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

[Map showing the location of NASA Field Centers across the United States]
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
Under the Space Act of 1958 that created NASA, the Agency is mandated to transfer the technologies that it develops in the conduits of its 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
<table>
<thead>
<tr>
<th>Applications of NASA-Derived Technology</th>
<th>Public Benefits of NASA-Derived Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Health and Medicine</td>
<td>• Economic Growth</td>
</tr>
<tr>
<td>• Transportation</td>
<td>• New Jobs</td>
</tr>
<tr>
<td>• Public Safety</td>
<td>• New Markets</td>
</tr>
<tr>
<td>• Consumer, Home &amp; Recreation</td>
<td>• Increased Efficiency</td>
</tr>
<tr>
<td>• Environmental and Agricultural</td>
<td>• Improved Competitiveness</td>
</tr>
<tr>
<td>Resources</td>
<td></td>
</tr>
<tr>
<td>• Computer Technology</td>
<td></td>
</tr>
<tr>
<td>• Industrial Productivity</td>
<td>• Quality of Life</td>
</tr>
<tr>
<td></td>
<td>• Improved Safety</td>
</tr>
<tr>
<td></td>
<td>• New Products</td>
</tr>
<tr>
<td></td>
<td>• Lives Saved or Extended</td>
</tr>
<tr>
<td></td>
<td>• Green Technologies</td>
</tr>
<tr>
<td></td>
<td>• Environmental Cleanup</td>
</tr>
</tbody>
</table>
Building Partnerships, Technology Transfer/Infusion

**Technology Partnerships**
- **NASA**
  - R&T Investments and Assets
  - Technology Expertise
  - Enterprise Objectives
  - Mission Needs
- **INDUSTRY**
  - Capital
  - Technology Expertise
  - Equipment
  - Market Knowledge

**Benefits**
- Shorter Technology Development
- Enhanced Technical Capabilities
- Higher Technology Readiness
- New and Improved Products
- Access New Markets
- Improve Competitiveness
- Mature Technology
- Adoption of New Technology
  - Meet NASA Enterprise Goals
- Meet NASA Enterprise Goals

*Bringing NASA Technology Down to Earth*
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

**NASA Missions**
- Planned human-machine interaction in natural and time delayed environment
- Space & planetary navigation
- Spacecraft autonomy
- Cyber-security for "one-off" systems
- Limited ability to address/recover faults

**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 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

Bringing NASA Technology Down to Earth

technology.nasa.gov
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

Bringing NASA Technology Down to Earth
NASA’s Technology Transfer Portal

Welcome to the T2 Portal

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.

Contact Us
Visit the T2 Program Feedback page to find out who we are and how you can reach us.

T2 Social Media

Search for NASA technologies

Discover Technologies for your Business

Patent Portfolio

software catalog

SPINOFF

2016
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

<table>
<thead>
<tr>
<th>Year</th>
<th>FY06</th>
<th>FY07</th>
<th>FY08</th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>137</td>
<td>129</td>
<td>125</td>
<td>159</td>
<td>131</td>
<td>128</td>
<td>130</td>
<td>150</td>
<td>140</td>
<td>126</td>
</tr>
</tbody>
</table>
NASA Patent Portfolio Analysis

Total Patents Available for Licensing as of Jan. 2016

- 759 Issued
- 372 Applications

- Aeronautics: 98
- Communications: 33
- Electrical and Electronics: 52
- Environment: 28
- Health, Medicine and Biotechnology: 60
- IT and Software: 54
- Instrumentation: 43
- Manufacturing: 36
- Materials and Coatings: 222
- Mechanical and Fluid Systems: 60
- Optics: 66
- Power Generation and Storage: 34
- Robotics, Automation and Control: 68
- Propulsion: 17
- Sensors: 194

Bringing NASA Technology Down to Earth
Software Catalog and Categories

Browse by Category

- Business systems and project management
- System testing
- Operations
- Design and integration tools
- Vehicle management
- Data servers and 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
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.

Bringing NASA Technology Down to Earth
technology.nasa.gov
### NASA Technologies Enabling a Sustainable Earth

<table>
<thead>
<tr>
<th>Assistance to Developing Countries</th>
<th>Use of Green Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Drinking Water</td>
<td>Aeronautics Technologies</td>
</tr>
<tr>
<td>Improved Agriculture</td>
<td>Green Buildings</td>
</tr>
<tr>
<td>Telemedicine and wireless networks</td>
<td>Encouraging Green Technologies</td>
</tr>
<tr>
<td>Improved Environmental Decision Making</td>
<td>Solar Power Applications</td>
</tr>
<tr>
<td></td>
<td>Paint Stripping</td>
</tr>
<tr>
<td></td>
<td>Global Research into Energy and the Environment at NASA (GREEN)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Cleanup</th>
<th>Disaster Warning and Relief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater Remediation</td>
<td>Earthquake relief</td>
</tr>
<tr>
<td>Land Mine Cleanup</td>
<td>Tsunami Warning</td>
</tr>
<tr>
<td>Landfill Cleanup</td>
<td>Wildfire Response</td>
</tr>
<tr>
<td>Oil Spill Cleanup</td>
<td>Hurricane Warning</td>
</tr>
</tbody>
</table>

*Bringing NASA Technology Down to Earth*
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

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

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

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

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

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

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

Bringing NASA Technology Down to Earth
## 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 Fastners
Space Technology Pipeline

Approach for Maturing Promising Low-TRL Technologies

Bringing NASA Technology Down to Earth

nasa.gov/spacetech
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.

---

**Value to NASA**  **Value to the Nation**

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

*Bringing NASA Technology Down to Earth*

nasa.gov/spacetech
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

Spacecraft Disturbance Isolation

Point-Ahead Mirror

Flight Laser Transceiver

Photon-Counting Camera

Electronics & Control

Laser Transmitter

Laser Communication Relay Demonstration

Bringing NASA Technology Down to Earth

nasa.gov/spacetech
Space Instruments and Sensors

Deep Space Atomic Clock

Bringing NASA Technology Down to Earth
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

Power Processing Units (PPUs)

Thrusters

Propellant Feed System & Storage Tanks

SEP Applications

SEP “Space Tugboat”

nasa.gov/spacetech
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

Bringing NASA Technology Down to Earth

nasa.gov/spacetech
Entry, Descent, and Landing

Supersonic Retro Propulsion

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

Computer Modeling and Data

Instrumentation

Low Density Supersonic Decelerator

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

Bringing NASA Technology Down to Earth
Environmental Control and Life Support

Alternate Water Processor

Advanced Oxygen Recovery

Portable Life Support System Integrated Test

Variable Oxygen Regulator 3.0

Mars Oxygen ISRU Experiment (MOXIE)
There are many searchable databases available to help identify technologies of interest. Some of these are summarized below:

NASA Game Changing Technology: [http://nasa.gov/spacetech](http://nasa.gov/spacetech)
NASA Software Catalog: [http://software.nasa.gov/](http://software.nasa.gov/)
NASA Spinoff: [http://spinoff.nasa.gov/](http://spinoff.nasa.gov/)
Partnerships Points of Contact at NASA Ames

Licensing: Trupti Sanghani
  trupti.d.sanghani@nasa.gov (650) 604-6889

Software: Martha Del Alto
  martha.e.delalto@nasa.gov (650) 604-4865

International: Terry Pagaduan
  terence.pagaduan@nasa.gov (650) 604-1181

Technology Transfer: David R. Morse
  david.r.morse@nasa.gov (650) 604-4724