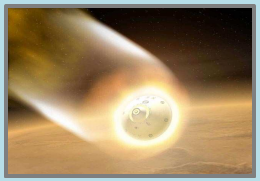
Crosscutting Capabilities

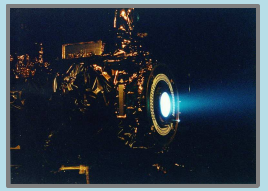

Supersonic Inflatable Aerodynamic Decelerator


Cryogenic Propellant Storage & Transfer

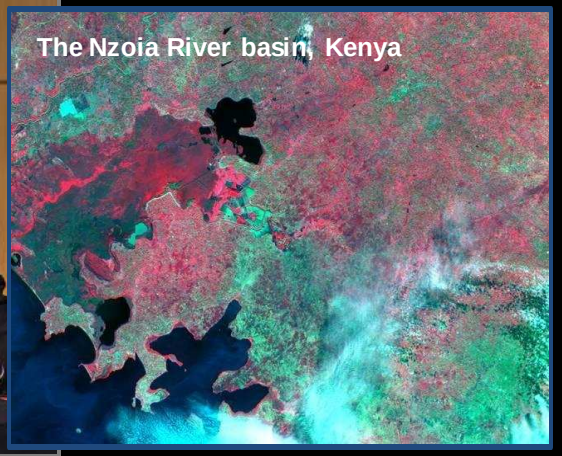

Human Exploration Tele-robotics

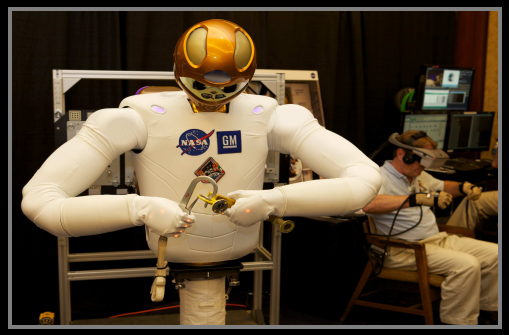

Autonomous Landing & Hazard Avoidance Technology (ALHAT)

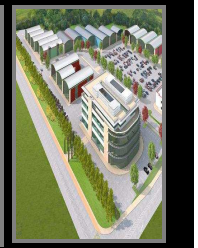

MSL Entry Descent and Landing Instrument (MEDLI)

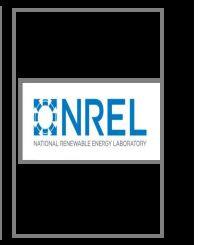

Solar Electric Propulsion

Partnerships and Technology Transfer









NASA Space Technology Improving Our Lives

Advanced Diagnostic Ultrasound in Microgravity

LED Light Therapy For Pain Management

Groundwater Remediation

Clean Energy

Winglets Save Fuel Cost

Lithium Batteries for Cars

Aerogel Insulation

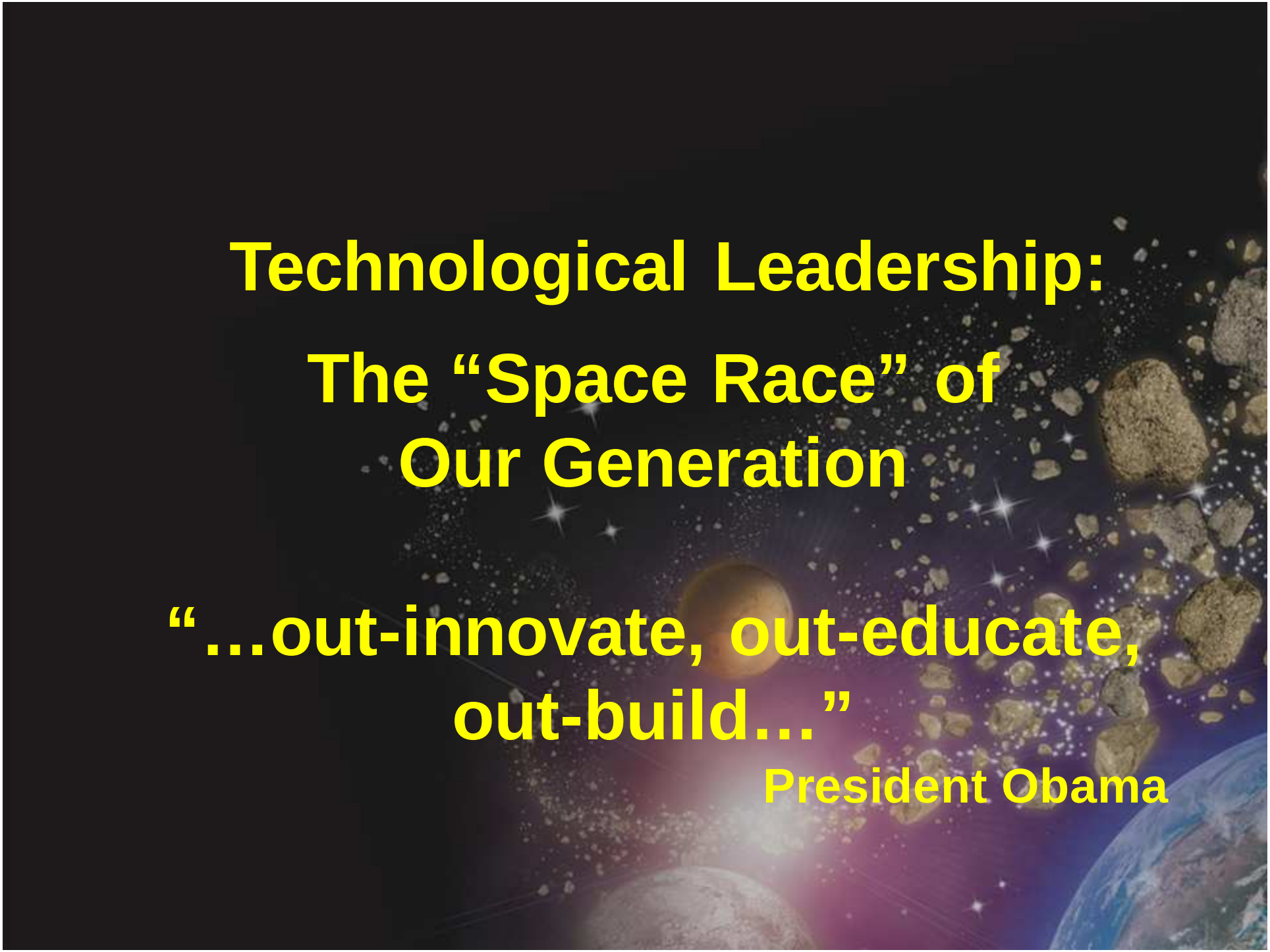
Eye Exams

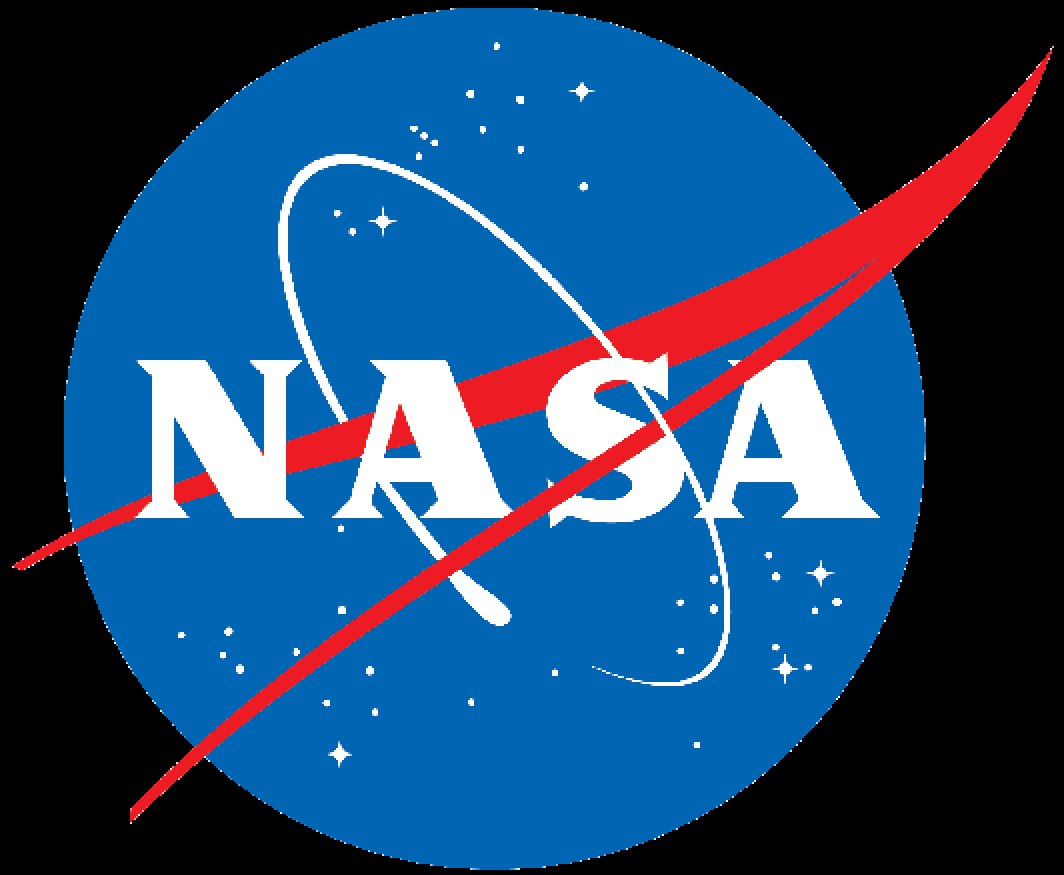
Infrared Thermometers

Memory Foam

Nutritional Supplements

Sports and Recreation


Technological Leadership:
The "Space Race" of
Our Generation
"…out-innovate, out-educate,
out-build…"
President Obama



www.nasa.gov/oct