NASA’s Space Product Development (SPD) division supports the strategic missions to understand and protect our home planet and to explore the universe and search for life. It also seeks to find answers to the biological and physical research organizing sub-question that asks: How can research partnerships—both market driven and interagency—support our national goals, such as contributing to economic growth and sustaining human capital in science and technology? Innovative proposals are sought for market driven technologies and processes that will support NASA’s goals and include dual-use market needs on Earth. There are four initiative areas where NASA space research has strong potential for dual market use on Earth:

1. Self-calibrating and self-repairing bio-MEMS devices for such uses as monitoring crew health in space along with dual applications on Earth for monitoring biological/physical interfaces;

2. Space resource utilization techniques that enable the use of in situ planetary resources along with dual applications on Earth that create products by combustion synthesis of materials, extraction of volatiles, separation of solids;

3. Spacecraft technologies that enhance spacecraft inspections, robotic processing, or Free Flyer experiments with dual applications on Earth, such as high density video and advanced sensor networks;

4. Life support technologies that enable health monitoring, provide functional foods and nutraceuticals and environmentally clean habitats with dual applications on Earth, such as high-resolution wireless ultrasound for patient monitoring, improved crop productions, and new forms of drug delivery. Small business applicants must have strong intentions of becoming a part of NASA’s Research Partnering Center initiatives leading to partnered Phase III contracts for products to be used in space and on the Earth.

Subtopics
The commercial development of space offers enabling benefits to space exploration for NASA. In accordance with the Space Act, as amended, to “seek and encourage to the maximum extent possible the fullest commercial use of space,” NASA facilitates the use of space and microgravity for the development of commercial products and services. The products may use information from in-space activities to enhance an Earth-based effort, or may require in-space use. This subtopic has three goals. The first goal is the commercial demonstration of pivotal technologies or processes, for example, self-calibrating and self-repairing bio-MEMS devices for such uses as monitoring crew health in space along with dual applications on Earth for monitoring biological-physical interfaces. The second goal is the development of associated infrastructure equipment for commercial experimentation and operations in space, or the transfer of these technologies to industry in space or on Earth. An example of this is the automated processes and hardware (robotics), which will reduce crew exposure and time, and which are a priority. The third goal is the commercial research and technologies pursued and developed in the program often have direct applicability to NASA priority mission areas. This dual-use strategy for research and technology has the potential to greatly expand what the NASA scientific and engineering communities can do in advancing exploration mission requirements. All Agency activity in microgravity, including those in life science and microgravity sciences, which lead to commercial products and services as well as benefits to the mission requirements of exploration objectives, are of interest. Below are some specific areas for which proposals are sought.

**Biotechnology**

This category comprises biotechnology, biomedical, and agricultural instrumentation or techniques that exploit space-derived capabilities or data to support the commercial development of space by the agricultural, medical, or pharmaceutical industry.

- Portable biological sensors: The need for sensing devices that can detect and identify biological pathogens (airborne or *in vivo*) is desired to support NASA's mission for a permanent presence of man in space.

- Development of noninvasive health monitoring systems and models: Application to NASA's crew health program for extended duration missions. For example, (1) novel *in vitro* cell-matrix models for studying the effects of microgravity on human tissue repair and wound healing, (2) novel orga-notypic skin models that simulate physiological changes found in humans under a microgravity environment, and (3) functional models for delineating the MG-inducible or MG-responsive pathways of human tissue angiogenesis (new blood vessel formation).

- Physiological measurement in microgravity of bone growth and the immune system in microgravity.

- Innovative research in plant-derived pharmaceuticals using microgravity.

- Agricultural research, i.e., genetic manipulation of plants using microgravity.

- Instrumentation or technology to explore the use of microgravity in genetic assay, analysis, and manipulation.

- Instrumentation to analyze cell reactor systems and characterize cell structure in microgravity in order to develop enhanced drug therapies that can also be applied to pharmaceutical development and commercialization.

- Innovative techniques for dynamic control and cryogenic preservation of protein crystals.

- Innovations in preparation of protein crystals for x-ray diffraction experiments without the use of frangible
Innovation of low-technology temperature control chambers requiring little or no power for bringing temperature sensitive experiments up to, or back from, the International Space Station.

Materials Science

Areas in which Materials Science innovations are sought include the following:

- Applications using space-grown semiconductor crystals, including epitaxially grown materials for commercial electronic devices. The applications will also attempt to use the knowledge of the space-grown material behavior to enhance ground processing of the materials to achieve equivalent performance of space-grown materials in electronic circuitry.

- Applications using space-grown optical electronic materials such as fluoride glasses and nonlinear optical compounds for commercial optical electronic devices and to achieve equivalent performance of space-grown materials in ground processing.

- Innovations using nonlinear optical material to be processed in space.

- Innovations for new space-processed glasses for optical electronic applications.

B4.02 Market Driven Space Exploration Payloads

Lead Center: MSFC

NASA has an interest in the development of science and experiments that support strategic aspects of exploration, as well as the development of technologies to extend humanity's reach to the Moon, Mars, and beyond. This includes designing exploration microgravity payloads. For example, life support technologies that enable health monitoring, provide functional foods and nutraceuticals, and environmentally clean habitats with dual applications on Earth such as high-resolution wireless ultrasound for patient monitoring, improved crop productions, and new forms of drug delivery. Preparing for exploration and research will accelerate the development of technologies that are important to the economy and national security as well as accelerate critical technologies.

Microgravity Payloads

- Design and develop microgravity payloads for space station applications that lead to commercial products or services.

- Enabling commercial technologies that promote the human exploration and development of space.

- Enabling commercial technologies through the use of ISS as a commercial test bed for hardware, products, or processes.
• Enabling technology designed to reduce crew work loads and/or facilitate commercial investigations or processing through automation, robotics, or nanotechnology.

**Combustion Science**

Innovative applications in combustion research that will lead to developing commercial products or improved processes through the unique properties of space or through enhanced or innovative techniques on the ground.

**Food Technology**

Innovative applications of space research in food technology that will lead to developing commercial food products or improved food processes through the unique properties of space or through enhanced or innovative techniques on the ground.

**Biomedical Materials**

Innovative materials where microgravity promotes structures such as biodegradable polymers for use in wound healing and orthopedic applications.

**Entertainment Value Missions**

Innovative approaches for commercial economic benefit from space research involving broadcasting, e-business, or other activities that have entertainment value.

**B4.03 Market Driven Space Infrastructure**

**Lead Center: MSFC**

In accordance with the Space Act, as amended, to "seek and encourage to the maximum extent possible the fullest commercial use of space," NASA facilitates the use of space for commercial products and services. For example, space resource utilization techniques that enable the use of *in situ* planetary resources along with dual applications on Earth that create products by combustion synthesis of materials, extraction of volatiles, and separation of solids; also, spacecraft technologies that enhance spacecraft inspections, robotic processing or Free Flyer experiments with dual applications on Earth, such as high density video and advanced sensor networks. The products may use information from in-space activities to enhance an Earth-based effort or may require in-space manufacturing. This subtopic's goal is the development of infrastructure technology that will enable or enhance commercial space operations. Processes and hardware that have a clear utilization plan are a priority. All space activities that lead to commercial use *in space* are of interest. Some specific areas for which proposals are sought include the following:

**Power and Thermal Management**
Power and thermal management technologies that enable or enhance commercial satellites or space systems are sought.

**Communications**

Broadband, data compression, and imaging that can enable or enhance commercial operations in space or commercial satellites. This includes use of hyperspectral imagery and remote sensing.

**Space Vehicles and Platforms**

Improved technologies are sought for autonomous commercial vehicles and platforms. These technologies include autonomous rendezvous and docking, structures, and avionics.

**Space Resources Utilization**

Advanced commercial space activities will benefit from using nonterrestrial resources. These resources include propellants, power, and structural materials.

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**B4.04 Partnering Innovations for Security and Safety**

Lead Center: MSFC

NASA also has the goal to protect its assets, on Earth and in space, as well as our home planet and better understand the use of technologies that improve the quality of life in space and on Earth. By investing in space research and by collaborating with other agencies, industry, and academia, NASA has the opportunity to contribute to the creation of a more secure environment in space and on Earth. By leveraging resources in support of research in the unique environment of space, NASA goals and national priorities, such as security, as well as market needs, may be achieved. This dual use with good potential for commercial product development is strongly encouraged. Following are some example areas for which proposals are sought:

- Sensors and detection systems to improve processes and operations in support of NASA space research and exploration goals, national security, and industrial processes.
- Improved communication systems to effectively and efficiently gather information from space-based research and provide better communication capabilities in support of NASA; its space and ground-based research and exploration goals are a priority. These systems could also be used to disseminate warnings and other critical information, in the event of a national disaster.
- Innovative devices and procedures for the use of technologies to protect NASA's personnel and assets as
well as citizens from various threats to their personal security and/or property. These devices and procedures for the use of technologies would also provide protection to personnel carrying out NASA space research and exploration operations, both in space and on Earth.

- Countermeasure systems and/or devices to better effect rescue, recovery, treatment, and environmental safety during and after the occurrence of a disaster or a related accident.