NSF SBIR / STTR SOLICITATION TOPICS AND SUBTOPICS

For proposals due June 2015

The National Science Foundation's SBIR/STTR program provides seed money for startup and small business private ventures. For more information, please visit http://www.nsf.gov/eng/iip/sbir.

Please note that the topics and subtopics listed here are examples only and are NOT exhaustive. NSF SBIR/STTR encourages proposals in all areas of science and engineering. An exact fit into one of these topics or subtopics is not required!

Smart Health (SH) and Biomedical (BM) Technologies

Smart Health (SH)

The need for a significant healthcare transformation has been recognized by numerous organizations, including the President's Council of Advisors on Science and Technology (PCAST), National Research Council (NRC), Institute of Medicine (IOM), Computing Community Consortium (CCC), the National Academy of Engineering and the Office of the National Coordinator for Health Information Technology (ONC).
The Smart Health subtopics aim to support the early stage development of novel devices, components, systems, algorithms, networks, applications, or services that will enable the much needed transformation of healthcare from reactive, hospital-centered, and indemnity-based to proactive, person-centered, preventive, and cost-efficient. **The SH 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.**

SH1. Business Models for User-Centered Healthcare

Proposed projects should include transformative business models that are enabled by novel technologies and are designed for the benefit of healthcare providers, consumers, patients and/or their caregivers. Such technology-driven business models will: reduce the cost of health care; facilitate the shift of public and private incentives toward patient-centric goals; empower patients and healthy individuals to participate in their own health and treatment, such as educating customers, accessing, and visualizing health data and knowledge; reduce the impact of socio-economic status, gender, and ethnicity in the participation of people in their own health treatment. Overall, these new business models are expected to improve health-related behaviors; improve patient-physician communication, patient engagement, and care coordination. Proposed projects must a) focus on the development of technology that enables such novel business model(s); and b) demonstrate the expected economic benefit of the novel business model in user-centered healthcare.

SH2. Digital Health Information Infrastructure

Proposed projects may include technologies that will enable: interoperable, distributed, federated, and scalable digital infrastructure; languages and tools for effective sharing and use of electronic health record data, data representation for such including semantic metadata, and networked applications that access such data; continuously extensible universal exchange language for current and future health and wellness data originating from diverse sources in multiple formats; data methods for controlling and maintaining data integrity, provenance, security, privacy, and reliability of original as well as aggregated data, providing trustworthy patient identification and authentication and access control protocols, and maintaining sensitivity to the legal, cultural, and ethical issues associated with universally accessible digital health data in the U.S.; or systems methods for measuring and optimizing operations to improve quality and productivity of healthcare delivery systems.

SH3. From Data to Decisions

Proposed projects may include methods and algorithms that: aggregate multi-scale clinical, biomedical, contextual, and environmental data about each patient (e.g., in EHRs, personal health records - PHR, etc.); enable unified and extensible metadata standards; serve as decision support tools to facilitate optimized patient-centered, evidence-based decisions; evaluate the safety, effectiveness, efficiency, and clinical outcomes of mobile health applications; integrate patient information with delivery systems performance

and economic models to support operations management decisions; support inferences based on individual or population health data, multiple sources of potentially conflicting information, while complying with applicable policies and preferences; enable the secondary use of health data to support the assisted and automated discovery of reliable knowledge from aggregated population health records and the predictive modeling and simulation of health and disease. Proposals are encouraged to integrate technological, behavioral, socio-economic, value-driven actions, ethical, and systemic factors that interfere with patients' collaboration in care teams, adherence to treatment, and wellness regimens.

SH4. Interoperability of Medical Sensors, Devices and Robotics
Proposed projects may include protocols and interface standards to enable interoperable, temporally synchronized, medical prosthetic and embedded devices and devices for the continuous capture, storage, and transmission of physiological state and environmental data; assistive technology systems and devices for improved health and healthcare that incorporate sensory inputs and computational intelligence ranging from internal and external sensors, wearable prosthetics, and cognitive orthotics to surgical-assist robots and social robots; sensors, analysis tools, and activators needed to assess and limit adverse environmental effects on health and wellbeing; simulation and modeling methods and software tools that aid in the design and evaluation of sophisticated medical devices and how they communicate to medical information systems in the clinic, home, and in and around the person.

Biomedical Technologies(BM)
The Biomedical Technologies subtopics aim 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 U.S. as well as globally. **The BM subtopics areare 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.**

BM1. Pharmaceutical Manufacturing
Proposed projects must include new processing or manufacturing devices, components, and systems that will improve the efficiency, competitiveness, and output of the nation's pharmaceutical manufacturing sector; that will reduce the cost, risk, and time-to-market of new pre-clinical and clinical-stage drugs and biological products; or that address major market opportunities in the developing world. Proposed projects may include transformative approaches and methods in manufacturing operations, project management, process development, process engineering, analytical development, or quality control and assurance. Proposals are strongly encouraged to address the net preservation and extension of natural resources, a reduction in the use or release of toxic or harmful constituents, the use of less extreme temperatures or conditions, or a reduction in the production of waste.

BM2. Materials for Biomedical Applications
Proposed projects may include biological materials, biomimetic, bioinspired, bioenabled materials and synthetic materials, all intended for biological, medical, veterinary, or healthcare applications. Examples of proposals may include (but are not limited to) the synthesis, purification, functionalization, characterization, development, validation, processing, scale up, and manufacturing of biomaterials. Novel polymeric materials, polymers, plastics, additives, sealants, elastomers, textiles, alloys, ceramic and composite biomaterials, improved implants; coatings for therapeutic applications; or nanomaterials.

BM3. Tissue Engineering and Regenerative Medicine
Proposed projects may include enabling engineering and manufacturing approaches, technologies and systems that will advance the research, development, quality control, and production of artificial tissues and their derivatives in scientific, therapeutic, or commercial applications. Proposed projects may also include novel methods or technologies to replace or regenerate damaged or diseased animal or human cells, tissues, or organs to restore or establish their normal function.

BM4. Biomedical Engineering

Proposed project should focus on using engineering approaches to develop transformative methods and technologies that will solve problems in medicine. Proposed projects may include devices and systems that provide new strategies for the prevention, diagnosis, and treatment of health conditions; advance end-of-life or palliative care; reduce drug counterfeiting; and enable new and more efficient risk-management methods to better address safety issues of drugs and medical devices; motion or structural biomechanic technologies for the improvement of human motion, and sensors, actuators, and intelligent systems for surgical robotics. Proposers are encouraged to form an interdisciplinary team that includes relevant engineering as well as biology/health-related expertise.

BM5. Noninvasive Imaging of Brain Function

Proposed projects may include novel, noninvasive technologies and instrumentation for imaging the structure and function of the in vivo human brain. Proposed projects should focus on developing engineering, multidisciplinary, or multi-modality noninvasive brain imaging tools that could overcome current limitations of existing techniques (such as, for example, constraints on subject motion during imaging, requirements for elaborate electromagnetic shielding from the environment, requirements for active cooling of imaging system sensors, and system resolution that is much coarser -millimeter to centimeter scale- than that required to detect activity corresponding to individual neuronal signaling). Projects may also be aimed at developing new data processing techniques or approaches to data interpretation.

Technologies not aimed at brain imaging must be submitted under subtopic BM6.

BM6. Medical Imaging Technologies

Proposed projects may include (but are not limited to) novel or improved imaging technologies and/or imaging agents to advance the diagnosis and treatment of disease, and to improve prognosis. Technologies aimed at brain imaging should be submitted under subtopic BM5.

BM7. Diagnostic Assays and Platforms

Proposed projects should focus on transformational diagnostic technologies. Proposed projects may include (but are not limited to) non- or minimally-invasive disease diagnosis, detection and monitoring, software-based diagnostic methods, biomarker development, disease-specific assays, personalized medicine, flexible implantable devices, lab-on-a-chip technologies, and low-cost point-of-care testing for diseases.

BM8. Drug Delivery

Proposed projects may include novel, early-stage, and transformative platforms, chemical formulations, excipients, devices, or methodology for the delivery of drugs or biological products.

Biological Technologies (BT)

BT1. Agricultural and Food Safety Biotechnology
New approaches for meeting the world's future nutritional needs. For Agricultural Biotechnology, target areas for improvement may include (but are not limited to) drought tolerance, improved nutritional value, enhanced disease resistance, and higher yield. Proposers should use biotechnology in their approach, and should give consideration to technologies that enhance biodiversity, produce less carbon dioxide, and use less water and fertilizer. For Food Safety, this may include handling, preparation, and storage of food in ways that prevent foodborne illness, as well as origins of food including the practices relating to food tracking, hygiene, additives, and certification systems.

BT2. Biosensors
Biosensors are sensors that contain a biologically-based sensing element. Proposed projects might include (but are not limited to) real-time sensors, microbial component-based sensors, sensors for monitoring fluxes of metabolites, nanobiotechnology-based sensors, biomedical sensors, and micro- or nanofluidic-based sensors. Application areas of interest may include (but are not limited to) toxicity testing, food safety, drug evaluation, environmental monitoring, and bio-prospecting. Other types of sensors should refer to the EI topic.

BT3. Life Sciences Research Tools
Developing novel technologies that will advance scientific research across the biological spectrum. This may include enabling technologies for drug discovery (high-throughput screening assays and platforms, and high-content screening assays and platforms; novel high-content screening technologies based on characterization of physical properties of cells are of high interest). Proposals should focus primarily on the development of innovative consumables, processes, and services where there is significant market opportunity.

In addition, we are interested in new tools for brain research, especially those that aid in addressing fundamental neurobiological questions about brain function, laying the groundwork for advancing treatments for nervous system disorders or traumatic brain injury, and for generating brain-inspired "smart" technologies to meet future societal needs.

BT4. Bioinstrumentation
The development of technology for novel or improved instrumentation primarily for biological research applications. In addition, this may include low cost instruments for science and engineering that are aimed at students or others in working in low resource settings.

BT5. Synthetic Biology and Metabolic Engineering
Using synthetic biology to engineer novel biologically-based (or inspired) functions that do not exist in nature. Proposed projects may include creating new manufacturing capability by designing microorganisms, plants, and cell-free systems for the production of novel chemicals and biomolecules. Applications may include (but are not limited to) health-care products, food ingredients, chemicals, and other biomaterials such as enzymes and bio-based polymers.

BT6. Fermentation and Cell Culture Technologies
Proposed projects might include (but are not limited to) novel or improved microbial fermentation or mammalian and plant cell culture technologies, bioreactors, processes, scale-up, development of expression platforms, and purification. This may include technology development for pilot and large scale manufacturing of biopharmaceutical and other products.

BT7. Computational Biology and Bioinformatics
Developing and applying computationally intensive techniques (e.g., pattern recognition data mining, machine learning algorithms, and visualization) and may include (but are not limited to) sequence alignment, gene finding, genome assembly, drug design, drug discovery, protein structure alignment, protein structure prediction, prediction of gene expression and protein-protein interactions, genome-wide association studies, and the modeling of evolution. Proposed projects might include the creation and

advancement of databases, algorithms, computational and statistical techniques, and theory to solve problems arising from the management and analysis of biological data.

BT8. Advanced Biomanufacturing
Developing design and automation tools in synthetic biology and cellular engineering for bio-based production, which may include scale-up and implementation as well as the development of standards that will facilitate interoperability and reproducibility.

Chemical and Environmental Technologies (CT)

The Chemical and Environmental Technologies (CT) topic covers a wide range of technology areas of current and emerging commercial significance pertaining to the broad chemical industry and the environment. Phase I proposals would typically be at the proof of concept/technical feasibility stage on new or novel technology concepts and innovations when submitting to this overall topic area. A proposal should present a clear value proposition, the market opportunity, a strategy for commercialization of the innovation, a business case for how the innovation could rapidly lead to revenue generation for the small business, a clear detailed description of the technical innovation and the key technical challenges that need to be overcome with SBIR/STTR funding, and finally, a clearly defined research and development (R&D) program detailing tasks, timelines and success metrics for a Phase I R&D program. It is important that the proposed project involve novel, discontinuous, disruptive innovations and be built on a firm framework of sustainability involving green chemistry and green engineering approaches. The project should focus on addressing clear commercial and societal needs, with strong potential to catalyze and accelerate U.S. job creation through scalable business growth.

CT1. Bio-Based Chemicals
Relevant projects could involve novel chemical/biochemical/biotechnological process technologies for the conversion of renewable raw material sources to cost-competitive products that represent new products or, sustainable alternatives to existing commercial industrial commodity, intermediate, specialty and fine chemicals and pharmaceuticals products derived from non-renewable sources. Technology proposed should also be built on sustainable, energy efficient, and waste minimization or waste elimination paradigms with scalable process technologies for the production of bio-based chemicals and products. Projects could involve proof of concept or technical feasibility work on all aspects of proving out a production process. Technologies that primarily focus on the separation and purification of products made through biochemical pathways should submit to the Separations Technology (CT2) topic. Process intensification approaches should consider the CT12 topic.

CT2. Separations
Relevant projects could involve any separation technology that enables and/or enhances the efficiency of separations in existing or new process technologies in any industrial application with a focus on facilitating particularly challenging separations resulting in economically significant improvements in selectivity, throughput, energy efficiency, capital/operating costs and environmental impact. Application areas include (but are not limited to) air separations; separations for multi-component streams; multiphase streams; separation technologies in both inorganic and organic chemical applications in any industry; novel purification processes; materials that permit effective separations; sensor designs based on separations; recycle and recovery of higher value materials from waste; separations of toxics from waste; recycle and recovery of critical and strategic materials and metals. Novel separation techniques and media as disruptive improvements to current established separation technologies are encouraged, including (but not limited to) organic/inorganic membranes, novel materials and biologically mediated separations. Applications of the proposed technologies could belong in any industrial sector, including (but not limited to) drinking water and wastewater treatment; food, medical, pharmaceutical, chemicals, metals/mining, natural resource extraction, materials processing, waste recycling and biochemical/biotechnological processes.

CT3. Chemicals, Polymers and Plastics Technology
Relevant proposals could involve new and novel chemical and biochemical routes to making any commodity, intermediate, specialty, fine, consumer chemicals, polymers, plastics, polymeric materials and composites with unique and novel properties and functionality for any existing or new industrial or consumer products. Projects may focus on novel approaches that possess superior cost and performance characteristics compared to an existing commercial technology/product; show enhanced end-of-life biodegradability and superior recyclability. Projects may involve (but are not limited to) the development of novel polymeric materials; bioplastics; biosurfactants; coatings; sealants; elastomers; adhesives; composites; pesticides, herbicides and insecticides; self-healing polymers, fibers, films and coatings; multifunctional polymers and polymeric materials for use in electrochemical and electronic applications; sustainable packaging materials for food and non-food applications; novel materials/barriers/coatings enhancing health and safety in industrial/commercial applications; bioengineered polymers/plastics and biochemically produced chemicals, monomers and polymers that lead to more sustainable, greener replacements to current products/materials. Projects of interest may seek to develop technologies that facilitate recycle, and conversion of post-consumer waste, industrial, agricultural and food waste, waste polymeric materials, plastics, etc., into cost competitive products for commercial use.

CT4. Novel Catalytic Processes and Reaction Technology
Processes that chemically or biochemically (including catalytic/biocatalytic approaches) produce products from renewable and abundant natural resources with substantially improved process, energy efficiency, reduced capital and operating costs, and reduced environmental impact compared to current approaches. New or novel green chemistry processes in any industry; technologies involving the development of novel homogeneous and heterogeneous catalysts and biocatalysts, co-catalysts, promoters, and/or novel supports that are highly active, selective and have longer lifetimes compared to the state-of-the-art. Proposals may seek to develop sustainable catalysts that are based on environmentally friendly and non-toxic metals, non-metallic, and earth-abundant elements; catalysts enabling the simplification of complex multistep chemistries into fewer steps and ideally a single step with high selectivity, productivity and life.

CT5. Carbon Dioxide and Methane Conversion to Industrial Chemicals
Proposed approaches could include novel chemical/catalytic/biochemical/biotechnological routes to achieving the industrial scale conversion of carbondioxide and/or methane to useful commercial products/materials. Proposals of interest could seek to develop and commercialize processes for efficient carbon dioxide capture and its conversion to cost competitive chemicals and materials resulting in net carbon sequestration on a life cycle analysis. Proposals of interest could also include those with catalytic process technologies for the conversion of methane (from natural gas, landfills, wastewater treatment, etc.) to industrial chemicals; novel catalytic or biochemical/biocatalytic process technologies to directly convert captured carbon dioxide to methanol through non syngas routes, as well as novel technologies to convert methane directly to methanol and hydrocarbons and cost competitive chemicals (through non syngas routes).

CT6. Food / Pharmaceutical Technology
Proposals of interest could involve developing new production and manufacturing innovations in food processing or active pharmaceutical intermediates and finished product production; reaction engineering; innovative process technology for scale-up and sustainable manufacture of new and existing products; novel process designs, unit operations, separations, purification approaches applied to food or pharma production; upgrading food and agricultural waste to higher value products; process intensification innovations; technology for improved process monitoring, control, and sensing technologies for production quality and safety; novel food and pharma storage technologies; innovations that conserve the food supply and lead to lower wastage in the supply chain from farm to consumer; sustainable packaging materials; intelligent/active/smart packaging for food and pharma safety and protection in the supply chain; real-time microbial contamination sensing and control, improvements in speed, reliability and efficacy in detection of contamination, adulteration, chemical degradation; technologies to enhance process safety and sanitation; new materials and benign protective coatings for food and pharma processing, handling and storage in industrial and domestic use; food and pharma ingredient traceability; real-time detection of chemical and microbiological hazards. Proposals may bring forth innovations to solve significant process development and scale-up challenges in development of new food and/or pharmaceutical processes.

CT7. Sustainable Technologies for Energy Efficiency, Capture, Storage and Use
Proposed projects could include novel technology and approaches for the direct capture, conversion, storage, and use of any renewable energy sources such as wind, solar, solar-thermal, ocean, geothermal, bioenergy etc; and waste heat recovery. Projects may include novel technology that leads to substantial enhancement in energy storage capacity, energy use efficiency, smart energy management, thermal management and insulation; superior energy recovery from waste streams compared to currently available technologies in any applications, including (but not limited to) residential, commercial, and industrial applications. Technologies may include innovations in (but not limited to) combinations of mechanical, electrical, electrochemical, chemical/material, and biochemical approaches to improving energy efficiency in any commercially relevant application with potential for a significant scalable societal impact. Innovations for existing or novel energy storage and conversion technologies (such as batteries, capacitors, supercapacitors, novel fuel cells/engines, etc.) are also relevant; nature-inspired processes for sustainable energy generation or capture; materials innovations in energy applications; lubrication/tribology innovations leading to enhancing energy efficiency; innovations in insulation materials; off-grid portable energy generation and storage technologies that completely rely on renewable sources to allow supporting industrial energy needs in remote and underdeveloped economic regions. Proposals may also cover new or novel system level optimization/monitoring/control approaches to enhancing sustainability and energy usage and efficiency of any industrial process and manufacturing technologies.

CT8. Bioenergy and Renewable Fuels Technology
Proposed projects might include new and novel methods to generate energy from (but not limited to) marine, plant, algal, biomass and microbial bio-energy sources; microbial hydrogen production, delivery and

storage; novel fuel cell technologies; innovations in high-yielding biomass crops for energy and chemicals production that do not compete with food supply. Proposed projects might involve the development of new, commercially viable renewable fuel options with reduced environmental impact relative to existing fuels, including (but not limited to) drop-in replacements to petroleum-based transportation fuels.

CT9.Water Conservation, Treatment and Reuse, Waste Minimization, Recycling and Environmental Sustainability

Proposed projects may present novel process and product technologies for pollution prevention; technologies that dramatically reduce water usage in industrial and domestic/municipal use; technologies that lead to more efficient use of water as a resource; technologies leading to substantial reduction or even elimination of industrial water usage by developing sustainable alternatives. Technologies proposed could involve improvements in the energy efficiency of water/wastewater treatment approaches; remove challenging pollutants from industrial and municipal wastewater that have a significant short term and/or long term environmental, ecological and economic impact. Technologies proposed should be significant breakthroughs or enhancements relative to the current state of the art and seek to address current and emerging industrial/municipal and agricultural challenges with water conservation, use, recycle and treatment. The proposed technology projects could span a broad spectrum of operational arenas including point of use, portable, off-grid, and fixed installations for domestic, municipal, industrial, and agricultural applications to enhance waste minimization, water and wastewater treatment, water resource recycle, reuse and conservation. Projects of interest may seek to develop technologies that facilitate recycle and possibly recover valuable products from (but not limited to) reprocessing of waste from agricultural operations, food processing, post-consumer and industrial waste, waste chemical, plastics, polymeric materials, plastics, etc.; recycle of precious metals, critical and strategic metals from industrial waste. Projects may include the development of technologies (smart sensors, novel process equipment, novel process technology designs, etc.) that facilitate more efficient operation of production processes and waste minimization in any aspect of commerce or industrial production/manufacturing operations.

CT10. Environmental Pollution Control and Mitigation

Proposed projects may include methods to reduce human ecological and environmental impacts; microbial contamination sensing and control; the detection of toxic and hazardous chemicals; the removal of toxic and hazardous compounds from the environment and from consumer products to enhance human/animal health and safety; pathogen and toxin diagnostics technologies; novel bioremediation technologies; air pollution monitoring, mitigation and removal of gaseous pollutants and particulates; explosives detection; technologies that reduce and remove greenhouse gases by converting them to useful products; improvements in environmental compatibility and sustainability of manufacturing/production/processing operations. Projects could involve real-time sensing, internet enabled distributed and networked systems and smart devices/sensors/analyzers/detectors for local and remote environmental (soil, water and air) pollution/emissions monitoring, control and minimization; innovations that use big data and Internet of Things approaches for pollution tracking and monitoring; technologies that enhance safe monitoring of hazardous and toxic chemicals; innovations that provide superior end-of-life handling and disposal technologies of equipment/material, etc., that eliminate pollution, environmental and public health impact would be relevant.

CT11. Sustainable Plant-based Products and Agricultural Technology

Proposed projects may seek to develop novel technologies that allow for the more effective use of renewable forestry as a biomass feedstock through biochemical, bioengineered or green chemistry pathways for the production of plant and wood based industrial chemicals, cellulosic fibers, lignin-based materials, plastics from cellulose, packaging and building materials, coatings, sealants, elastomers, adhesives, etc. Technologies that allow for the more efficient processing of plants and wood for industrial use and technologies that enhance the renewal and management of forests for sustainable industrial and commercial use would be relevant. Of relevance would be: plant and agricultural biotechnology innovations that increase the efficiency of nutrient assimilation; improved drought tolerance and resistance; sustainable and commercially viable precision agricultural and forestry technologies; high productivity harvesting technology; soil, environmental sensing and monitoring technologies that improve forest and agricultural crop management and productivity, reduce carbon foot print, and enhance the sustainability of silviculture/agricultural practices.

CT12. Process Intensification Technology

Proposals may seek to develop innovative process equipment and technology across all chemical and industrial manufacturing operations that lead to significant process simplification, intensification, enhanced efficiency, productivity enhancement, waste minimization or waste elimination, lower carbon footprint and greener, more sustainable processes; systems that lead to substantially improved energy efficiency and

substantially improved transport characteristics in challenging heat transfer, mass transfer, mixing and reaction applications, including but not limited to systems involving multiple phases and complex rheology; novel unit operations, improved heat transfer and insulation technology; reaction technology and process design innovations in the production of (but not limited to) commercial chemicals, metals, materials, food, pharmaceutical, commodities and finished products; novel micro reactors; process miniaturization, lab on a chip approaches; process automation systems that facilitate the safe conduct of complex and hazardous chemistry through novel system designs that include (but are not limited to) process simplification, capital efficiency, retrofittability, leading to greener and more efficient process technology in new and existing manufacturing/production facilities.

CT13. Smart Chemical Processes and Process Equipment Technology
Proposals may involve innovations that seek to develop smart production technology, process engineering real-time modeling software along with smart hardware systems to enhance the energy efficiency, sustainability, resource utilization efficiency and operational reliability and safety of existing and new manufacturing capacity in the broad chemical industry. The effective use of big data and Internet of Things paradigms for enhancements in chemical process technology and manufacturing systems; improvements in managing the sustainability of industrial supply chains; dynamic production and supply chain optimization; smart systems that use process data from sensors for real-time and dynamic process optimization and control; enhancing process safety; process control; fault detection, tolerance and mitigation; operational reliability and efficiency would be relevant to this topic. Technologies that are discontinuous and breakthrough innovations that can improve existing manufacturing and production processes and unit operations, either as new or retrofittable or drop-in solutions, would be relevant.

CT14. Sustainable Chemistry and Green Engineering Technology
This topic seeks to broadly capture innovative technology development projects that are seeking to develop engineered products, technologies and system solutions involving green engineering and green chemistry approaches that may also involve cross-cutting and multidisciplinary approaches to addressing significant commercial and societal needs through technological solutions. Projects may propose innovations that enhance sustainability through any combination of reducing carbon foot print, energy intensity, natural resource use, pollution, toxicity, safety hazards and environmental impact. Projects may include any breakthrough technology development that will result in new solutions to significant societal needs, or significantly enhancing or replacing existing commercial products/technologies/processes with greener, sustainable alternatives.

Educational Technologies and Applications (EA)

Administrative Information
Submitted proposals for education applications should provide storyboards, sketches, or descriptions of how the proposed application will work and provide examples of how users would interact with the application and how learning takes place. Projects that propose technologies or products similar to those in the marketplace or those similar to existing products and processes are unlikely to be funded without a case for a strong innovative technical component. Projects that can be easily replicated by potential competitors such as curricula, tutorials, and paper or generic electronic publications are not likely to be funded as they usually lack sufficient technical innovation. Systems that simply combine existing knowledge with existing technologies tend to lack innovation and are unlikely to be funded.
When submitting a proposal to the EA Topic, indicate the corresponding subtopic where the strongest case for the project's technical innovation can be made. For example, use EA1 for proposed projects that are in the area of "General Education Applications", followed by appropriate keywords such as K-12, high school, informal education, chemistry, health, information technology, physics, social media, search engines, robotics, etc. Keywords may be used by NSF to help find reviewers familiar with your project's innovation, technology, education, and commercial environment. Proposals submitted to the EA topic areas may also be considered in consultation with the United States Department of Education prior to the NSF SBIR/STTR program making an award decision.

EA1. General Education
EA1 topics can include 1) technology transfer of innovative and sustainable products and services that leverage and commercialize education research investments made to educational institutions by the National Science Foundation and other government agencies; 2) authentic and active learning approaches that are more student-centered in environments that are familiar to learners; these approaches should provide solutions that address the needs of a variety of learners, including K-12 students, college students, families, particular types of community members, teachers, and the general public; 3) innovative delivery, applications, open content, and curricula on science, technology, engineering, and math (STEM) that provides new or alternative forms of sharing and repurposing of information, content, pedagogies, and experiences that are long-term and sustainable; 4) learning technologies that motivate and enhance the self-esteem and learning performance of students; 5) innovative applications that better enable classroom management, recordkeeping, and standards-aligned planning, and facilitate or ease the burden of the ever-increasing roles and responsibilities of educators while permitting more effective use of educational resources; 6) systems and tools that may better enable education leaders to benefit from agile start up models to implement change across institutional settings; and 7) authoring systems and content generators that easily allow educators to create, distribute, and share new resources across multiple platforms; 8) applications that better enable informal and traditional learning or applications that help bridge formal and informal learning environments or effectively promote positive behavior changes; and 9) technologies to preserve the nation's collective and cultural heritage including the protection of objects, artifacts, documents, conservation, and archival objects that can include physical, artistic, cultural, engineering, electronic, and other multi-disciplinary educational documents.

EA2. Global and Collaborative Education
EA 2 topics can include 1) innovative applications that use online learning, hybrid learning, crowdsourcing, collective intelligence, and collaborative models with new tools with the potential to deliver new and powerful educational opportunities in STEM disciplines; 2) learning environments that allow students to control and experiment with educational situations in relationship to their personal learning style to acquire knowledge anytime, anywhere; 3) technologies that enable innovative forms of educational collaboration across national boundaries; 4) learning applications that provide for better decision making and informed judgments about problems and situations affecting global issues related to theory, education technology, and data; 5) projects in which technology allows the tailoring of learning experiences to special needs and interests of groups or individuals or allows expanding formal education beyond classroom settings; 6) applications that support and promote cultural diversity, international awareness, and understanding; 7) interoperable mobile learning environments that enable students to access and connect to vast resources of knowledge, wherever they may be located, through smart phones, tablets, wearable devices, or tools that have yet to be developed; 8) virtual and remote laboratories that enhance the physical science laboratory for use in global and distance learning to leverage the availability of equipment that may otherwise be unavailable; 9) natural voice, video, and online learning tools that humanize the online learning experience such as mimicking and detecting face-to-face experiences and interactions to communicate more

authentically in a global environment; 10) gesture-based computing applications, semantic analysis, and intuitive technology tools that enable individual and collaborative work with multiple students interacting on content simultaneously; and 11) sensors and systems that detect student engagement, frustration, or boredom while providing real time feedback to both students and teachers.

EA3. Simulations and GamingTechnologies
EA3 topics can include STEM-related innovative educational gaming applications that enable engaging learning experiences, digital literacy, collaboration, problem solving, communications, critical thinking, and skill improvement; 1) single-player, small-groups, or massively multiplayer online gaming applications that foster cooperation and can include card, board, or digital games; 2) serious games, simulation-based games, and entrepreneurial type games with substantial innovations that go beyond porting current knowledge, processes, and applications towards existing technologies and delivery platforms; 3) games that target the assessment of student knowledge while providing intrinsic motivation for student participation; 4) games that better enable entrepreneurs to learn and effectively compete in a global economy; 5) games that support immersive and experimental learning; 6) simulations and role-playing games where students can participate in providing creative solutions to difficult or complex situations; and 7) laboratory simulations that accurately reflect similar physical environments that may otherwise be costly, use precious resources, expose students to dangerous situations, or otherwise be unavailable for general student use.

EA4. Entrepreneurial and Maker Education
EA4 topics can include 1) entrepreneurship education and training that integrates diverse topics such as strategic planning, business model development, opportunity recognition, product design development and entry, intellectual property, project management, legal requirements, custom manufacturing, production scale-up, crowdsource funding, and business constraints in in new and innovative ways for success in the contemporary global economy; 2) maker empowerment with education and innovative tools for citizens who create things such as entrepreneurs, scientists, engineers, inventors, researchers, educators, and students to dream, design, create, manufacture, and commercialize products and services or to provide life-long learning experiences; 3) innovative techniques and systems that can increase the participation or demonstration in hands-on learning related to citizen science, engineering, technology, and entrepreneurship of technical products and services; 4) innovative tools to learn or judge the effectiveness and validity of external resources for research, product launch, and effective operations of technological and education related products and services; and 5) devices and tools that enable expanded dimensional learning such as 3D modeling and printing, computer aided design (CAD), as well as new materials and technologies for science, engineering, and technological learning environments.

EA5. Learning and Assessment
EA5 topics can include 1) data-driven learning and assessment using new sources of data for a personalized learning experience and the assessment and measurement of performance, 2) *learning analytics* tools to process and analyze data streams to modify learning goals and strategies in real time; 3) adaptive learning environments combined with assessments that provide alternative paths of instruction; 4) personal learning environments that allow students to control their environment in relationship to their personal learning style to acquire knowledge with consideration of their teacher's expectations; 5) big data, searching, data mining, data analysis, intelligent agents, knowledge modeling, user models, mobile tools, and decision support systems that improve the understanding of teaching and learning to improve student performance, retention, and transfer in environments that may include one-to-one, one-to-many, and many-to-many relationships; and 6) collecting, analyzing, sharing, and managing data that promotes learning or leads to designed learning environments.

EA6. Computer Science and Information Technology for Education
EA6 topics can include 1) tools that build real-time information from data-mining on complexity, diversity, and similar types of information to generate knowledge that can be used to revise curricula and teaching; 2) cloud-based services and applications that support collaboration, file storage, teacher and student productivity, data collection, data security, data privacy, and ubiquitous access to information in secure environments in an educational setting; 3) innovations that provide for better learning and knowledge transfer in many-to-one, one-to-many, and many-to-many environments; 4) education tools that benefit from objects having their own IP address or location based services for new types of communications, assistive technologies, and new applications of benefit primarily to education; 5) wearable information centers, power sources, flexible displays, jewelry, glasses, output devices, and input tools that allow students to interface with computers and other devices in creative new ways that help overcome natural or physical barriers to learning; 6) virtual assistive technologies that may combine developments in

engineering, computer science, and biometrics that add substance to both formal and informal learning situations; 7) systems and applications that address privacy concerns of educators and students including the safeguarding of personal data in connected education environments; 8) innovative tools to quickly automate and allow for the rapid conversion of educational media for easy archival and porting to multiple devices and formats; 9) innovations that allows students and others to use technologies that may improve their performance, knowledge, expertise, and provide for a rich educational experience.

Electronic Hardware, Robotics and Wireless Technologies (EW)

Sensors (SE)

Recent technological advancements in materials science and bioengineered systems have made inexpensive, powerful, and ubiquitous sensing a reality. Examples range from truly smart airframes and self-evaluating buildings and infrastructure for natural hazard mitigation to large-scale weather forecasting, self-organizing energy systems, and smart devices that self-assemble into networks leading to the first electronic nervous system that connects the Internet back to the physical world. New detection technologies that overcome barriers of time, scale, materials, and environment, and emphasize self-calibration, selectivity, and sensitivity are solicited.

Wireless Technologies (WT)

Wireless has become the platform for many applications with direct impact on virtually every aspect of life, evolving well beyond mobile phones and PDAs to other devices, services, channels, and content. Microwave circuits afford wider frequency spectrum and very short antennae. With GaAs and SiGe, entire microwave transceivers can be inexpensively put on a single chip. Modulation methods, like spread-spectrum and orthogonal frequency-division multiplexing, bring greater spectral efficiency and more bits/Hz of bandwidth, and lead to less susceptibility to noise, interference, and multi-path distortion. On-chip DSPs allow new signal-processing functions. RFID chips are providing improvements in warehousing, materials handling, and shipping operations, replacing bar-code labels in many areas.

WT1. Systems and Devices

Proposals that 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 are sought.

WT2. Spectrum Usage

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 Americans to access spectrum-related services.

Energy and Power Management (EP)

In the power electronics realm, as CMOS chips go to finer lithography with each new generation, their multiplying transistors require lower voltages and higher currents. These trends have driven up power demands on printed circuit boards and placed constant pressure on power-supply and power-system developers to increase the efficiency and power or current density. At the same time, the trends toward lower voltages and higher currents have encouraged migration from centralized to distributed and portable power architectures.

EP1. Electronic Devices, Boards and Interfaces

Newer chips with lower supply-voltage requirements has greatly complicated power-system and power-supply design. Innovations in the areas of low-power device design and manufacturing as well as printed circuit and other boards that will operate at lower power and longer lifetimes are welcome.

EP2. Sustainable Energy Harvesting, Storage and Management - Device and System Level

Proposals are solicited in the areas of electronic systems for portable energy sources for mobile technologies and off-grid type applications, including new energy sources. Proposals in the areas of power management systems for energy scavenging/harvesting and compact energy conversion systems, conversion from renewable resources, interface devices between batteries and super-capacitors as well as smart power demand-response management systems are welcome. 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 sought. Innovative projects may include new critical devices, components, and systems for energy harvesting and conversion from renewable resources (excluding solar technologies). Refer to PH topic for solar technologies.

EP3. Smart Grids and Infrastructure
Proposals that address innovations in new technologies that support smart infrastructures (such as materials, sensors, devices, and control systems) to ensure efficient and sustainable energy transmission, distribution, monitoring, and management are sought.

EP4. Power Management
Innovations in the areas of (but not limited to) novel voltage conversion, micro-inverters and DC-DC voltage converters, and compact hi-voltage, hi-power systems are welcome. Proposals covering new energy sources for portable and mobile devices, smart power demand-response management systems (e.g. smart grids, buildings, and circuits), inverters, motors, and generators for higher efficiency, smaller size and power factor corrections are encouraged.

Robotics and Human Assistive Technologies (RH)
Considerable progress will be made if robots possessed the high intelligence needed to cope with uncertainty, learn from experience, and work as a team. Robot designers are borrowing features from insect nervous systems, and engineers and computer scientists collaborate with biologists, neuroscientists, and psychologists to exploit new knowledge in the study of the brain and behavior. Some robots will help people do what they can't or would rather not do. Other robots will tackle complex projects by working as teams. Robots will help protect critical infrastructure and monitor the environment as mobile, intelligent sensors. High-performance processors, hardware to provide situational awareness, and improved artificial intelligence (AI) are enabling researchers to create lifelike robots with an entire gamut of facial expressions.

RH1. Learning, Intelligence and Motion
Proposals addressing robot intelligence and experiential learning, particularly those in the areas of high-performance processors/hardware to provide situational awareness, and improved artificial intelligence, are welcome. Innovations in voice, obstacle and image recognition, emotional response, and eye-hand coordination are encouraged. Proposals describing projects that borrow features from other animal nervous systems and include biologists, neuroscientists, and/or psychologists in their team in order to exploit new knowledge in the study of the brain and behavior, are encouraged.

RH2. Robotic Applications
Proposals involving robotics and intelligent machines having complex, human-like behavior for applications such as the protection of critical infrastructure or the monitoring of the environment while using mobile technologies and sensors networks are sought. Innovations in areas such as improved time imaging, visualization, deep learning, neuromorphic computing, biorobotics, brainOS, human-robot interaction, dexterity and manipulation, anthropomorphic (human-shaped) robots, naturally inspired, biomimetic, neuromechanical robotics, haptic, real-time and bio-inspired feedback are also welcome. Other applications, including (but not limited to) precision agriculture, are also appropriate.

RH3. Robotics in Agile Manufacturing
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 are sought.

RH4. Co-Robots
Innovations in the development of co-robots, robots that work symbiotically (beside, in direct support, or cooperatively) with people, to extend or augment human capacities are welcome. Proposals describing the next generation of robotic systems able to safely co-exist in close proximity to humans in the pursuit of mundane, dangerous, precise, or expensive tasks; for sensors and perception, actuators and control, intelligence, machine learning techniques, architectures, systems, human/robot interfaces, and other developments that either realize or help to realize co-robots in manufacturing, service, construction, exploration, and assistive applications are encouraged.

RH5. Control and Architecture
Proposals involving novel and advanced approaches to sensing, perception, and actuation in embedded and highly distributed systems; intelligent control architecture for robotic systems; the development of human-robot interfaces; communication and task sharing between humans and machines, and among machines; and self-diagnosing, self-repairing robots, are sought.

RH6. Human Assistive Technologies and Bio-related Robotics
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 (tele-robotics, robotic prosthesis, robot-assisted rehab, miniature robotics, high-throughput technologies - imaging, screening of drugs, surgical procedures) 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, increased autonomy; robots of augmentation are welcome. Proposals that address concepts for protecting human hands (in various extreme environmental conditions), and haptic, real-time and bio-inspired feedback concepts and mechanisms are also sought.

Micro-electronics Packaging, Thermal Management & Systems Integration (MT)
Proposals are solicited on more efficient means of integrating semiconductor components and devices into systems. The growth in chip density, coupled with the demand for high performance, small size, light weight, and affordable reliability has placed enormous pressure on interconnect technology and packaging at all levels. Innovations include (but not limited to) improved techniques for interconnect and packaging at the board level, packaging approaches for the board components, the passive components, techniques for board assembly, and applications of techniques to packaging and systems integration for optoelectronics and wireless systems.

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, information, communication, and actuation technologies.

Today, most of what we consider as IoT is a variety of largely stand-alone devices and isolated systems, such as wearable fitness monitors, home thermostats and lighting, remote video streaming, smartphones, and smart watches. Emerging IoT implementations will use smaller and more energy- efficient embedded sensor technologies, enhanced communications, advanced data analytics, and more sophisticated actuators to collect and aggregate information and enable intelligent systems that understand context, track and manage complex interactions, and anticipate requirements.

IoT is expected to become ubiquitous, with implementations in the smart home - management of energy use, control of appliances, monitoring of food and other consumables; consumer applications - health and fitness monitoring, condition diagnosis; manufacturing and industrial settings - supply chain management, robotic manufacturing, quality control, health and safety compliance; utility grids and other critical infrastructure - grid optimization, automated fault diagnosis, automated cyber security monitoring and response; and automotive/transportation - optimization for driving conditions, assessing driver alertness, collision/accident avoidance, managing vehicle health.

Proposals are encouraged that address key challenges across the full range of IoT applications.

IoT1. IoT Sensors and Actuators
IoT is on track to connect 50 billion "smart" things by 2020, and one trillion sensors soon after. This subtopic includes (but is not limited to) innovations in device and materials technology to enable new sensor functionality, further sensor miniaturization, improved sensor performance or more efficient energy use; actuator technologies to enable new IoT functionalities; and device packaging innovations that enable further sensor or actuator miniaturization and embedding in a greater range of smart objects and devices.

IoT2. IoT Energy and Power Systems
Many of the components that enable IoT will have to operate in severely power constrained network edge environments, requiring improvements in energy efficiency in simple, low-cost systems. In many cases, the devices will not have a consistent power supply, and local energy harvesting will therefore be required. This subtopic includes (but is not limited to) novel power management integrated circuits aimed at miniaturizing devices and increasing energy efficiency; power management systems for energy harvesting to enable mobile or remote IoT devices and systems; and smart power protocols for IoT devices. This subtopic can also include broader categories of energy-efficient technologies to enable mobile IoT applications, such as displays, power efficient IC's, and innovative mobile battery solutions.

IoT3. IoT Communications
Enabling ubiquitous connectivity and the aggregation of IoT data presents key data processing and communications challenges as the industry tries to simplify and define how "smart" things interact. A wide variety of communication solutions, both wired and wireless, will likely emerge. This subtopic includes (but is not limited to) innovations that will substantially improve the underlying technical performance, or extend the functionality, of IoT communication systems. Particular emphasis is placed on low-power and data-efficient communications schemes, as these are required to enable IoT in resource-constrained environments. Examples of relevant technical fields include (but are not limited to): short range and long distance transmission technologies - optical, RF, microwave or ultrasonic; communication signal sources and detectors - optical (lasers, LEDs, photodetectors), RF, microwave or ultrasonic; and electronic or optoelectronic signal processing technologies to facilitate efficient low-power data transmission or reception.

IoT4. IoT Integrated Systems

Many of the benefits of IoT require the full integration of complex systems to enable developers to build innovative service delivery platforms. This subtopic includes (but is not limited to) new design and development platforms that facilitate widespread adoption of IoT; IoT systems with the flexibility to allow rapid development and deployment of new use cases and functionalities; and shared platforms designed for lean, power-constrained environments that enable the easy integration of sensors and actuators, communication technologies, and data processing to create new business models for IoT.

IoT IT. Cloud, Big Data and Security and Privacy (see IT portfolio topics)

Data is rapidly emerging as the most important currency driving IoT. Offloading computation to the cloud, providing overall system security, and guaranteeing the privacy of users remain key challenges in IoT. Companies developing innovations in these spaces should refer to the IT topics of this SBIR/STTR solicitation.

Information Technologies (IT)

Introduction
Information technology is increasingly impacting almost every aspect of our lives, from communicating with friends and family to manufacturing of the products we use, the efficient supply of food and provision of healthcare services, and the performance of financial markets and our nation's economy.

The past decade has seen explosive growth in the generation of data and the creation of usable information from that data. This is expected to accelerate into the foreseeable future, fueled in part by the increasing interconnectedness of the products and services that we use.

This topic encourages the submission of proposals that present ground-breaking innovations in the generation, analysis, or use of information, where such innovations offer the potential for substantial commercial returns and a positive impact on society and the world in which we live. The subtopics below provide specific examples of technologies and applications, although given the enormous range of information technology applications, these examples are inevitably incomplete. Proposals are encouraged under any of the specific subtopics IT1 to IT9. Proposals that do not fit these subtopics can be submitted under the subtopic "IT10: Other".

IT1. Big Data; Advanced Data Analytics
This subtopic focuses on information technology innovations in the fields of big data and advanced data analytics. These fields cover a wide range of technical sub-specialties and applications, and the examples provided are indicative only.

Examples of relevant technical fields include (but are not limited to): predictive analytics; simulation; optimization; data visualization; network visualization; visual data analytics and optimization (image and video); data fusion and integration. Applications are many and varied - examples include (but are not limited to): predicting buying patterns and trends, insurance claims, mortality rates, tax fraud, traffic patterns and delays, equipment failure, election outcomes, criminal/terrorist activities, and the spread of disease; improving healthcare outcomes; optimization of equipment performance and maintenance scheduling; optimization of manufacturing processes; predicting and optimizing traffic flow (internet traffic, road traffic, etc.); internet search; business informatics; logistics management; supply chain management; visualization of utility networks; climate modelling; geographic information systems (GIS); crowdsourcing; detecting and preventing cyber-attacks.

IT2. Cloud Computing; High-Performance Computing; Cloud-based IT Services
This subtopic focuses on information technology innovations in computing capabilities that are aimed at enabling or enhancing the analysis of complex science, engineering, medical, business or social issues. A specific focus is technologies related to internet-based networked computing resources.

Examples of relevant technical fields include (but are not limited to): infrastructure as a service; platform as a service; software as a service; virtualization; cloud-based storage; distributed computing; computer cluster architectures; in-memory processing; device⇔cloud architecture; data integrity and availability; data security and confidentiality in distributed computing networks. Applications include (but are not limited to): stock market analysis and prediction; cryptanalysis; weather forecasting; fluid dynamic modelling, acoustic modelling and other computationally intensive engineering modelling; advanced speech processing; video analysis and processing.

IT3. Artificial Intelligence, Machine Learning, Natural Language Processing (NLP)
This subtopic focuses on information technology innovations in the field of artificial intelligence(AI), which refers to intelligence exhibited by machines or software. AI is usually limited or targeted in nature, with general machine-based intelligence remaining an elusive long-term goal.

There are many technical approaches to AI, and an even greater diversity of potential applications. Current fields of use include (but are not limited to): intrusion detection - in software systems, communications networks, and sensor systems; the finance industry - optimizing operations and stock investments; medicine - clinical decision support, computer-aided interpretation of medical images; industry - robotics and automation, process management, quality control; and online/telephone customer service - automated assistants.

This subtopic includes a particular focus on machine learning and natural language processing (NLP), both of which are disciplines within the broader field of artificial intelligence. Machine learning refers to processes in which an automated system can learn from data, rather than following a pre-specified set of rules, and in many cases can predict outcomes relating to the learned process. NLP uses machine learning to extract information or derive meaning from human language (written or spoken) or to generate human language.

Examples of relevant technical fields within machine learning include (but are not limited to): supervised machine learning; semi-supervised machine learning; unsupervised machine learning; neural networks; machine learning algorithms - e.g. decision tree learning; robot learning; pattern recognition; image recognition. Examples of technical fields within NLP include (but are not limited to): parsing; named entity recognition; data extraction from text; natural language understanding; natural language generation; automatic summarization; machine translation; analysis of structured or unstructured text; speech recognition; speech analysis; speech processing. Applications across both technical fields include (but are not limited to): improvements in human-computer interaction - e.g. computers anticipating users' needs; automated manufacturing; machine vision; robotic control systems; cyber-physical control systems; sentiment analysis; analysis of online commentary; automated medical diagnosis; stock market analysis; translation services (including speech-to-speech translation).

IT4. Networking Technology
This subtopic focuses on information technology innovations that will enhance the performance, functionality and monitoring of information networks, with particular emphasis on the internet and Internet of Things (IoT) networks.

Examples of relevant technical fields include (but are not limited to): software defined infrastructure - including software defined networking and software defined storage; software defined data centers; analytics to optimize network performance; network visualization; network protocols; technologies to reduce network congestion and improve network resiliency; data management and processing technologies for resource-constrained environments such as in Internet of Things (IoT) applications; machine-to-machine networks; network-based data storage and retrieval technologies; data distribution - e.g. video distribution; anywhere/anytime access to data and services.

IT5. Mobile Computing and Internet of Things IT
This subtopic focuses on information technology innovations that will improve the performance or functionality of mobile devices and devices that operate in resource-constrained environments - such as in Internet of Things (IoT) applications. While there is some overlap with other subtopics, proposals submitted to this subtopic should be focused on innovations specifically intended for these platforms.

Examples of relevant technical fields include (but are not limited to): location technology; image recognition and processing; video processing; speech recognition and generation; translation services; gesture and expression recognition and processing; biosignal processing; crowdsourced storage; crowdsourced processing; peer-to-peer device networking; user/device collaboration (e.g. device anticipating and addressing a user's needs); device - cloud architecture; data analytics and data processing to facilitate the Internet of Things (IoT)s; mobile commerce; vehicle-based computing platforms.

IT6. Image/Video Processing
This subtopic focuses on information technology innovations that enhance the storage, transmission, processing or use of image and video data.

Examples of relevant technical fields include (but are not limited to): image recognition and tagging; facial recognition; automated video categorization; video summarization; 3D image capture and processing; video compression; video analysis; video enhancement; storage and transmission of video data; video curation.

IT7. Social Media /Collaborative Networking
This subtopic focuses on information technology innovations that will add value to social, professional, business, or technical interactions over the internet.

Examples of relevant technical fields and applications include (but are not limited to): collaborative healthcare; the sharing economy; professional networks; B2B networking; image and video centric

networks; micro video; social media advertising and marketing; social networking tools; visual content optimization (image and video) for social media; video sharing.

IT8. Cyber Security and Privacy
This subtopic focuses on information technology innovations that protect networks and devices against cyber-attack, or protect data and user information against compromise.

Examples of relevant technical fields include (but are not limited to): big data security; data/network analytics to detect cyber vulnerabilities and cyber-attacks; human factors analytics - to assess people risk; mobile device security; deviceïƒ³cloud security infrastructure; cloud computing security; security/privacy policy compliance; security for BYOD (bring-your-own device) and BYOC (bring-your-own-cloud); security for the Internet of Things (IoT), from industrial IoT settings to smart homes to wearable devices; data loss prevention; information assurance; data integrity; encryption; key generation, key management and key distribution; access authorization; identity management; personal authentication - biometrics, multi-factor authentication.

IT9. Software
This subtopic focuses on information technology innovations that are embodied in software and provide important new capabilities. Usually these will be generalized capabilities, not directed to a specific use case. Examples of such features or benefits 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 far too broad to attempt to describe here. Past examples of significant software innovations cover a broad range of technical approaches and resulting new capabilities, and 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.

IT10. Other
This general subtopic is intended to capture any information technology innovations that are not covered in the preceding subtopics, and that have the potential to generate substantial commercial returns and to lead to a positive societal impact.

Semiconductors (S) and Photonic (PH) Devices and Materials

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. Proposals should be motivated by market opportunity, a compelling value proposition, clearly identified end users and customers of the proposed technology, and a viable pathway to commercialization.

PH1. Lighting and Displays

Subtopic includes (but is not limited to) solid state lighting and smart lighting systems and controls, energy efficient display technologies, light emitting diodes (inorganic or organic), display backplane technology, and transparent conductors.

PH2. Communications, Information, and Data Storage

Subtopic includes (but is not limited to) optical communication and networking infrastructure and components, photonic integrated circuits, new materials and systems for data storage, novel components for network applications, and multifunctional and other novel optical fibers implementations.

PH3. Energy

Subtopic includes (but is not limited to) photovoltaic materials and devices, systems for smart glass applications, breakthrough thermophotovoltaics, metamaterials, and materials and systems for solar thermal applications.

PH4. Advanced Metrology and Sensors

Subtopic includes (but is not limited to) sources and detectors for advanced IR systems, advanced remote sensing systems, sources and detectors for advanced microscopy, novel camera systems for 3D metrology, and advanced imaging systems.

PH5. Advanced Optical Components and Systems

Subtopic includes (but is not limited to) the building blocks for next generation optical components and systems, such as new photonic materials, breakthrough process technologies, nanophotonics, biophotonics, plasmonics, photonic integrated circuits, and manufacturing techniques to enable low-cost breakthroughs for advanced photonic components. Proposals in this area should take special care to clearly highlight real market opportunity and a compelling value proposition for the technology.

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. Proposals should be motivated by market opportunity, a compelling value proposition, clearly identified end users and customers of the proposed technology, and a viable pathway to commercialization. The program encourages cooperation with the semiconductor industry to address current challenges as well as new frontiers.

S1. Electronic Materials

Subtopic includes (but is not limited to) novel semiconductor materials, magnetic materials, advanced thermal management materials for device integration, materials for advanced lithography, and materials for high-temperature, high-power, or high-frequency applications.

S2. Electronic Devices

Subtopic includes (but is not limited to) advanced semiconductor devices, bioelectronics and biomagnetics, quantum devices, magnetic and multiferrous and spintronics devices, memory devices, power electronics, flexible electronics, and nanoelectronic devices.

S3. Processing and Metrology Technology
Subtopic includes (but is not limited to) processing and metrology technologies that enable low cost, high performance or novel, advanced semiconductor devices.

S4. Integrated Circuit Design
Subtopic includes (but is not limited to) low power circuits and architecture, novel chip architectures, and the integration of nano- to micro-scale devices on circuits.

Advanced Materials and Instrumentation (MI)

Introduction
The Advanced Materials and Instrumentation (MI) topic addresses the development of new and improved materials and instruments for a wide variety of commercial and industrial applications. Proposals in Advanced Materials 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. Proposals in Instrumentation may focus on 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, characterization, measurement, processing, control, and/or monitoring. A wide variety of applications areas will be considered as part of this topic.

MI1. Metals and Ceramics
Material innovations to improve the performance of and/or allow new functions in metallic and ceramic materials. This topic includes bulk materials (e.g. superalloys, ceramics, and composites) and coatings (e.g. thermal and environmental barrier coatings, and tribological coatings), as well as other morphologies (e.g. foams). This subtopic also includes composites of metallic and ceramic materials (metal-matrix and ceramic-matrix composites).

MI2. Structural and Infrastructural Materials
Material and process innovations to improve the performance of materials in structural applications. Includes (but is not limited to) materials for civil infrastructure (e.g. cement, concrete, structural panels, etc.) and polymer composites for various applications. Structural materials that are metallic or ceramic should be submitted under topic MI1.

MI3. Coatings and Surface Modifications
Material and process innovations in surface modifications and coatings. Includes (but is not limited to) coatings for improved corrosion and wear resistance, anti-microbial and anti-fouling coatings, surface modifications for specialized applications such as superhydrophobic or biologically/chemically active surfaces, and techniques to improve manufacturability and reduce cost. Refer to the MI1 topic for proposals related to inorganic coatings.

MI4. Multiferroics and Specialized Functional Materials
Innovations related to multiferroics or other functional materials for specialized applications. Includes (but is not limited to) piezoelectrics, ferroelectrics, thermoelectrics, magnetostrictives, or electrochromics, shape memory alloys, ferrofluids, materials for high or low thermal conductivity applications, novel materials for active device or energy harvesting applications, functional thin films, and novel materials for sensing or instrumentation.

MI5. Materials for Sustainability
Material innovations designed for improved sustainability, mitigating adverse environmental impacts, and/or improved public health. Includes (but is not limited to) new processes and techniques that allow for new or increased use of recycled, renewable, non-toxic and/or environmentally-benign materials. Proposals are also encouraged for new innovations that reduce overall energy consumption or waste, or that increase recyclability or reusability at end-of-life.

MI6. Other Materials
New innovations in materials that do not fit into any of the above five materials topics but that nevertheless meet the intellectual merit and broader/commercial impact criteria of the NSF SBIR/STTR program.

MI7. Instrumentation for Characterization and Imaging
New innovations in instrumentation whose primary purpose is measurement, characterization, or imaging. Includes (but is not limited to) optical and electron microscopy, scanning probe methods, magnetic imaging (NMR, MRI, etc.), spectroscopic and chemical methods, and other scientific instrumentation.

MI8. Instrumentation for Detection, Actuation, Control, and Manipulation
New innovations in instrumentation whose primary function is detection, control, or manipulation. Includes

(but is not limited to) new instruments for use in industrial processes, manufacturing, research, engineering, military, and/or consumer applications.

MI9. Other Instrumentation

New innovations in instrumentation that do not fit into either of the above two instrumentation topics but that nevertheless meet the intellectual merit and broader/commercial impact criteria of the NSF SBIR/STTR program. Refer to the BT topic for bioinstrumentation.

Advanced Manufacturing & Nanotechnology (MN)

Advanced Manufacturing (M)

The Advanced Manufacturing (MN) subtopic aims to support all current and emerging aspects of manufacturing innovations that have the potential to rejuvenate the nation's manufacturing sector and also improve its efficiency, competitiveness, and sustainability. Proposals should be driven by societal/market needs and opportunities, and should identify both the end users of the proposed technology and the proposed pathway to commercialization. Proposals that are responsive to strong societal needs while meeting commercial sustainability thresholds are also encouraged.

M1. Personalized Manufacturing

Proposals centered on innovative, new-to-the-world manufacturing methods and machines leading to mass customization are invited. The applications may include (but are not limited to) clothing, footwear, furniture, ear buds, headbands, hearing aids etc. The resultant products may need to be cost competitive with the relevant mass manufactured products. Technologies focused on rapid and lower cost production of personalized biomedical implants, and human assistive products that support the unique needs of individuals with disabilities are also encouraged. Proposals may include development of software-as-a-service or workflow-as-a-service tools to assist young personalized manufacturing businesses.

M2. Maker Manufacturing

Makers represent a wellspring of innovation, creating new products and eventually manufacturing them. Proposals having roots in such activities, involving innovations in one or more stages of design, engineering, and manufacturing and having significant commercialization potential are solicited. Commercially sustainable ideas that seek to address significant local, national, or global societal problems (e.g., energy/water/ resource conservation, youth unemployment), or enable spreading of citizen science through such innovations are especially encouraged.

M3. Additive Manufacturing

Innovations in processes or machines that permit manufacturing through a layering process, including 3D printing, to achieve fabrication of a range of products including near net shape products. Proposals by young companies to develop sustainable businesses based on 3D printing are especially encouraged. Proposals are also encouraged that permit the manufacturing of complex multi-scale and/or multi-functional products for superior performance and productivity.

M4. Manufacturing for Emerging Markets

Transformative technological innovations that enable the manufacturing of ultra-low-cost products designed to tap into the vast commercial potential of global underserved markets. The proposals must aim to produce products that are affordable and that have significant societal impact in the intended markets such as enhancing accessibility, reducing environmental impact, improving health etc.

M5. Modeling & Simulation

Innovations in the modeling and simulation of enterprise operations, manufacturing processes for intermediate or finished products, machines and equipment, predictive modeling of tooling and machine performance and discrete event simulation of manufacturing systems. Innovative approaches that bring the benefits of cloud computing and/or big data analytics to the manufacturing sector are especially encouraged. Virtual manufacturing software products that allow designers to create a three-dimensional (3-D) model of a product and then virtually test the efficiency of its performance are also relevant. Technologies enabling real-time prediction or optimization are also encouraged.

M6. Sustainable Manufacturing Technology

Proposals may cover technologies that present new process and system design paradigms, employ internet-of-things to dynamically optimize complex industrial manufacturing processes, enhance environmental sustainability with reductions in carbon footprint and/or water usage, and promote the sourcing, use, and recycle of materials and energy streams; technologies that take a systems approach to green engineering for industrial, residential, and commercial infrastructure, industrial manufacturing infrastructure design innovations; novel tools for the real-time analysis of system performance and the dynamic global

optimization of system performance; innovations in technologies for the improved efficiency, control; new technologies (involving materials, sensors, devices, and control systems) that support smart infrastructures to ensure efficient and sustainable energy transmission, distribution, monitoring, and management.

M7. Manufacturing Processes
Innovative technologies for the processing of a variety of materials, including metals, alloys, ceramics, polymers, and novel composites using processes such as casting, forming, machining, and joining. Proposals that lead to significantly improved efficiency (in terms of materials, energy, time, or money) and sustainability are encouraged. The topic also includes on-line detection and/or control of defects in those processes.

M8. Rare Earths and Critical Materials Processing Technology
Proposals of interest would involve production technologies enabling the development of new sources for rare earths, metals, and critical materials of strategic national importance; improving the economics of existing sources; accelerating the development and deployment of alternatives to rare earths and critical materials currently in use; technologies and processes for more efficient use in manufacturing; recycling and reuse; new processes for critical and strategic metals and minerals extraction; novel purification processes; recycle and recovery by separation of rare earths and strategic materials from waste; novel ways to reduce the amount of critical materials currently utilized in current and emerging technology products.

M9. Transportation Technologies
Proposed projects might include (but are not limited to) the reduction of engine emissions; the reduction of greenhouse gases resulting from combustion; vehicle weight reduction; vehicle components; improved engine and fuel efficiency; reduction of SOx, NOx, and particulates resulting from combustion; reduction in wear and environmental pollutants. Projects may include technologies of commercial importance for low-temperature combustion, flexible fuel and fuel blends for automotive applications, improved atomizers and ignition characteristics, low heat-loss (coatings, materials, etc.) engines, on-board energy harvesting (e.g., thermoelectric generators), energy conversion and storage, improved catalyst systems, and other alternative technologies to improve fuel efficiency, reduce energy loss, and reduce environmental emissions; advanced batteries for transportation, including radically new battery systems or breakthroughs based on existing systems with a focus on high-energy density and high-power density batteries suitable for transportation applications.

M10. Manufacturing Technologies involving Chemical Transformations
New process technologies for the production of novel materials include (but not limited to) high-performance bio-materials, inorganic and composite materials, alloys, novel materials with optimized design at an atomic scale, nano- and micro-scale metallic materials, and nano-materials and metallurgical products of commercial relevance.

M11. Machines and Equipment
Innovative machines and equipment in a range of operations for making nano-, micro-, and macro-scale products in all industries, from biomedical engineering and flexible electronics, to manufacturing, mineral processing, agriculture, construction, and recycling. Innovative equipment modification or retrofitting to enable manufacturing of completely new products is encouraged.

Nanotechnology (N)
The Nanotechnology subtopic 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). Proposals should be driven by market needs and demand and should identify both the end users of the proposed technology and the pathway to commercialization.

N1. Nanomaterials
Proposals may include material innovations in scalable synthesis, purification, and processing techniques for hierarchical nanostructures, nanolayered structures, nanowires, nanotubes, quantum dots, nanoparticles, nanofibers, and other nanomaterials.

N2. Nanomanufacturing
Proposals that seek to develop innovative processes, including self-assembly, nanolithography, nano-patterning, nano-texturing, nano-3D printing etc., techniques, and equipment for the low-cost, large-area or continuous manufacturing of nano-to micro-scale structures and their assembly/integration into higher order

systems are encouraged.

N3. Nano-enabled Commercial Solutions to Global Problems
Proposals focusing on global problems through innovative nano-enabled processes are solicited. Examples of such problems include desalination of seawater to solve the emerging water crisis, solar energy collection, storage, and conversion for contributing to energy solutions for the future, and solid-state refrigeration for reducing global greenhouse emissions.