

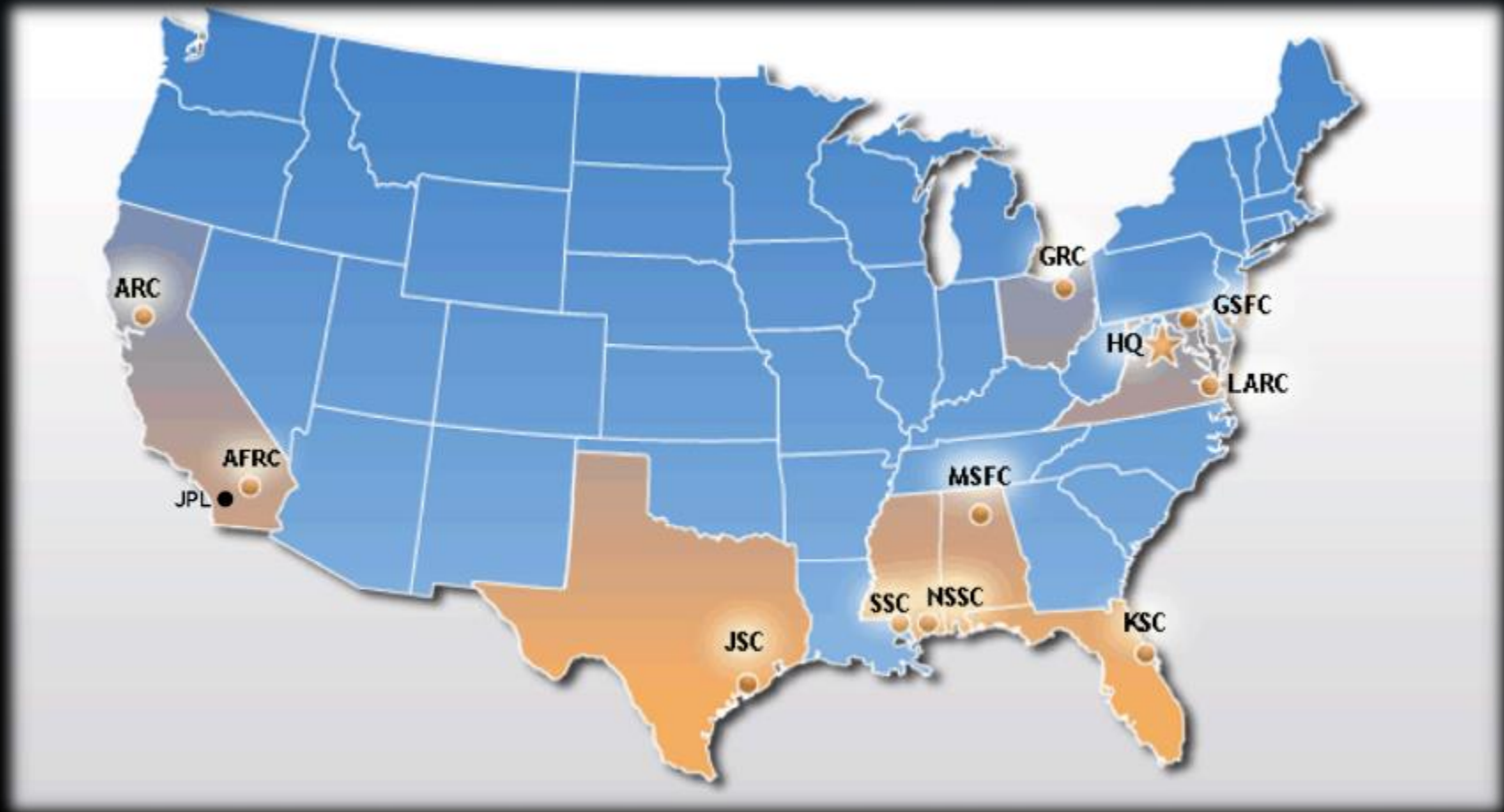


# Developing Game Changing Technologies & Bringing Them Down to Earth

David Morse  
Chief, Technology Partnerships Office  
NASA Ames Research Center  
October 25, 2016



# Location of NASA Field Centers



# NASA Missions and Program Priorities



- Aeronautics - Design, Testing and ATM
- Human Space Exploration and Operation
- Space Technology
- Earth, Life, and Space Science Research
  
- Innovative Partnerships/Collaborations
- Spin-offs/Technology Transfer
- Spin-ins/Technology Infusion
- Education

# NASA Partnering for Public Benefit and Innovation

Under the Space Act of 1958 that created NASA, the Agency is mandated to transfer the technologies that it develops in the conduits of it's aeronautics and space missions to the public sector to benefit life on Earth:

*“The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind.”*

NASA Shall...

*“Provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.”*

This Provides for:

- Access to NASA Technologies
- Access to NASA's Unique Facilities
- Access to NASA's Unique Expertise

# Applications and Public Benefits Technology



## Applications of NASA-Derived Technology

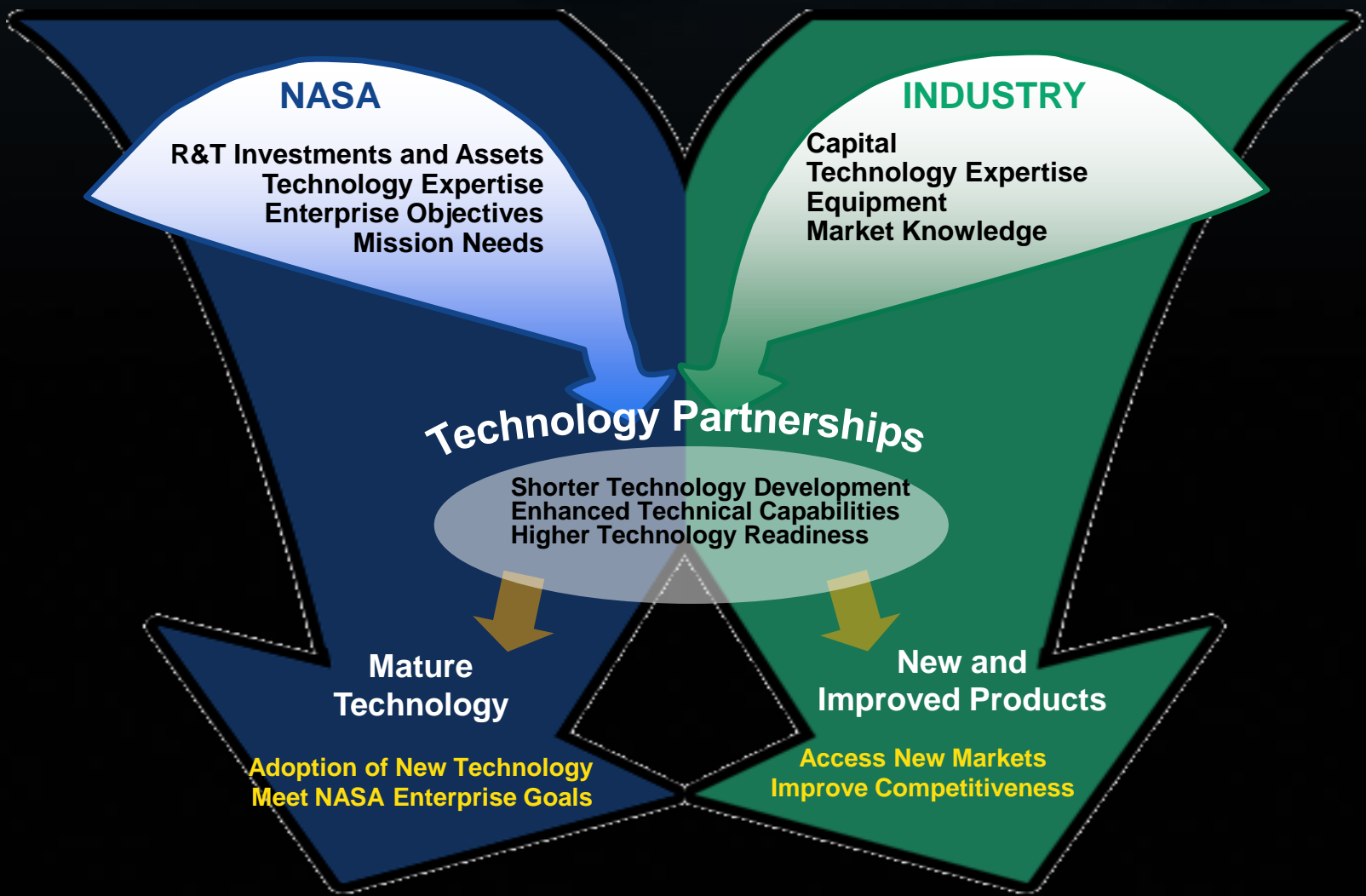
- Health and Medicine
- Transportation
- Public Safety
- Consumer, Home & Recreation
- Environmental and Agricultural Resources
- Computer Technology
- Industrial Productivity

## Public Benefits of NASA-Derived Technology

- Economic Growth
  - New Jobs
  - New Markets
  - Increased Efficiency
  - Improved Competitiveness
- Quality of Life
  - Improved Safety
  - New Products
  - Lives Saved or Extended
  - Green Technologies
  - Environmental Cleanup



# Building Partnerships, Technology Transfer/Infusion



# Technology Areas of Common Interest



## Self-Driving Cars and UAVs

Diverse human-machine interaction in a structured environment

GPS & map-based navigation

Distributed and cloud-based autonomy

Cyber-security for consumer product

### Autonomy

Advanced Planning & Scheduling Algorithms, etc.

### Human-Autonomy Teaming

Robotic Supervision including Human/Robotic Interactions, etc.

### Networked Operations

Remote Vehicle Management, etc.

### Prognostics and Diagnostics

Including State Management, etc.

### Sensor Technologies

Data Processing / Fusion Methodologies, etc.

### Verification & Validation

Methodologies & Application Experiences, etc.

## NASA Missions

Planned human-machine interaction in natural and time delayed environment  
Space & planetary nav

Spacecraft autonomy

Cyber-security for "one-off" systems

Space environment

Limited ability to address/recover faults

# NASA Partnership Vehicles



## There are Many Ways to Partner with NASA

- Space Act Agreements
  - Non-Reimbursable
  - Reimbursable
  - Memorandum of Agreement/Understanding
  - Interagency
  - International
- Licensing Agreements
  - Exclusive
  - Nonexclusive
  - Limited Exclusive
- Software Agreements





# Selected Key Partnerships



Planetary Skin Initiative and Rainforest Skin Layer



1. Quantum Computing
2. Planetary Content
3. Disaster Response
4. Autonomous Vehicles



Worldwide Telescope Project



Direct-To Software for Airplane Flights



Pipeline Rights-of-Way and Liquid & Gas Leak Detection



Model-Based Spaceflight Software Development

NASA Earth Exchange Services on the Amazon Cloud



Skin Radiation and Lunar Dust Toxicity Studies



# Selected Key Partnerships Continued...



1. Commercial Crew Dev
2. Risk Analysis
3. TPS Design and Analysis
4. High-End Computing



Robotics Technologies for Autonomous Vehicles



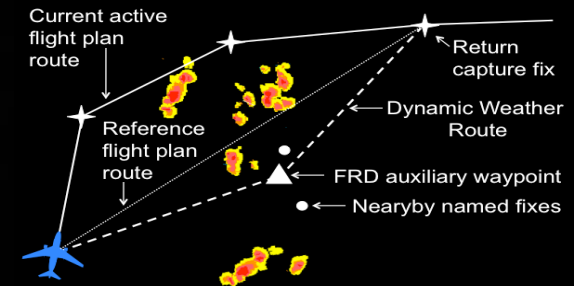
Wildfire Monitoring and Disaster Response



Robotic and Spacecraft Technology Research



Dynamic Weather Routes (DWR) Tool

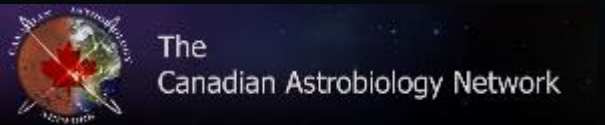


Carbon Nanofiber Electrodes for Deep Brain Stimulation and Neural Prosthesis

# Selected NASA Ames – Canada Partnerships



Aerosciences/Aerodynamics



Astrobiology/Life Science



Astrobiology/Rover Demonstrations  
Human Factors/Adaptive Systems



Nanosatellite Energy Storage



Robotics and Spacecraft Technology



Human Computer Interactions

# NASA's Technology Transfer Portal



The screenshot shows the NASA Technology Transfer Program website. At the top, the logo reads "TECHNOLOGY TRANSFER PROGRAM" with the tagline "BRINGING NASA TECHNOLOGY DOWN TO EARTH". The main banner features a rocket launch with the text "SPINOFF 2016" and a sub-headline: "The 2016 issue of Spinoff has launched! See how NASA technology benefits our nation and world." Below the banner is a search bar for NASA technologies, a "Features Archive" link, and a "Contact Us" section. The "Contact Us" section includes a video player and text stating: "NASA's Technology Transfer Program ensures that technologies developed for missions in exploration and discovery are broadly available to the public, maximizing the benefit to the Nation." Below this is a "T2 Social Media" section with icons for Twitter, YouTube, and LinkedIn. At the bottom, there are three tiles: "Patent Portfolio", "software catalog 2015-16", and "SPINOFF".



# Patent Strategy and Application Areas

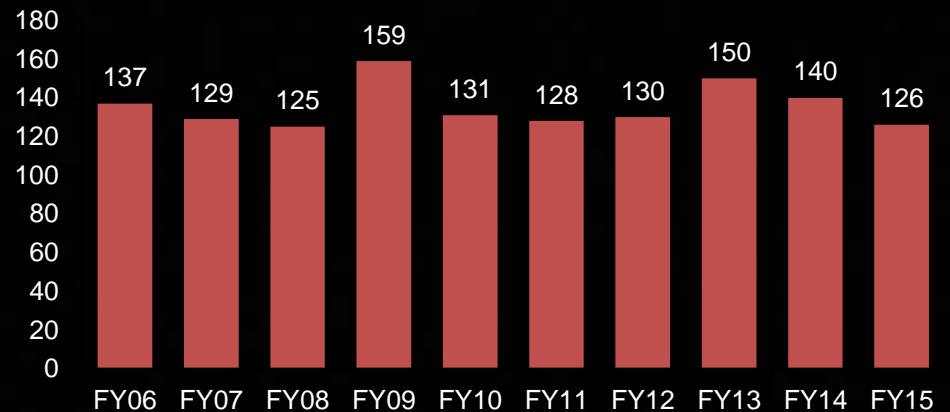


## Why does NASA Patent?

- **Technology has Commercial Potential**
- **Will Actively and Aggressively Market**
- **Best Way to Transfer the Technology**



## US Patent Applications Filed



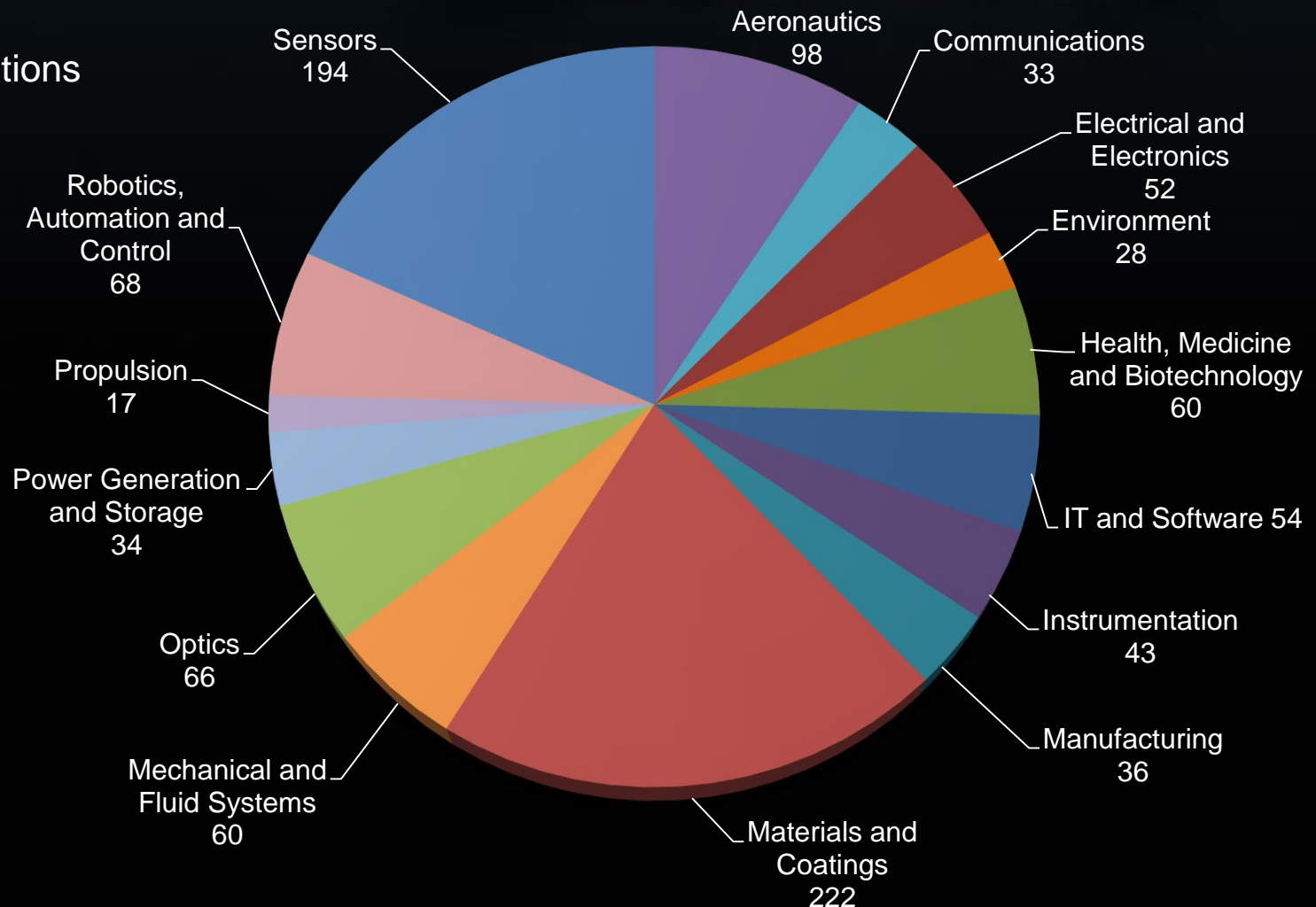


# NASA Patent Portfolio Analysis

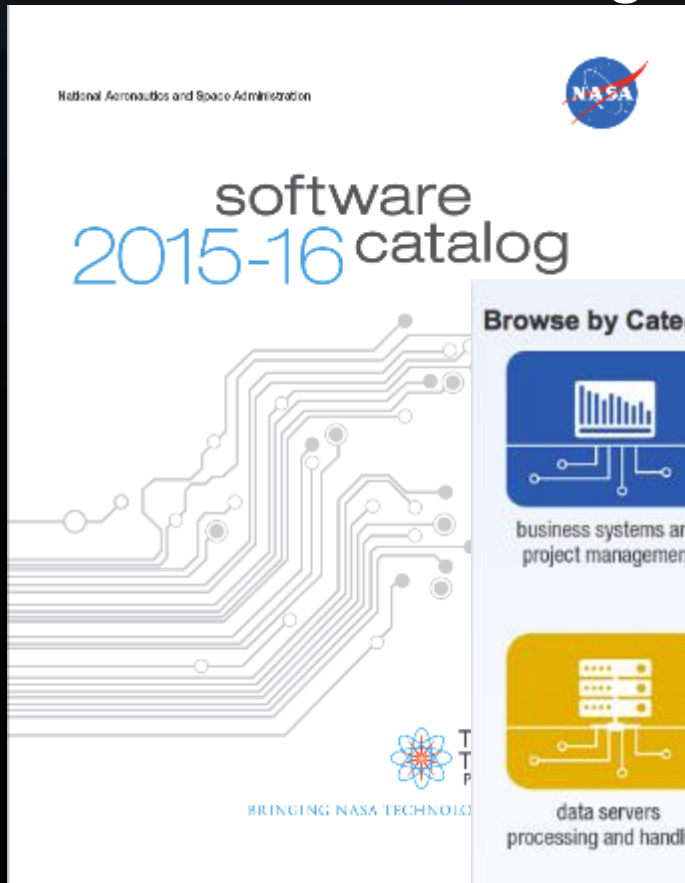


## Total Patents Available for Licensing as of Jan. 2016

- 759 Issued
- 372 Applications



# Software Catalog and Categories



## Browse by Category



business systems and project management



system testing



operations



design and integration tools



vehicle management



data servers processing and handling



propulsion



structures and mechanisms



crew and life support



data and image processing



materials and processes



electronics and electrical power



environmental science



autonomous systems

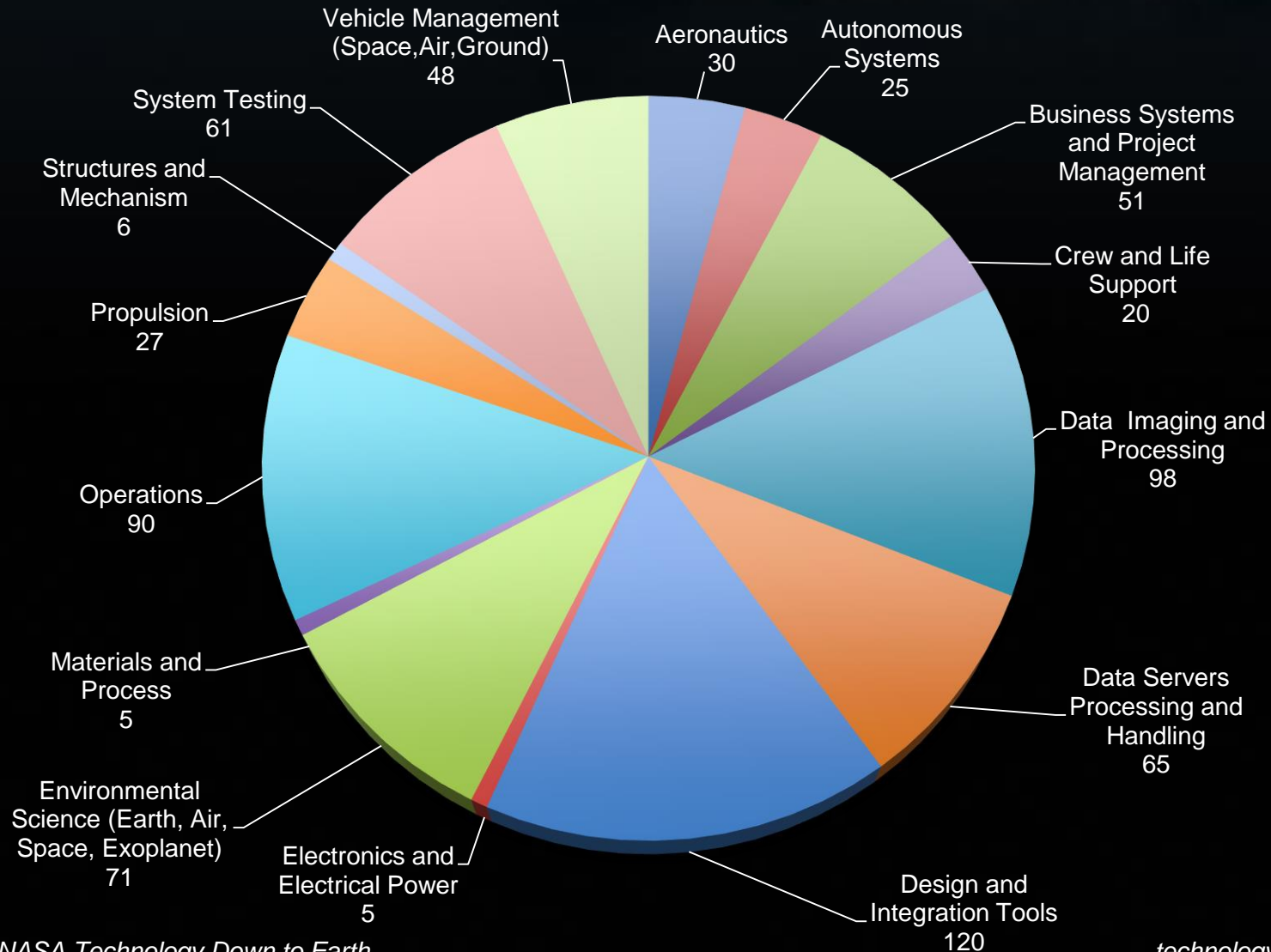


aeronautics

# NASA Software Catalog



## Total Software Available for Licensing as of Feb. 2016





# 40 Years of NASA Spinoffs



Some of the best of over 2,000 recorded Spinoffs



CMOS camera-on-a-chip technology used in nearly all digital cameras, including smartphones

International search-and-rescue system has saved 40k lives worldwide since 1982



Ubiquitous aerodynamic innovations in airplanes and trucks



Voltage controller saves energy in nearly all load-bearing electrical machines



Precision GPS enabled self-driving tractors that are now used to work the majority of the world's farmland.

# NASA Technologies Enabling a Sustainable Earth



## Assistance to Developing Countries

- Clean Drinking Water
- Improved Agriculture
- Telemedicine and wireless networks
- Improved Environmental Decision Making

## Use of Green Technologies

- Aeronautics Technologies
- Green Buildings
- Encouraging Green Technologies
- Solar Power Applications
- Paint Stripping
- Global Research into Energy and the Environment at NASA (GREEN)

## Environmental Cleanup

- Groundwater Remediation
- Land Mine Cleanup
- Landfill Cleanup
- Oil Spill Cleanup

## Disaster Warning and Relief

- Earthquake relief
- Tsunami Warning
- Wildfire Response
- Hurricane Warning



# NASA-Derived Tech Contributing to Security



## Improving Operational Systems

- Health & Performance Monitoring for Aviation Security
- Safe Composite Over-wrap Pressure Vessels
- Fire-Protective Fabrics & Smoke Masks
- Intumescent Materials
- Neutralizing Land Mines
- Secure Networks for First Responders and Military

## Inspection Technologies

- Crack Detection in Nuclear Power Systems
- Hyperspectral Imaging for Food Safety
- Inspection of Suspicious Liquid/Solid Substances

## Threat Detection

- Detection/Warning of Chem/Bio Attack
- Hyperspectral Imaging for Counter-Terrorism
- Anthrax Smoke Detectors
- Fiber Optic Chemical Agent Sensing

## Identification & Investigation

- Pattern Recognition for Security Applications
- Video Enhancement Supporting Criminal Investigations

# NASA-Derived Technologies Used in Homes



## Bathrooms

- Infrared Ear Thermometer
- Ingestible Toothpaste
- Cosmetics
- Memory Metal Alloys
- Polished Brass Finish
- Bacteriostatic Water Softeners
- Reflective Insulation
- Environmentally Safe Sewage Treatment

## Living Rooms

- Audio Equipment
- Insulated Paint
- Wireless Headset
- Carbon Monoxide Detection
- Environmental Cleansing
- Scratch Resistance and UV Blocking
- Portable X-Ray Device for Carpet Cleaning

## Bedrooms/Sports

- Work Surface Light Bulbs
- Temper Foam
- Phase Change Materials
- Better Software
- Improved Footwear
- Liquid Glass for Tennis Rackets
- Sport Helmets

## Kitchens

- Water Purification
- Portable Cordless Vacuum Cleaners
- Freeze Dried Technology
- Advanced Solar Cells
- Space Garden
- Enriched Baby Food
- Refrigerator Internet Connected Wall

# NASA-Derived Technologies Used in Cities



## Aircraft and Airports

- Collision Avoidance Systems
- Clean Burning Engines
- Nitrogen Oxide Reduction
- Anti-Icing Systems
- Optics for High-speed Ticket Processing
- Pilot Stress Tests
- Cabin Pressure Devices
- Parachute Systems

## Automotive

- Improved Radial Tires
- Cleaner Burning Cars
- Advanced Lubricants
- Crash and Structural Analyses
- Highway Safety
- Air Conditioning
- Refrigerant Enhancer
- Car Chassis & Brake Systems

## Medical

- Light Emitting Diodes
- Automatic Insulin Pumps
- Artificial Limbs
- Diamond Coatings and Artificial Hip
- Corneal Refractive Therapy
- Precision Dialysis Pumps and Filters
- Ventricular Assist Device

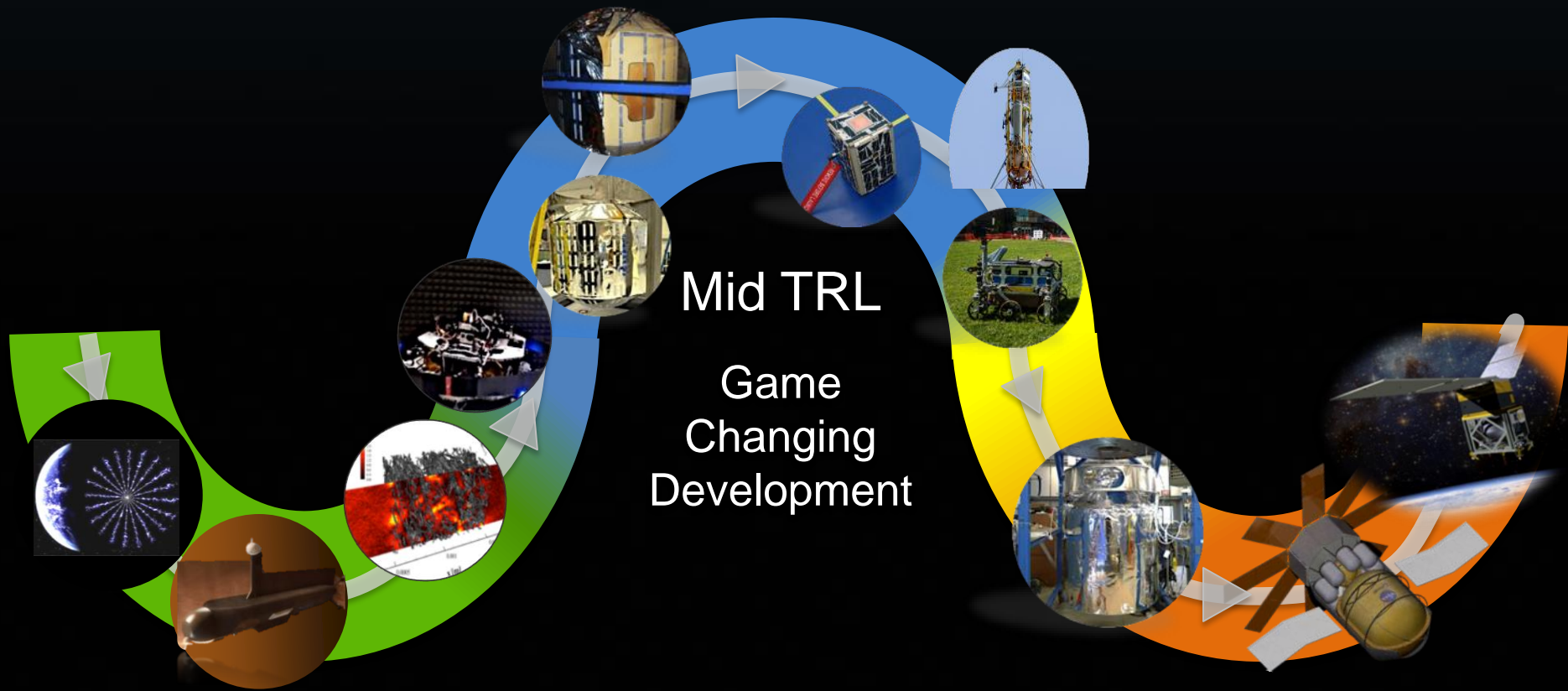
## Manufacturing

- Powdered Lubricants
- Improved Welding
- Power Plant Design and Monitoring
- Smokestack Monitors
- Chemical Detection
- Rapid Prototyping
- Improved Mine Safety
- Quick Fasteners

# Space Technology Pipeline



*Approach for Maturing Promising Low-TRL Technologies*



# Space Technology – An Investment for the Future



Enables a **new class of NASA missions** beyond low Earth Orbit.

**Delivers innovative solutions** that dramatically improve technological capabilities for NASA and the Nation.

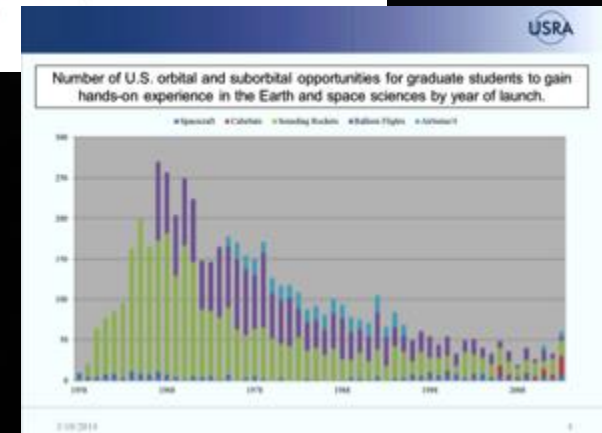
Develops technologies and capabilities that make NASA's missions **more affordable and more reliable.**

Invests in the economy by **creating markets and spurring innovation** for traditional and emerging aerospace business.

**Engages the brightest minds** from academia in solving NASA's tough technological challenges.

## Addresses National Needs

A generation of studies and reports (40+ since 1980) document the need for regular investment in new, transformative space technologies.



Value to NASA

Value to the Nation





# Guiding Principles of the Space Technology Investments



- **Adhere to a Stake-holder Based Investment Strategy**
- **Invest in a Comprehensive Portfolio**
- **Advance Transformative and Crosscutting Technologies**
- **Develop Partnerships to Leverage Resources**
- **Select Using Merit-Based Competition**
- **Execute with Lean Structured Projects**
- **Infuse Rapidly or Terminate Promptly**
- **Place NASA at Technology's Forefront**
- **Create Pipeline of NASA and Public Inventors**

# NASA's Game Changing Technology Focus Areas



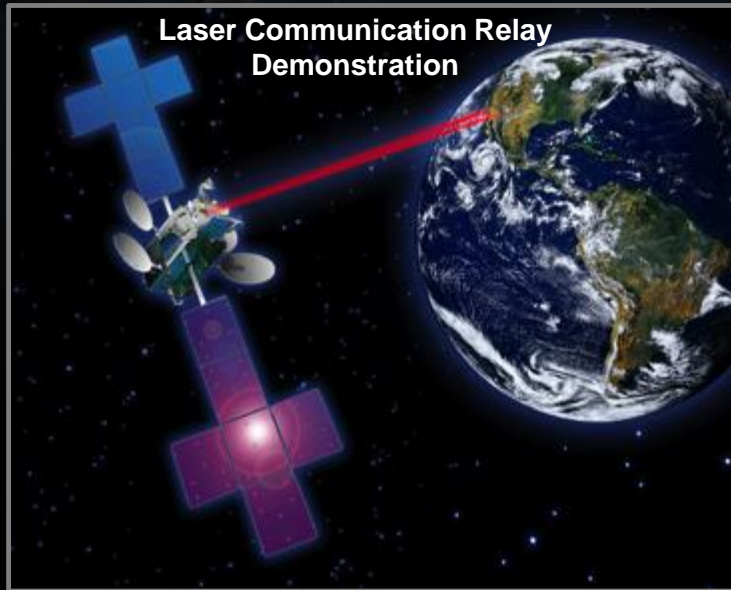
- High Data Rate Communications
- Space Instruments and Sensors
- Robotics and Autonomous Systems
- Space Radiation
- Launch and In-Space Propulsion
- Lightweight Space Structures
- Entry, Descent and Landing
- Energy Storage
- Environmental Control and Life Support

# High Data Rate Communications

## Optical Space Communication



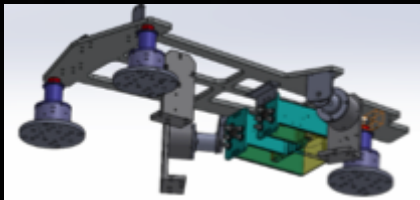
**Spacecraft  
Disturbance  
Isolation**



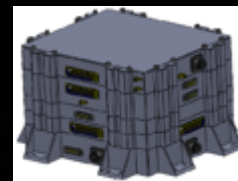
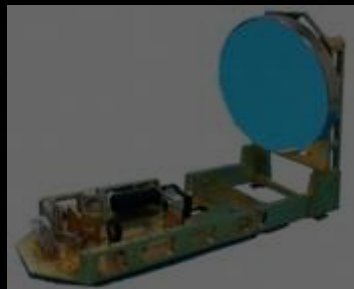
**Laser Communication Relay  
Demonstration**

**Flight Laser  
Transceiver**

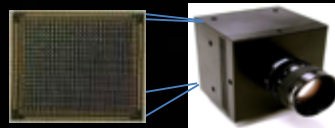
**Electronics  
& Control**



**Point-  
Ahead  
Mirror**



**Photon-  
Counting  
Camera**

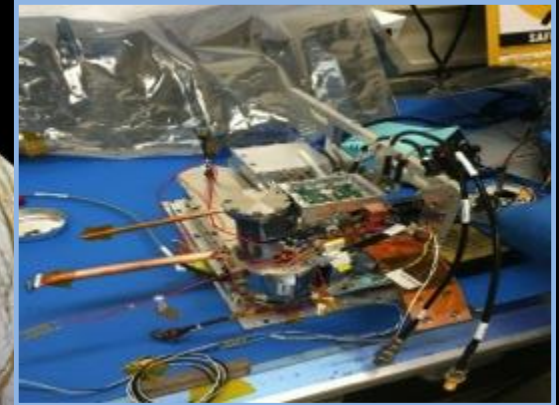


**Laser  
Transmitter**



# Space Instruments and Sensors

## Deep Space Atomic Clock



Bringing NASA Technology Down to Earth

[nasa.gov/spacetech](https://nasa.gov/spacetech)

# Robotics and Autonomous Systems



## Self-Driving Cars at NASA Ames

- Aligned with NASA autonomy development priorities
- Enables NASA to gain valuable knowledge and lessons learned from extensive real-world testing
- Enables joint development and demonstration of high-impact vehicle applications
  - Mobility, transport, remote ops, and cyber-physical systems
- Facilitates spin-off of NASA technologies to the private sector
  - Robot navigation, perception, user interface
  - Dual-use in energy, environment, security, and other terrestrial domains.



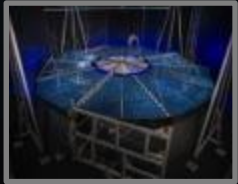


# Launch and In-Space Propulsion



## High Power Solar Electric Propulsion

### Solar Arrays



**SEP**  
**"Space Tugboat"**

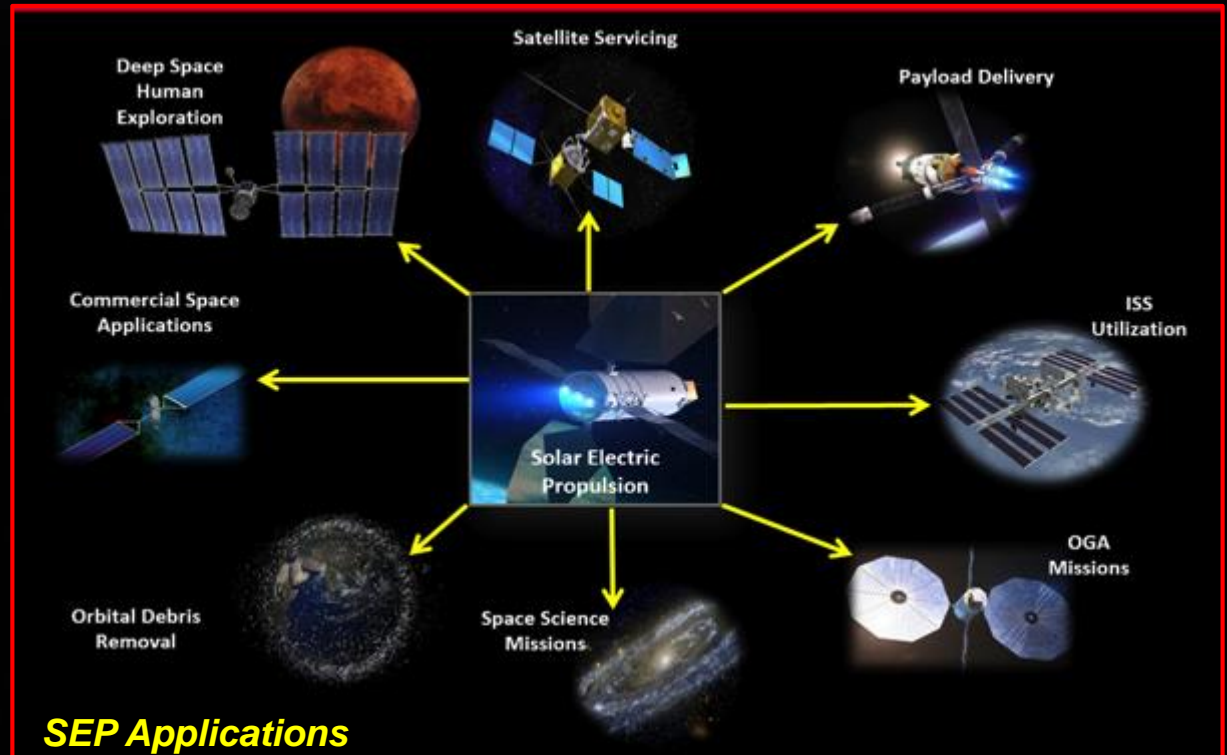
### Power Processing Units (PPUs)



### Thrusters



### Propellant Feed System & Storage Tanks



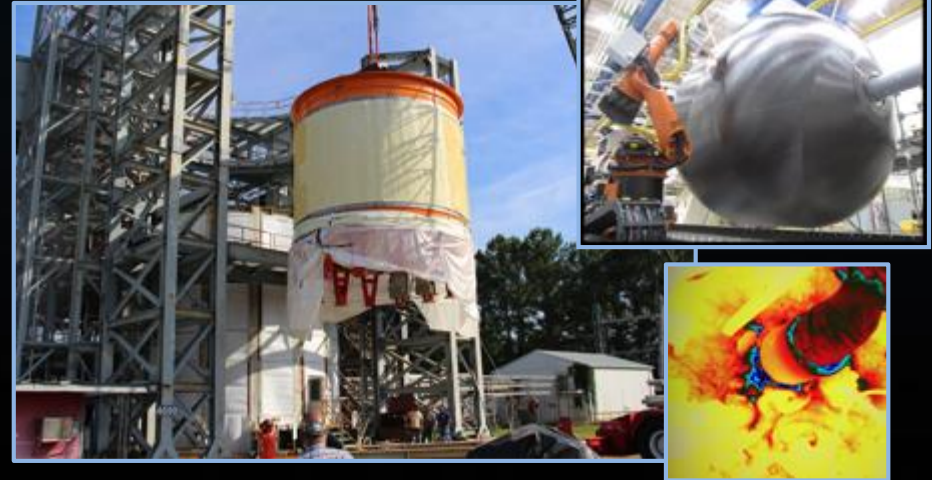
# Lightweight Space Structures



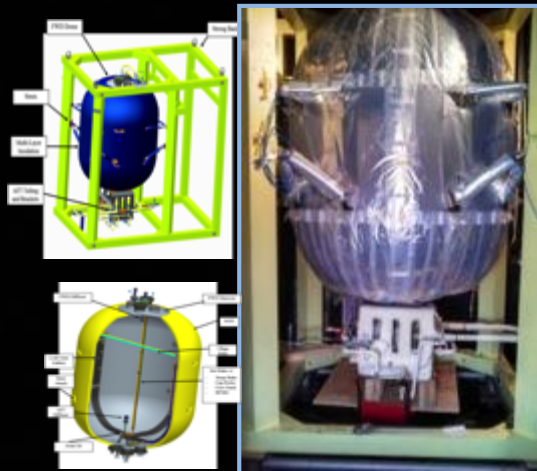
## Advance Launch Systems



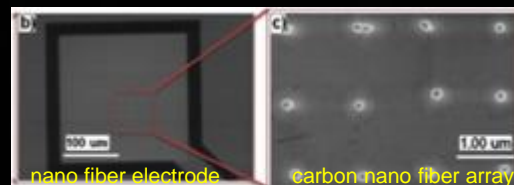
Additive Manufacturing for combustion chambers and nozzles



Composite Cryotank and dry structures



eCryo for upper stage



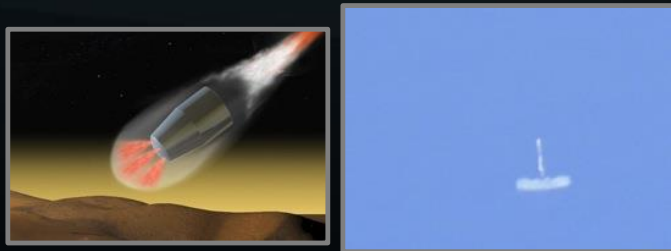
Nanotechnology



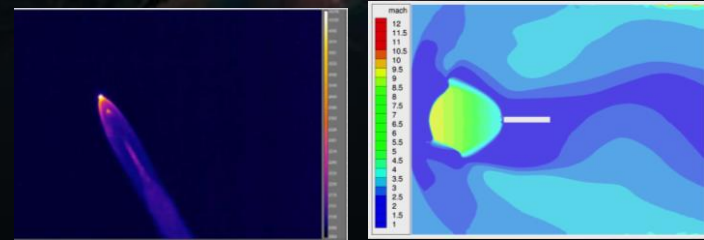
Composites for upper stage



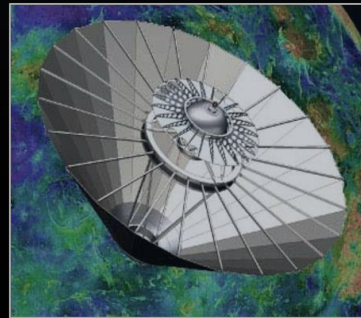
# Entry, Descent, and Landing



Supersonic Retro Propulsion



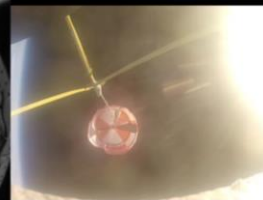
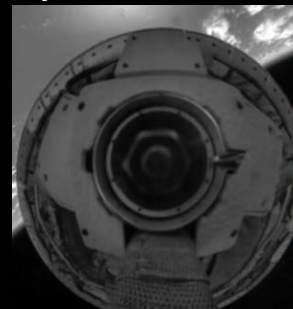
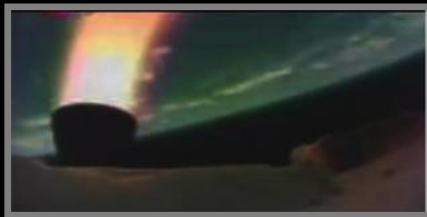
Computer Modeling and Data



Inflatable (THOR) or Mechanically Deployable (ADEPT) Entry Systems



Instrumentation



Low Density Supersonic Decelerator



3-D, multi-layer preform weaving technology for thermal protection



# Finding Technologies



There are many searchable databases available to help identify technologies of interest. Some of these are summarized below:

NASA Technology Transfer Portal: <http://technology.nasa.gov/>

NASA Game Changing Technology: <http://nasa.gov/spacetech>

NASA Software Catalog: <http://software.nasa.gov/>

NASA Tech-Briefs: <http://www.techbriefs.com/>

NASA Spinoff: <http://spinoff.nasa.gov/>



# Partnerships Points of Contact at NASA Ames



**Licensing: Trupti Sanghani**

**[trupti.d.sanghani@nasa.gov](mailto:trupti.d.sanghani@nasa.gov)**

**(650) 604-6889**

**Software: Martha Del Alto**

**[martha.e.delalto@nasa.gov](mailto:martha.e.delalto@nasa.gov)**

**(650) 604-4865**

**International: Terry Pagaduan**

**[terence.pagaduan@nasa.gov](mailto:terence.pagaduan@nasa.gov)**

**(650) 604-1181**

**Technology Transfer: David R. Morse**

**[david.r.morse@nasa.gov](mailto:david.r.morse@nasa.gov)**

**(650) 604-4724**

# Space Technology Drive Exploration

