Developing Game Changing Technologies & Bringing Them Down to Earth

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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
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
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 Partnerships

NASA
- R&T Investments and Assets
- Technology Expertise
- Enterprise Objectives
- Mission Needs

INDUSTRY
- Capital
- Technology Expertise
- Equipment
- Market Knowledge

Shorter Technology Development
Enhanced Technical Capabilities
Higher Technology Readiness

Mature Technology
Adoption of New Technology
Meet NASA Enterprise Goals

New and Improved Products
Access New Markets
Improve Competitiveness
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 navigation
Spacecraft autonomy
Cyber-security for “one-off” systems
Limited ability to address/recover faults

*Bringing NASA Technology Down to Earth*
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 Simulation and Neural Prosthesis
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>US Patent Applications Filed</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY06</td>
<td>137</td>
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<tr>
<td>FY07</td>
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<td>FY14</td>
<td>140</td>
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<tr>
<td>FY15</td>
<td>126</td>
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</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
- Propulsion: 17
- Robotics, Automation and Control: 68
- Sensors: 194
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

Vehicle Management (Space, Air, Ground) 48
Aeronautics 30
Autonomous Systems 25
Business Systems and Project Management 51
Crew and Life Support 20
Data Imaging and Processing 98
Data Servers Processing and Handling 65
Design and Integration Tools 120
Operations 90
Electronics and Electrical Power 5
Environmental Science (Earth, Air, Space, Exoplanet) 71
Data Servers 65
Propulsion 27
Structures and Mechanism 6
System Testing 61
Materials and Process 5

Bringing NASA Technology Down to Earth
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.

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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

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

<table>
<thead>
<tr>
<th>Bathrooms</th>
<th>Bedrooms/Sports</th>
<th>Kitchens</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Infrared Ear Thermometer</td>
<td>• Work Surface Light Bulbs</td>
<td>• Water Purification</td>
</tr>
<tr>
<td>• Ingestible Toothpaste</td>
<td>• Temper Foam</td>
<td>• Portable Cordless Vacuum Cleaners</td>
</tr>
<tr>
<td>• Cosmetics</td>
<td>• Phase Change Materials</td>
<td>• Freeze Dried Technology</td>
</tr>
<tr>
<td>• Memory Metal Alloys</td>
<td>• Better Software</td>
<td>• Advanced Solar Cells</td>
</tr>
<tr>
<td>• Polished Brass Finish</td>
<td>• Improved Footware</td>
<td>• Space Garden</td>
</tr>
<tr>
<td>• Bacteriostatic Water Softeners</td>
<td>• Liquid Glass for Tennis Rackets</td>
<td>• Enriched Baby Food</td>
</tr>
<tr>
<td>• Reflective Insulation</td>
<td>• Sport Helmets</td>
<td>• Refrigerator Internet Connected Wall</td>
</tr>
<tr>
<td>• Environmentally Safe Sewage Treatment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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 Footware
- 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

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# 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 – 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**

[technology.nasa.gov](http://technology.nasa.gov)
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
Approach for Maturing Promising Low-TRL Technologies
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

Flight Laser Transceiver

Point-Ahead Mirror

Photon-Counting Camera

Electronics & Control

Laser Transmitter

Laser Communication Relay Demonstration

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technology.nasa.gov
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

“Space Tugboat”

Deep Space Human Exploration

Satellite Servicing

Payload Delivery

Commercial Space Applications

Orbital Debris Removal

ISS Utilization

OGA Missions

Space Science Missions
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

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technology.nasa.gov
Entry, Descent, and Landing

Supersonic Retro Propulsion

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

Low Density Supersonic Decelerator

Computer Modeling and Data

Instrumentation

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

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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)

Mars 2020 Rover

Life Support aboard ISS

Bringing NASA Technology Down to Earth
Finding Technologies

There are also 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://gcd.larc.nasa.gov/
NASA Software Catalog: http://software.nasa.gov/
NASA Spinoff: 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 Pagduan
  terence.pagduan@nasa.gov (650) 604-1181

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  david.r.morse@nasa.gov (650) 604-4724