Research Focus Groups Subcommittee Report Version 5.0

Faculty Research Advisory Board
DRAFT

Vision: Research Focus Groups identify core and multi-disciplinary research strengths at NJIT. These research foci should be used to represent the NJIT Research Enterprise internally as well as externally. The spectrum of research and innovation at NJIT is very broad. Focusing, summarizing, and quantifying our research strengths will better position us to advance current and future research trends, recruit key faculty and students, attract external collaborators, and compete for extramural funding. These Research Focus Groups will allow us to enhance and build upon our existing strengths while also developing strategic new directions.

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Research Focus Group Clusters

A. Life Sciences and Engineering

1. Life Sciences and Healthcare

Definition and Scope of the Focus Group

The emphasis of the Focus Group on Life Sciences and Healthcare includes the following primary areas for technology development of medical devices and systems:

- Neuroscience and engineering
- Regenerative medicine
- Point of care technologies

1) Neuroscience: Neuroscience has been a long-standing focus of research and research funding by federal, state and private funding agencies. As recently as last year, a new presidential initiative on Brain Research through Advancing Innovative Neurotechnologies (BRAIN) was launched that greatly expands NIH's scientific scope and budget for neuroscience. At NJIT, several groups, distributed among the departments of Biomedical Engineering, Biological Sciences and Mathematical Sciences exist whose goal is the understanding of the functions of the nervous system using human, animal, and computer models, some of which fall within the mission of the BRAIN initiative and could greatly benefit from it. Most of the 13 faculty members in the Department of Biomedical Engineering are focused on neuroscience and engineering in terms of imaging, instrumentation, rehabilitation, vision, hearing and brain/spinal cord injury. The Departments of Biological Sciences and Mathematical Sciences have established a highly interactive group of 10 faculty members working in neuroscience using experimental and theoretical approaches to address core issues of cellular and systems neuroscience and its application to animal behavior. There is also great expertise at NJIT in applied and translational neuroscience with the faculty in Biomedical Engineering as well as Biology exploring important issues related to tissue repair and replacement, enhancement of central and peripheral nervous system, biomechanics of motion, brain imaging of large networks, chronic recordings of brain networks, etc. Some of these groups, e.g., members of the recently established Center for Injury Biomechanics, Materials and Medicine, work in collaboration with medical schools and the VA.

2) Regenerative Medicine: Tissue engineering and Regenerative Medicine is a multi-disciplinary field of biology, medicine and engineering with the goal of restoring, maintaining tissue and organ function. At NJIT faculty from biomedical engineering, and biological sciences are involved in biomaterials, biomechanics, and biomolecular engineering in manipulating human systems under non-optimal operating conditions.

3) Point-of-care Technology: Point-of-care technology delivers healthcare to patients and patient health information to providers. Inherently interdisciplinary, it is a confluence of biomedical engineering, telecommunications, computing, behavioral science, and regulatory policy. NCE, CCS, and SOM conduct research in this field collaboratively with local, State, Federal, and international healthcare organizations; individual projects range in scope from wearable sensor design and the exploitation of real-time global remote sensing data to the deployment of operational systems. Point-of-care technology thus serves as a platform for research that is both narrowly-defined and far-reaching.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Tara Alvarez	BME	Vision, Neuor-learning
Treena L. Arinzeh	BME	Stem cell, Spinal cord
Bharat Biswal	BME	Neuro-imaging
Namas Chandra	BME	Brain Injury
Sergei Adamovich	BME	Virtual Reality, Rehabilitation
Richard Foulds	BME	Neuromuscular Engineering
Bryan Pfister	BME	In-vitro modeling
Mesut Sahin	BME	Neural Prostheses
Michael Jaffe	BME	Biomaterials
James Haorah	BME	Biochemical, and cellular mechanisms of blood-brain barrier, neurovascular response, substance abuse, blast-wave brain injury, HIV infection.
Yi Chen	SOM	Healthcare Informatics
Eric Fortune	Biology	Neuro-sensory-motor systems
Dirk Bucher	Biology	Axonal neuromodulation
Gal Haspel	Biology	Locomotion/recovery from injury
Jorge Golowasch	Biology	Network homeostasis/computational neuroscience
Farzan Nadim	Biology	Cell and synaptic dynamics/computational neuroscience
Brook Flammang-Lockyer	Biology	Locomotion biomechanics
Daphne Soares	Biology	Brain Evolution
Casey Diekman	Biology	Circadian rhythms/computational neuroscience
Victor Matveev	Biology	Synaptic mechanisms/computational neuroscience
Horacio Rotstein	Biology	Brain rhythms/computational neuroscience
Simon Garnier	Biology	Collective Behavior
Gareth Russell	Biology	Computational Biology
Amitabha Bose	Biology	Neural dynamics/computational neuroscience
Gordon Thomas	Physics	Point-of-care devices
Sunil Dhar	Mathematics	Biostatistics
Ji M Loh	Mathematics	Biostatistics
Raj Dave	Chemical, Biological & Phrama Engrg.(CBPE)	Drug delivery, bioavailability enhancements, drug composites
Roman Voronov	CBPE	Computational fluid dynamics, tissue engineering
Xiaoyang Xu	CBPE	novel biomaterials, nanotechnologies for diagnosis, bioimaging, drug delivery, and

		regenerative medicine
Ecevit Bilgili	CBPE	Nanocomposites for bioavailability enhancement, pharmaceutical processing
Sagnik Basuray	CBPE	Nanotechnology, , Nanofluidics, Microfluidics, Electro-Kinetics, Lab-On-A-Chip, Point-of-Care Diagnostics
Kamalesh Sirkar	CBPE	Membrane applications: nanocoating for controlled release, drug delivery
Eon Soo Lee	MIE	Microfluidic devices for medical applications
Shawn Chester	MIE	Biomechanics
Siva Nadimpalli	MIE	Experimental biomechanics
Joga Rao	MIE	Biomechanics, smart material
Pushpendra Singh	MIE	Biological fluid dynamics, drug delivery
Anthony Rosato	MIE	Particulate flows
Chao Zhu	MIE	Nanomaterials
Cesar Bandera	SOM	Telemedicine, mobile outreach and situation awareness, intelligent health care records
Edgardo T. Farinas	CES	Enzyme and protein chemistry and technology, metabolic pathway engineering in bacteria
Haidong Huang	CES	DNA detection and technology, artificial ribonucleases
Kevin D. Belfield	CES	Biophotonics, targeted probes for cancer and neuroscience imaging, angiogenesis imaging, photodynamic therapy, multiphoton fluorescence imaging
Cristiano L. Dias	Physics	Molecular mechanisms of protein folding involved in neurodegenerative diseases
Camelia Prodan	Physics	Cellular dynamics and dynamical instability, effect of drugs on cellular dynamics, dielectric spectroscopy in neuroscience
Xuan Liu	ECE	Biomedical optics, optical coherence tomography and endoscopic microscopy
Linda Cummings	Math	Fluid dynamics in cells and tissue engineering
Amitabha K. Bose	Math	Mathematical neuroscience, synaptic plasticity in neuronal networks
Casey O. Diekman	Math	Mathematical biology, gene expression, and neuroscience
Victor V. Matveev	Math	Computational neuroscience
Cyrill B. Muratov	Math	Modeling and analysis of cell communication

Research Centers:

- **Applied Biomaterials and Tissue Engineering Laboratory**: Bone repair, nerve tissue regeneration
- **Center for Brain Imaging:** Functional neural imaging
- **Center for Injury Biomechanics, Materials and Medicine**: Traumatic Brain Injury

- **Engineering Research Center for Structured Organic Particles:** Particle technology to improve the way pharmaceuticals, foods and agriculture products are manufactured.
- **The Medical Device Concept Laboratory** : Synthetic materials in biomedicine.
- **Membrane and Separation Technologies**: Micro- and nanoporous filters for medicine and pharmaceutical manufacture.
- **Neural Interface Laboratory:** Interfaces with the central nervous system to record volitional control signals and micro-stimulate the spinal cord to improve the motor function after injury.
- **Rehabilitation Engineering Research Center**: Neurorehabilitation and robotics; virtual reality rehabilitation.
- **Stem Cells and Tissue Engineering Lab:** Natural biopolymer, micropatterning techniques.
- **Tissue Models Lab:** Cell and tissue biology based on the use of micro- and nanotechnologies.
- **The Vision and Neural Engineering Lab:** Oculomotor dynamics, vergeance eye movements.

Current and Future Trends of the Focus Group

As indicated above, funding agencies assign high priority to basic research in neuroscience and to applied areas of research in regenerative medicine and point-of-care technology in hopes that new discoveries and technologies can impact healthcare just as cell phones have impacted other aspects of human productivity and quality of life. Healthcare technology is a growing research and commercial market, evidenced by the nature of the start-up companies in NJIT's Enterprise Development Center (themselves frequent research collaborators with NJIT) and the structure of the New Jersey Innovation Institute, and point-of-care technology (sometimes referred to as mobile health) is among the fastest growing subgroups within this market. Neuroscience has also received strong support at NJIT recently with a number of high-profile new hires. Biomedical optics, biophotonics, and bioimaging expertise is fast developing at NJIT and provides the tenets for developing noninvasive detection, diagnostic, and therapeutic methodology for advances in the treatment of cancer, neurodegenerative diseases, and metabolic diseases. New and experienced researchers have been further successful in securing extramural funding for their different research programs. Support of all these foci that are well represented at NJIT should add strength to our research as well as instruction missions.

2. Healthcare Systems, Informatics and Analytics

Definition and Scope of the Focus Group

The delivery of affordable and effective healthcare is a critical area of healthcare research. Healthcare Systems Engineering (HSE) topics range from big data productivity analysis tools, smart health systems analysis, to advanced mathematical models for optimizing healthcare operations. At NJIT faculty in Industrial Engineering, Computer Science and SOM are involved in patient appointment and surgery scheduling methods, resource utilization in healthcare networks, meaningful use EHR analysis and big data hospital productivity analysis.

This Focus Group includes Medical Informatics and Bioinformatics research. Faculty in Medical Informatics are investigating medical terminologies and ontologies, specifically the summarization and abstraction of complex, large medical ontologies, and methods for finding errors (auditing) and displaying ontologies without overwhelming human comprehension (visualization). Connections with Adverse Drug Reactions, Big Medical Knowledge, Electronic Health Records and Ontology Integration are also topics of interest.

Researchers in Bioinformatics are utilizing machine learning, statistical inference, and high performance computing to solve hard problems in genomics. These problems include the comparison of genome sequences, analysis of large genome-wide studies, prediction of phenotypes and disease risk from genomic data, RNA and protein sequence analysis, and genomic variant detection.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Sanchoy Das	MIE	Big Data Hospital Productivity
Wenbo Cai	MIE	Patient and Surgery Scheduling
Shivon Boodhoo	MIE	Big Data Hospital Productivity
Yi Chen	SOM	Healthcare Informatics
James Geller	CS	Medical informatics
Yehoshua Perl	CS	Medical informatics
Usman Roshan	CS	Bioinformatics
Zhi Wei	CS	Bioinformatics
Songhua Xu	BME	Bioinformatics
Lian Duan	BME	Bioinformatics
Eun Jung Lee	BME	Biomedical Engineering
Wenge Guo	Math	Bioinformatics
Ji Meng Loh	Math	Biostatistics, functional MRI image modeling
Antai Wang	Math	Microarray data analysis

Research Centers

- **Center for Applied Genomics**: Development and application of DNA microarray technology.

- **Data and Knowledge Engineering Laboratory:** Data mining, bioinformations, computational biology.
- **New Jersey Health Care Innovation Center:** Better health care through technology.
- **New Jersey Health Information Technology Extension Center**: Meaningful use of electronic health records.
- **Structural Analysis of Biomedical Ontologies Center:** Medical terminologies and ontologies.

Current and Future Trends of the Focus Group

Faculty in this area is currently offering various courses addressing this topic. For example bioinformatics has undergraduate and graduate degrees and fulfills computing requirements for biology and related majors. In addition faculty has current funding in this area and is also seeking new grants. The work of this group would lead to better prevention strategies and lower healthcare cost both of which are in line with the aims of the medical industry. Thus we expect growth moving forward.

B. Sustainable Systems

3. Water-Energy Nexus

Definition and Scope of the Focus Group

The Focus Group on Water-Energy Nexus includes emphasis on

- Clean water
- Green energy

This area is focused on the nexus that exists between the need for clean water, the need to reduce conventional energy expenditures in the processes, and the need to generate green energy during such activities. Current water treatment technologies involving clarification/pretreatment, purification, disinfection, and distribution consume huge volumes of energy in different societal sectors including municipal water treatment, oil and gas production, power generation, mining, industrial activities, and the agricultural and animal husbandry sector. As we move toward more stringent water quality, the need for greater availability and production volumes, and semi-permanent drought-like conditions in parts of the country, it is paramount that we produce clean water in higher volumes with the least energy and capital expenditure.

This overarching goal will require us to develop the next generation of technologies for water treatment that can achieve a much higher level of treatment with a much lower level of energy expenditure and capital investment. Furthermore, we need to exploit the potential for green energy extraction/generation during such water treatment or otherwise via the following sources: solar power; warm nuclear power plant effluents; hot produced water from oil and gas production; elevated temperatures in large anaerobic digesters using thermoelectric effects, distillation etc.; tidal and wave energy; biogas generation; biofuel cells relying on pollutant degradation; hydraulic and mass losses in water distribution systems; ambient microwave energy-driven sensor technology and underwater acoustic sensor systems for water quality monitoring and water distribution system performance; adoption of such technologies at system and community levels and their implications for achieving regulatory water quality and energy efficiency standards as defined and implemented through various legislations such as Clean Water Act and Safe Drinking Water Act.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Piero Armenante	Chemical, Biological and Pharmaceutical Engineering (CBPE)	Single and multiphase, , Computational Fluid Dynamics, Particle Image Velocimetry
Robert Barat	CBPE	Environmental pollutants, applied optics, pharmaceutical reaction engineering, reaction control
Sagnik Basuray	CBPE	Nanotechnology, Pasmonics, Photonics, Nanofluidics, Microfluidics, Electro-Kinetics
Ecevit Bilgili	CBPE	Powder technology, particle engineering,

		pharmaceutical solids manufacturing technology
Rajesh Dave	CBPE	Particle engineering, filtration, nanocomposites, crystallization, materials for membranes
Edward Dreizin	CBPE	Energetic materials, thermal analysis, metal combustion, high-energy density materials, solid propellants, solid fuels
Boris Khusid	CBPE	Electro-microfluidics, particles, cells, micro-organisms, electro-hydrodynamics, applied life sciences, sustainable systems
Kamalesh Sirkar	CBPE	Membrane separation techniques, fabrication of membranes, biotechnology,
Xianqin Wang	CBPE	Nanomaterials, environmental protection, clean energy
Somenath Mitra	Chemistry and Environmental Science (CES)	Sensor instrumentation, analytical instrumentation, nanotechnology, sustainable systems
Zafar Iqbal	CES	Nanotechnology, carbon nanotubes, nanoenergetics, nanocomposites, sensors, hydrogen storage, biofuel cells, solar cells
Zeyuan Qiu	CES	Natural resources, environmental economics, sustainable systems
Nancy L. Jackson	CES	Coastal processes on beaches and dunes
Michel Boufadel	Civil and Environmental Engineering (CEE)	Sustainability, contaminants, water flow transport, coastal systems, oil spills
H-N. Hsieh	CEE	Water treatment, wastewater treatment, sludge treatment, solid waste disposal, stormwater management
Taha Marhaba	CEE	Pollution detection, water treatment, raw water, natural organics, drinking water, sustainable systems
Jay Meegoda	CEE	Geo-environmental engineering, contaminated soils, centrifugal modeling, ultrasound research, underground infrastructure, sustainable systems
Sunil Saigal	CEE	Computational mechanics, nanotechnology, composite structures
Wen Zhang	CEE	Environmental applications, implications of nanotechnology, engineered nanomaterials, manufacturing, Renewable energy technologies
Lisa Axe	CEE	Biogeochemical processes, environmental systems, chemical and physical treatment processes

Reggie Caudill	MIE	Multi-lifecycle engineering, sustainable systems
Eon Soo Lee	MIE	Energy systems, microfluidic devices
Paul Ranky:	MIE	Green energy
Chao Zhu		Filtration, heat transfer
Trevor Tyson	Physics	transition-metal oxide systems, thin films, atomic physics, molecular physics, myoglobin, hemoglobin, sustainable systems

Research Centers

- **Center for Natural Resources Development and Protection:** Field, analytic and computational studies of techniques for dealing with coastal pollution and stormawater management.
- **Geoenvironmental Engineering Laboratory:** Solid waste management and disposal, environmental systems, waste water treatment, site remediation.
- **Membrane Science, Engineering and Technology (MAST) Center:** Development of specialized membrane technology for Energy Production, Water Treatment, Pharmaceutical Purification and Chemical Processing.
- **Laboratory for Process and Field Analytical Chemistry:** On-line process analysis, environmental monitoring, portable instruments for on-sire environmental measurement.
- **Northeast Hazardous Substance Research Center:** Hazardous substance handling, reduction, assessment and management.
- **York Center for Environmental Engineering and Science**: Hazardous substance management, pollution remediation and prevention, sustainable manufacturing.

Current and Future Trends of the Focus Group

The current focus includes: 1. Develop a multi-site NSF Industry/University Cooperative Research Center (I/UCRC) with NJIT and Columbia U. on the Water-Energy Nexus. 2. Continue research on membrane-based energy-efficient processes for water treatment within the Membrane Science, Engineering and Technology (MAST), a NSF I/UCRC; develop collaborative submissions of proposals. 3. A variety of proposals can be submitted to the Environmental Engineering Program and Reaction Engineering Program under NSF, the EPA Star Program and The NIEHS Program on Hazardous Leachate Treatment. 4. Water-Energy Nexus will be explored in fracking operations carried out in areas facing water scarcity with potential funding from DOE, NSF and EPA and potential industry-university consortiums. 5. Oil recovery from oil spills and management of the spill-contaminated environment. 6. Visible light photocatalysis, algal system-based reactive processing and synthesis, and water splitting. Future trends of activities will include: Active collaboration with (1) Nanotechnology Focus Group on developing novel sorbents, membranes, electrodes and batteries, (2) Urban Ecology and Sustainability Group on sustainable water management strategies and programs including life-cycle analysis and sustainability metrics, and (3) Center for Natural Resources Development and Protection.

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4. Urban Ecology and Sustainability

Definition and Scope of the Focus Group

The Focus Group on Urban Ecology and Sustainability includes emphasis on

- Sustainable Infrastructure
- Resilient Coastal Environments
- Ecological Communities
- Urban Modeling and Simulation

Sustainable urban systems depend on complex and dynamic interactions among both built and natural environments and support a strong economic engine with vibrant private business and public service sectors. With these interdependent system elements working in harmony, urban areas create value and opportunities for job growth while providing for the needs and wants of the populous in a safe and healthy environment, using resources wisely and without overly stressing the Earth's natural ecosystems or exceeding its carrying capacity. How do we measure urban sustainability? When do we know that an urban community is truly sustainable? What are the research, educational and outreach priorities to be undertaken that will help move our urban communities towards sustainability? Urban Ecology and Sustainability addresses these issues and many more. While significant work has been done to better understand the cause and scope of climate change and global warming, a comprehensive research program is needed to focus specifically on the critical challenges facing urban areas in the face of global environmental change. Urban Ecology and Sustainability addresses a range of critical issues from basic scientific discovery and theoretical development to engineering applications, technology innovation and professional practice. The complexity and magnitude of this challenge should not be understated.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Michel Boufadel	Civil and Environmental Engineering (CEE)	Sustainability, contaminants, water flow transport, coastal systems, oil spills
Jay Meegoda	CEE	Geo-environmental engineering, contaminated soils, centrifugal modeling, ultrasound research, underground infrastructure, sustainable systems
Lisa Axe	CEE	Biogeochemical processes, environmental systems, chemical and physical treatment processes
Reggie Caudill	MIE	Multi-lifecycle engineering, sustainable systems
Eon Soo Lee	MIE	Energy systems, microfluidic devices
Paul Ranky:	MIE	Green energy, sustainability
Siva Nadimpalli	MIE	Experimental solid mechanics, nano and micro mechanics of materials, energy storage Materials,

Sanchoy Das	MIE	Supply chain modeling and analysis, Sustainability of industrial systems, Design for manufacturability
Chao Zhu	MIE	Multiphase flows, evaporative jets, drag forces, collisions of interacting particles, interacting particle collision, pneumatic conveying, turbulence modulation, particulate pollution, fibrous filtration
Norman Loney	Chemical, Biological and Pharmaceutical Engineering (CBPE)	Mathematical modeling, drug delivery, membrane separation, chemical engineering
Piero Armenante	CBPE	Single and multiphase mixing, Computational Fluid Dynamics, Particle Image Velocimetry, biological treatment of hazardous substance
Ecevit Bilgili	CBPE	Powder technology, particle engineering, pharmaceutical solids manufacturing technology
Kamalesh Sirkar	CBPE	Membrane separation techniques, fabrication of membranes, biotechnology,
Raj Dave	CBPE	Particle technology, applied life sciences
Edward Dreizin	CBPE	Energetic materials, thermal analysis, metal combustion, high-energy density materials, solid propellants, solid fuels
Somenath Mitra	Chemistry and Environmental Science (CES)	Sensor instrumentation, analytical instrumentation, nanotechnology, sustainable systems
Zeyuan Qiu	CES	Natural resources, environmental economics, sustainable systems
Nancy Jackson	CES	Beach processes, management in estuarine , sheltered coastal systems, aeolian sediment transport, coastal management
Alexei Khalizov	CES	Environmental impacts of atmospheric pollutants
Maurie Cohen	HUM	Sustainable consumption, alternative mobility futures, sociotechnical transition management, industrial ecology, environmental politics, sustainable systems
Tom Dallessio	College of Architecture and Design (CoAD)	Sustainability, resilient structures
Keith Krumwidie	CoAD	Sustainability, architectural design
Richard Garber	CoAD	Building sciences, green architecture,
Martina Decker	CoAD	Smart materials, sustainability
Taha Narahara	CoAD	Computational design, digital interaction,

		robotics
Zeynep Celik	CoAD	Architectural history, urban history, cross-cultural history
Eric Fortune	Biology	Neurophysiology, pharmachological studies, mathematical modeling
Daniel Bunker	Biology	Global warming, environmental studies, biological observation, ecology, sustainable systems
Gareth Rissell	Biology	Community ecology, conservation biology, computational applications
Brook Flammang-Lockyer	Biology	Biological sciences, functional morphology, comparative biomechanics, fluid dynamics, macroevolution, bioinspired robotics
Daphne Soares	Biology	Biological sciences
Simon Garnier	Biology	Collective Behavior, Social Behavior, Swarm Intelligence, Collective Intelligence, Ecology
John Federici	Physics	Terahertz spectroscopy and imaging, synthetic aperture, interferometric imaging, pump spectroscopy, probe ultrafast spectroscopy, sensors, biophotonics

Research Centers

- **Center for Building Knowledge:** Educational facilities, health care and aging environments, developmental disabilities planning, historic preservation, housing and community development.
- **Center for Resilient Design:** Ready-to-build designs and expertise forfor smarter, more sustainable designs in areas affected by natural and man-made disasters.
- **Concrete Testing Laboratory:** Reinforced and high-strength concretes.
- **Imaging Laboratory:** Computer-aided design in architecture.
- **Center for Airborne Organics:** Detecting and tracing organic pollutants, preventing pollutant emissions.
- **Center for Natural Resources Development and Protection:** Field, analytic and computational studies of techniques for dealing with coastal pollution and stormawater management.
- **Laboratory for Process and Field Analytical Chemistry:** On-line process analysis, environmental monitoring, portable instruments for on-sire environmental measurement.
- **Northeast Hazardous Substance Research Center:** Hazardous substance handling, reduction, assessment and management.
- **Swarm Lab:** Mechanisms underlying the coordination of large animal groups.
- **York Center for Environmental Engineering and Science**: Hazardous substance management, pollution remediation and prevention, sustainable manufacturing.

Current and Future Trends of the Focus Group

The overarching objective of sustainability research at NJIT is to advance an understanding of urban ecology, a rapidly emerging focus on the intersection of urban and human dynamics with ecological and industrial systems that draws from several fields of study, ranging from industrial ecology, resource management and conservation biology to environmental engineering, computer science, environmental and urban planning and architecture. This initiative will leverage existing faculty strengths and build on the foundations in this field already developed at NJIT and other institutions.

NJIT is uniquely situated as a public urban university to provide an evidence based, translational research initiative in Urban Ecology and Sustainability that advances basic and applied knowledge in the dynamics and interactions of plant, animal, human, land, and climate systems of urban settings and the impacts of urban settings on environmental and economic ecosystems. The research program envisioned is comprehensive in scope, but well-focused in terms of needed skills, with the following primary goals and outcomes that are both compelling and distinct: (a) better understand the human impacts on urban ecological systems and their fundamental relationships and interdependencies for sustainability toward the goal of designing healthier and better managed communities, as well as protecting and conserving ecological systems; (b) examine the effects of natural resource use in urban settings as a means of improving knowledge of urban resource management and greening of the built infrastructure; (c) analyze the dynamics of urban climate systems and natural hazards as a basis for improved knowledge about climate and hazards mitigation and resiliency in urban regions; (d) contribute to knowledge and practice at the intersection of environmental and water quality, biodiversity, the food chain and public health concerns; (e) providing best practices solutions for aging urban infrastructure utilizing smart information, communication and network systems; and (f) contribute to short, middle and long-term solutions through innovations in technology, policy, and management for urban environmental systems.

NJIT has a tremendous opportunity to work closely with the City of Newark on Sustainability. The City of Newark has extensive experience in green communities and sustainable practices; and, NJIT has enjoyed a close working relationship with Newark for decades. The City of Newark will be a hands-on test bed for pilot studies, technology demonstration sites, and as an innovation partner. This unique partnership will promote the development and transfer of technologies, systems and materials from the research labs into applications and practice. Together, we have the potential to stimulate new-firm startups, create job opportunities, and promote sustainable communities across New Jersey and the region. In addition, the campus of NJIT will serve as a Living Laboratory for nucleating ideas with the surrounding communities.

By 2020, more than 50% of the world's population will be living in cities. This has implications for both existing areas, as well as new cities being planned in rapidly developing countries, such as those in Asia. Closer to home, the New York-Newark urban area has an estimated population of 19,040,000, which is second in the world after Tokyo[1]. Research projects that engage problems of sustainable and ecological infrastructure, urban modeling, and design and planning have been executed by our faculty. NJIT has researchers from the College of Architecture and Design, as well as the College of Engineering and Department of Chemistry and Environmental Science engaged in issues of density and the design and planning of communities and watershed restoration. Faculty includes Richard Garber and Georgeen Theodore, CoAD, and Zeyuan Qiu, Chemistry and Environmental Science.

[1] CIA World Factbook - http://teacherlink.ed.usu.edu/tlresources/reference/factbook/geos/xx.html

5. Manufacturing Systems

Definition and Scope of the Focus Group

The Focus Group on Manufacturing Systems includes emphasis on:

- Additive Manufacturing (AM),
- Pharmaceutical Manufacturing

This research initiative addresses grand challenges and opportunities and aligns with NJIT's thematic areas, the State's Strategic Plan, and Governor Christie's new economic growth initiative. As indicated in the NJ Strategic Plan, healthcare, advanced manufacturing, and transportation, logistics and distribution are three of the top five industry clusters, in terms of both employment and total wages. The recent NJ strategic focus on new growth opportunities in "build-to-suit" manufacturing and supply chain facilities demand management strategies that incorporate sustainability into every business practice.

1) Additive Manufacturing. Additive manufacturing has been referred to as a disruptive technology with the potential to change well-established processes and procedures for product innovation, design and production and to dramatically restructure industrial supply chains across the global economy. Additive manufacturing, also known as 3D printing, "…is a suite of computer automated technologies to fabricate three-dimensional structural and functional parts, usually layer by layer, from metallic, plastic, ceramic, electronic, biological, and composite materials based on computer aided design models [NSF 2013]."

2) Pharmaceutical Manufacturing. Pharmaceutical processing and manufacturing is an important research area for NJIT and especially for the CBPE department, where several NJIT investigators are active in different aspects of pharmaceutical manufacturing processes. To put all this in context, the overall manufacturing process of a pharmaceutical product can be divided in two distinct series of manufacturing activities, each involving a large number of unit operations and aimed at manufacturing (1) the *Active Pharmaceutical Ingredient* (API) and (2) the finished *Drug Product* (DP). The API is the molecular species capable of exerting its therapeutic or diagnostic effects when administered to a patient. An API is rarely administered in its pure form as a final drug product. More frequent is the case in which the API is compounded with biologically inactive substances ("excipients") added to achieve optimal therapeutic effects, be dispensed and administered effectively, or ensure that the product can be reliably manufactured. Hundreds of excipients exist, each designed with a specific function in mind (e.g., preservative, binder, disintegrant, etc.). The API manufacturing process is either based on chemical synthesis (typically for "small-molecule" API's) or bioprocessing (especially for "large-molecule" API's, i.e., proteins-based product). In most cases, API's are manufactured using a synthetic route where a precursor molecule is reacted with the appropriate reactant(s) to obtain an intermediate molecular species, which is separated and reacted again under different conditions and with different reactants to obtain a second intermediate. This process is repeated as needed to obtain eventually the final API molecule. Each reaction/separation unit in this sequence is considered as a single "step". Typically, some 5 to 15 steps are needed to synthesize an API's. Most of these operations are conducted in batch. The API is then incorporated in the drug product. The processes needed to manufacture the DP depend on the type of dosage form (tablets, ointments, suppositories, injectables, etc.), and many of these processes are physical in nature rather than chemical. Many drug products are formulated as solid dosage forms (tablets, capsules, etc.) typically containing only 5% to 10% of API. Manufacturing solid oral dosage forms involves operations such as solids mixing and blending, granulation, drying, milling,

compression, and tableting. Projects conducted at NJIT over the years have been focused on all aspects of pharmaceutical manufacturing.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Reggie Caudill	MIE	Industrial engineering, manufacturing, multi-lifecycle engineering, sustainable systems
Sanchoy Das	MIE	Supply chain modeling and analysis, Sustainability of industrial systems, Design for manufacturability
Ian Fischer	MIE	Spatial mechanisms, dual-number mechanics, particulate flows
Paul Ranky	MIE	Integrated product, process design, advanced manufacturing, assembly, test systems, interactive multimedia, virtual reality simulation, medical engineering instrumentation
Raj Sodhi	MIE	Mechanism synthesis, mechanical design, design for manufacturability, multi-life cycle design, rehabilitation engineering
Zhiming Ji	MIE	Biomechanics, system integration, system robotics, system design and control, mechanical systems, electromechanical systems, mechatronics, sustainable systems
Piero Armenante	Chemical, Biological and Pharmaceutical Engineering (CBPE)	Single and multiphase mixing in pharmaceutical systems, dissolution testing, pharmaceutical processes, Computational Fluid Dynamics, Particle Image Velocimetry
Raj Dave	CBPE	Particle technology, image processing, cluster analysis, pattern recognition, applied life sciences
Ecevit Bilgili	CBPE	Powder technology, particle engineering, pharmaceutical solids manufacturing technology, rubber elasticity, finite thermoelasticity, rubber processing, recycling,
Leonid Tsybeskov	ECE	Nanostructures, quantum devices, solid state VLSI, electro-optics systems
Haim Grebel	ECE	Nano-technology, artificial dielectrics, optical bench, laser-induced etching of optical filters, holographic optical interconnects, solid state VLSI, electro-optics systems,
Mengchu Zhou	ECE	Computer-integrated manufacturing, intelligent automation, petri nets, neural networks, computer networking, bioelectronics, intelligent systems
Treena Arinzeh	BME	Stem cells, materials testing, cell

		bio-material interaction, nerve tissue regeneration, musculoskeletal tissues,
Bryan Pfister	BME	Tissue engineering, developmental neural biology, axon growth, mechanisms of neural injuries, nervous system injury repair
Cheul Cho	BME	Stem cell bioengineering, regenerative medicine, tissue engineering, polymeric biomaterials,
N. M. Ravindra	Physics	Silicon interface, silicon oxide interface, SiO2, advanced metallization, rapid thermal processes, infrared detectors, temperature sensors, spectral emissometry

Research Centers

- **Center for Manufacturing Systems:** Advanced technology center with a dual mission of providing manufacturing support for university research programs and offering design and manufacturing expertise to small and mid-size companies.
- **W.M. Keck Laboratory:** Manipulation of liquid flows and the small particles/microorganisms they transport in biological and biomedical technologies.
- **ManufactureNJ (MNJ):** is one of several New Jersey Talent Networks each of whose focus is on the specific needs of other key industries including: Financial Services; Health Care; Transportation, Logistics, and Distribution' Life Sciences; Hospitality and Retail; and Technology and Entrepreneurship.
- **Microelectronics Fabrication Center:** Application-specific integrated circuits, optical switches, pressure sensors, and MEMS for biomedical, biometrics, and microfluidics application.
- **Polymer Processing Institute:** Modification of polymers processing into special property products for the medical, health care, automotive, electronics, construction, and packaging industries
- **Vincent A. Stabile Lab:** "Hands-on" training in solving practical problems using robotics for today's automated manufacturing.

Current and Future Trends of the Focus Group

Over the last decade, significant progress have been made in developing and demonstrating a range of AM technologies from 3D polymer printing to powder-metal fusion with applications in biological printing, electronic devices and mechanical systems. However, many scientific and technical barriers must be overcome before AM can begin to realize its full promise.
The primary objective of the AM research area is to explore and resolve the critical technical, operational and sustainability challenges facing the successful implementation of additive manufacturing systems. The National Science Foundation also clearly recognizes the significance and the need for further research in AM, with a series of NSF Workshops on Frontiers of Additive Manufacturing Research and Education held over the past year.

Based on these NSF workshops and previous research by members of the research team, the following topical areas fits well within NJIT strengths and will be the focus of this research planning grant:

1. Multi-functionality, Multi-technology Systems Integration and Sustainable Operations
2. Product and Process Design for Sustainable Additive Manufacturing
3. Adaptive Control with Enhanced Sensor Fusion and In-situ Repair/Rework
4. Innovative Applications in Biological Structures, Energy Technologies and Mechatronic Devices
5. Network of AM Laboratories for Engineering Education and Industrial Innovation Partnerships

As for pharmaceutical manufacturing, in recent years, several NJIT researchers have conducted a large number of investigations aimed at providing a fundamental understanding of mechanisms behind the operation of many processes associated with the manufacturing of both API's and finished products. For example, these projects included quantifying the hydrodynamics of reactors, mixing systems, analytical equipment, and a variety of systems of relevance to API manufacturing, using both experimental approaches and computational methods. Similarly, a large number of projects were conducted to develop a fundamental understanding of the controlling physico-chemical parameters and mechanisms by which drug particles can be produced and incorporated into drug products (micro- and nano-particles, films, etc.) and to develop a mechanistic understanding of the functional responses of active (drug) agent-carrying solid dosage forms via process–structure–property–performance interrelationships. These projects were conducted through past and ongoing grants obtained primarily from federal agencies and pharmaceutical companies. It is expected that the success of these projects will results in more grants be awarded to these investigators to continue their investigation of the fundamental processes associated with all aspects of pharmaceutical manufacturing.

6. Advanced Materials and Engineered Particulates

Definition and Scope of the Focus Group

The Focus Group on Advanced Materials and Engineered Particulates includes emphasis on:

- Advanced Material Science and Engineering
- Advanced Engineered Particulates
- Multi-Materials Characterization and Testing

This is a unique interdisciplinary strategic research area dealing with engineering and use of particulates and their composites to make advanced materials, targeted at maintaining US competitiveness in an increasingly complex global economy. It deals with the synthesis, functionalization, and/or utilization, augmented by state-of-the-art characterization of nano-sized particles or material domains and assembly of the particulates to exploit unique properties of nanostructured materials in a variety of particulate composites. Research in this area impacts such industries as pharmaceuticals, biotechnology, biomedical, defense, food, cosmetics, ceramics, electronics and specialty chemicals; New Jersey being home to a number of them. The faculty members involved have obtained competitive research funding from NSF, NASA, DARPA and other defense agencies, as well as from industries. These funds have enabled establishment of the research equipment infrastructure worth over $3M for formation and comprehensive characterization of engineered particles, and current annual funding of the core group is over $1.5M per year. The group also has a very high publication rate as well as intellectual property generation rate, and there are recent successes in commercial licensing of their work. Interdisciplinary research has led to substantial contributions in material science and engineering including material characterization and developing advanced materials for pharmaceuticals, food industry, energy, cosmetics, ceramics, defense, electronics and specialty chemicals.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Raj Dave	Chemical, Biological and Pharmaceutical Engineering (CBPE)	Particle technology, image processing, cluster analysis, pattern recognition, applied life sciences
Ecevit Bilgili	CBPE	Powder technology, particle engineering, pharmaceutical solids manufacturing technology, rubber elasticity, finite thermoelasticity, rubber processing, recycling,
Edward Dreizin	CBPE	Energetic materials, thermal analysis, metal combustion, high-energy density materials, solid propellants, solid fuels, combustion phenomena, transport phenomena, microgravity, arc plasmas, micro-joining, metal surface treatment
Sagnik Basuray	CBPE	Nanotechnology, Pasmonics, Photonics, Nanofluidics, Microfluidics, Electro-Kinetics, Lab-On-A-Chip, Point-of-Care Diagnostics

Roman Voronov	CBPE	High performance super computer modeling, complex porous media flows, bone tissue engineering, blood systems biology, 3D Printing, Bioprinting
Kamalesh Sirkar	CBPE	Membrane separation techniques, fabrication of membranes, biotechnology, pharmaceutical technology, membrane-based bioseparations, applied life sciences
Xiaoyang Xu	CBPE	Biomaterials, nanomedicine, controlled drug delivery, nanotechnology, bioimaging, regenerative medicine
Xianqin Wang	CBPE	Nanomaterials, environmental protection, clean energy, biology, pharmaceutical engineering
Ian Fischer	MIE	Spatial mechanisms, dual-number mechanics, particulate flows
Eon Soo Lee	MIE	Nano materials, energy materials, micro fuel cells, proton exchange membrane fuel cells, solid oxide fuel cells
Shawn Chester	MIE	Solid mechanics and materials, large deformation elasticity and plasticity, multiphysics behavior of materials, computational solid mechanics
Siva Nadimpalli	MIE	Experimental solid mechanics, nano and micro mechanics of materials, energy storage materials, fracture mechanics, plasticity, finite element modeling, and microelectronic packaging
Joga Rao	MIE	Biomechanics, smart material
Pushpendra Singh	MIE	Nanomaterials, smart fluids
Anthony Rosato	MIE	Particulate systems
Chao Zhu	MIE	Nanomaterials
Leonid Tsybeskov	ECE	Nanostructures, quantum devices, solid state VLSI, electro-optics systems
Haim Grebel	ECE	Nano-technology, artificial dielectrics, optical bench, laser-induced etching of optical filters, holographic optical interconnects, solid state VLSI, electro-optics systems,
Durga Misra	ECE	VLSI devices, design, integrated sensors, vlsi, electro-optics systems, computer architecture
Mengchu Zhou	ECE	Computer-integrated manufacturing, intelligent automation, petri nets, neural networks, computer networking, bioelectronics, intelligent systems
Treena Arinzeh	BME	Stem cells, materials testing, cell bio-material interaction, nerve tissue regeneration, musculoskeletal tissues,
Bryan Pfister	BME	Tissue engineering, developmental neural

		biology, axon growth, mechanisms of neural injuries, nervous system injury repair
Cheul Cho	BME	Stem cell bioengineering, regenerative medicine, tissue engineering, polymeric biomaterials,
N. M. Ravindra	Physics	Silicon interface, silicon oxide interface, SiO2, advanced metallization, rapid thermal processes, infrared detectors, temperature sensors, spectral emissometry
Ken Chin	Physics	Inorganic semiconductor materials
Trevor Tyson	Physics	Metal oxide thin films
Zafar Iqbal	CES	Nanotechnology, carbon nanotubes, nanoenergetics, nanocomposites, sensors, hydrogen storage, biofuel cells, solar cells
Edgardo Farinas	CES	Enzyme design, biocatalysts, proteins
Joseph Bozzelli	CES	Atmospheric photochemistry, gas chromatography
Kevin D. Belfield	CCES	Functional polymeric materials, organic and organometallic photonic materials
Lou Kondic	Math	Modeling and simulation of fluid flows and dynamics of granular systems
Linda Cummings	Math	Computation and modeling of fluid dynamics
Catalin C. Turc	Math	Solar photovoltaic technology

Research Centers

- **CNBM Photovoltaic Material Research Center:** Cadmium telluride semiconductor materials for use in thin-film solar cells.
- **Electronic Imaging Center:** Infrared filters, sensors and detectors utilizing terahertz radiation, carbon nanotubes.
- **Engineering Research Center for Structured Organic Particles:** Particle technology to improve the way pharmaceuticals, foods and agriculture products are manufactured.
- **W.M. Keck Laboratory:** Manipulation of liquid flows and the small particles/microorganisms they transport in biological and biomedical technologies.
- **Membrane Science, Engineering and Technology (MAST) Center:** Development of specialized membrane technology for Energy Production, Water Treatment, Pharmaceutical Purification and Chemical Processing.
- **Microelectronics Fabrication Center:** Application-specific integrated circuits, optical switches, pressure sensors, and MEMS for biomedical, biometrics, and microfluidics application.
- **Microgravity Research Laboratory:** High energy density additives to propellants and explosives, gas sensors, fuel cells, and ultra-hard material coatings
- **New Jersey Center for Engineered Particulates:** Tailored particle coatings for pharmaceuticals, food, cosmetics, ceramics, defense, electronics and specialty chemicals.

- **Polymer Processing Institute:** Modification of polymers processing into special property products for the medical, health care, automotive, electronics, construction, and packaging industries

Current and Future Trends of the Focus Group

Current NJIT efforts are in developing novel, cost-effective, environmentally benign methods of materials processing that are predictable and scalable for commercial applications. This is the only group that has also been part of a national NSF funded Engineering Research Center in the area of pharmaceuticals and has been responsible for developing several key enabling technologies, including a bioavailability enhancement platform based on strip-film technology with ability to incorporate sensing and control technologies for predictive design and control that would allow for developing real-time release pharmaceutical products. There are also manufacturing platforms that enable flexible dosages, on-demand production and personalized medicine, having potential for improved health-care and delivery and making significant impact in the emerging area of delivery of biologics and vaccines. The fundamental understanding of powder processing has also been applied to precisely tailored ultra-fine structured particle composites as well as reactive nano-materials for solid and gelled propellants, explosives, and pyrotechnics, where the product has better performance, higher energy density, and safer profile. We anticipate significantly increased funding, including from NIH, FDA, Foundations (e.g., Keck and Gates), PRF, DOE, etc. The group will also expand their international partnerships and significant additional technology transfer activities and royalty bearing licensing.

7. Nanotechnology

Definition and Scope of the Focus Group

Nanotechnology is a field dealing with underlined phenomena at the nanoscale; this dimension scale covers molecular interactions and material surface properties and hence, is important to fields, such as, Chemistry, Engineering, Life sciences, Material Sciences and Physics. Nanotechnology is expected to create millions of new jobs and to generate ~ $1 trillion in product revenues worldwide by 2015 (B. Rogers, J. Adams, S. Pennathur, Nanotechnology: the whole story, CRC Press (2013) ISBN-10: 1439897808). The scope of Nanotechnology is to understand these phenomena and utilize them for the benefit of our society.

A good number of NJIT members are associated with Nanotechnology, either directly or indirectly. The field has implications towards Health Care, Energy, Manufacturing, Pollution Prevention and Urban Life. On-going ten-year program, and funded by NSF is devoted (among other things) to nano-particles and nano-composites. On-going five-year program, funded by NASA on electric-field-driven colloid phenomena (nanoparticles) is conducted aboard the International Space Station. Overall, it is estimated that the Focus Group brings to NJIT more than $1 M in external revenues, annually.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Raj Dave	Chemical, Biological and Pharmaceutical Engineering (CBPE)	Particle technology, image processing, cluster analysis, pattern recognition, applied life sciences
Boris Kushid	CBPE	Electro-microfluidics, particles, cells, micro-organisms, electro-hydrodynamics, applied life sciences, sustainable systems
Edward Dreizin	CBPE	Energetic materials, thermal analysis, metal combustion, high-energy density materials, solid propellants, solid fuels, combustion phenomena, transport phenomena, microgravity, arc plasmas, micro-joining, metal surface treatment
Sagnik Basuray	CBPE	Nanotechnology, Pasmonics, Photonics, Nanofluidics, Microfluidics, Electro-Kinetics, Lab-On-A-Chip, Point-of-Care Diagnostics
Kamalesh Sirkar	CBPE	Membrane separation techniques, fabrication of membranes, biotechnology, pharmaceutical technology, membrane-based bioseparations, applied life sciences
Xiaoyang Xu	CBPE	Biomaterials, nanomedicine, controlled drug delivery, nanotechnology, bioimaging, regenerative medicine

Xianqin Wang	CBPE	Nanomaterials, environmental protection, clean energy, biology, pharmaceutical engineering
Leonid Tsybeskov	ECE	Nanostructures, quantum devices, solid state VLSI, electro-optics systems
Haim Grebel	ECE	Nano-technology, artificial dielectrics, optical bench, laser-induced etching of optical filters, holographic optical interconnects, solid state VLSI, electro-optics systems,
Durga Misra	ECE	VLSI devices, design, integrated sensors, vlsi, electro-optics systems, computer architecture
Dong Kyuan Ko	ECE	Quantum dots, nanocomposites, advanced materials design, nanotechnology, nanoelectronics, solar cells, thermoelectrics
Hieu Pham Trung Nguyen	ECE	Nanotechnology
Treena Arinzeh	BME	Stem cells, materials testing, cell bio-material interaction, nerve tissue regeneration, musculoskeletal tissues,
Raquel Perez-Castillejos	BME	Microfluidics and Lab on a Chip, micro- and nano-technology for cell biology and medicine, BioMEMS, BioNEMS, micro-tissue models,
Cheul Cho	BME	Stem cell bioengineering, regenerative medicine, tissue engineering, polymeric biomaterials,
Eon Soo Lee	MIE	Nano materials, energy materials, micro fuel cells, proton exchange membrane fuel cells, solid oxide fuel cells
Pushpendra Singh	MIE	Nanomaterials, smart fluids
Chao Zhu	MIE	Nanomaterials
Somenath Mitra	Chemistry and Environmental Science (CES)	Sensor instrumentation, analytical instrumentation, nanotechnology, sustainable systems
Zafar Iqbal	CES	Nanotechnology, carbon nanotubes, nanoenergetics, nanocomposites, sensors, hydrogen storage, biofuel cells, solar cells
Edgardo Farinas	CES	Enzyme design, biocatalysts, proteins
Kevin D. Belfield	CES	Polymers and nanoparticles for biomedical theranostic applications
Lisa Axe	CEE	Biogeochemical processes, environmental systems, chemical and physical treatment processes
Jay Meegoda	CEE	Geo-environmental engineering, contaminated soils, centrifugal modeling, ultrasound research, underground infrastructure, sustainable systems
John Federici	Physics	terahertz spectroscopy, terahertz imaging, synthetic aperture, interferometric imaging,

		pump spectroscopy, probe ultrafast spectroscopy, sensors, biophotonics
Trevor Tyson	Physics	transition-metal oxide systems, thin films, atomic physics, molecular physics, myoglobin, hemoglobin, sustainable systems

Research Centers

- **Engineering Research Center for Structured Organic Particles:** Particle technology to improve the way pharmaceuticals, foods and agriculture products are manufactured.
- **Applied Biomaterials and Tissue Engineering Laboratory**: Bone repair, nerve tissue regeneration
- **Membrane and Separation Technologies**: Micro- and nanoporous filters for medicine and pharmaceutical manufacture.
- **Neural Interface Laboratory:** Interfaces with the central nervous system to record volitional control signals and micro-stimulate the spinal cord to improve the motor function after injury.
- **Stem Cells and Tissue Engineering Lab:** Natural biopolymer, micropatterning techniques.
- **CNBM Photovoltaic Material Research Center:** Cadmium telluride semiconductor materials for use in thin-film solar cells.
- **New Jersey Center for Engineered Particulates:** Tailored particle coatings for pharmaceuticals, food, cosmetics, ceramics, defense, electronics and specialty chemicals.
- **York Center for Environmental Engineering and Science**: Hazardous substance management, pollution remediation and prevention, sustainable manufacturing.

Current and Future Trends of the Focus Group

External funding and related activities are expected only to grow as more applications are targeted: photovoltaic cells and water splitting (use of sun radiation for hydrogen generation from water) are but a few examples of future energy harvesting; novel membrane technologies for power sources and pollution prevention; point of care medical detection (e.g., flu virus detection and bio-scaffolds); remote sensing; smart cards and novel building materials.

C. Data Science and Information Technology

8. Information and Communications Technology (ICT)

Definition and Scope of the Focus Group

Information and Communications Technology (ICT) is shaping many aspects of the society and economy, and is evolving rapidly to provide access to unprecedented amounts of information anytime and anywhere from any device. ICT is enabling advances in other sectors to provide smart transportation, better healthcare, reliable utility services, smart grids, smart cities, industrial automation, and so on. Emerging research topics include Internet of Things, Cloud Computing, 5G Wireless Systems, Green Communications and Networking, Networking for "Big Data", Data Mining, Mobile Health, and Cyber Security.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Ali Akansu	Electrical and Computer Engineering (ECE)	Signal and transform theories, 4th paradigm and sensing-sensors-signals, quantitative finance and financial engineering, wireless Internet engineering and multimedia applications
Ali Abdi	ECE	Wireless communication in underwater and terrestrial channels, channel estimation and modeling, blind modulation recognition, systems biology, computational biology, analysis of molecular networks
Nirwan Ansari	ECE	Broadband networks, multimedia communications, computational intelligence, advanced networking
Hongya Ge	ECE	Statistical processing, array signals, detection theory, estimation theory, communications, mimo system, broadband wireless, transceiver design, ds-cdma systems, numerical analysis, approximation theory
Alexander M Haimovich	ECE	Signal processing, interference rejection, wireless communications, personal communications systems, smart antennas, cellular wireless systems, adaptive signal processing, radar, communications
Abdallah Khreishah	ECE	Network coding, wireless networks, congestion control, cloud computing, network security, database systems
Joerg Kliewer	ECE	Error correcting codes, information theory, communication networks, secure communication
Roberto Rojas-Cessa	ECE	QoS traffic, high-speed switches, computer

		architecture and systems, computer networking
Yun-Qing Shi	ECE	Stereo image sequences, communications, signal processing, bioelectronics, intelligent systems
Osvaldo Simeone	ECE	Cognitive radio, secure communications, distributed synchronization, communications, signal processing
Mengchu Zhou	ECE	Computer-integrated manufacturing, intelligent automation, petri nets, neural networks, computer networking, bioelectronics, intelligent systems
Cristian M Borcea	CS	Computer Science, mobile computing, sensor networks, distributed systems
Reza Curtmola	CS	Information security, web technologies, computer science
Vincent Oria	CS	Computer science, virtual mall, virtual catalogs, courseware on demand
Kurt Rohloff	CS	Computer science, cyber-secuirty
Yehoshua Perl	CS	Computer science, ontology, semantic web
Andrew Sohn	CS	Computing infrastructure, autonomous migration, virtual machines, maximizin cluster, virtualization
Jason Wang	CS	Computer science, software development, computational proteomics, computational genomics, bioinformatics, cyberinfrastructure, digital libraries, integration informatics
Guiling Wang	CS	Network security, systems security, wireless ad-hoc, sensor networks, vehicular networks, mobile computing
Zhi Wei	CS	Bioinformatics, statistical learning, machine learning, biostatistics, computational genetics, systems biology
Xiaoning Ding	IS	Information system, multi-core computer science
Quentin Jones	IS	Computer-Supported Collaborative Work (CSCW), Human-Computer Interaction (HCI), Pervasive Computing, Computer-Mediated Communication (CMC), Virtual Community Systems
Donghee Wohn	IS	Information systems
Songhua Xu	IS	Artificial Intelligence: Web Intelligence, Innovative Applications of AI, Social Networks, Intelligent Systems
Yi Chen	SOM	Data management, informatics

Research Centers

- **Advanced Networking Laboratory:** Research to improve the performance, dependability, and trustworthiness of telecommunications networks.
- **Center for Information Age Technology:** Technology assessment and planning, systems integration for business, government and academia.
- **Center for Wireless Communications and Signal Processing Research:** Multi-carrier systems, Turbo Coding techniques, ultra-wideband communications, MIMO systems.
- **Collaborative Hypermedia Laboratory:** Asynchronous learning systems, online communities, digital libraries.
- **Cryptography & Telecommunication Laboratory:** Cryptography, computer security and telecommunications networks.
- **CSRZIC Laboratory for Rail System Network and Information Technologies:** Wireless communications on high-speed trains.
- **Data and Knowledge Engineering Laboratory:** Data mining, bioinformations, computational biology.
- **electronic Arts Habitat (eArtH):** Multimedia, social computing, human-computer interaction.
- **Leir Center for Financial Bubble Research:** Quantitative and qualitative research to determine how a financial bubble can be identified including its stages of development and what policies can best manage its impacts.
- **LIXIN-NJIT Economic Risk Early Warning Center**: Methodologies of early warming for studying macroeconomic risk; industry risk identification and early warning; bank liquidity risk warning index system; bank credit risk and internal credit rating.
- **NJEdge.net:** Advanced Internet technologies and digital communications
- **New Jersey Health Information Technology Extension Center**: Meaningful use of electronic health records.
- **Smart Campus:** Social interference in the context of social computing applications.

Structural Analysis of Biomedical Ontologies Center: Medical terminologies and ontologies.

Current and Future Trends of the Focus Group

NJIT has contributed to technological advances in many areas of ICT including wireless communications, software-defined radio, bio-inspired communications, underwater communications, optical communications and networks, high speed rail communications, Internet of Things, multimedia communications, cloud radio access networks, data center networks, green communications and networks, wireless sensor networks, vehicular networks, socially-aware networking, digital forensics, cryptography, secure storage, network security, compressed sensing, cloud computing, data mining, bioinformatics, medical informatics, coordination and collaboration in wireless networks, radar, signal intelligence, etc., and has been recognized by a number of accolades including best paper awards, awards by NJ Inventors Hall of Fame, Thomas Alva Edison Patent Awards, NJIT Excellence in Research Lifetime Achievement Award, etc. The potential for growth is tremendous, and funding agencies such as NSF, DARPA, and DHS have several core

programs to support research in this focus group. Furthermore, there is significant potential for collaboration with industry and technology transfer.

9. Cyber-Physical Systems

Definition and Scope of the Focus Group

Cyber-physical systems (CPS) are complex engineering systems that rely on the integration of physical, computation, and communication processes to function. The research in physical sciences is advancing rapidly due to the development of state-of-the-art experiments and modeling. However, the field is also facing tremendous challenges in handling a huge amount of data in near real-time and in extracting the relevant information that leads to scientific discovery. This is particularly true for all four major research directions related to Physics: Biophysics, Materials Science, Optics/Sensors and Solar-Terrestrial Research.

In Biophysics, the need to analyze and manipulate terabytes of data has led to the advent of new disciplines motivated by high-throughput genomic projects. "System Biology" focuses on complex interactions within and between cells and its aim is to understand life and the mechanisms of diseases. With the cost of genetic screening dropping below $1,000 now, it is easy to envisage a future in which every hospital will need a Biophysicist to analyze the message blueprinted in DNA. The candidate could be a scientist with cross-disciplinary expertise to analyze and model large data in Biology and prepare new generations of Biophysicists for the future.

For the field of Optics/Sensors, various new imaging techniques produce very large volumes of digital image data. These images need to be stored and cataloged to allow for fast access to desired features in the data. Algorithms and systems need to be developed to analyze these data, and convert them into structural or developmental information of the systems that were imaged.

For the field of Materials Science, understanding emergent phenomena requires 2D and 3D mapping of magnetic, electrical, chemical and structural properties over a broad range of length scales (atomic, nano, mesocopic and micron) and time scales (femtoseconds to years) in systems ranging from biological materials to magnetic data storage systems. New instruments and national facilities being developed to image emergent phenomena will produce massive datasets.

In the area of Solar-Terrestrial Research, new facilities at NJIT, such as the world's largest aperture solar telescope NST at Big Bear Solar Observatory, the Expanded Owens Valley Solar Array radio facility in California, the Automated Geophysical Observatories in the Antarctic, and the NJIT-managed RBSPICE instrument on the NASA Radiation Belt Storm Probes spacecraft all provide exciting new opportunities for research in handling big data in the order of terabytes each day. It becomes fundamentally critical to develop computational techniques to automatically detect, visualize and characterize features and events immediately after the data is acquired.

This focused-study aims at handling these emerging “big data” and artificial intelligence problems. The research will expand the research frontier in a multi-disciplinary manner, involving researchers across colleges in Physics and Computing Sciences. We have demonstrated such a potential with a previous million dollar grant from NSF's Information Technology Research program, which had a Physics faculty member as PI and computer science faculty members as Co-PIs.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Andy Gerrard	Physics	Thermospheric winds, mesospheric winds, temperatures, doppler imager, plasma physics, space weather
Dale Gary	Physics	Radio solar physics, microwave imaging observations
Sasha Kosovichev	Physics	Solar physics
Wenda Cao	Physics	Infrared solar physics, astronomical instrumentation, high-resolution astronomical observation, imaging technology
Haimin Wang	Physics	Solar physics, gamma-ray observations, electrons, ions, radio emission
John Federici	Physics	Terahertz spectroscopy, terahertz imaging, synthetic aperture, interferometric imaging, pump spectroscopy, probe ultrafast spectroscopy, sensors, biophotonics
Ian Gatley	Physics	Physics, astronomy, infrared detectors
Andrei Sirenko	Physics	Optics, x-ray, raman scattering in solids
Cristiano Dias	Physics	Amyloid formation, Protein interaction, Protein folding, Solvation of Bio-molecules and hydrophobic solutes
Trevor Tyson	Physics	Transition-metal oxide systems, thin films, atomic physics, molecular physics, myoglobin, hemoglobin, sustainable systems
Vincent Oria	CS	Computer science, virtual mall, virtual catalogs, courseware on demand
Usman Roshan	CS	Bioinformatics, phylogeny reconstruction, multiple sequence alignment, computational genetic epidemiology, machine learning, discriminative methods, computer science
Frank Shih	CS	Digital watermarking, digital steganography, digital forensics, image processing, computer vision, information security, computer graphics, robot sensing, medical imaging, fuzzy logic, pattern recognition, neural networks, artificial intelligence, parallel processing
Guiling Wang	CS	Network security, systems security, wireless ad-hoc, sensor networks, vehicular networks, mobile computing
Xiaoning Ding	IS	Information system, multi-core computer science

Research Centers

Center for Solar Terrestrial Research: Solar optical astronomy, solar radiophysics, terrestrial science. The Center for Solar-Terrestrial Research (CSTR) at NJIT is an international leader in ground- and space-based solar and terrestrial physics, with interest in understanding the effects of the Sun on the geospace environment. CSTR operates the Big Bear Solar Observatory (BBSO) and Owens Valley Solar Array (OVSA) in CA, the Jeffer Observatory at Jenny Jump State Forrest in NJ, and the Automated Geophysical Observatories (AGOs) distributed across the Antarctic iceshelf. The Center also manages a large number of instruments at South Pole Station, McMurdo Station, across South America, and across the United States. CSTR is also a PI organization in the NASA Van Allen Probes mission and houses the Space Weather Research Laboratory (SWRL), which does scientific research in the area of space weather with the mission to understand and forecast the magnetic activity of the Sun and its potential influence on Earth. Such instrumentation and data resources enable scientific studies spanning from the Sun's surface, into the Sun's extended atmosphere, and onwards into the Earth's atmosphere.

Current and Future Trends of the Focus Group

There are growing activities in this research area as will be measured by proposal submissions, student recruitments, delivery of data systems, and publication of research results.

10. Cyber Security

Definition and Scope of the Focus Group

Cyber technologies are prevalent in modern society and include communication networks, handheld computers, cloud computing environments and embedded computing technologies such as integrated into all modern automobiles, airplanes and military systems. Cyber technologies are inherent across the breadth of modern industries including in financial, defense, automotive and information technology domains, as well as in public utilities. Many of these systems are not secure by any reasonable definition of security. Further, when compromised, the loss of these systems cause dramatic loss of data and capabilities, resulting in exposure of private information, financial loss, loss of services and even death. There is an ongoing and long-term future need to research new methods for understanding how these systems can be compromised and fail, how to design cyber systems so they are secure, and how to improve or fix the cyber infrastructure that has already been deployed. Current areas of investigation to address these challenges include developing and applying new approaches to practical encryption, securing cloud computing services, privacy technologies, improved software engineering techniques, better data encoding and communication protocols, human factors research and so on.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Ali Akansu	Electrical and Computer Engineering (ECE)	Signal and transform theories, 4th paradigm and sensing-sensors-signals, quantitative finance and financial engineering, wireless Internet engineering and multimedia applications
Nirwan Ansari	ECE	Broadband networks, multimedia communications, computational intelligence, advanced networking
Abdallah Khreishah	ECE	Network coding, wireless networks, congestion control, cloud computing, network security, database systems
Joerg Kliewer	ECE	Error correcting codes, information theory, communication networks, secure communication
Roberto Rojas-Cessa	ECE	QoS traffic, high-speed switches, computer architecture and systems, computer networking
Yun-Qing Shi	ECE	Stereo image sequences, communications, signal processing, bioelectronics, intelligent systems
Cristian M Borcea	CS	Computer Science, mobile computing, sensor networks, distributed systems
Reza Curtmola	CS	Information security, web technologies, computer science
Vincent Oria	CS	Computer science, virtual mall, virtual catalogs, courseware on demand

Kurt Rohloff	CS	Computer science, cyber-secuirty
Quentin Jones	IS	Computer-Supported Collaborative Work (CSCW), Human-Computer Interaction (HCI), Pervasive Computing, Computer-Mediated Communication (CMC), Virtual Community Systems
Ali Mili	CS	High assurance, systems engineering, verification, validation, software, engineering trends
Frank Shih	CS	Digital watermarking, digital steganography, digital forensics, image processing, computer vision, information security, computer graphics, robot sensing, medical imaging, fuzzy logic, pattern recognition, neural networks, artificial intelligence, parallel processing
Jason Wang	CS	Computer science, software development, computational proteomics, computational genomics, bioinformatics, cyberinfrastructure, digital libraries, integration informatics
Guiling Wang	CS	Network security, systems security, wireless ad-hoc, sensor networks, vehicular networks, mobile computing

Research Centers

- **Center for Information Age Technology:** Technology assessment and planning, systems integration for business, government and academia.
- **Cryptography & Telecommunication Laboratory:** Cryptography, computer security and telecommunications networks.
- **CSRZIC Laboratory for Rail System Network and Information Technologies:** Wireless communications on high-speed trains.
- **Data and Knowledge Engineering Laboratory:** Data mining, bioinformations, computational biology.
- **electronic Arts Habitat (eArtH):** Multimedia, social computing, human-computer interaction.
- **Leir Center for Financial Bubble Research:** Quantitative and qualitative research to determine how a financial bubble can be identified including its stages of development and what policies can best manage its impacts.
- **LIXIN-NJIT Economic Risk Early Warning Center**: Methodologies of early warming for studying macroeconomic risk; industry risk identification and early warning; bank liquidity risk warning index system; bank credit risk and internal credit rating.
- **NJEdge.net:** Advanced Internet technologies and digital communications
- **Smart Campus:** Social interference in the context of social computing applications.

Current and Future Trends of the Focus Group

The common thread and wider impact of cyber-security research is to support a growing need for secure ad-hoc interaction and collaboration between computation devices, whether in enterprise, embedded or cyber-physical systems. Also of ongoing interest are software security, software assurance/verification/validation/certification, static and dynamic software analysis, malware analysis, security and privacy of mobile systems and apps, systems approaches to security including compiler design, programming languages for more natural design, and visualization techniques for cyber-security. At a higher level, research is needed in network and systems security, networked systems and cloud computing security, mathematical modeling of emergent behavior leading to vulnerabilities, security of critical infrastructure systems and emerging technologies such as Internet of Things (IoT), wearable devices, applied cryptography, and application of machine learning techniques in network/system security. These challenge areas imply the need for secure, ad-hoc, tactical information sharing for robust analytics and feedback control systems enabled by mathematically provable security, but implemented in a practical, cost-effective manner.
From a funding perspective, the growing importance of Cyber Security has been recognized by a growing number of programs and significant increases to support research in Cyber Security from corporations such as GE, GM, Microsoft, Google, etc…. and federal agencies such as:

- NSF (multiple directorates)
- DARPA (I2O and STO)
- DHS (HSARPA)
- IARPA (Safe and Secure Operations Office)
- ONR (Codes 30 and 31)
- AFRL (Rome)

11. Data Science and Systems

Definition and Scope of the Focus Group

Data science is the study and practice of extracting knowledge and structure from data that can then be used for reasoning. It spans various fields in computer science and mathematics such as machine learning and statistical inference, computer programming, software engineering, high performance computing, and cloud computing. Various faculty members in the computer science department and the larger university are engaged in research that falls under the umbrella of data science. For example in computer science we have faculty working in bioinformatics, medical informatics, image processing, data mining, and the areas mentioned above. In mathematical sciences, physics, and engineering faculty are engaged in analyzing large datasets that usually involve statistical inference, machine learning, and high performance computing. Thus the scope of this focus group extends across the university.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
James Geller	Computer Science (CS)	Computer science, ontology, semantic web
Cristian M Borcea	CS	Computer Science, mobile computing, sensor networks, distributed systems
Reza Curtmola	CS	Information security, web technologies, computer science
Vincent Oria	CS	Computer science, virtual mall, virtual catalogs, courseware on demand
Chengjun Liu	CS	Pattern recognition, machine learning, computer vision, security, image processing
Ali Mili	CS	High assurance, systems engineering, verification, validation, software, engineering trends
Marvin Nakayama	CS	Simulation, reliability theory, fault-tolerant systems, computer analysis, applied probability, statistics
Usman Roshan	CS	Bioinformatics, phylogeny reconstruction, multiple sequence alignment, computational genetic epidemiology, machine learning, discriminative methods, computer science
Frank Shih	CS	Digital watermarking, digital steganography, digital forensics, image processing, computer vision, information security, computer graphics, robot sensing, medical imaging, fuzzy logic, pattern recognition, neural networks, artificial intelligence, parallel processing
Dimitri Theodoratos	CS	Databases, query processing, xml, data warehousing, olap, multidimensional databases, data integration, semantic web

Jason Wang	CS	Computer science, software development, computational proteomics, computational genomics, bioinformatics, cyberinfrastructure, digital libraries, integration informatics
Guiling Wang	CS	Network security, systems security, wireless ad-hoc, sensor networks, vehicular networks, mobile computing
Zhi Wei	CS	Bioinformatics, statistical learning, machine learning, biostatistics, computational genetics, systems biology
Michael Bieber	Information Systems (IS)	Hypermedia and Web Engineering, Digital Libraries, Collaborative Learning, Virtual Communities, Relationship Analysis (Software Requirements Engineering)
Lian Duan	IS	Data mining, bioinformatics, patterns, social networking
Songhua Xu	IS	Artificial Intelligence: Web Intelligence, Innovative Applications of AI, Social Networks, Intelligent Systems
Yi-Fang Brook Wu	IS	Medical Text Mining, Information Extraction, Knowledge Organization, Information retrieval, natural language processing, Recommender Systems
Yi Chen	SOM	Data management, informatics
Mark Somers	SOM	Management, business, finance, marketing
Bruce Bukiet	Mathematical Sciences (MS)	mathematical modeling, mathematical physiology
Shahriar Afkhami	MS	Applied mathematics, computational fluid mechanics, scientific computing, complex flowing, viscoelastic flows, electro/magnetohydrodynamics, microfluidics, electrowetting, contact line instability
Daniel Bunker	MS	global warming, environmental studies, biological observation, ecology, sustainable systems
Victor Matveev	MS	Cell biophysics, computational neuroscience
Richard Moore	MS	Industrial mathematics, modeling, optical communications, nonlinear wave equations, dynamical systems, stochastic processes, numerical methods
Gareth Russell	Biology	Community ecology, conservation biology, computational applications
Sotirios Ziavras	ECE	Computer architecture, reconfigurable computing, high-performance computing, parallel processing, chip multiprocessors, system-on-chip (SoC), embedded systems.
Cristiano L. Dias	Physics	Amyloid formation, Protein interaction, Protein folding, Solvation of Bio-molecules

		and hydrophobic solutes
Keun Ahn	Physics	Condensed matter, magnetoresistive manganites, physics
Anthony Rosato	MIE	Particle technology, computational modeling, discrete element, monte carlo simulations, solids, applied dynamical systems

Research Centers

- **Center for Applied Mathematics and Statistics:** Mathematical biology, fluid dynamics, wave propagation.
- **Center for Information Age Technology:** Technology assessment and planning, systems integration for business, government and academia.
- **Collaborative Hypermedia Laboratory:** Asynchronous learning systems, online communities, digital libraries.
- **Cryptography & Telecommunication Laboratory:** Cryptography, computer security and telecommunications networks.
- **CSRZIC Laboratory for Rail System Network and Information Technologies:** Wireless communications on high-speed trains.
- **Data and Knowledge Engineering Laboratory:** Data mining, bioinformations, computational biology.
- **electronic Arts Habitat (eArtH):** Multimedia, social computing, human-computer interaction.
- **LIXIN-NJIT Economic Risk Early Warning Center**: Methodologies of early warming for studying macroeconomic risk; industry risk identification and early warning; bank liquidity risk warning index system; bank credit risk and internal credit rating.
- **Structural Analysis of Biomedical Ontologies Center:** Medical terminologies and ontologies.

Current and Future Trends of the Focus Group

Present trends include new courses in data science areas, data science seminar, current funding, and new attempts at external funding. Our new course enrollments are high. Faculty in this group also represents NJIT in the New Jersey Big Data Symposium (NJBDA) particularly in creating workshops for academic and industrial training. Given the increasing influence of data driven research in academia and applications in industry we expect enrollments as well as research output and funding to increase.

D. Trans-disciplinary Areas

12. Mathematical Modeling and Computational Science (MMCS)

Definition and Scope of the Focus Group

Mathematical modeling and computational science (MMCS) describes the development and application of computational algorithms and mathematical modeling to problems in the physical sciences, biology, engineering, and social sciences. This includes both the design of novel algorithms and analytical models, as well as the application of previously existing methods to new scientific and technological applications.

The primary goal of the focus group is to foster research and educational activities that highlight novel computational algorithms and mathematical modeling and their interplay with physical science, biological science, engineering and social sciences.

Rapid growth in the capabilities of high performance computers has transformed the methodology of scientific investigation. Scientific computation has joined experiment and theory as one of the fundamental tools of investigation. A strong aim of this research focus group is to encourage the exchange of ideas and cross-fertilization of research activity at NJIT that lies at the interface between different scientific fields utilizing scientific computation and mathematical modeling. There is substantial breadth and depth of research activities involving MMCS at NJIT, as is described below. It is believed that MMCS activities occur in nearly every department at NJIT, and this research focus group will help tie together groups with common research interests and aims, as well as enhance funding opportunities.

Research activities involving mathematical modeling and computational science are ubiquitous at NJIT. They include, for example, theoretical investigations based on multi-scale modeling/simulations in solar physics and in fluid dynamics; electromagnetic and acoustic scattering, remote sensing, and imaging; mathematical biology, ecology, and biomechanics; protein folding and molecular modeling; materials science and nano-structures; risk analysis; optimization; mathematical finance; networks; data analysis; numerical analysis; automated writing and text analysis; and applied and bio- statistics.

Faculty Name	Department	Primary Areas of Interest
Michael Siegel	Mathematical Sciences (MS)	Fluid mechanics, materials science, scientific computation
Shahriar Afkhami	MS	Applied mathematics, computational fluid mechanics, scientific computing, complex flowing, viscoelastic flows, electro/magnetohydrodynamics, microfluidics, electrowetting, contact line instability
Bruce Bukiet	MS	Mathematical modeling, mathematical physiology
Denis Blackmore	MS	Dynamic systems
Michael Booty	MS	Applied mathematics, mathematical modeling, asymptotic analysis, numerical methods,

		nonlinear waves
Yassine Boubendir	MS	Mathematical analysis of wave propagation, finite element methods, integral equations
Daniel Bunker	MS	Global warming, environmental studies, biological observation, ecology, sustainable systems
Linda Cummings	MS	Physically-arising free boundary problems
Wooyoung Choi	MS	Fluid mechanics, nonlinear wave mechanics, free surface flows, geophysical flow processes, naval hydrodynamics, vortex dynamics, hydrodynamic stability
Sunil Dhar	MS	Model building, inference
Casey Diekman	MS	Dynamical systems, modeling, mathematical biology, computational neuroscience, circadian rhythms
Roy Goodman	MS	Nonlinear waves, optics, dynamical systems
Wenge Guo	MS	Large-scale multiple testing, high-dimensional inference, bioinformatics, statistical learning, design and analysis of clinical trials.
David Horntrop	MS	Scientific computing, monte carlo methods, numerical solution of stochastic equations, statistical mechanics, turbulent transport, fluid dynamics
Shidong Jiang	MS	Numerical algorithms, nonreflecting boundary conditions, nonlinear optics
Lou Kondic	MS	Thin films, granular materials
Ji-Meng Loh	MS	Applied spatial data analysis
Victor Matveev	MS	Cell biophysics, computational neuroscience
Eliza Michalopoulou	MS	Ocean acoustics, signal detection, inverse problems
Cyrill Muratov	MS	Reaction-diffusion equations, propagation phenomena, analysis of nonlinear PDEs, cell communication
Richard Moore	MS	Industrial mathematics, modeling, optical communications, nonlinear wave equations, dynamical systems, stochastic processes, numerical methods
Peter Petropoulos	MS	Scientific computing, absorbing boundary conditions, high-order finite differences
Horacio Rotstein	MS	Mathematical biology, computational neuroscience, dynamical systems
Sundar Subramanian	MS	Survival analysis, nonparametric functional estimation, efficient estimation, semiparametric inference
Catalin Turc	MS	Solar photovoltaic technology
Yuan Young	MS	Mathematical sciences, fluid dynamics, biological fluid dynamics, numerical analysis,

		turbulence
Antai Wang	MS	Survival Analysis, Microarray Data Analysis
Keun Ahn	Physics	Condensed matter, magnetoresistive manganites, physics
Wenda Cao	Physics	Infrared solar physics, astronomical instrumentation, high-resolution astronomical observation, imaging technology
Andy Gerrard	Physics	Thermospheric winds, mesospheric winds, temperatures, doppler imager, plasma physics, space weather
Dale Gary	Physics	Radio solar physics, microwave imaging observations
Sasha Kosovichev	Physics	Solar physics
Camelia Prodan	Physics	Cellular dynamics and dynamical instability, effect of drugs on cellular dynamics, dielectric spectroscopy in neuroscience
Gordon Thomas	Physics	Optics, biophysics
Trevor Tyson	Physics	Transition-metal oxide systems, thin films, atomic physics, molecular physics, myoglobin, hemoglobin, sustainable systems
Haimin Wang	Physics	Solar physics, gamma-ray observations, electrons, ions, radio emission
John Federici	Physics	Terahertz spectroscopy, terahertz imaging, synthetic aperture, interferometric imaging, pump spectroscopy, probe ultrafast spectroscopy, sensors, biophotonics
Andrei Sirenko	Physics	Optics, x-ray, raman scattering in solids
Cristiano Dias	Physics	Amyloid formation, Protein interaction, Protein folding, Solvation of Bio-molecules and hydrophobic solutes
Ali Akansu	Electrical and Computer Engineering (ECE)	Signal and transform theories, 4th paradigm and sensing-sensors-signals, quantitative finance and financial engineering, wireless Internet engineering and multimedia applications
Hongya Ge	ECE	Statistical processing, array signals, detection theory, estimation theory, communications, mimo system, broadband wireless, transceiver design, ds-cdma systems, numerical analysis, approximation theory
Osvaldo Simeone	ECE	Cognitive radio, secure communications, distributed synchronization, communications, signal processing
Boris Khusid	CBPE	Electro-microfluidics, particles, cells, micro-organisms, electro-hydrodynamics, applied life sciences, sustainable systems

Kamalesh Sirkar	CBPE	Membrane separation techniques, fabrication of membranes, biotechnology,
Michel Boufadel	Civil and Environmental Engineering (CEE)	Sustainability, contaminants, water flow transport, coastal systems, oil spills
Gareth Russell	Biology	Computational Biology
Amitabha Bose	Biology	Neural dynamics/computational neuroscience
Farzan Nadim	Biology	Cell and synaptic dynamics/computational neuroscience
Treena Arinzeh	BME	Stem cells, materials testing, cell bio-material interaction, nerve tissue regeneration, musculoskeletal tissues,
Tara Alvarez	BME	Neural control of oculomotor movements, functional magnetic resonance imaging
Shawn Chester	MIE	Solid mechanics and materials, large deformation elasticity and plasticity, multiphysics behavior of materials, computational solid mechanics
Joga Rao	MIE	Biomechanics, smart material
Pushpendra Singh	MIE	Nanomaterials, smart fluids
James Calvin	CS	Global optimization, algorithms, simulation modeling, computer analysis
Reza Curtmola	CS	Information security, web technologies, computer science
Marvin Nakayama	CS	Simulation, reliability theory, fault-tolerant systems, computer analysis, applied probability, statistics
Chengjun Liu	CS	Pattern recognition, machine learning, computer vision, security, image processing
Jason Wang	CS	Computer science, software development, computational proteomics, computational genomics, bioinformatics, cyberinfrastructure, digital libraries, integration informatics
Guiling Wang	CS	Network security, systems security, wireless ad-hoc, sensor networks, vehicular networks, mobile computing
Zhi Wei	CS	Bioinformatics, statistical learning, machine learning, biostatistics, computational genetics, systems biology

Research Centers

- **Center for Applied Mathematics and Statistics:** Mathematical biology, fluid dynamics, wave propagation.
- **Center for Information Age Technology:** Technology assessment and planning, systems integration for business, government and academia.

- **Collaborative Hypermedia Laboratory:** Asynchronous learning systems, online communities, digital libraries.
- **Data and Knowledge Engineering Laboratory:** Data mining, bioinformations, computational biology.
- **Leir Center for Financial Bubble Research:** Quantitative and qualitative research to determine how a financial bubble can be identified including its stages of development and what policies can best manage its impacts.
- **LIXIN-NJIT Economic Risk Early Warning Center**: Methodologies of early warming for studying macroeconomic risk; industry risk identification and early warning; bank liquidity risk warning index system; bank credit risk and internal credit rating.

Current and Future Trends of the Focus Group

The increasing importance of mathematical modeling and computational science in science, technology and industry is underscored by the rapid creation of new programs in the area. For example, Stanford, the University of Pennsylvania, the University of Minnesota and Harvard have all created new interdisciplinary programs in `scientific computation and mathematical engineering' or `computational science and engineering'. These are highly interdisciplinary programs created in response to a growing demand for graduates who can take a scientific approach to data analysis or modeling and simulation of complex systems. Typically, these programs build on a school's strengths in applied mathematics, computer science, and applied science and engineering, which are strengths that are clearly present at NJIT.

Opportunities for funding in MMCS are growing, including both governmental and industrial sources. Currently, nearly a third of the NSF grants awarded to NJIT fall into this general area. An example of the new funding resources available in MMCS includes NSF-EXTREEMS and related programs, which fund education, research, and faculty development in computational data analysis and modeling and simulation of complex systems. Recently, an interdisciplinary team of researchers at NJIT was awarded a substantial grant from this program, and it is believed that the formation of a research focus group will greatly enhance the opportunities for education, research collaboration, and funding in this area.

13. Transportation Systems

Transportation is vital to our society's proper functioning, providing mobility of people, goods and services. It enables people to access job markets and participate in recreational, cultural, educational, and social activities. It adds value to products by moving them to their destination in time for their use. The transportation field also is a major contributor to the economy, as a consumer of resources and as a supplier of jobs.

Transportation functions in a very complex environment which, at the beginning of the 21st Century, is characterized by constant change in the technological, regulatory and legal frameworks. Transportation professionals must not only be able to meet the technological challenges of new systems, they must also be capable of fitting these systems into the social, economic, and physical environments in a manner that preserves and improves the nation's critical infrastructure, promotes sustainable development, and improves the quality of life for all.

Department of Civil and Environmental Engineering is the focal point of transportation related research activities at NJIT. The Department conducts educational, research and technology transfer activities to achieve the objectives set forth by the U.S. Department of Transportation's University Transportation Centers Program. This is accomplished by undertaking high quality, multi-disciplinary, innovative education and research activities that can withstand rigorous peer review in the areas of freight and passenger movement efficiency, and facility, institutional, and regulatory transportation efficiency.

The Interdisciplinary Program in Transportation leads toward designated M.S. and Ph.D. degrees in Transportation. The program is designed to meet the needs of students with engineering and science backgrounds who desire to study planning, design and operation of highway and public transit systems. The degree program has three areas of specialization: Transportation Engineering; Transportation Planning; and Advanced Transportation Systems and Technology.

Through the NJIT-based Transportation Centers and activities, the transportation graduate program provides excellent opportunities for students to engage in research on all modes of transportation, including all phases of activities concerned with the provision of services and the movement of people and goods. The Center for Transportation is a major resource for public and private organizations and has established regional and national reputation for its academic programs and research activities.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Steven I-Jy Chien	CEE	Public Transportation Systems, Intelligent Transportation Systems, Transportation Systems Analysis
Janice Daniel	CEE	Transportation safety, traffic operations and control, congestion strategies, adaptive traffic control, urban freight movement, and work zone analysis.
Robert Dresnack	CEE	Environmental impact analysis (noise, air, water and traffic engineering), Storm water

Faculty Name	Department	Primary Areas of Interest
		management.
Eugene Golub	CEE	Water supply modeling and storm water management.
Hsin-neng Hsieh	CEE	Water and wastewater treatment, sludge treatment, solid waste disposal, and stormwater management
Fadi Karaa	CEE	Decision and risk analysis, Construction management, Project management and control, Project evaluation and financing
Walter Konon	CEE	Infrastructure remediation, rehabilitation and development, Context-sensitive roadway design.
Jo Young Lee	CEE	Traffic Operations, Intelligent Transportation Systems, Vehicular Wireless Communications, Connected Vehicle, Transportation Systems Modeling and Simulation.
Rongfang (Rachel) Liu	CEE	Travel behavior, Demand forecast modeling, Intermodal transportation planning, Network simulation.
Taha Marhaba	CEE	Analytical techniques for evaluation and development of sustainable environmental systems
Jay N. Meegoda	CEE	Mechanics of Geo-environmental Engineering, Corrugated Steel Culvert Pipe Deterioration
Mohamad A. Saadeghvaziri	CEE	Structural engineering with emphasis on non-linear response of structures and FSI, Extreme Events Engineering and Structural Qualifications, Structural applications of composite materials.
John Schuring	CEE	In-situ remediation of contaminated soil and groundwater, Reconnaissance site evaluation using engineering geomorphology, and Deep foundations.
Brijesh Singh	CEE	Transportation data analytics and visualization, Information systems.
Lazar N. Spasovic	CEE	Optimizing Container Port Operations, Freight Demand Forecasting, Incident Management Strategies, and Traffic Simulation and Modeling
Athanassios Bladikas	MIE	Transportation systems analysis and modeling
Thomas Juliano	ET	Intelligent Systems for Storage and Conveyance, Corrugated Steel Culvert Pipe Deterioration
Laramie Potts	ET	Real-time Geospatial Information Management System, Crust/mantle dynamic and lithospheric stress modeling from combination of satellite gravity and topography data

Faculty Name	Department	Primary Areas of Interest
David W. Washington	ET	Transport Engineering technology
Edip Niver	ECE	Electronic toll collection and applications of microwave engineering to transportation, frequency scan antenna arrays, communications, signal processing.
Darius T. Sollohub	COAD	Urban design, sustainable infrastructure
Hindy L. Schachter	SOM	Public transportation systems, Behavioral science, Organizational partnerships

Research Centers

- **Intelligent Transportation System Resource Center**
  The main purpose of the Center is to assist NJDOT in evaluating ITS technologies and optimizing strategies for deployment of ITS to meet the transportation needs of the State. The Center enhances NJDOT's ITS resources through technology assessment, technology transfer and training, evaluation of ITS strategies and deployment scenarios, application of advanced transportation and traffic modeling tools for statewide transportation planning, management and operation. It is also a valuable resource for data, such as ITS data warehouse, traffic counts, and GIS, as well as transportation models, such as corridor simulation models, regional travel demand forecasting and activity-based models.

- **International Intermodal Transportation Center**
  University-based resource program that works closely with public and private sector transportation stakeholders to facilitate economic development and quality of life improvement efforts linked to the congressionally designated International Intermodal Transportation Corridor. The center addresses broader issues such as freight transportation, brownfields, and passenger transportation.

- **National Center for Transportation and Industrial Productivity**
  Established to scientifically study the means to increase efficiency and productivity of private or public sector entities and industries through transportation improvements. This is accomplished by undertaking high quality, multi-disciplinary, innovative education and research activities that can withstand rigorous peer review in the areas of freight and passenger movement efficiency, and facility, institutional, and regulatory transportation efficiency.

- **North Jersey Transportation Planning Authority**
  The NJTPA is the Metropolitan Planning Organization (MPO) for the 13 northern counties in New Jersey. With an operating budget of approximately $11M, the NJTPA oversees over $1 billion in transportation investments, evaluates and approves proposed transportation improvement projects, and provides a forum for interagency cooperation and public input into funding decisions. It also sponsors and conducts planning studies, assists county planning agencies and monitors compliance with national air quality goals.

- **Transportation, Economic and Land Use System (TELUS)**
  A research and innovation program whose mission is to develop and deploy a fully integrated information management and decision support system to help MPOs and State DOTs develop

their transportation improvement programs (TIP) and carry out other transportation planning responsibilities. Particularly it enables public participation and transparency in the transportation planning process by implementing interactive web tools, including mapping and visualization of TIP projects. TELUS software tools are developed and maintained by NJIT with the support of a grant from the Federal Highway Administration. TELUS is recognized as the FHWA Priority, Market-Ready Technology and Innovation (T&I).

- **CSRZIC Laboratory for Rail System Network and Information Technologies**
  Wireless communications on high-speed trains.

Current and Future Trends of the Focus Group

- *Connected vehicle (CV) technology* – Development and testing of vehicle-to-infrastructure (V2I) communication and automation systems. This includes automated vehicle detection and highway system management, enhancement of adaptive signal control systems, and the development of the V2I Pilot Test-bed for the implementation of local level ITS and CV applications.
- *Transportation Systems Operations and Management* – Evaluation, modeling, and deployment of intelligent transportation system (ITS) technologies and advanced transportation management strategies aimed at more efficient utilization of highway infrastructure. This includes implementation of systems engineering approach to development and deployment of active traffic demand management (ATDM) strategies, effective incident management and management of traffic control zones (i.e., work zones), effective arterial management through the use of advanced signal systems and coordinated corridor signalization.
- *Freight Movement Efficiency* – The movement of goods over complex networks of shippers, terminal facilities, carriers, distributors, and receivers. Increasingly intermodal, the optimized flow and management of information used for tracking and operations are critical. Development of freight transportation management system and performance-based planning of transportation infrastructure that supports freight operations and goods movement is critical to economic growth.
- *Transportation data analytics* –Wealth of data on transportation system performance and operations that is becoming available requires a systematic approach to data collection, processing, storage, and analysis. It is critical that collected data is properly used to derive meaningful and actionable information about transportation system and corrective measures that ought to be taken to improve system's performance. Effective data visualization tools, as well as efficient data integration and data mining algorithms are critical to achieving this goal and present another interdisciplinary focus area of the transportation research group.
- *Passenger Movement Efficiency* – Focusing on operations planning solutions for transit properties designed to stimulate productivity growth through improvements such as unimpeded access to jobs and services.
- *Facility, Institutional, and Regulatory Efficiency* – The physical and regulatory environments in which vehicles function. Although these may affect more than one mode of transportation, there are cases, such as rail transit and freight railroads, that have dedicated rights of way or specialized regulations and institutional arrangements under which they operate. Problems that affect productivity in such cases are also addressed within this area. This focus area also includes a growing need to integrate performance measures and into regional, metropolitan, and statewide transportation planning and programming, including utilization of data-driven analytical methods for project evaluation and prioritization, as well as efficient project delivery process.

14. Science-Technology-Society Interactions

Definition and Scope of the Focus Group

Research on technology and society interactions encompasses a wide range of projects that speak to how science and technology are being utilized in practice in contemporary society. In addition to such research being meritorious in its own right, most STEM funding agencies require projects to include such research to asses effectiveness (e.g., measuring behavioral change in the intended audience or market), the work's greater societal benefits and risks, its commercial potential, and its ethics.

Research on technology and society interactions encompasses many disciplines, but is usually concentrated among experts with training in the social science and humanities. Research within this category is defined broadly to include modes of scholarly production that reach beyond the STEM fields. However, such research is also inclusive of STEM approaches and might incorporate STEM practices and methods alongside historical analysis, sociological analysis, philosophical analysis, artistic as well as critical commentary on the ethical, social, cultural or economic dimensions of contemporary investments in science and technology. Such research is, and has been supported, over the years by NSF, NIH, NEH, and private foundations. The goal would be for NJIT and R&D to help coordinate and support initiatives in this area so that existing and future faculty is competitive for these sorts of grants as well as fellowships.

NJIT hosts faculty and programs that research technology and society interactions, such as policies for innovation and business incubation, and the impact of pervasive, healthcare, and distance learning technologies on human behavior. This research supports NJIT's mission statement and typically involves collaboration between NJIT's assets including its Colleges, the Enterprise Development Center, and the New Jersey Innovation Institute.

Such scholarship is being produced at a high level in the History and Humanities departments, but is not currently being supported institutionally with resources that would raise their profiles and provide for more interdisciplinary interactions on campus as well as beyond. The Humanities Department has a unit dedicated to STS and offers a major in STS for undergraduates. While there is no social science unit at NJIT, social scientists doing research that would fall under this research focus area are currently active in CSLA, SOM and COAD.

Current Researchers

Faculty Name	Department	Primary Areas of Interest
Stephen Pemberton	History	Medicine, biomedical sciences and technology, public health, twentieth-century U.S. history
Alison Lefkovitz	History	The law and its history, gender, political economy
Neil Maher	History	20th century history, environmental history, social history, political history, technology and medicine, landscape studies
Lisa Nocks	History	Science, technology, media culture, public perception of techno-science, popular science publishing, recent history, robotics, space, exploration biotechnology, Victorian science

		and culture
Elizabeth Petrick	History	Research specializations: information technologies, development and use of technology, civil rights, public policy
Kyle Riismandel,	History	Suburban and Urban History and Culture, Legal History of Media, United States Social and Urban History, United States Cultural History and the Study of Popular Culture, Film History and Theory
Richard Sher	History	Social history of technology, history of the book and print culture, intellectual and cultural history
Maurie Cohen	HUM-STS	Sustainable consumption, alternative mobility futures, sociotechnical transition management, industrial ecology, environmental politics, sustainable systems
Christopher Funkhouser	HUM-STS	Poetry, digital literature, eletronic media, computer writing, digital literature, technology and society
Eric Katz	HUM-STS	Environmental ethics, technology philosophy, holocaust studies
Andrew Klobucar	HUM-STS	social media, literature
Bernadette Longo	HUM-STS	Science and technology
David Rothenberg	HUM-STS	Nature, technology, music in philosophy, literature
John Wolf	HUM-STS	Science and technology
Caitlyn Wylie	HUM-STS	Science and technology
Cesar Bandera	SOM	Telemedicine, mobile outreach and situation awareness, intelligent health care records
Martina Decker	College of Architecture and Design (CoAD)	Smart materials, sustainability
Tom Dallessio	CoAD	Sustainability, resilient structures

Current and Future Trends of the Focus Group

The best Polytechnic universities in the United States all have dedicated STS academic units that are producing high level research; including MIT, Caltech, Georgia Tech, Harvey Mudd, etc. NJIT's faculty working on STS interactions is capable of obtaining a high profile that would be competitive with such research activity if given adequate support. Collaborations between faculty in some STEM units and non-STEM units could be effectively built and facilitated by investments in the STS area, such as in statistical experiment design and assessment. The cost of doing so is relatively inexpensive since faculty working on science, technology and society and interactions often do not require significant overhead to make significant contributions to scholarship and policy. Small grants and fellowships in this area could pay huge dividends in the cultural capital that accrues throughout NJIT.

E. Key Performance Index (KPI)

- KPI should be tractable and accountable.
- KPI should be measured per annum for a moving window of three (or more) years.
- Possible metrics:
  - ✓ Number of awards and total amount of research funding per focus group (Research Office, Office of Development)
  - ✓ Funding per focus group member (Research Office, Office of Development)
  - ✓ Number of fellowships per focus group (based on annual faculty reports?)
  - ✓ Number of fellowships per focus group member (based on annual faculty reports?)
  - ✓ Total number of doctoral and MS students per focus group (Graduate Studies Office)
  - ✓ Total number of grant supported doctoral and MS students per focus group (Graduate Studies Office)
  - ✓ Doctoral and MS students per focus group member (Graduate Studies Office)
  - ✓ Granted supported doctoral and MS students per focus group member (Graduate Studies Office)
  - ✓ Total number of peer-reviewed journal articles per focus group (based on annual faculty reports)
  - ✓ Total number of peer-reviewed conference papers per focus group (based on annual faculty reports)
  - ✓ Peer-reviewed journal articles per focus group member (based on annual faculty reports)
  - ✓ Peer-reviewed conference papers per focus group member (based on annual faculty reports)
  - ✓ Peer-reviewed books per focus group (based on annual faculty reports)
  - ✓ Peer-reviewed books per focus group member (based on annual faculty reports)
  - ✓ Peer-reviewed book chapters per focus group (based on annual faculty reports)
  - ✓ Peer-reviewed book chapters per focus group member (based on annual faculty reports)
  - ✓ Patent portfolio per focus group (Patent and Licensing Administration)