



America's Seed Fund powered by the  
National Science Foundation  
Small Business Innovation Research (SBIR)/  
Small Business Technology Transfer (STTR) program  
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## **SOLICITATION TOPICS & SUBTOPICS**

*America's Seed Fund powered by NSF encourages proposals in all areas of science and engineering. An exact fit into one of these topics or subtopics is not required.*

*For proposals due in 2020*

For 40 years, America's Seed Fund powered by NSF has helped startups and small businesses transform their ideas into marketable products and services. We focus on deep technologies — those that are based on discoveries in fundamental science and engineering — and each year, we award about \$200 million in funding to entrepreneurs across the country. Our goals are to foster innovation and help create businesses and jobs in the United States. We are a congressionally mandated program — Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR).

## Technology Topic Areas

- Advanced Manufacturing (M)
- Advanced Materials (AM)
- Artificial Intelligence (AI)
- Biological Technologies (BT)
- Biomedical Technologies (BM)
- Chemical Technologies (CT)
- Digital Health (DH)
- Distributed Ledger (DL)
- Energy Technologies (EN)
- Environmental Technologies (ET)
- Information Technologies (IT)
- Instrumentation and Hardware Systems (IH)
- Internet of Things (I)
- Medical Devices (MD)
- Nanotechnology (N)
- Other Topics (OT)
- Pharmaceutical Technologies (PT)
- Photonics (PH)
- Power Management (PM)
- Quantum Information Technologies (QT)
- Robotics (R)
- Semiconductors (S)
- Space (SP)
- Wireless Technologies (W)

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## Advanced Manufacturing (M)

The Advanced Manufacturing topic aims to support emerging innovations in manufacturing with the potential to stimulate the nation's manufacturing sector by improving its efficiency, competitiveness, and sustainability. Proposed technology should be environmentally friendly, compatible with human health and planet health, and driven by technological advancements. Examples include, but are not limited to, innovative technologies for the processing of a variety of single-component and multi-component materials, biological and bio-inspired materials, flexible electronics, ceramics, polymers, metals, alloys, and novel composites using a variety of advanced manufacturing processes. Regenerative designs using a circular economy approach (a systemic approach to economic development designed to benefit businesses, society, and the environment) are encouraged.

### **M1. Additive Manufacturing Components and Systems**

### **M2. Bio-Inspired Manufacturing**

### **M3. Cybermanufacturing**

### **M4. Human-Centric Industrial Technologies**

### **M5. Manufacturing Technologies**

### **M6. Modeling and Simulation**

### **M7. Personalized Manufacturing / Maker Manufacturing / Maker to Manufacturer**

### **M8. Sustainable Manufacturing Technology / Circular Economy Technologies**

### **M9. Transportation Technologies**

### **M10. Other Manufacturing Technologies**

## Advanced Materials (AM)

The Advanced Materials topic addresses the development of new and improved materials for a wide variety of commercial and industrial applications. Proposals may focus on the creation of innovative material systems and/or on critical fabrication, processing, or manufacturing challenges involved in the successful commercialization of materials. A broad range of applications areas will be considered as part of this topic.

### **AM1. Coatings and Surface Modifications**

### **AM2. Materials for Sustainability**

### **AM3. Metals and Ceramics**

### **AM4. Novel Advanced Materials-based Sensors**

### **AM5. Specialized Functional Materials**

### **AM6. Structural and Infrastructural Materials**

### **AM7. Other Advanced Materials Technologies**

## Artificial Intelligence (AI)

This topic focuses on innovations in the field of artificial intelligence (AI), which refers to intelligence exhibited by machines or software. AI is not a specific technology or technical method — it is instead a field of study aimed at achieving machine-based intelligence. Current AI technologies are targeted at specific problem sets. Artificial general intelligence — machines that can reason like humans — remains a more elusive long-term goal.

AI has the potential to be enormously societally disruptive, and the consequences of its introduction must be carefully considered. Proposers are encouraged to discuss possible negative effects of the proposed technology and how these may be avoided or mitigated.

AI proposals may be submitted either to a broad technical subtopic or under the primary application space, examples of which are listed below.

### **AI1. AI-Optimized Hardware (e.g., electronic chips)**

### **AI2. Business Intelligence**

### **AI3. Computer Vision, Image and Video Processing**

### **AI4. Decision Management and Optimization (e.g., enterprise platforms, finance)**

### **AI5. eCommerce**

### **AI6. Education Technologies**

### **AI7. Human-Computer Interaction**

### **AI8. Industrial Systems, including Robotics**

*Note: This subtopic includes AI innovations pertaining to Industrial Systems. Non-AI innovations related to Industrial Systems should be submitted to the Robotics (R) topic or another suitable topic.*

### **AI9. Language-Based Technologies (e.g., natural language processing, natural language generation, speech recognition, text analytics)**

### **AI10. Machine Learning Algorithms and Platforms**

**AI11. Medical Diagnostics**

*Note: This subtopic includes AI innovations pertaining to Medical Diagnostics. Non-AI innovations related to Medical Diagnostics should be submitted to the Digital Health (DH) topic, the Medical Devices (MD) topic or another suitable topic.*

**AI12. Sales, Advertising, and Marketing****AI13. Security, Cybersecurity, and Authentication****AI14. Smart Agriculture**

*Note: This subtopic includes AI innovations pertaining to Smart Agriculture. Non-AI innovations related to Smart Agriculture should be submitted to the Robotics (R) topic or another suitable topic.*

**AI15. Vehicle-Based Systems****AI16. Virtual Agents and Assistants****AI17. Other AI Technologies**

## Biological Technologies (BT)

The Biological Technologies topic covers a wide range of technology areas to advance engineering and science innovation across the biological spectrum. Biological technologies have disrupted decades-old chemical, agricultural, and medical products and services, producing a new bioeconomy. Potential breakthroughs in this space are on course to make major socioeconomic contributions to the economy by boosting productivity in industrial and agricultural processes, improving human health, and making advances toward environmental sustainability.

Proposed projects should be focused on using or modifying living organisms, systems, or biological processes to develop novel technologies to produce biochemicals, medical products, and agricultural products. They may involve bioengineering to improve function in molecules, cells, and tissues in humans, plants, animals, and microbes. NSF also encourages proposals for enabling technologies, such as new tools for genomics, proteomics, and drug discovery, the development of instruments for biological applications, computational and bioinformatic tools, and new manufacturing technologies for cells, tissues, organs and biologics.

### **BT1. Animal Biotechnology**

### **BT2. Bioinstruments**

### **BT3. Biosensors**

### **BT4. Cell and Tissue Engineering**

### **BT5. Computational Biology and Bioinformatics**

### **BT6. Fermentation Technologies**

### **BT7. Food Processing and Safety Technology**

### **BT8. Life Science Research Tools**

### **BT9. Plant Biotechnology**

### **BT10. Synthetic Biology and Metabolic Engineering**

### **BT11. Other Biological Technologies**

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## Biomedical Technologies (BM)

The Biomedical Technologies topic aims to support the early-stage development of novel products, processes, or services that will enable the delivery of high-quality, economically-efficient healthcare.

**Subtopics are not aimed at supporting or conducting clinical trials, clinical efficacy or safety studies, the development pre-clinical or clinical-stage drug candidates or medical devices, or work performed primarily for regulatory purposes.** Limited studies with human subjects may be acceptable to the extent that they are performed in support of feasibility, proof-of-concept studies of early-stage technologies. **Proposals that request support for clinical studies will be deemed non-compliant with the SBIR/STTR solicitations and may be returned without review.**

**BM1. Diagnostic Assays**

**BM2. Materials for Biomedical Applications**

**BM3. Medical Imaging**

**BM4. Monitoring Devices**

**BM5. Other Biomedical Technologies**



## Chemical Technologies (CT)

The Chemical Technologies topic covers a wide range of technology areas of current and emerging commercial significance pertaining to the broad chemical industry, food processing and technology, agrochemicals, chemical alternatives and organics, green chemicals, water treatment and separations, advanced catalysts and materials, and biochemicals. Sensing, data, and advanced analytics technologies relevant to these fields are also appropriate for this topic area. Beyond improvement on technical specifications, it is important to also clearly identify the competitive landscape of what is currently possible, and why the proposed innovation will an impact commercially and/or from a societal benefit standpoint.

### **CT1. Biochemicals**

### **CT2. Catalysts, Advanced Chemicals and Materials**

### **CT3. Chemical and Environmental Sensing and Data**

### **CT4. Food Processing, Chemicals and Agriculture**

### **CT5. Green Chemicals and Chemical Alternatives**

### **CT6. Separations and Water Treatment**

### **CT7. Other Chemical Technologies**

## Digital Health (DH)

The Digital Health topic aims to support the early-stage development of novel devices, components, systems, algorithms, networks, applications, or services that will enable the transformation of healthcare from reactive, hospital-centered, and indemnity-based to proactive, person-centered, preventive, and cost-efficient.

**Subtopics are not aimed at supporting clinical trials, the clinical validation of information technologies, or medical devices or studies performed primarily for regulatory purposes.**

Limited studies with human subjects may be acceptable to the extent that they are performed in support of feasibility, proof-of-concept studies of early-stage technologies. **Proposals that request support for clinical studies will be deemed non-compliant with the SBIR/STTR solicitations and may be returned without review.**

**DH1. Clinical Decision Support**

**DH2. Healthcare System Workflow**

**DH3. Medical Diagnostics**

**DH4. Personalized Software Systems**

**DH5. Other Digital Health**

## Distributed Ledger (DL)

The Distributed Ledger topic area covers a wide range of technology areas of current and emerging commercial significance and impact spanning all areas of distributed ledger including blockchains, Directed Acyclic Graphs (DAGs), and related capabilities (cryptography, smart contracts, etc.). Applications of these technologies and approaches across any range of industries and commercial uses are appropriate for this topic area. It is important that the proposed project involve novel, distinctive approaches and/or disruptive innovations that enable high potential impact and competitive advantage in its field of use. These subtopic areas are meant to serve as examples of what entrepreneurs may propose in this space; all distributed ledger proposals with technical innovation and significant commercial potential are welcome, regardless of the specific area of focus of the project.

**DL1: Autonomous Systems and Economies; Smart Contracts**

**DL2: Blockchain, DAGs, and Next Gen Protocols**

**DL3: Convergence with Big Data, and Artificial Intelligence**

**DL4: Convergence with Internet of Things, Crowdsourcing and Crowdsensing**

**DL5: Cryptography; Security; Cybersecurity**

**DL6: Distributed Consensus; Fault Tolerance Mechanisms**

**DL7: Distributed Ledger in Edge and Cloud Computing**

**DL8: Distributed Ledger Interoperability**

**DL9: Distributed Ledger in Network Architecture and Management**

**DL10: Financial Technologies**

**DL11: Human-to-Technology Interface; Decentralized Applications (dApps)**

**DL12: Scalability Solutions; Accumulators**

**DL13: Trusted Identity; Identity Management**

**DL14: Other Distributed Ledger Technologies**

## Energy Technologies (EN)

Proposals in the Energy topic are encouraged in the areas of new energy sources and resources, power generation, energy storage, and electronic systems for portable energy sources for mobile technologies and off-grid type applications.. Proposals in all areas of energy generation are welcome, with an emphasis on how the new idea competes favorably with existing solutions. Proposals in oil and gas and related processes are welcome. Proposals that focus on the intersection of energy technologies and data are welcome across all areas where integrations to energy technology, applications are the primary thrust (including computational technologies). Proposals with ideas on nature-inspired processes for sustainable energy solutions and carbon storage, reducing the carbon and resource intensity of hydrocarbon extraction, energy conversion, and its uses are also sought. Proposals involving energy storage from the scale of wearable devices to power plant, and energy conversion are encouraged.

### **EN1. Energy Efficiencies, and Data Technologies**

### **EN2. Energy Production and Power Generation**

### **EN3. Energy Storage**

### **EN4. Petrochemicals, Oil and Gas**

### **EN5. Other Energy Technologies**

## Environmental Technologies (ET)

Environmental Technologies cover a range of innovations that bring the promise of sustainability, high commercial impact and/or societal and environmental benefits. The topic covers a wide range of technology areas of current and emerging commercial significance pertaining to the technologies and materials that improve environmental and or environmental health outcomes. Sensing, data, and advanced analytics technologies relevant to these fields are also appropriate. If the proposed technology or approach addresses a problem without a current solution or one which is underdeveloped, this should be highlighted.

### **ET1. Computational Sustainability**

### **ET2. Emission/Waste Reduction and the Circular Economy**

### **ET3. Food, Agriculture, and Energy**

### **ET4. Habitat Conservation, Adaptation and Restoration**

### **ET5. Sustainable Community Systems**

### **ET6. Water Treatment, Resilience, and Sanitation**

### **ET7. Other Environmental Technologies**

## Information Technologies (IT)

The Information Technologies topic encourages the submission of proposals that present groundbreaking innovations in the generation, analysis, use, transmission, or protection of information, where such innovations offer the potential for substantial commercial returns and positive societal impact. The subtopics below provide specific examples of technologies and applications, although given the enormous range and diversity in the field of IT these examples are inevitably incomplete.

### **IT1. Big Data and Advanced Analytics**

### **IT2. Cloud Computing and High-Performance Computing**

### **IT3. Cloud-based IT Services**

### **IT4. Cybersecurity, Authentication, and Privacy**

### **IT5. Cybersecurity for the Internet of Things**

*Note: This subtopic is focused on cybersecurity innovations pertaining to IoT. Hardware innovations related to IoT should be submitted to the Internet of Things (I) topic.*

### **IT6. Education Technologies**

### **IT7. Human-Computer Interaction, Virtual Reality, and Augmented Reality**

### **IT8. Image and Video**

*Note: Image- and video-based innovations that rely on the use of artificial intelligence should be submitted under the AI3 subtopic.*

### **IT9. Mobile Computing and Internet of Things**

*Note: This subtopic includes IT-based innovations pertaining to Internet of Things (IoT) devices. Hardware innovations related to IoT should be submitted to the Internet of Things (I) topic.*

### **IT10. Networking Technology**

*Note: This subtopic includes IT-based innovations pertaining to IoT networking technology. Hardware innovations related to IoT should be submitted to the Internet of Things (I) topic.*

### **IT11. Social Media and Collaborative Networking**

**IT12. Software**

*Note: This subtopic focuses on IT innovations that are embodied in software and provide important new or enhanced capabilities that will usually be generalized, rather than directed to a specific use case. Examples of such capabilities include (but are not limited to): enhanced computational speed or efficiency; new or improved functionality; improved or extended performance; increased ease of use and accessibility. The range of possible innovations under this subtopic is too broad to describe here. Past examples of significant software innovations cover a wide range of technical approaches and resulting new capabilities, and they include (but are obviously not limited to): object-oriented programming; the GUI; HTTP; HTML; TCP/IP; SQL; internet search engine(s); the spreadsheet; word processing; MapReduce; virtualization.*

**IT13. Other Information Technologies**

## Instrumentation and Hardware Systems (IH)

The Instrumentation and Hardware Systems topic addresses the research and development of new and improved instrumentation and related systems for a wide variety of commercial and industrial applications. Proposals in this topic may deal with new instruments for use in scientific, industrial, engineering, or manufacturing environments, among others. Types of instruments that will be considered include systems and tools designed for the purposes of detection, manipulation, characterization, measurement, processing, control, and/or monitoring. A wide variety of applications areas will be considered as part of this topic.

### **IH1. Instrumentation or Hardware Systems for Actuation, Control, and Manipulation**

### **IH2. Instrumentation or Hardware Systems for Detection and Characterization**

### **IH3. Instrumentation or Hardware Systems for Imaging**

### **IH4. Other Instrumentation or Hardware Systems Technologies**



# Internet of Things (I)

The Internet of Things (IoT) is a rapidly evolving field that involves the interconnection and interaction of smart objects (objects or devices with embedded sensors, onboard data processing capability, and a means of communication) to provide automated services that would otherwise not be possible. IoT is not a single technology, but rather involves the convergence of sensor, actuator, information, and communication technologies. Emerging IoT implementations will use smaller and more energy-efficient embedded sensor technologies, more sophisticated actuators, enhanced communications, and advanced data analytics to collect and aggregate information and enable intelligent systems that understand context, track and manage complex interactions, and anticipate requirements. Market verticals that are potentially impacted by innovations in this area include connected cities and homes, smart transportation, smart agriculture, industrial IoT, and retail IoT. Proposals are encouraged that address key challenges across the full range of IoT applications involving hardware devices and sensors. Advances focusing on software, cybersecurity, and computing technologies should apply under one of the Information Technologies (IT) subtopics.

## **I1. IoT Communications**

## **I2. IoT Integrated Systems**

## **I3. IoT Sensors and Actuators**

## **I4. Other IoT Technologies**

## Medical Devices (MD)

The Medical Devices topic aims to support the early-stage development of novel products, processes, or services that will enable the delivery of high-quality, economically-efficient healthcare in the United States and globally.

The medical devices topic is not aimed at supporting or conducting clinical trials, clinical efficacy or safety studies, the development of pre-clinical or clinical-stage drug candidates or medical devices, or work performed primarily for regulatory purposes. Limited studies with human subjects may be acceptable to the extent that they are performed in support of feasibility, proof-of-concept studies of early-stage technologies. **Proposals that request support for clinical studies will be deemed non-compliant with the SBIR/STTR solicitations and may be returned without review.**

### **MD1. Implantables**

### **MD2. Orthopedic**

### **MD3. Rehabilitation Devices**

### **MD4. Sensors**

### **MD5. Wearables**

### **MD6. Other Medical Devices**

## Nanotechnology (N)

The Nanotechnology topic addresses the creation and manipulation of functional materials, devices, and systems with novel properties and functions that are achieved through the control of matter at a submicroscopic scale (from a fraction of nanometer to about 100 nanometers). This includes, but is not limited to, innovative hierarchical nanostructures, nanolayered structures, nanowires, nanotubes, quantum dots, nanoparticles, nanofibers, and other nanomaterials and biomaterials and their composite structures. Proposals focusing on global technological challenges through development of innovative nanotechnologies are especially encouraged.

### **N1. Nanomanufacturing**

### **N2. Nanomaterials**

### **N3. Nanotechnology Solutions to Global Grand Challenges**

### **N4. Other Nanotechnologies**

## Other Topics (OT)

The Other Topics area is intended to be a home to any proposed project that does not seem to fit into one of the other technology topic areas, but still meets the NSF SBIR/STTR goals of supporting research and development of deep technology, with commercial viability and the potential to benefit society.

### **OT1. Other Topics**

## Pharmaceutical Technologies (PT)

The Pharmaceutical Technologies topics covers a wide range of technology areas to advance the discovery, early-stage development and characterization, formulation, delivery, and/or manufacture of novel drugs, moieties, compounds, products, processes, platforms or services that will improve the selection, quality, or price of pharmaceutical therapies.

The Pharmaceutical Technologies topic is not aimed at supporting or conducting clinical trials, clinical efficacy or safety studies, the development of pre-clinical or clinical-stage drug candidates or medical devices, or work performed primarily for regulatory purposes. Limited studies with human subjects may be acceptable to the extent that they are performed in support of feasibility, proof-of-concept studies of early-stage technologies and must follow NSF policies on research on human subjects (<https://www.nsf.gov/bfa/dias/policy/human.jsp>). **Proposals that request support for clinical studies will be deemed non-compliant with the SBIR/STTR solicitations and may be returned without review.**

**PT1. Artificial Intelligence for Drug Development**

**PT2. Cell and Biologics Manufacturing**

**PT3. Drug Delivery Methods**

**PT4. Drug Discovery Platforms**

**PT5. Pharmaceutical Bioinformatics**

**PT6. Pharmaceutical Manufacturing**

**PT7. Therapeutic Molecules**

**PT8. Other Pharmaceutical Technologies**

## Photonics (PH)

The Photonics topic addresses the research and development of new materials, devices, components, and systems that have the potential for revolutionary change in the optics and photonics industries. Photonic technologies can include anything generally operating in or using photons in the electromagnetic spectrum from gamma rays down to long radio waves. Examples include photovoltaics, lasers, various light emitting diode technologies (LED, OLED, QLED), radiation detectors, and novel communications technologies.

**PH1. Advanced Metrology and Sensors**

**PH2. Advanced Optical Components and Systems**

**PH3. Communications, Information, and Data Storage**

**PH4. Lighting and Displays**

**PH5. Photon-based Energy Conversion**

**PH6. Other Photonics Technologies**

## Power Management (PM)

The Power Management topic address the development of novel technologies that enable new power and thermal management solutions. Innovations supported could range from device-scale breakthroughs, to embedded or standalone systems, to grid-scale technologies.

**PM1. Energy Harvesting Devices and Systems**

**PM2. Materials and Devices for Power Electronics**

**PM3. Materials and Devices for Thermal Management**

**PM4. Novel Power and Thermal Management Sensors**

**PM5. Power Management Infrastructure and Smart Grid Systems**

**PM6. Systems for Thermal Management**

**PM7. Other Power Management Technologies**

## Quantum Information Technologies (QT)

This topic focuses on innovations in information and communications technologies that rely fundamentally on quantum mechanical properties and interactions. Typically, such innovations will involve the generation, detection, or manipulation of quantum states to provide faster, more efficient or more secure information processing and communications. Proposals may include innovations at the component, sub-system, or system level that result in substantial and usable improvements in the generation, transmission, detection, storage, or processing of information, or the security and privacy of information. Proposed innovations must offer the potential for robustness, reliability, scalability, and operation at temperatures that are practical within the constraints of the intended application. Innovations at the component and sub-system level should aim for compactness and energy efficiency, consistent with the requirements of the application.

Examples of technology innovations in the quantum computing subtopic could include qubit generation and detection; development of computational models (quantum circuits, etc.); error correction; algorithms; software; hardware sub-systems and systems; and Noisy Intermediate-Scale Quantum (NISQ) computers. Examples of technology innovations in the quantum communications subtopic could include components such as sources, memories, repeaters, detectors; hardware sub-systems and systems; networks; cryptography; and key distribution.

### **QT1. Quantum Communications**

### **QT2. Quantum Computing**

### **QT3. Quantum Sensing and Metrology**

### **QT4. Quantum Simulation**

### **QT5. Other Quantum Information Technologies**



## Robotics (R)

Proposals addressing robot intelligence and experiential learning, particularly those in the areas of high-performance processors or hardware to provide situational awareness, and improved artificial intelligence, are welcome. Innovations in voice, obstacle and image recognition, emotional response, and hand-eye coordination are encouraged. We encourage proposals describing projects that borrow features from other animal nervous systems and include biologists, neuroscientists, and/or psychologists on their team to exploit new knowledge in the study of the brain and behavior. NSF also seeks proposals that address next-generation automation, the flexible and rapid reconfiguration of assembly lines allowing mass customization, the use of advanced control, scheduling, modularization, and decentralization with agile, mobile robotic systems that can enable the cost-effective manufacture of small lot-size products, and on-demand parts manufacturing. Proposals to support the physical and educational needs of individuals with disabilities (e.g., vision, hearing, cognitive, motor related) are sought. Robotic applications in healthcare, smart drones and drone networks are appropriate. Medical devices that provide new capabilities to doctors including surgery; robotic exoskeletons to enhance human strength; personal robots with an emphasis on human-centered end use and interaction, personal caregiving and increased autonomy; and robots of augmentation are welcome.

### **R1. Human Assistive Technologies and Bio-related Robotics**

### **R2. Human-Machine Interfaces and Control/Architecture**

### **R3. Robotic Applications**

### **R4. Robotics in Agile Manufacturing, and Co-Robots**

### **R5. Other Robotics Technologies**

## Semiconductors (S)

The Semiconductors topic addresses the research and development of new designs, materials, devices, and manufacturing systems that have the potential for impactful change in the semiconductor industry.

**S1. Electronic Devices**

**S2. Electronic Materials**

**S3. Integrated Circuit Design**

**S4. Microelectronics Packaging and Systems Integration**

**S5. Novel Semiconductor-based Sensors**

**S6. Processing and Metrology Technology**

**S7. Other Semiconductor Technologies**

## Space (SP)

The Space topic will seek revolutionary technologies to be deployed outside Earth's atmosphere to enhance the commercial use of space. Technologies could include innovations that provide cheaper, safer, and more frequent products and solutions to commercial space customers. This topic particularly seeks to support growth-oriented small businesses who have not previously received significant SBIR/STTR funding and are seeking to contribute to economic growth by developing innovative technologies supporting the overall emerging space economy.

Proposals should be addressing real capability gaps or enabling technologies for the space industry, anchored with a solid understanding of the challenges of working in space, including launch, mass and volume restrictions, radiation and thermal environment, communications and latency, power and energy, etc. NSF encourages proposals with revolutionary satellite and vehicle hardware or systems innovations involving propulsion systems, navigation systems, and energy collection and power generation systems unique to space environments, in-space manufacturing systems and services; Earth imaging and sensing; planetary (other than Earth) physical surveying, mapping, and prospecting services; extraction and processes of water and volatiles (not on Earth); and analytic algorithms based on data collected extensively from space-based systems, either alone or in combination with terrestrial systems.

### **SP1. Extra-terrestrial Resource Extraction**

### **SP2. Geological and Geoclimatic Science Data Technologies**

### **SP3. Ground Launch Sites and Satellite Operations Technologies**

### **SP4. In-space Manufacturing Technologies**

### **SP5. Navigation and Positioning Technologies**

### **SP6. On-Orbit Technologies**

### **SP7. Remote Sensing Technologies**

### **SP8. Space Transportation and Access**

### **SP9. Spacecraft Development and Manufacturing**

### **SP10. Telecommunications Technologies**

### **SP11. Other Space-related Technologies**

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## Wireless Technologies (W)

Proposals of interest involve next-generation wireless communication technologies requiring systems with high data rates, low cost, and that support a wide variety of applications and services, while maintaining full mobility, minimum latency, and long battery life. Devices and subsystems that increase data throughput rates via cell density, increased spectrum, multiple input, multiple output (MIMO), massive MIMO, and new “antenna” concepts. NSF welcomes proposals involving modulation and demodulation techniques for signal generation and reception through spectral efficiency, noise immunity, jamming immunity, and power efficiency; radio frequency (RF) pollution: device and circuit; processing algorithms/3D spatial control; high efficiency devices such as micro-TWT, smart dust, and inductive couplers. NSF seeks proposals in the areas of spectrum-related research and development activities that improve the efficiency by which the radio spectrum is used, and the ability of all members of the public to access spectrum-related services. Mobile and automotive radar, smart solar panels, on-panel DC-AC converters, and self-testing and self-networking devices are also of interest.

### **W1. Wireless Devices and Components**

### **W2. Wireless Systems**

### **W3. Other Wireless Technologies**