IUSSTF

Indo-U.S. Science & Technology Forum

Catalyzing Indo-U.S. Science & Technology Cooperation

ANNUAL REPORT 2021-22

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IUSSTF
Indo-U.S. Science and Technology Forum

INDO-U.S. SCIENCE AND TECHNOLOGY FORUM
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www.iusstf.org

Contents

From the **Executive Director's** Desk

While 2021 began on a hopeful note with the approval of several vaccines, our resilience was tested once again with the second wave of COVID-19. The pandemic has certainly disrupted our lives and underscored the fact that we live in an interconnected world. Science and Technology are critical to addressing global challenges, and the pandemic has highlighted the need for scientific collaborations that leverage expertise across geographic and disciplinary boundaries.

Climate and Sustainability took center stage in April 2021, with Prime Minister Modi and President Biden launching the **U.S.-India Climate and Clean Energy Agenda 2030 Partnership**. With both sides committed to ambitious climate and clean energy targets by 2030, this partnership will help to accelerate the deployment of clean energy and the development of new technologies to decarbonize critical sectors including industry, transportation, and buildings. Later that year, world leaders came together at COP26 to reaffirm their commitment to climate action, highlighting the need for global cooperation to address critical issues related to climate finance, clean energy, and adaptation.

The Indo-U.S. Science and Technology Forum (IUSSTF) responded to the challenge, launching a new initiative under the auspices of the **United States–India Science & Technology Endowment Fund** to encourage collaborative projects that propose cutting-edge, disruptive technologies to address climate and clean energy challenges. Aligned with the goals of the U.S.-India Strategic Clean Energy Partnership, the ***Technology-based Energy Solutions: Innovations for Net Zero*** initiative supports innovative projects in the areas of Next Generation Clean and Renewable Energy, Energy Storage, and Carbon Sequestration. We are delighted to partner with Social Alpha, a multistage innovation curation and venture development platform for S&T start-ups that address critical social, economic and environmental challenges. This is the first partnership in the history of the Endowment Fund, a testament to the impact of the projects supported by the Fund over the past ten years.

IUSSTF's **U.S. India Artificial Intelligence (USIAI)** initiative continues to provide a unique platform for stakeholders from academia, government, and industry to identify synergistic areas for R&D collaboration and share insights for developing a robust AI workforce. With AI being a strategic priority for both countries, a partnership between the world's two largest democracies can provide a framework

that encourages responsible innovation for societal impact. The increasing use of AI tools and systems for autonomous decision making has brought to the forefront critical issues related to bias and trust. IUSSTF organized a series of roundtables addressing different dimensions of Trustworthy AI including privacy, explainability, robustness, and fairness. Speakers highlighted the need for interdisciplinary collaborations that bring together computer scientists with social scientists and legal scholars. IUSSTF, in partnership with the ***U.S. India Strategic Partnership Forum*** (USISPF), also organized a series of roundtables that addressed the critical role of AI in Pandemic Preparedness and Mobile Health.

With AI and other emerging technologies driving Industry 4.0, the demand for individuals with digital and data skills is predicted to grow exponentially. Academic institutions and industry need to come together to develop innovative programs in AI, Machine Learning, and Data Science to develop the 21st century workforce. In partnership with ***itihaasa Research and Digital***, IUSSTF is carrying out a survey of the AI and Data Science education and training landscape in India to identify current gaps and understand the underlying challenges. We are planning to organize a Visioning workshop that will bring together faculty from Indian and U.S. institutions with representatives from industry to identify potential solutions to these challenges as well as opportunities for partnerships.

IUSSTF's Annual Report for FY 2021-22 provides an overview of programmatic activities, including highlights of the two calls launched in 2020 to address COVID-19 challenges. Under the Indo-U.S. Virtual Networks for COVID-19 initiative, teams have conducted cutting-edge research in a number of areas including COVID-19 pathogenesis, antiviral coatings, immune modulation, tracking SARS CoV-2 in wastewater, and therapeutics. Under the call for COVID-19 Ignition Grants, teams have developed innovative products and technologies including CRISPR-based kits for diagnosis, wearable sensors for tracking symptoms, non-invasive ventilation devices, and electrostatic disinfection systems.

These initiatives highlight IUSSTF's ability to respond quickly to the evolving S&T landscape and address the priorities of both nations. As we look forward to a post-COVID future, we must continue to pursue new opportunities and engage with the stakeholder community to strengthen the Indo-U.S. S&T partnership.

I would like to place on record my appreciation of our partners, reviewers, stakeholders, and well-wishers who have been a part of IUSSTF's journey over the years. I would also like to thank my colleagues at IUSSTF for their dedication and hard work during these extraordinary times.

As my tenure as Executive Director comes to an end, I would like to express my deepest gratitude to the IUSSTF Governing Board for their support and guidance. Despite the many challenges, we have embarked on an ambitious journey launching new initiatives in two strategic areas: Artificial Intelligence and Climate and Clean Energy. It has truly been a privilege to lead the organization, and I look forward to seeing the next chapter in IUSSTF's history unfold in the coming years.

Dr. Nandini Kannan
Executive Director, IUSSTF

Introduction to IUSSTF

IUSSTF: The Genesis

The **Indo-U.S. Science and Technology Forum (IUSSTF)** is a bi-national organization jointly created by India and the United States of America, through a formal agreement signed by the two Governments on March 21, 2000. IUSSTF acquired legal status a few months later, when it was registered as a Society under the "Societies Registration Act" in India in June 2000. IUSSTF is headquartered at its office in New Delhi.

IUSSTF is also the secretariat for the **U.S. - India Science and Technology Endowment Fund**, which was jointly set up later by the two Governments, through a separate agreement in the year 2009.

The Department of Science and Technology (DST) of the Ministry of Science and Technology, Govt. of India, and the U.S. Department of State, are the arms of the two Governments that overview the functioning of IUSSTF through a Governing Body, having equal representation from both sides.

IUSSTF: Vision, Mission and Objectives

Vision

Excellence in Science, Technology and Innovation space through collaborative initiatives between India and the United States of America.

Mission

- Act as a catalyst to promote long-term scientific collaborations between India and the U.S. through partnership amongst individual scientists, scientific institutions and the scientific community at large.
- Establish platforms and mechanisms to connect the S&T eco-systems of both the countries to act as a fertile ground to foster individual and institutional partnerships in a natural and sustainable manner.

Objectives

- Create awareness through exchange dissemination of Information and Opportunities in S&T cooperation.
- Capitalize and build on the scientific and technological synergy leading to long term partnership on shared values.
- Support exciting program portfolio that leads to sustainable interactions and strengthens strategic partnerships.
- Nurture contacts between young and mid-career scientists to develop mutual trust, foster excellence and explore new frontiers.
- Encourage public-private partnership to foster elements of Innovation, Application and Enterprise.

IUSSTF Program Portfolio

(Classified by Verticals)

I. Strategic Initiatives

- IUSSTF's U.S. - India Artificial Intelligence (USIAI) Initiative
- Solar Decathlon Initiative

II. Scientific Networks

- Bilateral Workshops/Training Programs/Symposia
- Indo-U.S. Virtual Networked Centers

III. Innovation and Entrepreneurship

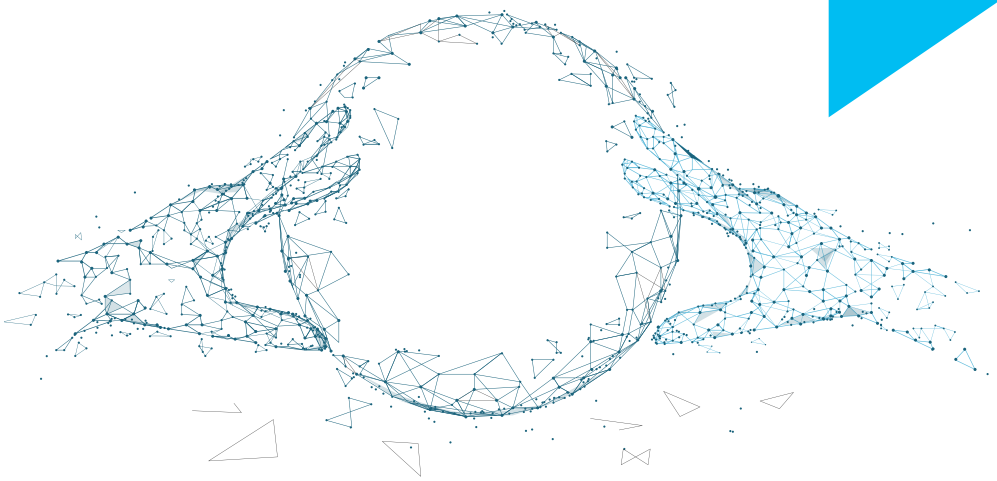
- U.S.-India Science and Technology Endowment Fund (USISTEF)

IV. Research and Development

- Indo-U.S. Joint Clean Energy Research and Development Center (JCERDC)
- PACEsetter Fund
- Real Time River Water and Air Quality Monitoring (WAQM)

V. Visitations and Fellowships

- ASM-IUSSTF Indo-U.S. Professorship in Microbiology
- IUSSTF-Viterbi Program



IUSSTF Program Portfolio

(Classified by Nature of Support)

I. IUSSTF Core

- Bilateral Workshops/Training Programs/Symposia
- Indo-U.S. Virtual Networked Centers
- IUSSTF-Viterbi Program
- ASM-IUSSTF Professorship
- IUSSTF's U.S. - India Artificial Intelligence (USIAI) Initiative
- Solar Decathlon Initiative

II. U.S.-India Science and Technology Endowment Fund (USISTEF)

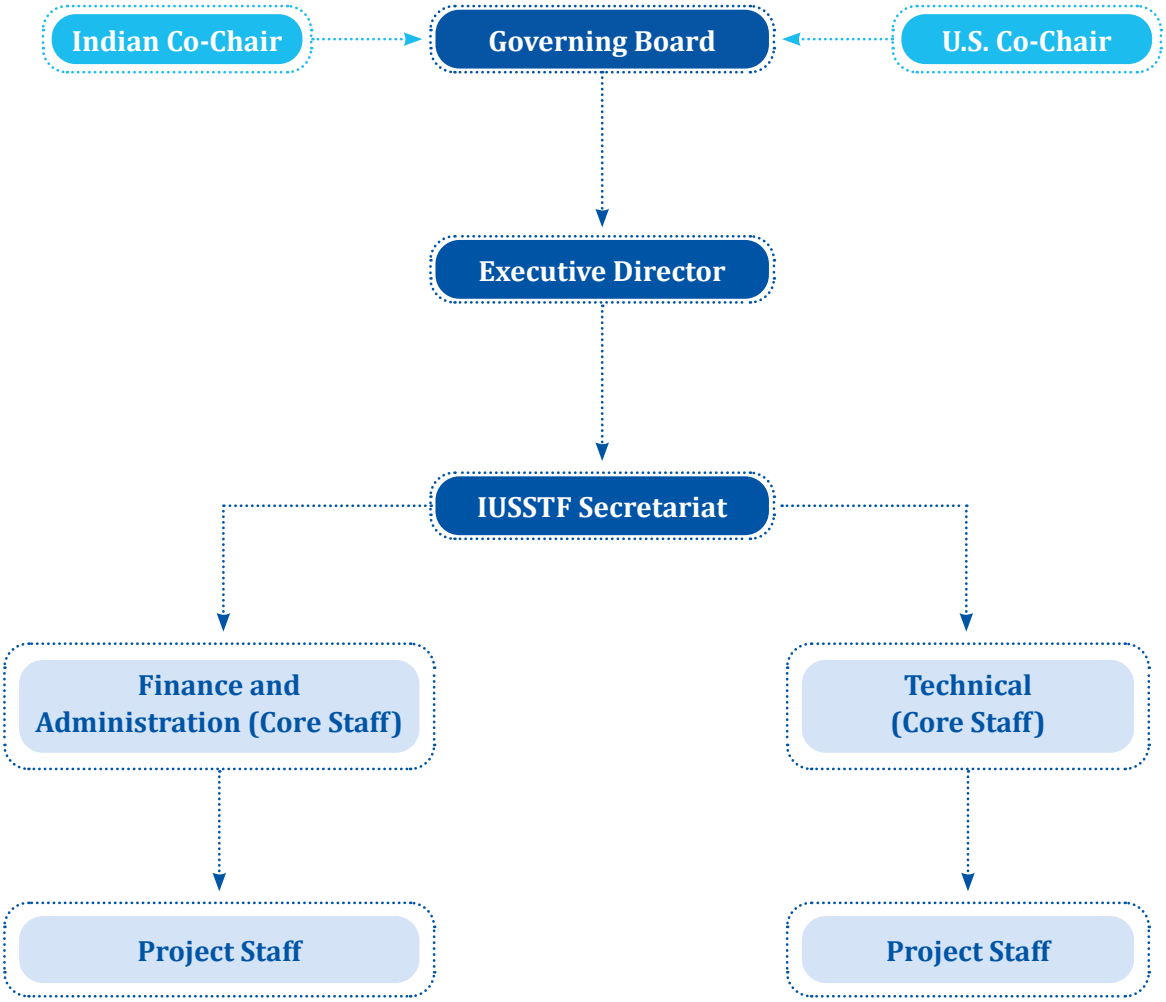
III. Extra Mural Programs- EMPs

(Supported by External Agencies/ Industry)

- Indo U.S. Joint Clean Energy Research and Development Center
- PACEsetter Fund
- Real Time River Water and Air Quality Monitoring

Governance Structure

IUSSTF Organizational Chart



Administrative Mechanism

- Autonomous
- Bilateral
- Non-Governmental
- Not for Profit Society

Funding Source

- Annual Interest from U.S. Endowment Fund with matching contribution from DST, Govt. of India
- Freedom to Secure Private and Other Funding

IUSSTF Governing Board

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Winstep Forward

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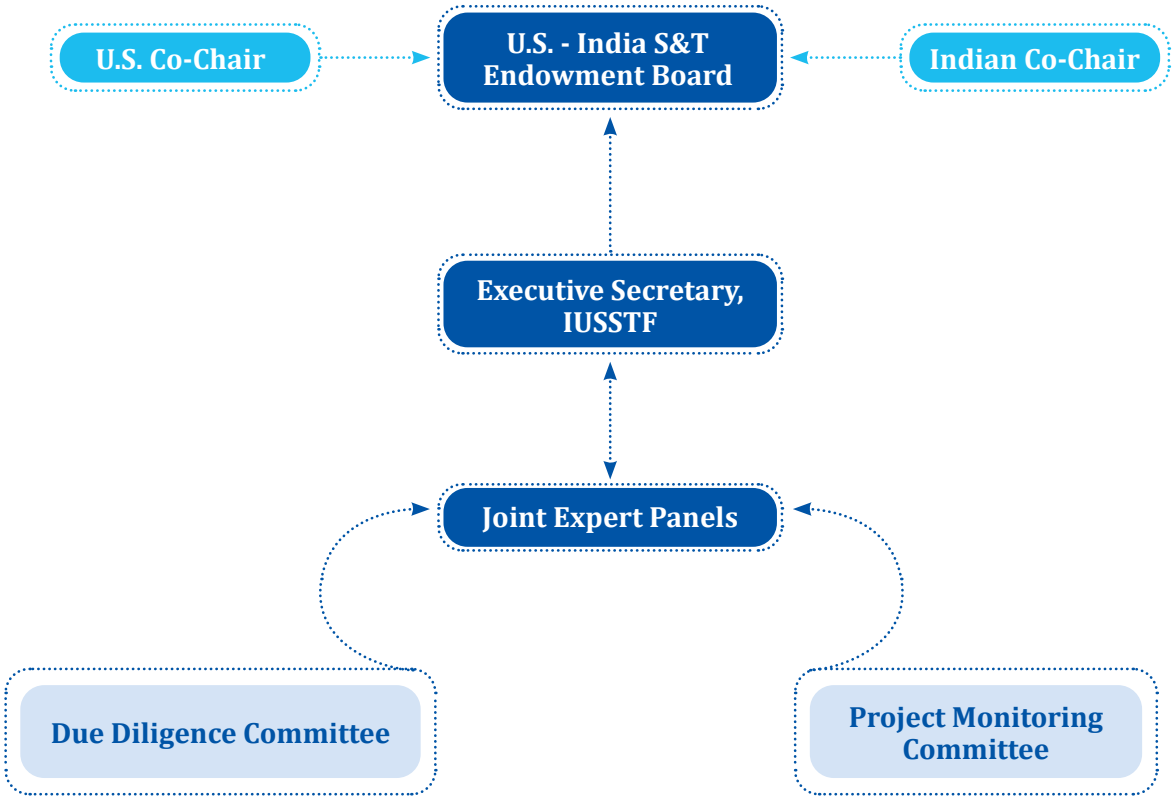
Functional Structure for USISTEF

USISTEF
UNITED STATES - INDIA
SCIENCE & TECHNOLOGY
ENDOWMENT FUND



USISTEF Board

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DreamCatcher Ventures

Somshubhro (Som) Pal Choudhury
Bharat Innovation Fund

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Chaitali Bhattacharya
Principal Science Officer

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Manoj Prasad
Assistant Admin Officer

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Priya Thomas
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Aashita Apoorva
Program Officer

Subhashree Basu
Program Officer

Rakesh Kumar Singh
Senior Accounts Associate II

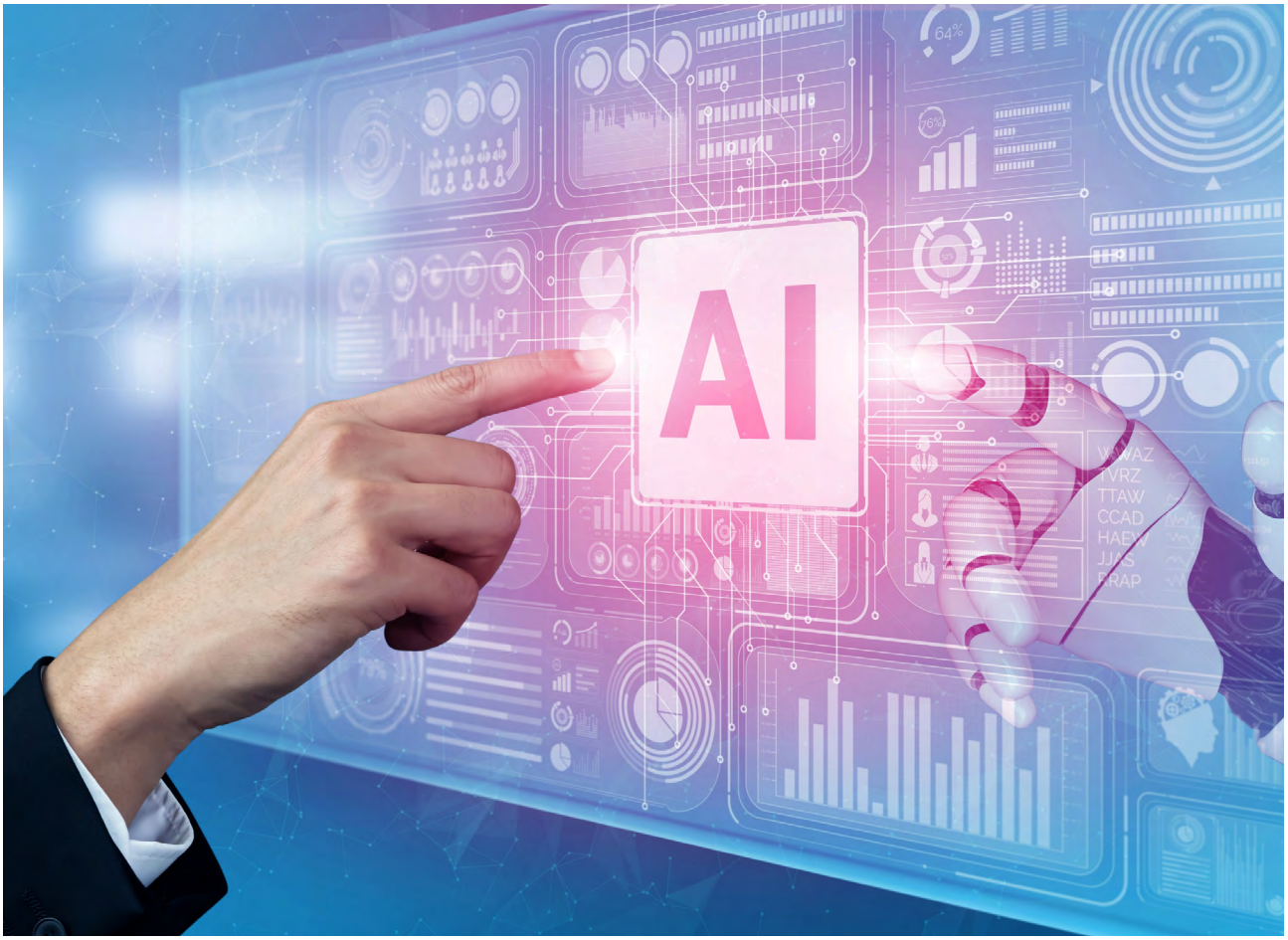
Year at a Glance

Highlights of the Year

Strategic Initiatives

- Under the aegis of IUSSTF's **U.S. India Artificial Intelligence Initiative (USIAI),** five roundtables were organized between 27th July 2021 and 11th August 2021 on different aspects of **Trustworthy AI,** including issues related to bias, privacy, explainability, and fairness. Two roundtables under the area of AI in Healthcare were held in the month of December 2021. A series of interviews were also conducted with experts from academia and industry to discuss capacity building and training, including development of new programs and skilling. IUSSTF is also conducting a survey of Indian Institutions to understand the programs they offer in AI, Machine Learning, Data Science. Based on these discussions, IUSSTF, along with a Standing Committee of Experts, will prepare white papers that identify technical, research, infrastructure, and workforce opportunities and challenges.

- In December 2021, the **United States–India Science & Technology Endowment Fund (USISTEF),** in partnership with **Social Alpha,** launched a call for ignition grants titled **Technology-based Energy Solutions: Innovations for Net Zero,** a new initiative that encourages cutting-edge, disruptive technologies to accelerate progress toward net zero and address climate and sustainability challenges.



Section I: Scientific Networks

Scientific Networks

IUSSTF-funded collaborations provide a platform for young and early-career scientists to interact and network with their seniors and counterparts, who could potentially become both mentors and collaborators. Building scientific networks not only helps share expertise thereby doubling the value of the effort; but also many times leads to the generation of completely novel ideas.

IUSSTF promotes such networks to foster long-term collaborations between the scientific communities of India and the United States through two separate yet complimentary programs. While **"Bilateral Workshops"** are expected to act as an instant connect and point of formal initiation; **"Virtual Networked Centers"** provide a formal mechanism to support specific collaborations for an extended period of time.

Bilateral Workshops

Bilateral Workshops are targeted to promote interactions between Indian and American scientists and engineers from academia, laboratories, and industry with the explicit aim to develop sustained linkages. The review parameters include novelty of topic, mutual benefits to India and the U.S., background of workshop coordinators and participants, potential for developing new and sustained bilateral linkages, student participation, etc.

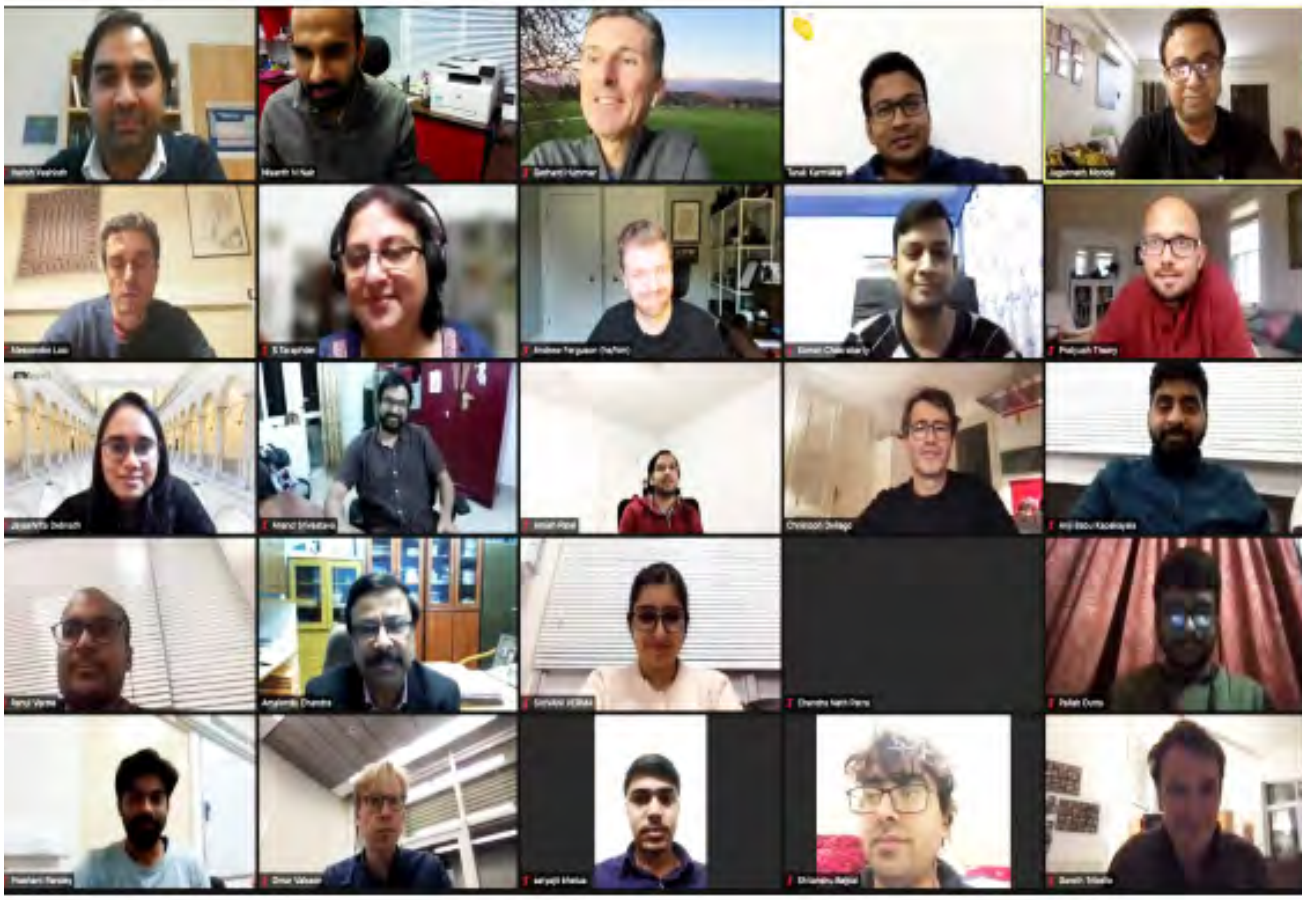
In light of the COVID-19 crisis, IUSSTF did not solicit new applications for Bilateral Workshops/Symposia/ Training Programs. However, **four workshops** supported under earlier calls were conducted in hybrid/ virtual mode during this period. A brief on these is presented below:

1. Enhancing Fire Safety in Built-Infrastructure

Fire represents one of the most severe environmental or accidental hazards to which buildings and built-infrastructure are subjected, and thus the provision of appropriate fire safety measures is a major requirement in building design. The magnitude of the fire problem in India and the United States has been getting worse in recent years due to increasing fuel loads in buildings, innovative structural and architectural concepts adopted, and the use of high performing construction materials with poor fire-resistant properties. However, much of the fire safety provisions in the current building codes and standards are based on outdated prescriptive-based methodologies that are not fully applicable to the current design scenarios and construction practices. With the aim of advancing the fire safety design concepts in India and the U.S., researchers at the Indian Institute of Technology (IIT) Delhi and Michigan State University (MSU) joined forces to address some of the technical challenges in the structural fire safety arena. This two-day Indo-U.S. Symposium for Enhancing Fire Safety in Built-Infrastructure was organized on 10-11 December 2021 by **Vasant Matsagar** (IIT-Delhi) and **Venkatesh Kodur** (MSU) at IIT Delhi in hybrid mode, i.e., in-person and online format. The Symposium consisted of a total of six technical sessions with sixteen talks delivered by distinguished speakers, who presented on topics such as behavior of classical and advanced construction materials at elevated temperatures; different structural systems and their behavior at elevated temperatures, and state-of-the-art review of existing code guidelines and current innovative practices in structural fire engineering. A visit to the structural engineering laboratory at IIT Delhi was also organized for the participants showcasing experimental research facilities available for fire-related research studies.

2. Recent Advances in Modeling RARE Events

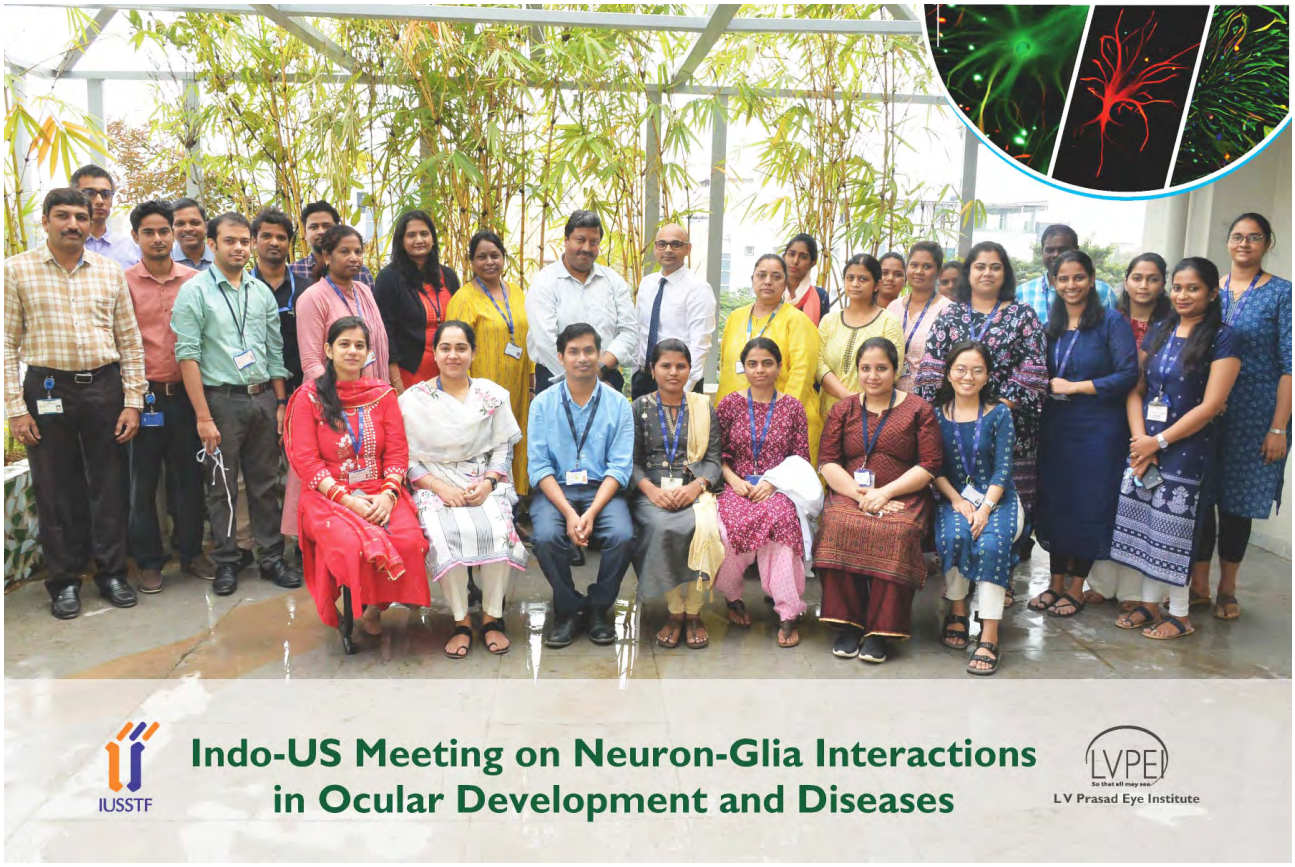
This workshop was organized on 15-18 December 2021 to discuss recent advances in the field of rare event sampling of molecular systems in chemistry, biology, physics and engineering. Computational modeling of molecular systems provides crucial atomic level insights into various possible conformations and pathways that these systems could adopt, along with their quantitative propensities. However, several challenges remain, especially in the prediction of long-time reaction dynamics from short time simulations without relying on chemical intuition. This requires a fundamental understanding of dynamics occurring at multiple spatiotemporal scales in complex systems. This virtual workshop organized by **Amalendu Chandra** (Indian Institute of Technology, Kanpur) and **Andrew Ferguson** (University of Chicago) took a deep delve into how machine learning and data sciences are informing our ability to simulate and predict rare events in the physical sciences. The symposium was focused on novel computational methods for rare event sampling and machine learning, and their applications in different domains of science and engineering. The event brought together participants to discuss established and novel methods as well as underlying theoretical principles in detail, and to form collaborations to develop new techniques.



3. Neuron-Glia Interactions in Ocular Development and Diseases

The retina is the light-sensitive tissue located in the back of the eye. Müller cells are specialized radial cells that span the whole retina and account for ~90% of the retinal glial population. They support functioning and metabolism of retinal neurons by releasing trophic factors, participating on phototransduction, recycling neurotransmitter glutamate, and controlling ion homeostasis. The astrocytes perform similar functions to Müller cells, ranging from neurotrophic, metabolic and mechanical support of neurons, and

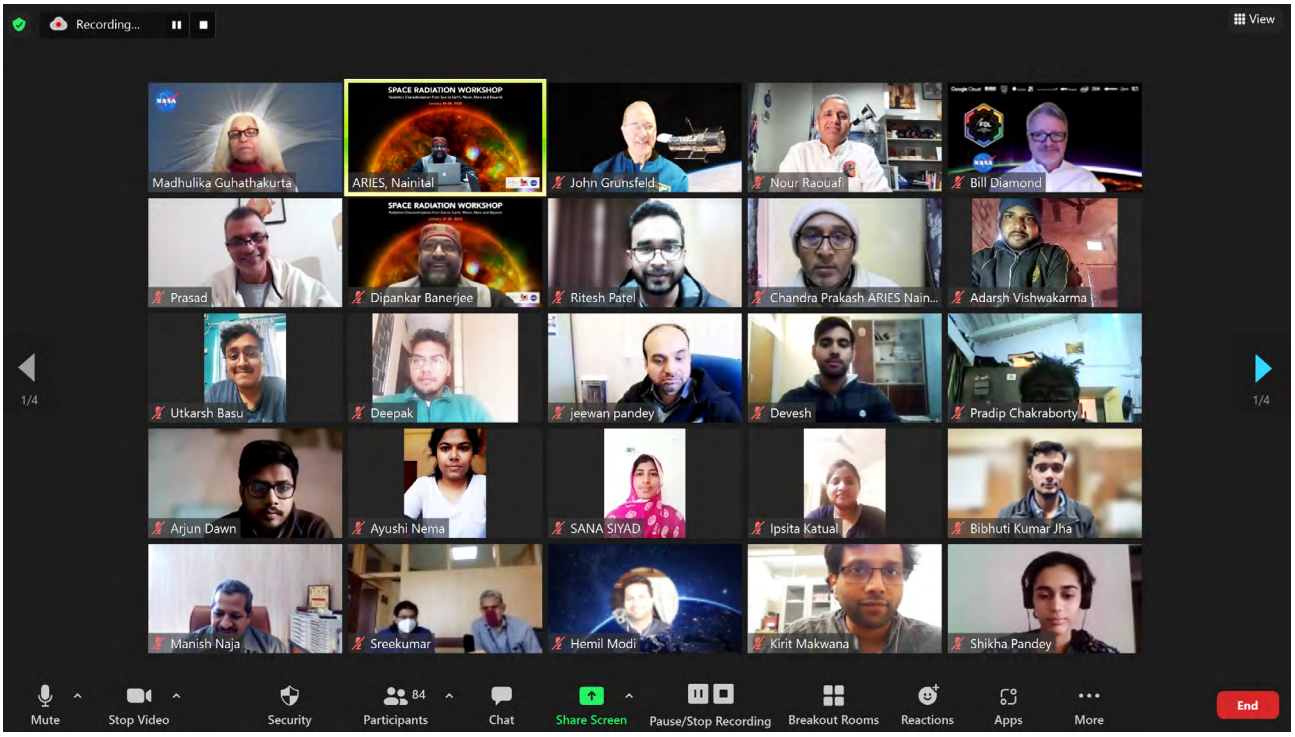
maintenance of the blood retinal barrier. Retinal astrocytes are mostly restricted to the nerve fiber layer and the ganglion cell layer. Microglia represent the resident tissue macrophages and play important roles in retinal homeostasis, recovery from injury and progression of disease. The neuron-glia crosstalk in the retina is crucial for not only the development of multilayered organization of retina, synaptic pruning and blood vessel network formation (retinal maturation) but also for maintaining retinal homeostasis by autophagy and release of suitable cytokines and chemokines and eventual repair of injured retina by regulating the de novo retinal regeneration. Thus, studying the crosstalk between different glial cell types, retinal neurons and endothelial cells would not only help to understand the retinal biology but also to develop suitable newer drug targets and effective cellular and gene therapies for the treatment of different retinal degenerative diseases. This virtual workshop organized by **Inderjeet Kaur** (LV Prasad Eye Institute, Hyderabad) and **Ashok Kumar** (Wayne State University, Detroit) on 9 January 2022 aimed to further unravel the enigmatic underpinning mechanisms and facilitate discussion of the neuro-glial axis in the context of the eye.



4. Radiation characterization from Sun to Earth, Moon, Mars and beyond

Space weather in general, and radiation in particular, affects us on a day-to-day basis. Space radiation affects satellites, airplanes, electrical grids, electronic technologies, and directly relates to the radiation dose received by humans. These impacts generally become more important as electronic equipment become a larger part of our daily activities, and as we venture into the skies, into space, and eventually past the Van Allen radiation belts to the Moon, Mars and beyond. This Indo-U.S. workshop organized virtually on 24-28 January 2022 by **Prasad Subramanian** (Indian Institute of Science, Education and Research, Pune), **Dipankar Banerjee** (Aryabhatta Research Institute of Observational Sciences, Nainital) **Madhulika Guhathakurta** (NASA Ames Research Center, Moffett Field) and **Hemil Modi** (NASA Ames

Research Center, Moffett Field) aimed to advance the state of characterization, forecasting and monitoring of space radiation environments for science, aviation and space exploration and development, including deep-space. The workshop deliberations included development of proposals and/or programs for new radiation detection sensors, advanced analytic models as well as other enabling technologies like Artificial Intelligence/Machine Learning tools, that can be applied to radiation characterization and predictions at altitudes ranging from the surface of Earth to aviation, to near-Earth space and deep-space. The workshop was organized around five broad themes - Earth, Air and Space Flight, Exploration, Space exploration and Biology, and, Space situational awareness and biology.



Indo-U.S. Virtual Networked Centers

The aim of **Virtual Networked Centers** is to enable Indian and American scientists to carry out joint research activities by leveraging already existing infrastructure and funding available with the partners on both sides through a linkage established by a virtual mechanism that provides for seamless connectivity and exchange of faculty/ scientists and students from both sides. These centers are supported under two categories:

- **Knowledge R & D Networked Centers:**
  - Partners: R&D labs and academia partnership (2+2)
  - Provide opportunities for integrating research and education
- **Public-Private Networked Centers:**
  - Partners: Academia/ R&D lab - Industry partnership (2+2)
  - Promote pre-commercial R & D with application potential

Due to the COVID-19 pandemic, the regular call for Virtual Network Centers was placed on hold for the year 2021-22. The progress vis-a-vis projects awarded earlier has been presented below.

1. Center for Distributed Deep Learning Framework for Classification

Principal Investigators:

Ashish Ghosh, Indian Statistical Institute, Kolkata

Lance Fiondella, University of Massachusetts, Dartmouth

Partnering Institutions:

- Indian Statistical Institute, Kolkata
- Jadavpur University, Kolkata
- University of Massachusetts, Dartmouth
- Harvard Medical School, Boston
- Rochester Institute of Technology, New York

Objectives

The team proposes to design a distributed fault tolerant deep learning-based system to perform the task of classification in big data. As the data is distributed in chunks across the network, a classifier only possesses a local view of the data which biases it towards particular classes, thereby degrading its performance. The team plans to develop a distributed deep architecture that can handle the problem of classification of big data. This will be a multi-agent-based framework, where each agent (a local computer) contains chunks of the data to be used by a deep network for training. The team will concentrate on dealing with two application areas -Natural resource classification from hyperspectral images, and, Medical image analysis.

Progress thus far

The team attempted to devise a novel technique for localization and recognition of actions in long-trimmed videos. They are trying to adhere to a Convolutional Neural Network (CNN) model followed by the action localization model. The CNN architecture provides generic video features for action localization in videos that contain different kinds of activities. It also provides compact representation as well as better separability across the action classes. They have developed a social learning model, where an individual agent can gather information from other agents in the network and utilize the knowledge effectively to improve the performance of the overall system. The team plans to evaluate the system with respect to scalability, fault-tolerance, distribution, and synchronization when performing big data classification.

Publications

1. Chakraborty D., Ghosh S., and Ghosh A. (2022) *Autoencoder based Hybrid Multi-Task Predictor Network for Daily Open-High-Low-Close Prices Prediction of Indian Stocks.* CoRR abs/2204.13422 .

2. Hatua A., Subudhi B.N., Thangaraj V. and Ghosh A (2021) *Early detection of diabetic retinopathy from big data in hadoop framework.* Displays 70: 102061.

2. Center for Nanomagnetics for Energy Efficient Computing, Communications and Data Storage

Principal Investigators:

Anjan Barman, S. N. Bose National Center for Basic Sciences, Kolkata

Supriyo Bandyopadhyay, Virginia Commonwealth University, Virginia

Partnering Institutions:

- S. N. Bose National Center for Basic Sciences, Kolkata
- Indian Institute of Technology, Kharagpur
- Virginia Commonwealth University, Virginia
- University of Texas at Austin, Austin

Objectives

This Indo-U.S. collaboration will conduct cutting-edge research developing nanomagnetic switches for myriad applications in computing, communication, information processing, medically implanted devices, wearable electronics, and sensors. Main objectives of this project include energy-efficient switching of nanomagnets via spin injection from a topological insulator film for logic and memory device and study of the associated ultrafast magneto-dynamics; extreme sub-wavelength on-chip antenna actuated by strain in thin films that undergo ferromagnetic to anti-ferromagnetic transitions; and, study of Dzyaloshinskii-Moriya interaction at the interface of graphene and a two-dimensional magneto-elastically coupled nanomagnet superlattice or magnonic crystal.

Progress thus far

The team has developed ultra-energy-efficient nanomagnetic switches consisting of ~100 nm nanomagnets delineated on a topological insulator that is switched by spin-injection. These switches

can be exploited to build unusual computing architectures to perform complex tasks with minimal energy cost and device count. These switches are expected to be at least one order of magnitude more energy-efficient than the current state-of-the-art. The team is currently building extreme sub-wavelength antennas by harnessing a certain class of metallic alloys that undergo phase transition from ferromagnetic to anti-ferromagnetic, or vice versa, near room temperature. The unique feature of these antennas is that they can be 105 times smaller than the electromagnetic wavelength, which would be unprecedented.

Publications

1. Fabiha R., Lundquist J., Majumder S., Topsakal E., Barman A. and Bandyopadhyay S. (2022) *Spin Wave Electromagnetic Nano-Antenna Enabled by Tripartite Phonon-Magnon-Photon Coupling.* Advanced Science 2104622.

2. Panda S.N., Majumder S., Choudhury S., Bhattacharya A., Sinha S. and Barman A. (2021) *Femtosecond laser induced spin dynamics in Single Layer Graphene/CoFeB Thin Films,* Nanoscale 13, 13709.

3. Panda S.N., Majumder S., Bhattacharyya A., Dutta S., Choudhury S. and Barman A. (2021) *Structural Phase Dependent Giant Interfacial Spin Transparency in W/CoFeB Thin Film Heterostructure.* ACS Applied Materials & Interfaces 13, 20875.

4. Bandyopadhyay S., Atulasimha J. and Barman A. (2021) *Magnetic Straintronics: Manipulating the Magnetization of Magnetostrictive Nanomagnets with Strain for Energy- Efficient Applications.* Applied Physics Reviews 8, 041323.

5. De A., Drobitch J.L., Barman S., Bandyopadhyay S. and Barman A. (2021) *Resonant Amplification of Intrinsic Magnon Modes and Generation of New Extrinsic Modes in a Two-Dimensional Array of Interacting Multiferroic Nanomagnets by Surface Acoustic Waves.* Nanoscale 13, 10016.

3. Center for Time and Length Scale Dependent Flow

Principal Investigators:

P. Sudharshan Phani, International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad

Erik G. Herbert, Michigan Technological University, Houghton

Partnering Institutions:

- International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad
- Indian Institute of Technology, Madras
- Michigan Technological University, Houghton
- Texas A and M University, College Station
- Nanomechanics Inc a KLA Tencor Company, Oak Ridge

Objectives

The main purpose of this Joint Center is to examine structure-property relationships in crystalline metals at sub-micron length scales and high homologous temperatures. Through state-of-the-art

nanoindentation and the implementation of novel two-dimensional nanomechanical characterization techniques, the goal of this project is to deepen the scientific community's understanding of the fundamental mechanisms that control the time and length scale dependent flow of crystalline metals at high homologous temperatures. Specifically, the center's goal is to provide critical information that will enable transformative insights into the complex coupling between the microstructure, its defects and the mechanical behavior of indium at high homologous temperatures.

Progress thus far

The team is using the controlled atmosphere of a dedicated glove box to perform nanoindentation experiments using a Berkovich indenter to measure the mean pressure (hardness) indium is capable of supporting as a function of length scale, strain rate, dislocation density and crystallographic orientation. They are using a custom-built specimen exchange chamber to mitigate surface contamination, perform x-ray photoelectron spectroscopy to asses the chemical composition of the indentation surface. They are utilizing electron backscatter methods to evaluate crystallographic orientation and identify grains with the most and least favorably oriented slip systems, and further refine and implement novel 2D nanomechanical testing techniques to measure the normal and lateral indentation depth, contact stiffness and energy dissipation as a function of increasing lateral strain.

Publications

1. Phani P.S., Oliver W.C. and Pharr G.M. (2021) *Influences of elasticity on the measurement of power law creep parameters by nanoindentation.* Journal of Mechanics and Physics of Solids:104527.

2. Phani P.S., Oliver W.C. and Pharr G.M. (2021) *On the effective load during nanoindentation creep testing with continuous stiffness measurement (CSM).* Journal of Materials Research, Volume 36, Issue 8, P.1740-1750.

3. Chavan N., Phani P.S., Ramakrishna M., Venkatesh L., Pant P. and Sundararajan G. (2021) *Role of stacking fault energy (SFE) on the high strain rate deformation of cold sprayed Cu and Cu–Al alloy coatings.* Materials Science and Engineering-A: 814, 141242.

4. Janakiram S., Phani P.S., Ummethala G., Malladi S.K., Gautam J., Kestens L.A.I. (2021) *New insights on recovery and early recrystallization of ferrite-pearlite banded cold rolled high strength steels by high speed nanoindentation mapping.* Scripta Materialia: 194, 113676.

5. Kommineni G., Alam Z., Phani P.S., Sarkar R., Prasad V.V.S. and Golla B.R. (2021) *Influence of Ti and Zr alloying elements on microstructure and micromechanical properties of neareutectic Nb-18.7Si alloy.* Materials Characterization: 110723.

4. Center for Development of Sustainable Materials for Soil Remediation

Principal Investigators:

Devendra Narain Singh, Indian Institute of Technology-Bombay

Arvin Farid, Boise State University, Boise

Partnering Institutions:

- Indian Institute of Technology-Bombay

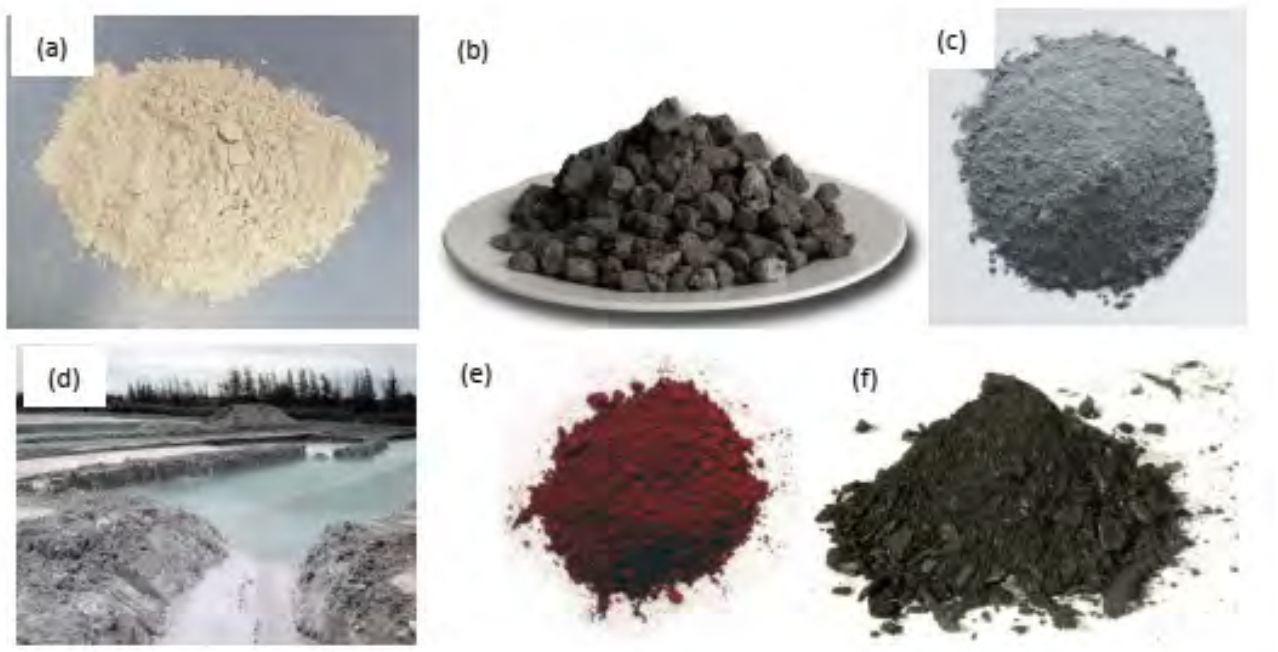
- Indian Institute of Technology-Madras
- Boise State University, Boise
- University of Hawaii at Manoa, Honolulu

Objectives

Soil contamination is a global problem that requires global collaboration. The research goal of this Center is to facilitate research into the development of novel materials from a variety of industrial by-products and wastes for the remediation of heavy-metal contaminated soils, and, to determine their engineering-performance parameters, fundamental mechanisms, and durability of remediated soils. The ultimate goal of the project is to create a team that will help initiate and enhance a long-lasting collaboration among the four Indian and American institutions involved in the project, and beyond, leading to ground-breaking innovations in the fields of geo-environmental, environmental, and civil engineering or other related fields.

Progress thus far

Novel materials have been developed from industrial by-products and wastes such as ground-granulated blast-furnace slag (GGBS), steel slag, coal fly ash, calcium carbide residue (CCR), red mud, and biochar, as shown in the figure below. Each task has been performed at one Indian partner institution and one U.S. partner institution to ensure replication for verification as well as enforce the transfer of knowledge among partner institutions.



Industrial by-products and wastes to be investigated in this study (a) GGBS; (b) steel slag; (c) coal fly ash; (d) CCR; (e) red mud; and (f) biochar

The team has developed novel alkali-activated cement material (AACM) and investigated their interactions with heavy metal contaminants. They have investigated heavy-metal mobility and ecotoxicity in contaminated soil treated by AACMs (w/o biochar enhancement) and looked into the mechanical properties of contaminated soil treated by novel AACMs (w/o biochar enhancement). They have also investigated durability of treated soil subjected to drying-wetting cycles, durability of treated

soils under acidic condition and durability of treated soils in presence of corrosive ions. The Center has facilitated cross-disciplinary interactions and graduate and undergraduate students from different technical backgrounds (geotechnical engineering, material science, and environmental engineering) will be recruited. The IUSSTF-funded Joint Center also actively encourages participation of women, veteran and under-represented minority students by leveraging existing institutional programs. For example at the University of Hawaii at Manoa, the Native Hawaiian Science and Engineering Mentoring Program (NHSEMP) facilitates exposure of the research project to Native Hawaiian students. At Boise State, there are programs, including The Louis Stokes Alliances for Minority Participation (LSAMP).

Publications

1. Tang C.S., Paleologos E.K., Vitone C., Du Y.J., Li J.S., Jiang N.J., Deng Y.F., Chu J., Shen Z., Koda E., Dominijanni A., Fei X., Vaverková M.D., Osiński P., Chen X., Asadi A., Takeuchi M.R.H., Bo M.W., Abuel-Naga H., Leong E.C. and Farid A. (2021) Environmental geotechnics: Challenges and opportunities in the post-Covid-19 world - "Environmental Geotechnics, Volume 8: 172-192.

2. Goli V.S.N.S., Paleologos E.K., Farid A., Mohamed A.M.O, ;O'kelly B.C., El Gamal M.M., Vaverková M.D., Jiang N.J., Wang J.J., Xiao L., Singh P., Han X.L., Shi Y., Li D., Sengupta A., Kayali S.L., Singh Y., Mohammad A. And Singh D.N. (2021) *Extraction and Characterization of Microplastics from Organic Solid Matrices and their Remediation.* Environmental Geotechnics.

3. Paleologos E.K., O'Kelly B.C., Tang C.S., Cornell K., Rodríguez-Chueca J., Abuel-Naga H., Koda E., Farid A., Vaverková M.D., Kostarelos K., Goli V.S.N.S., Guerra-Rodríguez S., Leong E.C., Jayanthi P., Shashank B.S., Sharma S., Shreedhar S., Mohammad A., Jha B., Kuntikana G., Bo M.W., Mohamed A.M.O. and Singh D.N. (2021) *Post Covid-19 water and waste water management to protect public health and geoenvironment*. Environmental Geotechnics, Volume 8: 193-207.

4. Shashank B.S., Kuntikana G., Jiang N.J. and Singh D.N. (2021) *Investigations on biosorption and biogenic calcite precipitation in sands. Soil Use and Management.* Volume 37: 772-789.

5. Center for Optimizing System Performance and Energy in Multi-sensor Visual Perception Systems

Principal Investigators:

M. Balakrishnan, Indian Institute of Technology-Delhi

Anish Arora, The Ohio State University, Columbus

Partnering Institutions:

- Indian Institute of Technology-Delhi
- Indraprastha Institute of Information Technology, Delhi
- The Ohio State University, Columbus
- The Samraksh Company, Dublin

Objectives

With the improvement in technology and computational power, along with newer techniques based upon machine learning and artificial intelligence, camera-based systems are becoming increasingly effective

and practical. While basic applications of camera-based systems have been around for many decades, it is only in recent years that such systems are being implemented for safety-critical applications such as autonomous driving, surveillance and assistive devices. As part of this Joint Center, the team is exploring problems related to performance and energy optimization of camera-based visual perception systems by employing additional sensors such as ultrasonic and RADAR.

Progress thus far

The team has demonstrated use of a low energy sensor for low energy cognition, which can be used to trigger a high energy sensor when an event occurs which needs more attention. They have identified failure of a particular modality/mode and dynamically chosen the modality/mode appropriate to a certain context. They are working with integrated multimodal capacities, i.e., a number of sensors are being integrated and verified before their trade-offs and enhancements would be tested. Integration of these sensors one after the other before addressing project objectives are in process.

The partnership in the domain of real-time vision/image processing primarily uses the image stream from RGB cameras. The team has finalized and built a device named MAVI (Mobility Assistant for Visually Impaired) that would make a VI person aware of his/her surroundings. This enhances safety as well as provides navigation assistance to the VI person. This collaboration has taken advantage of the experience of the U.S. team in the use of radars and acoustic sensors.

Publications

1. Abera S., Balakrishnan M. and Kumar A. (2021) *Performance-Energy Trade-off in Modern CMPs", ACM Transactions on Architecture and Code Optimization.* Volume 18 Issue 1, Article No.: 3 pp 1–26.

2. Balakrishnan M. (2021) ASSISTECH: *An Accidental Journey into Assistive Technology.* A Journey of Embedded and Cyber-Physical Systems. 57-77.

3. Upadhyay V. and Balakrishnan M. (2021) *Accessibility of Healthcare Facility for Persons with Visual Disability.* IEEE International Conference on Pervasive Computing and Communications. 87-92.

4. Akashdeep, M. Balakrishnan and Sorge V. (2021) *Evaluating Cognitive Complexity of Algebraic Equations", Journal on Technology and Persons with Disabilities.* Santiago, J. (Eds), 36th CSUN Conference, Virtual conference, 6-14 March 2021.

6. Center for Conservation and Restoration of Threatened Deer Species Through Conservation Breeding, Conservation Genetics and Community Development

Principal Investigators:

Khursheed Ahmad, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Srinagar

William J. McShea, Smithsonian Conservation Biology Institute, Virginia

Partnering Institutions:

- Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir (SKUAST Kashmir) Shalimar, Srinagar
- Wildlife Institute of India, Dehradun

- Department of Wildlife Protection, Jammu and Kashmir Govt., Srinagar
- Smithsonian Conservation Biology, Institute, Remount Road, Front Royal
- Montana Technological University, Butte

Objectives

Striking a balance between biodiversity conservation and sustainable development poses major challenges at the global level during the twenty-first century. Globally, most conservation organisations preserve natural resources including wildlife and their habitats through scientific research (assessment and monitoring) and community involvement. Emerging fields including population genetics, demography, conservation biology, disease monitoring and surveillance and biotechnology are now being explored at the international levels to acquire in depth scientific knowledge on the aspects of ecology prerequisite for effective management and long term conservation of these free-ranging mammals and their habitats and ecosystems. The main objectives of this Joint Center include capacity building in conservation breeding and reintroduction of species with special reference to deer species [so that these techniques can be applied to threatened species such as brow-antlered deer (Rucervus eldi) and the endemic and critically endangered Kashmir red deer (Cervus hanglu hanglu)]; capacity building in use of modern scientific techniques and technologies including conservation genetics and forensics in evidence-based wildlife management and conservation especially restoration of threatened species population and their habitats under in-situ and ex-situ conditions; and, monitoring and assessment of wildlife species and habitat management and restoration from a social perspective (alternative sustainable livelihood models on ecotourism and wildlife tourism for communities dependent on wildlife resources).

Progress thus far

The team has been able to effectively standardize the habituation process to lure animals to specific site(s) to support easy darting, and are also working to standardize the drug doses necessary for successful capturing of a limited number of Hangul individuals as founder breeding stock to initiate the Hangul conservation breeding program. The project team assessed the Hangul Conservation Breeding Centre (CBC) established for receiving/housing the founder breeding stock. Necessary modifications/ alterations in the CBC were also incorporated to make it more effective by taking into consideration knowledge of the animal behaviour (especially possible unpredictable behaviour when brought into captivity), specific needs of the animal and its husbandry requirements. The team has engaged in monitoring the Hangul and other threatened deer populations in the wild and in generating the genome level information through Hangul genome sequencing - an attempt to study the species/population level genomic variations, local adaptations, demography and evolutionary trajectories. Since there isnt any prior information on the Hangul genome, this will help in studying comparative genomics once the Hangul genome data is obtained. The team is setting up disease diagnostic and forensic laboratories for confirming status of significant wildlife trade, and, investigation and control of wildlife crime as well as generating conservation genetics and phylogenetic data base of unique faunal diversity of the region.

First ever pictures of Hangul herd in Shikargah-Tral WLS captured in camera traps

Male Hangul Captured and Satellite Collared in Dachigam National Park, Kashmir to study movement patterns and behavior

7. Center for Cellular Reprogramming in Regenerative Medicine

Principal Investigators:

Sujata Mohanty, All India Institute of Medical Sciences, New Delhi

Chandan K. Sen, Indiana University, Indianapolis

Partnering Institutions:

- All India Institute of Medical Sciences, New Delhi
- Indian Institute of Technology Delhi
- Indiana University, Indianapolis
- University of Bridgeport, Connecticut

Objectives

Cellular reprogramming has revolutionized the field of regenerative medicine through its immense potential in tissue repair and regeneration. Recent studies have demonstrated the applicability of this breakthrough technology for the treatment of innumerable degenerative diseases and injuries like Parkinson's disease, myocardial infarction, wounds, burns, etc. However, a few roadblocks such as exorbitant cost and low efficacy have prevented the clinical translation of this research. The objectives of this Joint Center are to develop strategies using cellular reprogramming technology in myocardial infarction, skin wounds, Parkinson's and Alzheimer's for translational research; and, use the IUSSTF project platform to identify, share and transfer research strategies, data and technologies amongst partners to foster new avenues of research.

Progress thus far

The team prepared detailed roadmaps with reference to objectives and sub-objectives and have narrowed them down to experimental aims. Joint teams of investigators from participating institutions plan to use the combined resources of their respective Institutions through short and long-term visits by overseas counterparts.

Publications

1. Gupta, S., Pinky, Vishal et al. (2022) *Comparative Evaluation of Anti-Fibrotic Effect of TissueSpecific Mesenchymal Stem Cells Derived Extracellular Vesicles for the Amelioration of CCl4 Induced Chronic Liver Injury.* Stem Cell Rev and Rep 18, 1097–1112.

2. Gupta S., Rawat S., Krishnakumar V., Rao E.P. and Mohanty S. (2022) *Hypoxia preconditioning elicit differential response in tissue-specific MSCs via immunomodulation and exosomal secretion.* Cell and Tissue Research 388(3): 535-48

3. Li Z., Xuan Y., Ghatak S., Guda P.R., Roy S. and Sen C.K. (2022) *Modeling the gene delivery process of the needle array-based tissue nanotransfection.* Nano Research 15(4):3409-21

4. Rawat S., Jain K.G., Gupta D., Raghav P.K., Chaudhuri R., Pinky R., Shakeel A. Arora V., Sharma H., Debnath D. and Kalluri A (2022) *Graphene nanofiber composites for enhanced neuronal differentiation of human mesenchymal stem cells.* Nanomedicine 16(22):1963-82.

5. Xuan Y., Ghatak S., Clark A., Li Z., Khanna S., Pak D., Agarwal M., Roy S., Duda P. and Sen C.K. (2021) *Fabrication and use of silicon hollow-needle arrays to achieve tissue nanotransfection in mouse tissue in vivo.* Nature protocols 16(12):5707-38.

6. Pinky R., Shakeel A., Arora V., Sharma H., Debnath D. and Kalluri A. (2021) *Graphene nanofiber composites for enhanced neuronal differentiation of human mesenchymal stem cells.* Nanomedicine16(22):1963-82.

Chandan Sen's Group (Indiana University) and Sujata Mohanty's Group (AIIMS, New Delhi) at a virtual symposium

8. Center for Transition Metal Carbide Nanomaterials for Energy Storage Application

Principal Investigators:

Subhash Singh, National Institute of Technology, Jamshedpur

Sanjay K. Behura, University of Arkansas - Pine Bluff

Partnering Institutions:

- National Institute of Technology, Jamshedpur
- Indian Institute of Technology-Kanpur
- University of Arkansas, Pine Bluff
- Auburn University, Auburn

Objectives

The main objectives of this Joint Center include design and fabrication of a few layered nanostructures and their heterostructures based on a variety of 2-D layered materials [for example Ti_2C, Ti_3C_2, and T_4C_3 from MAX phases like Ti_3AlC_2, Ti_2AlC, Ti_4AlC_3, $(V_{0.5},Cr_{0.5})3AlC_2$, etc., as well as other relevant promising Double Transition Metal Mxenes] with varying morphologies, modified electronic structures and properties; design and fabrication of phase-engineered and defect-engineered 2D inorganic compound's QDs and nanosheets directly deposited on conducting substrates following novel techniques; synthesis of quantum dots and nanosheets of MXene with engineered edge sites and doped heterostructures with focused studies on enhancement of catalytic properties of these materials towards energy storage applications; and tailor 2D Mxene nanostructure through chemical modification and/or functionalization in order to achieve functional materials with high activity and stability towards effective performance in electrochemical energy storage systems.

Progress thus far

A variety of materials have been synthesized and the synthesized nanostructure has been utilized for 3D electrode architectures. These materials are characterized by state-of-the-art experimental tools. Specific electrochemical measurements related to Supercapacitors and Batteries will be performed. Detailed theoretical investigations related to materials performance as well as interpretation/explanation of the experimental findings have been simultaneously carried out. The team has studied the light-matter interaction in the fabricated nanostructures through detailed photo-conductive transport and photocurrent spectroscopy measurements in a room and at low temperatures.They have studied the electronic structure of exfoliated MAX layers and bandgaps by varying the functional groups and also the MAX bonds consist of a mixture of covalent, metallic and ionic bonds.

Publications

1. Mishra M., Behura S.K., Beidaghi M., Verma K. and Singh S. (2021) MXene: *A Non-oxide Next-Generation Energy Storage Materials for Batteries and Supercapacitors.* Advanced Applications of 2D Nanostructures, Springer Pages 73-98.

2. Iqbal M., Kumar A. and Singh S. (2021) 2D *Nanomaterials Based Advanced Bio-composites.* Advanced Applications of 2D Nanostructures, 231-246.

3. Singh S., Singh D.P., Verma K. and Kumar V. (2021) *Different Techniques for Designing and Fabrication of 2D Materials.* Advanced Applications of 2D Nanostructures, 29-42.

4. Prasad S.V., Mishra R.K., Gupta S., Prasad S.B. and Singh S. (2021) *Introduction, History, and Origin of Two Dimensional (2D) Materials.* Advanced Applications of 2D Nanostructures, 1-9.

5. Maity C.K., Verma K., Nayak G., Akinwande D. and Berry V. (2021) *Induced conducting energy-levels in a boron nitride nano-framework for asymmetric supercapacitors in high charge-mobility ionic electrolytes.* Composites Part B: Engineering Volume 212, 108728.

6. Prasad S.V.S., Prasad S.B. and Singh S. (2021) *Nanostructured 2D Materials as Nano Coatings and Thin Films.* Advanced Applications of 2D Nanostructures, 55-72.

7. Singh S., Verma K. and Prakash C. (2021) *Advanced Applications of 2D Nanostructures: Emerging Research and Opportunities.* Springer.

9. Centre for Rational Engineering of Quantum Materials

Principal Investigators:

Srimanta Middey, Indian Institute of Science, Bengaluru

Jayakanth Ravichandran, University of Southern California, Los Angeles

Partnering Institutions:

- Indian Institute of Science, Bengaluru
- S. N. Bose National Centre for Basic Science, Kolkata
- University of Southern California, Los Angeles
- Argonne National Laboratory, Lemont

Objectives

The objective of the center is to create a fundamental understanding of the microscopic electronic degrees of freedom in the early transition of metal-based oxides and chalcogenides with the perovskite structure. The Center aims to create a close collaboration between a group of researchers with complementary expertise such as materials synthesis, first principles theory, advanced x-ray spectroscopy, electron transport studies, to tackle a broad range of problems related to this theme. The direct interactions and collaborations between faculty and researchers are essential to solving some of the important open problems in quantum materials research, which remains a key area to enable future technological innovations that will benefit humankind.

Progress thus far

The team has established a Centre for Rational Engineering of Quantum Materials that integrates materials synthesis, physical measurement and theoretical analysis to demonstrate new modalities for rational design and control of electronic functionalities in transition metal-based oxides and chalcogenides, both in bulk and heterostructure form. Non Strontium yitanate ($SrTiO_3$)-based heterostructures have been developed, equipped with high pressure RHEED (reflection high energy electron diffraction). During the materials development phase, the materials characterized by various laboratory-based techniques (x-ray reflectivity, x-ray diffraction, reciprocal space mapping, atomic force microscope) and basic transport measurement have been carried out at IISc. The films had been provided to Jayakanth Ravichandran's group for making patterned devices and advanced transport measurements such as thermoelectric measurements, Hall effect, magneto resistance studies, and magneto-thermoelectric measurements. These studies provided electronic and transport coefficients such as effective mass, scattering mechanism, carrier density and mobility. Bulk synthesis effort for Ti and V based chalcogenide materials will be carried out in parallel at USC.

The team's other target will be to understand the electronic structure of Ti and V-based chalcogenides with hexagonal perovskite structures which are potential candidates for various applications ranging from photovoltaics to infrared detectors.

Publications

1. Chakhalian J. and Middey S. (2022) *Perspective - Emergent Phases in Rare Earth Nickelate Heterostructure.* ECS Journal of Solid State Science and Technology, Volume 11.

2. Mandal P., Patel R.K., Rout D., Banerjee R., Bag R., Karmakar K., Narayan A., Freeland J.W., Singh S. and Middey S. (2021) *Giant orbital polarization of Ni2+ in a square planar environment.* Physical Review B, Volume 103.

3. Kumar S., Panda S.K., Patidar M.M., Ojha S.K., Mandal P., Das G., Freeland J.W., Ganesan V., Baker P.J. and Middey S. (2021) S*pin-liquid behavior of the three-dimensional magnetic system Ba3NiIr2 O9 with S=1.* Physical Review B, Volume 103.

4. Ojha S.K., Gogoi S.K., Mandal P., Kaushik S.D., Freeland J.W., Jain M. and Middey S. (2021) *Oxygen vacancy induced electronic structure modification of* $KTaO_3$, Physical Review B, Volume 103.

5. Liu X., Singh S., Drouin-Touchette V., Asaba T., Brewer J., Zhang Q., Cao Y., Pal B., Middey S., Kumar P.S.A., Kareev M., Gu L., Sarma D.D., Shafer P., Arenholz E., Freeland J.W., Li L., Vanderbilt D. and Chakhalian J. (2021) *Proximate Quantum Spin Liquid on Designer Lattice.* Article Nano Letters, Volume 21, Pages 2010-2017.

10. Centre for Sensor Science and Technology

Principal Investigators:

Shankar Kumar Selvaraja, Indian Institute of Science, Bengaluru

Mike A. Carpenter, SUNY Polytechnique Institute, New York

Partnering Institutions:

- Indian Institute of Science, Bengaluru
- Indian Institute of Technology Hyderabad
- SUNY Polytechnique Institute, New York
- University at Buffalo, Buffalo

Objectives

IoT solutions are slowly penetrating into both industry and everyday societal frameworks such as health, environment, and safety. It is essential that integrated sensor technology is in place to meet future needs. The key objectives of this collaboration include the development and demonstration of sensor-specific materials, devices, and circuit technologies for next-generation IoT-compatible physical and chemical sensor technologies for the environment and smart agriculture; development of energy efficient IoT sensor interconnects, protocols, and communication technologies; development of a workforce that is trained specially in sensor technology; and development and dissemination of a roadmap for next-generation comprehensive sensor technology roadmap covering material to systems.

Progress thus far

The partnering institutions bring in complementing expertise that provided a complete IoT physical and network layer solution. Though power and communication modules are well explored for IoT application, development of sensor technology is barely addressed. The team is in the final phase of development of physical and chemical sensors that use multianalyte and multi-mode sensing technology through system scaling and novel physical and chemical sensor development.Two types of sensors have been pursued in this project - physical sensors and chemical sensors. Physical sensors are predominately Micro

Electromechanical System (MEMS) based sensors, and for chemical sensing, the metal-oxide electro-chemical technique was used, as it offers micro-electronics compatible fabrication and integration opportunity. The team has integrated multiple sensors as a single sensor module.

Publications

1. Kumari K., Kumar S., Mehta M., Chatterjee A., Selvaraja S.K. and Avasthi S. (2022) *Laser-Crystallized Epitaxial Germanium on Silicon-Based Near-Infrared Photodetector.* IEEE Sensors Journal, Volume 22, Pages 11682-11689.

2. Duraiswamy P., Anusha U., Raghu S. and Selvaraja S.K. (2022) *Design and simulation of differential transimpedance amplifier with active feedback for optical receivers.* Microwave and Optical Technology Letters, Volume 64, Pages 1112-1117.

3. Rout D., Venkatachalam P., Singh R., Shreelakshmi K. P. and Selvaraja S. K. (2022) *Guided mode resonance aided polarization insensitive in-plane spectral filters for on-chip spectrometer.* Optics Letters, Volume 47, No. 18, Pages 4616-4619.

4. Samanta S., Kalathimekkad S. and Selvaraja S. K. (2021) *Fluid Sensing Strategies Adopted in Photonic Devices: A Review.* Elsevier Journal of Optics & Laser Technology , Volume 139, Page 106975.

5. Vura S., Jeyaselvan V., Biswas R., Raghunathan V., Selvaraja S. K., and Raghavan S. *(2021) Epitaxial BaTiO3 on Si(100) with In-Plane and Out-of-Plane Polarization Using a Single TiN Transition Layer.* ACS Applied Electronic Materials, Volume 3, No. 2, Pages 687-695.

The follwing Joint Centers received formal award notifications in 2021-22:

S. No.	Proposal Title	Lead Indian PI	Lead U.S. PI
1.	*Acidification and Pteropod Dissolution in the Indian Ocean*	**V.V.S.S. Sarma** National Institute of Oceanography, Visakhapatnam	**Richard A. Feely** NOAA Pacific Marine Environmental Laboratory, Seattle
2.	*Center for Secure and Resilient Quantum Optical Networks*	**Vimal Bhatia** Indian Institute of Technology, Indore	**Byrav Ramamurthy** University of Nebraska, Lincoln
3.	*Center on Advanced Bio-based Energy and value added Commodity Production: Moving towards next generation feed based Biorefinerie*	**Vibha Dhawan** The Energy and Resources Institute, New Delhi	**Wei Liao** Michigan State University, Michigan

S. No.	Proposal Title	Lead Indian PI	Lead U.S. PI
4.	*Center in Chronobiology*	**Sangeeta Rani** University of Lucknow, Lucknow	**Erik Herzog** Washington University, St. Louis
5.	*Polynomials as an Algorithmic Paradigm*	**Anand Louis** Indian Institute of Science, Bengaluru	**Prasad Tetali** Georgia Institute of Technology, Atlanta
6.	*Center for Big Data and the Brain for Precision Mental Health*	**Ramkrishna Pasumarthy** Indian Institute of Technology, Madras	**Vinod Menon** Stanford University, Stanford
7.	*Understanding the CME propagation and its internal structure in the interplanetary space to predict Bz*	**Nandita Srivastava** Udaipur Solar Observatory, Physical Research Laboratory, Udaipur	**Natchimuthuk Gopalswamy** NASA Goddard Space Flight Center, Maryland
8.	*Centre for Integrative Cancer Biology and Therapeutics*	**Rana P. Singh** Jawaharlal Nehru University, New Delhi	**Sanjay V. Malhotra** Oregon Health & Science University, Portland
9.	*Centre for Gravitational-Physics and Astronomy*	**K. G. Arun** Chennai Mathematical Institute	**B. S. Sathyaprakash** Pennsylvania State University, State College
10.	*Center for Self-powered Energy Harvesting and Storage Systems*	**Abha Misra** Indian Institute of Science, Bengaluru	**Apparao M. Rao** Clemson University, Clemson

Special Call: Indo-U.S. Virtual Networks for COVID-19

In response to the pandemic, IUSSTF had announced a Special Call for Proposals for Indo-U.S. Virtual Networks for COVID-19 in April 2020. The intent was to encourage proposals that convincingly demonstrate the benefits and value of the Indo-U.S. partnership to advance research and address critical challenges related to COVID-19. Following a rigorous binational peer-review process, IUSSTF announced awards to eight teams on 17 August 2020. These teams, representing leading researchers from top Indian and U.S. Institutions are now pursuing cutting-edge research in areas that include studies on pathogenesis and disease management in COVID-19, antiviral coatings, immune modulation, tracking SARS CoV-2 in wastewater, disease detection mechanisms, reverse genetics strategies, and drug repurposing. A brief on their progress is presented below:

1. Real time high-throughput cost-effective sequencing platform for 2019-nCOV detection and genotyping

Rajesh Pandey

CSIR-Institute of Genomics and Integrative Biology, Delhi

Sarath Chandra Janga

Indiana University, Indianapolis

Objectives

Due to the rapidly evolving nature of coronaviruses, their identification has become increasingly challenging. Hence, there is an urgent need to generate new diagnostic tests that combine scale, speed, sensitivity and generation of data that can be used to inform surveillance, public health strategy, and vaccine design. The project aims to combine an efficient, novel and high-throughput RNA isolation method, accompanied with pooled and high-throughput barcoded Nanopore sequencing of swab samples and develop automated computational pipelines to facilitate detection of SARS-CoV-2 from samples.

Progress thus far

The team has completed most of these milestones in the initial pilot and have published a comprehensive study on ~10,000 Indian cohort of COVID genomes based on both, in house nanopore based datasets as well as publicly generated Indian COVID genomes, using other sequencing technologies and are in the process of optimizing the steps to fully streamline the system for future use. The group has also developed specific website domain with a cohort of ~10,000 COVID genomes mapping the genome dynamics, transmission, evolution of SARS-COV2 genomes between the time-period April 2020 to March 2022.

Publications

1. Jha N., Hall D., Kanakan A., Maurya R., Mehta P., Mir Q., Gill H.M., Janga S.C., and Pandey R. (November 2021) Geographical landscape and transmission dynamics of SARS-CoV-2 variants across India: a longitudinal perspective. Frontiers in Genetics.

2. Mansi Srivastava M., Dwight Hall D., Okiemute Beatrice Omoru O.B., Hunter Mathias Gill H.M., Sarah Smith S., and Janga S.C. (August 2021) Mutational Landscape and Interaction of SARS-CoV-2 with Host Cellular Components. Microorganisms 9(9):1794.

3. Shastri J., Parikh S., Aggarwal V., Agrawal S., Chatterjee N., Shah R., Devi P., Mehta P., and Pandey R. (August 2021) Severe SARS-CoV-2 Breakthrough Reinfection with Delta Variant After Recovery from Breakthrough Infection by Alpha Variant in a Fully Vaccinated Health Worker. Frontiers in Medicine.

4. Mehta P., Alle S., Chaturvedi A., Swaminathan A., Saifi S., Maurya R., Chattopadhyay P., Devi P., Chauhan R., Kanakan A., Vasudevan J.S., Sethuraman R., Chidambaram S., Srivastava M., Chakravarthi A., Jacob J., Namagiri M., Konala V., Jha S., Priyakumar U.D., Vinod P.K., and Pandey R. (August 2021) Clinico-Genomic Analysis Reveals Mutations Associated with COVID-19 Disease Severity: Possible Modulation by RNA Structure. Pathogens.

5. Mehta P., Sahni S., Siddiqui S., Mishra N., Sharma P., Sharma S., Tyagi A., Chattopadhyay P., Vivekanand A., Devi P., Khan A., Waghdhare S., Budhiraja S., Uppili B., Maurya R., Nangia V., Shamim U., Hazarika P.P., Wadhwa S., Tyagi N., Dewan A., Tarai B., Das P., Faruq M., Agrawal A., Jha S., and Pandey R. (May 2021) Respiratory Co-Infections: Modulators of SARS-CoV-2 Patients' Clinical Sub-Phenotype. Frontiers in Microbiology.

6. Devi P., Khan A., Chattopadhyay P., Mehta P., Sahni S., Sharma S., and Pandey R. (July 2021) Co-infections as Modulators of Disease Outcome: Minor Players or Major Players? Frontiers in Microbiology.

2. Electron microscopy study to explore the effectiveness of HCQS on COVID-19 disease from *ex vivo* patient samples

Subhash Chandra Yadav

All India Institute of Medical Sciences, New Delhi

Wah Chiu

Stanford University, Stanford

Objectives

The team proposes to investigate the role of Hydroxychloroquine (HCQS) by exploring the significant alteration in cellular infectivity and multiplication of SARS-CoV-2 at different stages of the COVID-19 disease. The Indian group at AIIMS, New Delhi would be responsible for analysis of patient samples, while the exploration of molecular level interaction of coronavirus and cellular receptors would be carried out at Stanford University.

Progress thus far

The level of infectivity on a different layer of keratinized and non-keratinized oropharyngeal squamosal epithelium was evaluated and it was observed that active dividing cells of squamosal epithelium such as stratum spinosum, granulosum, intermedium, and superficial were mostly infected than non-active stratum corneum cells. The role of HCQS on the level of infection was insignificant in these cells. The level of SARS-CoV-2 infection and effect on ultrastructure of respiratory (ciliated epithelial cells, type-II pneumocytes) and hemopoietic cells (neutrophils, monocytes, macrophage, eosinophils, lymphocytes, non-nucleated cytoplasm) were comparatively evaluated in selected age group, severity as well as the co-morbidities of patients. It revealed that the younger population in each group and cell types showed higher infection and less cellular ultrastructural damage in comparison to old age patients. This may be due to high immunity and relatively healthy cells. The effect of HCQS on pre-treated (taken before the infection) patients' samples was also evaluated. It was found that the HCQS treated patient showed less infection in the ciliated epithelium as well as in type-2 pneumocytes cells. The team has 4 manuscripts currently under preparation.

Publications

1. Chaudhary S., Preeti Rai P., Sesham K., Kumar S., Singh P., Nag T.C., Chaudhuri P., Trikha A., and Yadav S.C. (2021) Microscopic imaging of bronchoalveolar fluids of COVID-19 positive intubated patients reveals the different level of SARSCoV-2 infection on oral squamosal epithelial cells. Indian Journal of Biochemistry and Biophysics (IJBB) 58 (3): 196-207.

3. Lymphopenia in COVID-19: Implication in pathogenesis and disease management

Jyotsna Agarwal

Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow

Ankita Garg

University of Georgia, Athens

Objectives

The team proposes to combine clinical and mechanistic/translational approaches to understand factors responsible for immune cell death. Clinical parameters of COVID-19 patients will be assessed at COVID-19 hospital and diagnostic BSL-2 laboratory in Ram Manohar Lohia Institute of Medical Sciences, Lucknow, whereas mechanistic/translational work will be undertaken in BSL-3 lab at the University of Georgia.

Progress thus far

COVID-19 patients exhibit multiple clinical and haematological manifestations including T-cell lymphopenia. Regardless of geographic location, low absolute T-cell, CD4+, and CD8+ T-cell counts are observed in critically ill COVID-19 patients. Various mechanisms have been proposed for lymphopenia seen in COVID-19 patients, these need to be proven. Whole blood samples were collected on bedside at the time of admission (sample 1) and on day 3-4 of their hospital stay (sample 2) in 30 patients with confirmed COVID-19 diagnosed participants (>18 years, both sexes, excluding pregnant women; after obtaining written informed consent) who were enrolled in this study. It was observed that due to

severity of the infection, T-cell death was found in severe and mild category and in sample-2 it was lesser as compared to sample-1. Further analysis is ongoing and the team has several manuscripts under preparation.

4. Development of antiviral coatings to prevent the transmission of SARS-CoV-2 viruses

Jayanta Haldar

Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru

Shiv Pillai

Ragon Institute of MGH, MIT and Harvard, Cambridge

Objectives

The SARS-CoV-2 pandemic has once again highlighted the dire need for antimicrobial surfaces to break the chain of transmission of droplet-borne viral diseases. The team's goal is to develop a one-step, permanent, robust, antiviral coating for daily encountered surfaces such as door-handles, railings, seat covers, switches, credit cards, ID cards and even currency notes.

Progress thus far

A quaternary small molecule (QSM) has been synthesized comprised of a benzophenone as well as cationic lipophilic moiety through 4 steps. This benzophenone moiety imparts ability to covalently crosslink on a wide range of surfaces. The molecule has been coated on polyurethane, polyethylene, surgical mask through spray-coating of ethanolic solution of the compound followed by UV irradiation. The antiviral efficacy of coated surfaces was studied at the Ragon Institute for their efficacy against SARS-CoV-2 through plaque reduction assay that estimates the number of infectious virions. Both polyurethane and mask surfaces with an antiviral coating exhibited a 2-log (i.e. ~99%) reduction in the plaque count within 30 minutes of exposure compared to the corresponding uncoated controls. Surprisingly, tests with both coated and uncoated cotton surfaces exhibited a dramatic reduction (>3-log reduction) in the recovery of any live virus across the entire range of dilutions examined.

Publications

1. Ghosh S., Jolly L. and Haldar J (2021) Polymeric paint coated common-touch surfaces that can kill bacteria, fungi and infuenza virus. MRS Communication

5. Mitigating COVID-19 infection and progression via innate immune modulation

Suparno Chakrabarti

Dharamshila Narayana Superspeciality Hospital, New Delhi

Sanjay V. Malhotra

Oregon Health & Science University, Portland

Objectives

Mycidac-C (Mw), a potent immune stimulant used for cancer treatment in India, has demonstrated significant inhibition of cytokine storm in gram negative sepsis with ~2X greater survival. With similarities of disease pathologies in both conditions, the team hypothesize that Mw treatment will decrease COVID infection and progression.

Progress thus far

In as single-center non-randomised cohort control study, the team selected 100 samples in which 50 were administered with 0.1ml of Mw and 50 samples remains as control for the study. Samples were collected before administration of Mw and after days 30, 60 and 100, time point samples were collected to study effect of Mw on the patients' samples. Twenty out of 100 subjects in the entire cohort had symptomatic COVID-19 infections during the study period. All infections on the Mw group had mild COVID-19 infection while 6 of 17 in control group had moderate disease and required hospital admission. No deaths were recorded in either group. The group has successfully isolated NK (Natural Killer) and monocytes from PBMC (Peripheral Blood Mononuclear Cells) of Mw treated samples and, optimized the immunological phenotyping from the PBMC of Mw treated samples as well as the control samples.

Publications

1. Jaiswal S.R., Arunachalam J., Bhardwaj A., Saifullah A., Lakhchaura R., Soni M., Bhagawati G. and Chakrabarti S. (2021) Impact of adaptive natural killer cells, KLRC2 genotype and cytomegalovirus reactivation on late mortality in patients with severe COVID-19 lung disease.

2. Jaiswal S.R., Arunachalam J., Saifullah A., Mehta A., Bhagawati G., Lakhchaura R., Aiyer H., Khamar B. and Chakrabarti S. (2021) Impact Of an Immune Modulator Mycobacterium-w On Adaptive Natural Killer Cells and Protection Against COVID-19.

6. Occurrence and persistence of SARS-CoV-2 (COVID-19) along with known biological indicators in waste waters of Mumbai city

Sandhya Shrivastava

Bhavan's Research Center (Microbiology), Mumbai

Joan Rose

Michigan State University, East Lansing

Objectives

Understanding the fate of SARS- CoV-2 through the different stages of wastewater treatment and the safety of treated waters to be discharged in the environment is required from epidemiological perspective. The team aims to study developing competency and methodology for sampling, effective recovery and detection of SARS-CoV-2. Successful evaluations would generate knowledge-based insights or guidelines for wastewater surveillance.

Progress thus far

A pilot study was carried out to assess the competency in methodology standardized from the Wastewater Treatment Plants (WWTP) located at the City Center (Colaba, Mumbai), seven (3 untreated and 4 treated) wastewater samples were analysed. Standardized method was used for virus concentration from the samples. The RNA extraction and RT-qPCR for detection of SARS-CoV-2 were carried out using ICMR approved kits. It was observed that SARS-CoV-2 was detected in all the untreated wastewater samples but not in treated wastewater samples. These results were communicated to Municipal Corporation Greater Mumbai to seek permission to carry out a comprehensive study from all the three WWTPs shortlisted. Once permission was granted, sample collection was carried out in April – June 2021. A total of 158 samples were collected from the WWTPs and processed for virus concentration. Bacteriophage phi-6 was spiked in all samples before processing in order to validate the virus concentration step. 131 samples were taken further for analysis to detect the prevalence SARS-CoV-2 RNA using ICMR approved kits. It was observed that 77.04% of untreated wastewater samples were positive for SARS-CoV-2 while only 7.14% of secondary treated samples were positive for the virus. SARS-CoV-2 was not detected in any of the tertiary treated samples.

7. Leveraging reverse genetics strategies to study structure-function interplay of virus host attachment spike protein to design therapies for COVID-19

Jayasri Das Sarma

Indian Institute of Science Education and Research Kolkata, Nadia

Maria Nagel

University of Colorado School of Medicine, Aurora

Objectives

Coronavirus spike gene that mediates infectivity and RdRp gene that regulates viral replication are the key regulators of SARS-CoV2 infectivity. This team's strategy combines novel murine coronavirus expressing the SARS-CoV-2 spike and RdRp genes coupled with humanized ACE-2 expressing mice to screen pharmacologic agents in a system that is translatable to clinical settings. They will assess the inflammatory effects of COVID-19 on lung, liver, kidney, and the central nervous system.

Progress thus far

The team has reported that the administration of Neem Plant's Bark Extract inhibits SARS-CoV-2 and m-CoV-RSA59 viral infection and replication in cell culture by reducing the expression of Envelope and Nucleocapsid genes. These findings correlate with in vivo experiments where restricted viral replication

and spread is observed due to amelioration of neuroinflammation and hepatitis by Neem Bark Extract (NBE) treatment. Nimbin-enriched isolated fractions of NBE were found capable of inhibiting m-CoV-RSA59 infection *in vitro*. Their studies have determined key features underlying SARS-CoV-2 that are conserved across human coronaviruses that may provide important strategies to develop novel therapies for the current as well as future pandemics.

Computation analyses of Spike protein's fusion loop revealed the organization of three fusion peptides present adjoining to each other that trigger the virus-host membrane fusion process. The group observed that a Contact Initiation Model may be the reason behind the initiation of the viral fusion process with the host membrane, where due to the Spike quaternary structure fusion loop is bound to interact with the host membrane to start the process. Overall, the importance of the fusion loop in contact initiation of the fusion process makes it an appropriate target for anti-virals and vaccine candidates.

Publications

1. Sarkar L., Oko L., Gupta S., Bubak A.N., Das B., Gupta P., Safiriyu A.A., Singhal C., Neogi U., Bloom D., Banerjee A., Mahalingam R., Cohrs R.J., Koval M., Shindler K.S., Pal D., Nagel M.and Sarma J.D. (2022) Azadirachta indica A. Juss bark extract and its Nimbin isomers restrict β-coronaviral infection and replication. Virology.

2. Pal D. (June 2021) Spike protein fusion loop controls SARS-CoV-2 fusogenicity and infectivity. Journal of Structural Biology.

8. Establishment of an Indo-U.S. Molecular Biomarker Knowledge Network for COVID-19

Shantikumar V. Nair

Amrita Centre for Nanosciences and Molecular Medicine, Kochi

Mohit Jain

University of California, San Diego, La Jolla

Objectives

This teams' focus is on discovery of molecular biomarkers of COVID-19 with respect to internal and external exposure factors called exposomes that can provide early warning for COVID-19 susceptibility and severity, as well as targets for therapeutic modalities.

Progress thus far

The team searched for markers in the blood plasma and peripheral blood mononuclear cells (PBMC) to identify susceptible groups of patients for the prognostication of the disease including identification of new leads towards understanding the molecular pathology of the disease. They observed significant differences in the expression of some of the blood plasma proteins involved in immune system homeostasis and their function including protecting lungs from inflammatory damage. These proteins include α-1-Acid glycoprotein (AGP), Haptoglobin, Transthyretin and Apolipoprotein A-I. Importantly, these liver produced proteins are associated with control of neutrophil trafficking, clearance of LPS

from circulation, and proteins that protects lung damage from inflammation and acts as antioxidants. These results indicate the significant involvement of liver proteins in the immune homeostasis and lung pathology. Differential regulation of these proteins in COVID-19 could cause inadequate host response to infection, which is generally the cause for sepsis and a similar scenario could be seen in severe COVID-19 patients also. The differences in levels of these proteins could be due to insult to liver. The results reported indicate that systemic involvement could be one of the major driving forces of COVID-19 severity. Additionally, the study comes out with the identification of set of markers related to pathophysiology of COVID-19 infection which has value in prognosis and perhaps in therapy of COVID-19 patients. Currently the team is working on two manuscripts and one patent application.

Section II: Strategic Initiatives

IUSSTF's U.S. - India Artificial Intelligence (USIAI) Initiative

IUSSTF's **U.S. – India Artificial Intelligence (USIAI) Initiative** provides a unique opportunity for the world's two largest democracies to strengthen their strategic partnership by focusing on AI cooperation in critical areas that are priorities for both countries. USIAI serves as a platform to discuss opportunities and barriers for bilateral AI R&D collaboration, share ideas for developing an AI savvy workforce, and recommend modes and mechanisms for catalyzing partnerships to facilitate these technologies for strengthening U.S.-India cooperation. All USIAI activities along with resources (reports, articles etc) can be accessed at our website https://usiai.iusstf.org.

The list of activities that was held during 2021-22 include:

1. A series of **Virtual Roundtables** with leading Indian and U.S. experts on:

a. Trustworthy/Fair AI

   i. Trustworthy AI for Social Good: AI technologies in the Indian and U.S. contexts

   ii. Principles of Trustworthy AI: Comparing Western and Non-Western conceptions of fairness and AI ethics

   iii. Trustworthy Security Systems (Biometrics)

   iv. Institutional Trust

   v. Federated AI and Computational Trust

b. AI in Healthcare

   i. Two Roundtables on AI and Pandemic Preparedness

      a. Predictive Modelling and Pathogen Surveillance

      b. Vaccines Discovery and Drug Repurposing

   ii. Two Roundtables on AI and Mobile Health

2. **AI and Workforce:** A series of interviews with experts from academia and industry. We are also conducting a survey of Indian Institutions to understand the programs they offer in AI, Machine Learning, Data Science.

Virtual Roundtables on Trustworthy AI

USIAI kicked-off its activities with a series of 5 roundtables under the broad theme of **Trustworthy AI** between 27 July 2021 and 11 August 2021. Ensuring AI systems that are trustworthy is critical to their adoption and deployment in different application domains. The roundtables focused on different dimensions of Trustworthy AI, bringing together experts from academia, industry, foundations, and government to discuss key challenges and identify opportunities for collaboration between the two

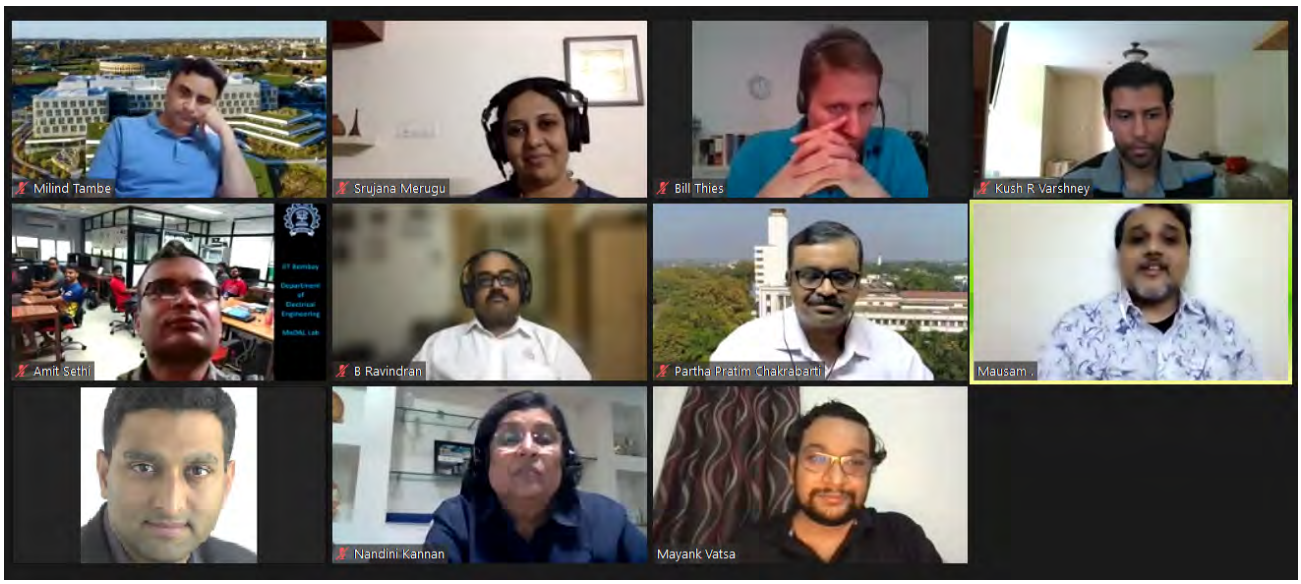
countries. The Trustworthy AI Roundtables were organized by a Standing Committee comprising leading researchers from academia and industry: Salman Avestimehr (Dean's Professor at University of Southern California, and Director of the Information Theory and Machine Learning research lab at USC's Electrical and Computer Engineering Department), Amit Deshpande (Researcher, Microsoft Research in India with expertise in fairness, accountability, transparency and ethics in machine learning), Kush Varshney (distinguished research staff member and manager at IBM Research at Thomas J. Watson Research Center in New York), and Mayank Vatsa (Professor and Project Director of the Technology and Innovation Hub on Computer Vision at the Indian Institute of Technology, Jodhpur).

I. The first roundtable titled ***Trustworthy AI for Social Good: AI technologies in the Indian and U.S. contexts*** was held on 27th July 2021

Panelists: Partha Pratim Chakrabarti (IIT, Kharagpur), Srujana Merugu (Google Research), Mausam (IIT Delhi), Prof Ramesh Raskar (MIT Media Lab), Balaram Ravindran (IIT Madras), Prof Amit Sethi (IIT Bombay), Amit Sethi (Harvard University) and Bill Thies (Microsoft Research)

Moderators: Kush Varshney and Mayank Vatsa

The Roundtable focused on how AI tools and technologies can help empower citizens and reduce inequities in society. Panelists discussed different AI application domains and the similarities and differences in the contexts of the two countries. Several areas where collaborations between India and the United States could lead to significant societal impact were identified. However, participants underscored the need to recognize the potential harms of these new technologies and issues related to fairness and privacy. The panelists also stressed the need for transdisciplinary collaborations and partnerships between academia, industry, and government to develop AI solutions for social good and social impact.



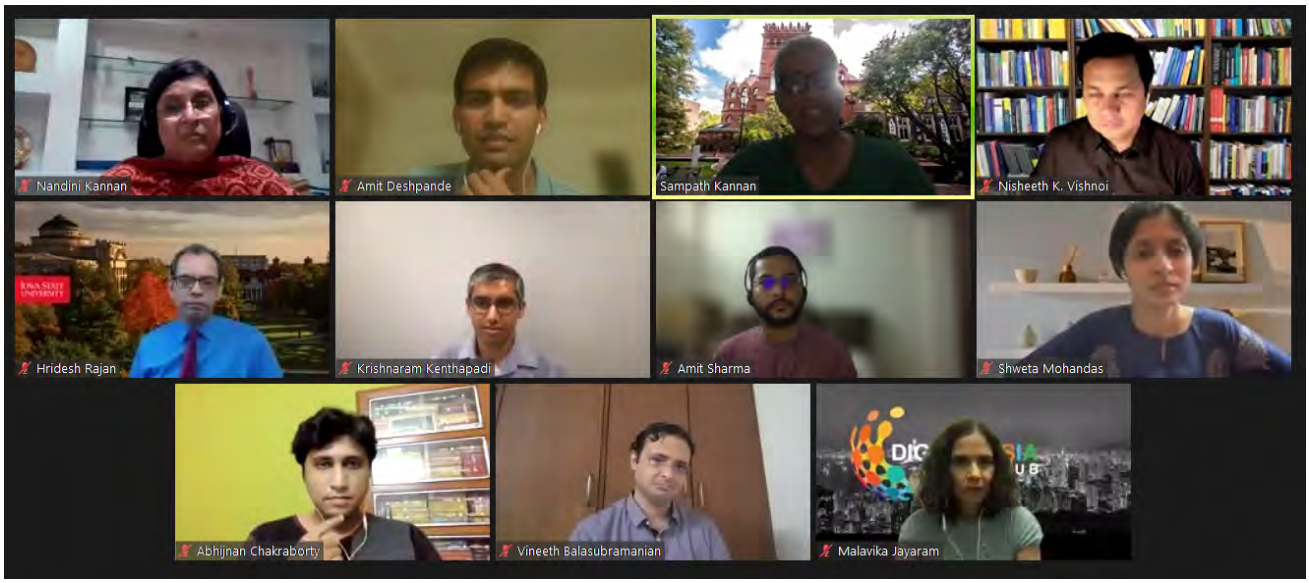
II. The second roundtable titled ***Principles of Trustworthy AI: Comparing Western and Non-Western conceptions of fairness and AI ethics*** was held on 29th July 2021

Panelists: Vineeth Balasubramanian (IIT, Hyderabad), Abhijnan Chakraborty (IIT Delhi), Malavika Jayaraman (Digital Asia Hub), Sampath Kannan (University of Pennsylvania), Krishnaram Kenthapadi

(Amazon AWS), Shweta Mohandas (Center for Internet and Society), Hridesh Rajan (IOWA State University), Nisheeth K. Vishnoi (Yale University), Amit Sharma (Microsoft),

Moderator: Amit Deshpande (IBM, India)

The focus of the Roundtable was to examine notions of privacy, fairness, and ethics both from a western and non-western context. Participants included legal experts who provided unique insights into regulatory and policy frameworks in India and the United States around emerging technologies including AI. While much of the current focus has been on data protection and privacy, panelists also discussed other dimensions of trust, the underlying technical challenges, and trade-offs between different axes of trustworthiness. Panelists agreed that there is a need to have robust metrics to quantify privacy and fairness and highlighted the need for more collaboration between computer scientists and policy/ legal experts.

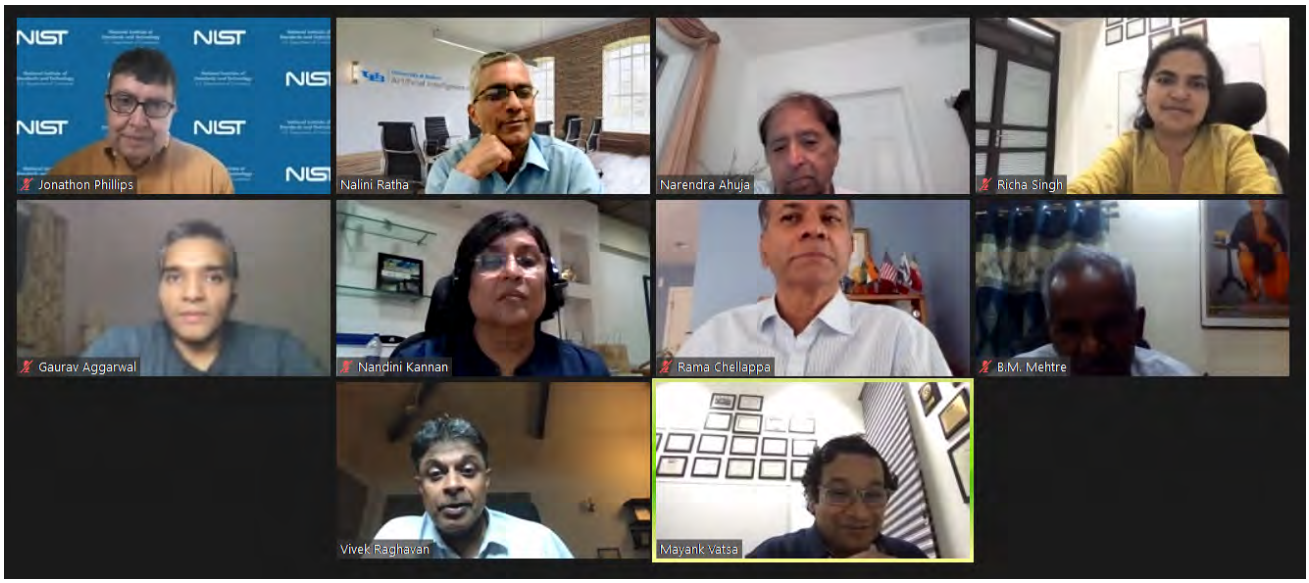


III. The third roundtable titled ***Trustworthy Security Systems (Biometrics)*** was held on 3rd August 2021

Panelists: Narendra Ahuja (University of Illinois at Urbana-Champaign), Gaurav Agrawal (Google Research), Rama Chellappa (Johns Hopkins University), B.M. Mehtre (IDRBT), Jonathon Phillips (NIST), Nalini Ratha (University at Buffalo), Vivek Raghavan (UIDAI), Richa Singh (IIT Jodpur)

Moderator: Mayank Vatsa (IIT Jodhpur)

The Roundtable focused on biometrics-based identity management systems and the underlying challenges related to fairness, robustness, explainability and privacy. Panelists noted that issues like explainable biometrics and addressing social/ regional variations are currently the big challenges when building a trustworthy security system. The example of Aadhar, the world's largest biometric system, was discussed in the context of inclusivity and access. Given the concerns about privacy leakage with respect to biometric data, panelists agreed that federated learning may be a solution. The panelists highlighted the need for data resources and the role of interdisciplinary collaborations in addressing the challenge of building trustworthy security systems.



IV. The fourth roundtable titled ***Institutional Trust*** was held on 5th August 2021

Panellists: Rahul Mattahan (TMT), Gretchen Greene (the Hasting center), Vidushi Marda (Article 19), Rahul Panicker (Vicarious AI), John Richards (T. J. Watson Research Center), Michelle Shevin (Ford Foundation)

Moderator: Kush Varshney (IBM Research)

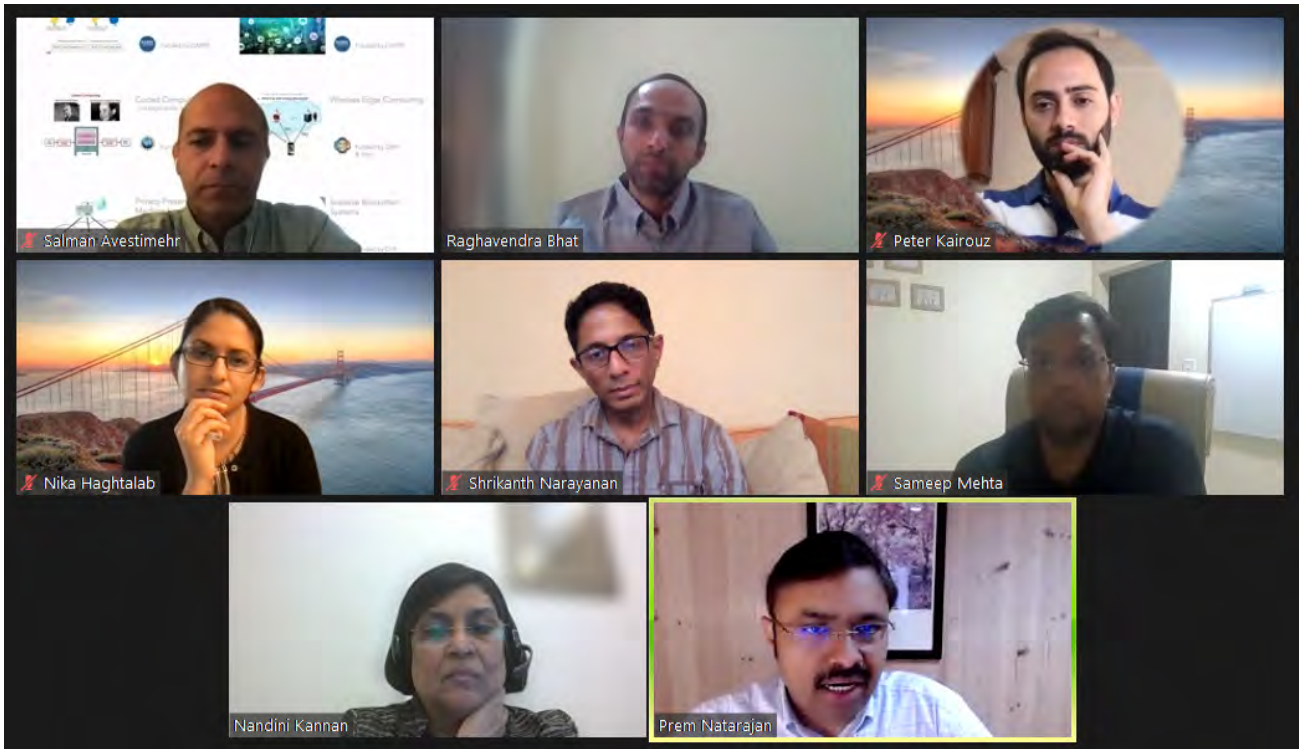
The Roundtable focused on the differences between institutional trust for AI platforms and the more traditional notions of trust for individual AI models and functions. Panelists highlighted the importance of viewing trust not as a monolithic concept, but as context driven and evolving over time. Participants, including legal and policy experts, discussed. discussed different notions of institutional trust as well as existing legal and regulatory frameworks in the U.S. and India. The panelists agreed that legal and regulatory systems should focus on applications of AI rather than the technology per se, and recommended collaborations between legal scholars, social scientists, and technologists to guide the R&D agenda.

V. The fifth roundtable titled ***Federated Learning and Computational Trust*** was held on 11th August 2021

Panelists - Raghavendra Bhat (Intel India), Nika Haghtalab (UC Berkeley), Peter Kairouz (Google), Sameep Mehta (IBM India), Shrikanth Narayanan (University of Southern California), Prem Natarajan (Amazon)

Moderator - Salman Avestimehr (University of Southern California)

The primary objective of the Roundtable was to address the societal and technical challenges that arise in federated learning, i.e., decentralization of existing machine learning systems across users. Panelists discussed the extent to which Federated AI can be effective in ensuring privacy, its role in strengthening trust in society, regulatory barriers to large-scale deployment, and emerging research directions. The gap between theory and implementation in practice is exacerbated in India because of the significant challenges posed by the different axes of diversity. Panelists highlighted the need for personalized systems to address the needs of different communities. With data playing a critical role in the development of robust federated AI systems, challenges with data quality and access were noted as key challenges.



The five roundtables provided a nuanced understanding on identifying both short-term and long-term goals to build strategic partnership between India and the U.S. in the field of AI. The short-term goals can focus on setting up collaborative projects between researchers from India and the U.S. and identifying industry partners in both the countries who are keen to collaborate with each other to develop AI technologies for social good. The long-term goal should focus on conducting research on finding answers to some core issues and challenges related to AI.

Roundtables on AI in Healthcare

IUSSTF partnered with the U.S-India Strategic Partnership Forum (USISPF), to organise a series of Roundtables in the area of AI in Healthcare as part of the USI-AI Initiative. The AI in Healthcare activity

was led by a Standing Committee consisting of four leading experts: Raghu Dharmaraju, ARTPARK; Abhiroop Gandhi, Verily (Google Life Sciences); Anurag Mairal, Stanford University; Tavpritesh Sethi, IIIT-Delhi. Two roundtables under the area of AI in Healthcare were held in the month of December 2021.

I. The first roundtable titled ***AI and Pandemic Preparedness: Predictive Modelling and Pathogen Surveillance*** was held on 2nd December 2021

Panelists: Anurag Agrawal (CSIR Institute of Genomics and Integrative Biology), Manindra Agrawal (Indian Institute of Technology, Kanpur), Gagandeep Kang (Christian Medical College, Vellore), Syra Madad (NYC Health + Hospitals), Aditya Prakash (Georgia Tech), Ajitesh Srivastava (University of Southern California)

Moderators: Raghu Dharmaraju (ARTPARK) and Tavpritesh Sethi (IIT-Delhi)

AI tools and technologies are being widely used to inform clinical and public health decision making to manage the COVID-19 pandemic. The objective of the Roundtable was to understand how AI can enable the development of early warning systems, hotspot prediction, modelling and prediction of emerging pathogens & strains. The panelists provided different perspectives on the role and effectiveness of AI in pandemic preparedness, the need for team science bringing together biological scientists and AI experts, and the data challenges that will need to be addressed to leverage the potential of AI tools and technologies.

II. The roundtable titled ***AI and Pandemic Preparedness: Vaccines Discovery and Drug Repurposing*** was held on 7th December 2021

Panelists: Giridhara R. Babu (Public Health Foundation of India), Mahesh Bhalgat (Syngene International Ltd.), Shoibal Datta (Data Sciences Institute at Takeda), Monica Gandhi (University of California, San Francisco), Cecile Viboud (National Institutes of Health)

Moderators: Raghu Dharmaraju (ARTPARK) and Tavpritesh Sethi (IIIT-Delhi)

Keeping in mind that AI tools and technologies have being widely used to develop new diagnostics and treatments for COVID-19, and to inform clinical and public health decision making, the roundtable brought together infectious disease experts, physicians, and biotech/pharma leaders to understand the role of AI in accelerating vaccine discovery and development, modelling and prediction of emerging pathogens and strains, drug repurposing using big-data and machine learning, and the associated data challenges. The panel along with identifying possible opportunities for synergy between the two countries also helped identify possible barriers and challenges in adopting and implementing AI in these critical areas.

AI Workforce Summit

Bringing together representatives from academic institutions and industry to discuss capacity building and training, including development of new programs and skilling. The Summit is tentatively planned for September.

Solar Decathlon India (SDI)

The Indo-U.S. Science and Technology Forum (IUSSTF) in partnership with the ***Indian Institute for Human Settlements (IIHS)*** and the **Alliance for an Energy Efficient Economy (AEEE)** launched the **Solar Decathlon India (SDI)** initiative in 2020. SDI is a unique design challenge for undergraduate and postgraduate students from Indian colleges and universities to address Climate Change challenges by developing innovative, net-zero energy and climate resilient solutions for the building sector. SDI is helping develop the next generation of architects, engineers, and entrepreneurs who can deliver net-zero-energy buildings and help India surpass its 175 GW renewable energy commitment. SDI aligns with the Panchamrit agenda and the Atmanirbhar Bharat Abhiyaan campaign, supporting India's ambitious climate targets while also helping to accelerate progress toward the goals of the U.S.-India Strategic Clean Energy Partnership.

SDI requires student teams to work on building projects with real-estate partners and developers, and to collaborate with technology providers from the manufacturing industry. Projects include residential, commercial, educational buildings, on-site housing for construction workers, as well as disaster relief community shelters. SDI is an 8-month long program that includes training modules as well as exposure to cutting edge research and best practices from industry. Teams are judged by an eminent panel of experts on various aspects of their designs including energy and water performance, resilience, affordability, innovation, scalability and market potential, comfort and environmental quality, and design and operation.

The **2021-22 Challenge** was launched in July 2021, with Stage 1 running until December 2021 and Stage 2 ending with the Design Challenge Finals event to be held on May 7-8, 2022, which would include a large Internship Fair for the finalist students. In the 2021-22 challenge, 99 teams from a mix of 109 academic institutions registered from 42 different cities in India. These teams were made up of a total of 1264 faculty mentors, 76 real estate Project Partners and 60+ Industry Partners. The panel of experts selected 35 teams which comprised a total of 437 students as Finalists for the 2021-22 Design Challenge.

Section III: Innovation and Entrepreneurship

Innovation and Entrepreneurship

Innovation supported by a vibrant entrepreneurial ecosystem will be the key to success in this era of rapid technological evolution. IUSSTF's innovation and entrepreneurship engagements are S&T driven and have the capability and potential to benefit not only our two countries, but the world at large.

IUSSTF provides grant-in-aid funding support to start-ups under the **United States India Science and Technology Endowment Fund (USISTEF)**. This program enables bilateral teams from India and the United States to translate S&T driven innovations with a tangible societal impact into distinct market opportunities.

United States–India Science & Technology Endowment Fund (USISTEF)

The governments of the United States of America (through the Department of State) and India (through the Department of Science & Technology) established the **U.S. - India Science and Technology Endowment Fund (USISTEF)** for the promotion of joint activities that would lead to innovation and entrepreneurship through the application of science and technology.

Through a highly competitive process, USISTEF selects and supports financially promising joint U.S.-India entrepreneurial initiatives on co-developing products or technologies that are beyond the ideation stage, high on societal impact, and have significant potential to commercialize within 2-3 years. USISTEF has thus far supported 43 joint U.S.-India entrepreneurial projects through 10 regular calls and 11 COVID-19 Ignition Grants projects under a special call.

Highlights:

The **22nd Meeting** of the **U.S.-India Science and Technology Endowment Board** (USISTEB) was held on April 12, 2021 under the Co-Chairmanship of **Mr. John Speaks,** Minister Counselor for Energy, Environment, Science, and Technology, U.S. Embassy, New Delhi (Acting U.S. Co-Chair) and **Dr. Ujjwala Tirkey,** Scientist G, International Cooperation, Department of Science & Technology, Govt. of India (Acting Indian Co-Chair). Board members acknowledged the excellent track-record of the USISTEF program and congratulated the ED and the Secretariat for successfully implementing the COVID-19 call as well as overseeing the Strategy and Vision Committee deliberations. At the meeting, the Board decided to place the 11th Call on hold and, in its place, advised the Secretariat to launch an Ignition Grants Call with a focus on Climate and Sustainability.

New Call on Technology-based Energy Solutions: Innovations for Net Zero

Climate Change is one of the biggest challenges facing our world today, spurring the call for global collaborations to tackle this crisis. The launch of the U.S.-India Climate and Clean Energy Agenda 2030 partnership in April 2021 reiterated the commitment of both nations to work together to achieve their ambitious climate and clean energy targets and to strengthen bilateral collaborations. With this background, USISTEF in partnership with Social Alpha launched a call titled ***"Technology-based Energy Solutions: Innovations for Net Zero".*** The intent of the call was to select and support "technology showstoppers" - promising joint U.S.-India S&T based entrepreneurial initiatives that address the development and implementation of new technologies, tools, and systems to address climate and clean energy challenges in the following focus areas: Next generation Clean and Renewable Energy; Energy Storage; and, Carbon Sequestration.

The Program was formally launched on December 16, 2021 by the USISTEF Co-Chairs, Mr. Sanjeev Varshney, Adviser & Head, International Bilateral Cooperation, Department of Science & Technology, Government of India and Mr. John Speaks, Minister Counselor for Energy, Environment, Science and Technology (Acting), U.S. Embassy, New Delhi. A panel of experts discussed the critical role of

stakeholders, including Industry, Academia, Financial Institutions, Government Agencies, Policy and Foundations, in the development of an enabling ecosystem to address clean energy and sustainability challenges. Speakers included **Ms. Seema Paul,** Program Director, Sequoia Climate Fund, **Mr. Prashanth Prakash,** Founding Partner, Accel, **Dr. Praveer Sinha,** CEO, Tata Power and **Dr. William Tumas,** Associate Laboratory Director, National Renewable Energy Laboratory.

The Call for Proposals was opened on December 17, 2021 with an application submission deadline of March 15, 2022.

Regular Call: USISTEF

Under the aegis of the regular call of the USISTEF program, a summary of the progress of ongoing projects is presented below:

1. Blood Test for All Forms of Active Tuberculosis (TB) for Commercialization in India

Sarman Singh

All India Institute of Medical Sciences, Bhopal

Vivek Chandra

NextGen InVitro Diagnostics (P) Ltd, New Delhi

Imran Khan

University of California- Davis

The Problem

India ranks at the top among the tuberculosis (TB) endemic countries due to a lack of diagnostics available for pulmonary, extra-pulmonary and pediatric TB.

The Solution

This project proposes the development of a multiplex blood-based test (RU-1) for the detection of all forms of TB. The test is cost-effective and can be used on dried blood spots (ensures easy collection in remote areas); displays 91% - 96% specificity; is instrument agnostic and runs on multiple systems. It is suitable for high-burden settings and provides quick turnaround of results when patient loads are high.

Progress thus far

The main objectives of this project were to evaluate multiplex microbead based immunoassay (RU-1 test) on Pulmonary, Extra-Pulmonary, Pediatric tuberculosis and other control groups; and, to commercialize

TB Diagnosis Assay in India. The team has completed prototype and patient sampling, and, studies on Extra-pulmonary TB (EPTB) & Pediatric TB (PED-TB) are currently under progress.

The multiplex blood-based test (RU-1) has high throughput (upto 360 patients/day) and with automation, it can analyze thousands of samples per day. It is suitable for high-burden settings and provides quick turnaround of results when patient loads are high. These are major advancements over the current front line, WHO recommended, sputum smear (SS) AFB-microscopy test with low sensitivity (~50%) and throughput. One RU-1 kit will provide from 1-90 tests (for up to 90 patients). The scale-up of prototype blood test kits with Luminex Technology is complete and the team is also in the process of transferring the technology to Beckton Dickinson (BD). As part of the project activities, 1989 samples have been collected, of which 681 samples have been serologically analyzed. Evaluation of Luminex-based multiplex test (RU-1) is almost complete on Pulmonary TB. The results so far show about 85% sensitivity and specificity. The plan moving forward includes BD producing the tests in the U.S. and shipping them to India to be marketed by NGIVD, and/or Vanguard Diagnostics Pvt. Ltd. manufacturing the test in India to be marketed by NGIVD.

2. Low-cost Companion Diagnostic Test for predicting benefit of Adjuvant Chemotherapy in ER+ Breast Cancer

Vani Parmar
Tata Memorial Centre, Mumbai

Anant Madabhushi
Case Western Reserve University, Cleveland

Mark Lloyd
Inspirata, Inc., Tampa

The Problem

There has been a dramatic increase in breast cancer incidence over the last decade, which has led to an increased demand for predictive and prognostic companion diagnostic (CDx) assays to ascertain the aggressiveness of cancer phenotypes so that patients with less aggressive biology can be spared chemotherapy.

The Solution

Predictive CDx assays can aid in design of clinical trials, and help reduce healthcare costs by optimizing treatment regimens. This project proposes an accurate and low-cost prognostic test based solely on

digitized Hematoxylin and Eosin (H&E) tissue slides for identifying which Indian women with Estrogen Receptor positive (ER+) breast cancers will receive additional benefit from adjuvant chemotherapy. The tool Ibris is an "Image-based Risk Score" to predict the added benefit of adjuvant chemotherapy for early stage estrogen receptor positive (ER+) breast cancers. It is a completely tissue non-destructive test that only employs digital images of standard H&E tissue images of early stage ER+ breast cancer specimens. Ibris extracts image features from these images and employs them to predict risk of recurrence and benefit to therapy. IbRiS would have significant cost advantages over molecular-based tests ($50-75 vs. $4,000 per test).

Progress thus far

The team studies have indicated unique attributes in South Asian (India) populations as compared to North American (Caucasian American and African American) women. Consequently, Ibris is being continually refined and validated. These differences need to be coded in to create more accurate classifiers. This data would also help differentiate cancers better – in terms of types/kinds and sites of cancer. Subsequent to the support received from USISTEF, the team was also able to apply for additional funding:

- CWRU and TMC laid the foundation for a recent $3.3M R01 grant in oral cancers from NIH/NCI. It covers a new application of the Ibris technology for oral cavity squamous cell cancers.
- CWRU and TMC also led a multi-institutional U01 application. The grant proposes to optimize and validate an AI-enabled Digital Pathology Platform (ADAPT) for Multi-Cancer Diagnosis Prognosis and Prediction of Therapeutic Benefit. ADAPT will involve optimizing the previously developed image assays by the CWRU group in the context of SA breast cancer patients.

3. Low-cost, Anti-counterfeiting labels

Deepak Gupta

Indian Institute of Technology, Kanpur

Pranav Asthana

Transpacks Technologies Pvt. Ltd. Indian Institute of Technology, Kanpur

Sudhanshu Bahadur

University of California, Berkeley

The Problem

Counterfeiting is a serious threat to health, life and business in life-critical sectors such as pharmaceuticals, personal care, automobile sector, and agro-products. Current labels such as holograms and bar-codes can be replicated and affixed to duplicate products.

The Solution

This project proposes the development of low-cost, anti-counterfeiting labels that are tamper-proof, cannot be cloned and can be used to verify the authenticity of the product using a low-end smartphone, without requiring any form of communication. The technology is based on a proprietary three-dimensional tag (patent filed) that has random patterns (physically un-clonable function). Subsequently, highly complex image processing and math allow offline verification using a mobile phone. The technology combines materials science with digital and mobile technology to offer a product that enables a user to authenticate a product before buying. This is a novel, innovative technology, and one that makes an important societal impact in combating counterfeiting.

Progress thus far

The team have implemented a proprietary method that relies on a set of pre-printed patterns for uneven and cylindrical surfaces. They have developed digital-physical interface for anti-counterfeiting technology. The Indian team has begun printing next-generation tags on rotary printers (designed for 50 m/min printing). Production partners are already in operation in Hyderabad and Kanpur. Also the app named "Checko" is available for download on the Android Playstore and the latest version was released in 2021. The Beta release for iOS is available. Checko technology has been incorporated and successfully printed directly on laminate packaging. The India team has also established an office in Hyderabad with a staff of 15 people. The product has been commercialized and customers include JK Agri (repeat orders), MP Beej Nigam, Coats India, Indian Oil (under execution for 3 months, automatic labelling also supplied), and Delhi Excise. The U.S. team has begun launching the product worldwide - securing unsecure RFIDs with Avery Dennison; anti-counterfeiting solution for HP Indigo clients in SE Asia; excise stamps for liquor, cigarettes, other taxable goods in Malawi; currency printing options for Sudan Currency Printing Press, to name a few.

Patents

1. Anti-counterfeiting mark with 3D features- U.S. Patent Granted, US10885415B2, 5 January 2021
2. Anti-counterfeiting mark with 3D features - Indian Patent Appl. No. 201611015765, 5 May2016, Second Examination responded to on 3 September 2021
3. Anti-counterfeiting tag, system and method of manufacturing and authentication therefor, U.S. Patent Granted US11,075,769 B2, 27 July 2021
4. Anti-counterfeiting tag, system and method of manufacturing and authentication therefor, Indian Patent Granted, No. 360230, 4 March 2021

4. GaN-based High Power LNA for 5G Applications

Yogesh Singh Chauhan

Indian Institute of Technology, Kanpur

Amitava Das

Tagore Technology Inc., Arlington Heights

The Problem

5G small cell is a new development and there is no established solution. The current alternate solutions for 10W small cell is to use pin diode which consumes a large amount of current and requires high voltage.

The Solution

5G is a key technology for mobile communication, IoT and automotive applications. Its implementation will require deployment of a large number of small cells (hundreds of thousands) in countries like India or the United States. There are four components in the block - power amplifier (PA), low noise amplifier (LNA), a protection switch and a circulator. The goal of this project is to develop the LNA using both Gallium Nitride (GaN) and Gallium Arsenide (GaAs) technologies. Novelty in this approach is the use of GaN and GaAs technologies in a cost-effective way on a module. The aim is to develop low-cost 5G small-cell front end, so that it can be widely deployed in cities and small towns.

Progress thus far

GaAs LNA's have been designed and fabricated and production has begun. These were best-in-class LNAs with the lowest noise figure available in the market. For GaN LNA's, the die has been fabricated, and further development is currently under progress. The Indian team worked remotely on design, and the U.S. team worked on characterization and measurement. The team is presently working on both GaN on Silicon Carbide (more expensive) and GaN on Silicon.

5. MIRACLE Dialysis - Wearable Alternate Kidney

Gowrishankar Wuppuluru

IPadmaseetha Technologies Pvt. Ltd., Chennai

Beth Kolko

Shift Labs, Seattle

The Problem

Patients of renal failure are dependent on dialysis for survival – the process is cumbersome, time and money-consuming and not available everywhere.

The Solution

The project aims at developing a wearable, simple and safe, anytime/anywhere Peritoneal Dialysis Cycler (PDC). Use of Recyclable Membranes (a patent applied nanotechnology cum proprietary chemicals-based urea/creatinine clearance) is anticipated to cut costs down to INR 10,000 per month per patient. The project aims to reduce the cost by 5x, while reducing the timing from twelve hours to six/eight hours of fully automatic dialysis. The PDC is wearable, thus allowing patients to carry out their work without any intervention or worry. Advantages of the technology include reduced risk of infection, better patient management and preventive care through an online Patient Management System. The Mobile App controls lets patients manage dialysis on their own.

Progress thus far

The development of the OmniPD prototype is complete. User studies with patients, technicians and nephrologists is currently under progress. The design protocols for Human Trials are complete and the trials (with 20-30 patients) would begin in 2022. Fluid bags currently available in the market cost INR 300/- each and have to be changed thrice a day. The fluid bags developed by the team however need to be replaced only once a day. Other accomplishments of the team include:

- U.S. Patent Approved. Patent No: 16/091,971

- Indian team received a BIRAC Biotechnology Industry Partnership Programme Award for Rs. 88 lakh
- 4 Patents Filed in India

6. ArmAble: An Interactive Arm Training Rehabilitation Device

Habib Ali
BeAble Health Pvt Ltd., Hyderabad

Ramana Kumar Vinjamuri
University of Maryland, Baltimore

The Problem

As a result of stroke, many patients experience upper extremity motor deficit that immensely affects the quality of life, independence and employment of the individual. The current methods available for rehabilitation are both inadequate and expensive.

The Solution

There is a definite need for an intensive and engaging rehabilitation therapy for individuals with upper extremity motor deficit in both clinical and home settings. This can minimize the burden on therapists without compromising on the quality of therapy. The project proposes a low-cost rehabilitation device that allows for intensive, interactive and engaging therapy with a full range of motion with appropriate multi-sensory biofeedback, and tracking capabilities. The device would enable individuals with upper-limb impairment to perform game-based bilateral and unilateral rehabilitation for restoring motor function.

Progress thus far

The team has been granted one patent and two patent applications have been filed. The prototype has been tested on 10+ individuals with disabilities. The team proposes two versions of the device – a clinical version and a home-use version. The devices have been sold (INR 5 lakh each) between January and March 2022 to physiotherapy clinics and rehabilitation centers.

7. Lab-on-a-strip (LOS): Towards Multi-analyte Screen Printed Biosensor Strips

Vinay Kumar

PathShodh Healthcare Pvt. Ltd., Bengaluru

Erik Sventeckis

Conductive Technologies, York

The Problem

Point-of-care diagnostics for multiple diseases is extremely important, especially for resource challenged areas and existing solutions are expensive and limited.

The Solution

The team proposes developing a lab-on-a-strip (LOS) to enable chemical analysis for multiple tests, on a low-cost screen-printed electrode for Hemoglobin (Hb) and Serum Albumin test for Anemia and Malnutrition screening; Serum Albumin and Glycated Albumin test for Advanced Diabetic Nephropathy management; and, Microalbminuria and Urine Creatinine test for early screening of Chronic Kidney Disease. The price point of the proposed LOS would be 70% lesser than what pathologists are charging currently for similar tests.

Progress thus far

The design and optimization of the screen-printed electrode with two working electrodes, one reference electrode and a single counter electrode on the same test strip is complete. The selection, lamination and characterization of porous membranes at the electrode surface to hold the sensing chemistry has also been completed, in addition to the functionalization of sensing chemistry using the automated dispensing machine at the membrane laminated electrode. The handheld device does not need any calibration at home by the user. The only part of the product that has a limited shelf life (10-12 months) are the test strips.

8. Commercialization of Advanced Multi-layer Wound Dressing, for Accelerated Healing and Infection Prevention of Indian Diabetic Foot Patients

Vijay Viswanathan

MV Hospital for Diabetes and Prof M. Viswanathan Diabetes Research Centre, Chennai

Ashwinraj Karthikeyan

InMEDBio LLC, Neenah

The Problem

In developing countries where health resources are limited, advanced chronic wound care management is costly and most times inaccessible for many patients. Specifically for diabetic patients, there is a heavy reliance on simple gauzes as the current method of treatment for their chronic foot ulcers. This ineffective method only provides temporary relief of pain, leads to low patient compliance, and increases the risk of complications or long-term infection, frequently resulting in amputations.

The Solution

The project aims to develop a clinic-ready, safe, cost-effective and comprehensive wound-care dressing designed to prevent infection and accelerate the wound-healing process for diabetic foot ulcer patients. The core technology comprises of a biocompatible five-layer cloth. The patent-pending composite configurations absorb large amounts of fluid waste while maintaining porosity throughout. The product is cost-effective, safely absorbs large amounts of exudate, and maintains a moist and oxygenated environment for accelerated healing, while protecting the wound from external pathogens

Progress thus far

The testing of materials is complete and the team is working at M.V. Hospital for Diabetes & Diabetes Research Centre to optimize the biocompatibility of current prototype products for two product lines: one that targets low-grade ulcers (grade 1-2), and another for high-grade ulcers (grade 3-4) for diabetic foot ulcer patients. The commercialization strategy is to manufacture the layers in the U.S. and package and sell the product in India. The U.S. team has completed the creation of functional prototypes based on initial study results; worked with CMO's converter on manufacturability/best practices; and conducted cost analysis of traditional products vs. the Phoenix-Aid product. The Indian team has conducted interviews on the supply chain and a larger, more in-depth patient study is underway. The U.S. team is also in the process of filing two patents covering significant improvements to the base dressing. They

also shared patient study data (collected on existing wound dressings) with regard to caretakers and dressing changes. They found that 51.1% of patients felt the dressing material was costly and 56.7% were willing to pay more for faster healing.

9. TranscribeGlass: Affordable Heads-Up Real-time Captioning Device for the Deaf and Hard-of-Hearing

Madhav Lavakare

TinkerTech Labs Private Limited, New Delhi

Kyle Keane

Massachusetts Institute of Technology, Cambridge

The Problem

There are 63 million people in India who suffer from significant hearing loss. Globally, more than 6% of the world's population, or 460 million people suffer from hearing loss. The communication barrier between the Hard-of-Hearing (HoH)/Deaf and the hearing leads to the isolation of the Deaf community from mainstream society and higher unemployment and lower wages for the Deaf/HoH. Existing solutions such as hearing aids or cochlear implants cost 5-10x the average annual income of the Deaf. Other 'heads-down' solutions such as mobile/tablet captioning are inconvenient for Deaf/HoH individuals who depend on visual communication cues.

The Solution

TranscribeGlass is an affordable assistive smart-glass for the HoH and Deaf. It is a nonintrusive wearable heads-up display that captions conversations in real-time. It is a retrofit smart-glass solution that overlays the captioned speech into the user's field of vision enabling users to simultaneously absorb non-verbal communication cues as well as the actual captions.

Progress thus far

TranscribeGlass is currently in the prototype stage. It is a retrofit smart-glass solution that overlays the captioned speech into the user's field of vision, and users are therefore able to absorb non-verbal communication cues as well as the actual captions at the same time. The latest prototype has been developed at a cost of Rs. 2,500, nearly 1/40th the cost of smart glasses such as Google Glass and 1/10th to 1/100th the cost of hearing aids or cochlear implants. The Indian team was selected to be part of

the incubation program of Digital Impact Square (DISQ), TCS (Tata Consultancy Services) Foundation (Jan-Apr 2021); and, was shortlisted and pitched at TiECON Delhi NCR 2021 (Entrepreneurs in Assistive Solutions for Special Needs session).

10. Empowering Energy Frugal, Inexpensive Waste-Less Food Storage and Transport (for Seven Lakh Indian Villages)

Anurag Agarwal

New Leaf Dynamic Technologies Pvt. Ltd., New Delhi

Srinivas Garimella

Georgia Institute of Technology, Atlanta

The Problem

India currently produces about 360 million tons of horticulture produce but has cold storage facilities of less than 40 million tons. While the country as a whole loses food, individual farmers suffer and remain poor because they are forced to sell their perishables at low market prices at harvest times since the produce cannot be preserved.

The Solution

The team proposes to develop a safe, easy to install, and simple to use environmentally- friendly refrigeration system to provide cold chain/storage at very low running cost for individuals and small communities. New Leaf has developed GreenCHILL, an environmentally friendly refrigeration system powered by farm waste. This project will focus on improving the thermodynamic performance and low-cost manufacturability of the GreenCHILL system. These improvements will enable compact and highly efficient adsorption components, leading to reduction in the overall size of the system.

Progress thus far

The team has completed activities that includes investigations on high efficiency, high heat flux evaporator and condenser designs, and, investigating adsorption bed designs with miniaturized flow features on the U.S. side; and, looking at market access and market entry strategies, and ensuring that designs are viable for manufacturing, on the Indian side. A major innovation the team has come up with is the Adiabatic Cooling Tower concept that reduces the consumption of water at moderate ambients and so conserves both energy and water. In terms of the adsorbent coating procedure implemented at Georgia Tech, after

investigating different mixture compositions, the team identified CaCl2 for optimization. Regarding market access, 9 GreenCHILL systems have been installed at the BigBasket Distribution Center in Hoskote, Bengaluru. Currently, 50 units are in continuous operation and the system is priced at approximately INR 14 lakh. The Confederation of Indian Industry (CII) has conducted measurement and validation studies of the systems at two GreenCHILL sites. The report generated validates all the claims made by GreenCHILL in terms of efficiency, cost savings and emission reduction. The Indian team has also entered into an agreement with Samunnati Financial Intermediation & Services Private Limited for financing units to Farmer Producer Organizations (FPOs). The team has also received $800,000 from Dustin Aaron Moskovitz, one of the founders of "Meta". The PIs also commented upon the intangible benefits accrued – in terms of preparing the next generation of engineers. Students have had the opportunity as part of this project to visually see how their research is helping the end-user.

11. Co-Design, Evaluation and Technology Transfer of an Adjustable, Affordable and Transportable Pediatric Postural Support Wheelchair for India

Soikat Ghosh Moulic
Mobility India (MI), Bengaluru

Anand Mhatre
University of Pittsburgh

The Problem

According to the United Nations, around 4 million children in India have disabilities such as paralysis, cerebral palsy or quadriplegia that limit their daily life activities, community access, education and growth. Only 5-15% of these children receive a device. It is often an inappropriate substandard wooden or hospital-style wheelchair due to a lack of regulations and awareness of wheelchair standards and clinical benefits. These products lack postural supports and break down often causing restricted growth, postural deformities and skin injuries that are painful and can cause death which is close to 80% for children with disabilities under five.

The Solution

The team proposes to design and commercialize affordable wheelchairs, made in India, for children with cerebral palsy and similar conditions. With essential features like wheelchair adjustability, tilt-in-space and durability and affordability, the product volume can be scaled according to need. The core

technology is a mechanism that attaches the seat to the base with a quick-release system that enables rapid disassembly and folding for easy transport.

Progress thus far

The team has established a testing laboratory at Mobility India which is a state-of-art wheelchair testing facility for stability and fatigue testing, preliminary functionality and reliability testing. In terms of project progress, Participant Assistive Products are providing prototypes for wheelchair evaluations. As part of the first milestone activities, MI has also conducted several community awareness programs for Anganwadi teachers and Village Rehabilitation workers on Pediatric wheelchairs. ISO Product Testing has been completed with 50 and 60kg user weights. The team has established durability and high quality of the product frame. Ethical approval for the trials has also been secured. Field trials timeline, protocol and questionnaires for data collection have been developed. 15 Participants have been selected for field trials from the MI registry and the trials will commence once the Cub wheelchair samples have been received (timeline for trials August 2022-October 2022). The team has also made several revisions to the design based on feedback received such as making the seat cushion cover closure flap more moisture resistant, making the armrest position more secure, etc.

12. An Affordable, Non-Invasive Multiplexed Platform to Rapidly Detect High Risk Oncogenic HPV Strains in Self-Collected Samples (Point of Care, Field Deployable, Highly Multiplex, Genital/Urinary Samples)

Nikhil Phadke

GenePath Diagnostics India Pvt. Ltd., Pune

Steven Benner

Firebird Biomolecular Sciences, LLC, Alachua

The Problem

Cervical cancer is the second most common cancer among Indian women, the fourth most common cancer in women worldwide. Human papillomavirus (HPV) infection is associated with almost all cervical cancer cases. However, cervical cancer is readily preventable by early detection and treatment of precursor lesions. In India, screening coverage is very low (3.1%) due to several barriers.

The Solution

The team is working on a novel platform using self-collected samples (urine and/or vaginal swab) for human papillomavirus (HPV) detection. This would be a low-cost, field-operable (minimal training; point-of-care) platform that can detect pathogenic HPV strains. The project's specific deliverable will be an HPV diagnostic kit and platform consisting of a sample collection kit for preserving and concentrating DNA in self-collected genito-urinary samples, multiplexed loop-mediated isothermal amplification (LAMP) assay for HPV, and sealed detection cartridge compatible with Achira Labs instrument (ACIX 100) for detecting LAMP products.

Progress thus far

As part of the project activities, the Indian partner in partnership with NGOs (I-SHARE Foundation and Prayas Group) have conducted outreach, sample collection and intervention. HPV testing was done by GenePath using Digene/Qiagen HC2. All the samples are stored and can be used for test validation under ethical consent. 7645 samples have been processed till date. The initial samples were collected by healthcare professionals; however, newer samples were self-collected. The positivity rate reported was approximately 8.5% and all positives have been followed up with and treated.

Multiple sample-preparation chemistries were developed and evaluated - immobilized surface chemistries such as chaotrope-silica based chemistries were selected over absorption "diaper" gels. LAMP (Loop-Mediated Isothermal Amplification) assays were done with 14 strains - HPV16, HPV18, HPV31, HPV33, HPV35, HPV39, HPV45, HPV51, HPV52, HPV56, HPV58, HPV59, HPV66, and HPV68 along with internal control. HPV lamp reaction was demonstrated successfully in the microfluidic cartridge.

13. An Affordable Ambulatory 24-Channel Clinical Grade Robotic Video Electroencephalography (VEEG) Solution for the Diagnosis and Monitoring of Neurological & Mental Health Conditions

Raja Aditya Kadambi
Mocxa Health Private Limited,
Bengaluru

Simon Griffin
Lifelines Neuro Company, LLC,
Louisville

The Problem

Neurological conditions such as seizures and epilepsy afflict more than 2 crore people in India. There are 4 lakh new sufferers of epilepsy alone each year. These conditions can have a significant negative impact on the social and economic wellbeing of the sufferer and their family. Diagnosis is the most critical aspect of the treatment as 70% of epilepsies are either curable or manageable. The gold standard diagnostic procedure, Video Electroencephalography (VEEG), requires a patient to be admitted to a hospital facility and monitored continuously over 5-7 days. To make matters worse, the procedure may need to be repeated multiple times due to many reasons including technical glitches.

The Solution

The team proposes to develop and commercialize an affordable ambulatory 24-channel clinical grade robotic Video Electroencephalography (VEEG) solution for the diagnosis and monitoring of neurological conditions such as seizures, epilepsy, sleep and movement disorders affecting millions. The patent-pending solution automates most of the tasks that were previously performed manually by hospital staff.

Progress thus far

The team has already developed the idea into a prototype device that was successfully validated in the neurology department of a large hospital in South India. The team now intend to integrate it with the US partners' proprietary ambulatory EEG technology to create a high quality ambulatory VEEG system at a price that is cost-effective for hospitals and affordable for patients.

The team have completed the key objective in the design phase was that involved the design and development of the stand (the monitoring station that tracks the patient, monitors his/her video and EEG readings); tracker (wearable tracker which continuously communicates data regarding the patient orientation and location with the stand); 360EVS firmware (underlying code that ensures that the electronics between tracker, stand and smartphone are able to interact seamlessly); EEG application (user-controlled software which controls the reception, processing and output of the EEG data); EVS application (user-controlled software for the reception, processing and output of the video data captured by the smartphone camera); and, desktop application (application that generates the final PDF files as well as seizure event and video synchronization files). The team has also raised additional capital of INR 2.5 Crore from Social Alpha and C-CAMP LEAP (Launching Entrepreneurs for Affordable Products) Fund.

Patent

- Anonymization Of Audio-visual Medical Data; Patent Number -11217345; Document ID, US 11217345 B2; Date Published-2022-01-04

Special Call: COVID-19 Ignition Grants

In keeping with its mission and vision, USISTEF had announced a call for proposals under the category of COVID-19 Ignition Grants in April 2020. The intent was to support promising joint U.S.-India entrepreneurial initiatives that address the development and implementation of new technologies, tools, and systems to address COVID-19 related challenges, including monitoring, diagnosis, health and safety, public outreach, information, and communications.

Project Monitoring Committee (PMC) meetings were held via videoconference to review the progress of the COVID-19 Ignition projects on July 28, 2021 for Ignition Stage-I projects and on August 10, 2021 and August 30, 2021 for the Ignition Stage-II projects. An update on their progress is presented below:-

Ignition Stage-I Awardees

1. Development of Antisense Morpholino (PMO)-based Antiviral Therapy against Coronavirus

Surajit Sinha

Indian Association for the Cultivation of Science, Jadavpur

Yanjin Zhang

University of Maryland, College Park

Objectives

Morpholino testing against other viruses has demonstrated a high efficiency in inhibiting viral replication. The project aims to develop antisense morpholino oligomer-based therapies against SARS-CoV-2. The genomic RNA of SARS-CoV-2, specifically the conserved regions, will be targeted to inhibit the viral replication. Antisense morpholinos will be synthesized using solid support synthesis method and will be conjugated with a delivery vehicle called internal guanidnium cellular transporter (IGT) for the effective delivery of the oligomer.

Progress thus far

Based on the experimental design against the genomic RNA of SARS-CoV-2, the team has synthesized three PMOs (phosphorodiamidate morpholino oligonucleotides). The delivery vehicle IGT was synthesized and conjugated with these PMOs to get IGT-PMOs. At the same time, one GMO-PMO was synthesized. Additionally, two control PMOs were synthesized for comparison. The team has also secured two SARS-CoV-2 strains and propagated the virus in a BSL-3 facility. The testing of the PMOs against SARS-CoV-2 in cultured cells shows limited effect against the viral replication. Further modification of the delivery strategy of PMOs is being conducted.

2. Development and validation of a CRISPR-based rapid and affordable kit for early diagnosis of COVID-19

Vinay Saini
Patanjali Pharma Pvt. Ltd., Mumbai

Piyush K Jain
University of Florida, Gainesville

Objectives

The team proposes to develop a prototype to detect SARS-CoV-2 by combining the loop-mediated isothermal amplification with an engineered CRISPR/Cas12a technology to achieve detection of SARS-CoV-2 genomic RNA with high specificity and sensitivity. The overall goal of this collaboration is to provide an affordable and accurate diagnosis for COVID-19.

Progress thus far

After receiving CDCSO (Central Drugs Standard Control Organization) test license which is prerequisite to develop proposed tests as per Medical Device Rules-2017, data was generated after RT – LAMP (Reverse-transcription-Loop-mediated isothermal amplification) amplification and CRISPR reaction. Evaluation and validation was performed in different positive and negative samples at Thyrocare, Mumbai. The tests were compared with positive samples (ct or cycle threshold values) and negative samples. Rapid tests were evaluated and compared with Gold Standard (RT-PCR) to achieve higher sensitivity and specificity of the tests. Further experiments are currently under progress.

3. Development of a diagnostic test using Multiplex in Solution Protein Array (MISPA) for distinguishing COVID-19 infection from other viral infections

Sanjeeva Srivastava
Indian Institute of Technology-Bombay

Joshua Labaer
Arizona State University, Tempe

Objectives

Many types of serology assays have been developed for SARS-CoV-2. However, the one-antigen-one-patient-at-a-time approaches provide very limited information and are slow, time consuming, and low throughput. To this end, the team is working on a high-throughput multiplex in solution serological assay (MISPA) that allows measuring antibody responses against the entire proteome of SARS-CoV-2 for many patients in a single test.

Progress thus far

Patient plasma samples from the Kasturba Hospital of Infectious Diseases in India were collected from COVID-19 positive patients with varying degrees of severity (mild, moderate, severe) and stages of illness progression. Also, plasma samples were taken from patients who were COVID-19 negative yet exhibited similar symptoms such as fever and breathlessness. This allowed the team to be able to test the MISPA array with enough material. The U.S. team has optimized the construction of the viral-MISPA array and screening protocol. A 4-Antigen Panel Serological Assay has been optimized against two control and two SARS-CoV-2 antigen nucleocapsid and Spike RBD (receptor-binding domain). The team is working on expanded MISPA with human coronaviruses (hCoVs) and other viruses, having a cumulative total of 95 antigens.

4. Development and Screening of Drug or Zinc Nanoparticle conjugated Synthetic Nano-bodies ("Sybodies") to Neutralize SARS-CoV-2 virus that causes COVID-19

Suresh Poosala
OncoseekBio Pvt Ltd., Hyderabad

Avery August
College of Veterinary Medicine, Cornell University, Ithaca

Objectives

The team proposes to create a therapeutic by developing neutralizing novel antibodies (unique class of synthetic antigen-binding fragments) directed against the receptor-binding domain and other epitopes of the Spike protein of SARS-CoV-2, bind it to drug/Zn nanoparticle conjugates (ADCs), which would release the drug of choice at the site of action.

Progress thus far

Unlike the traditional methodology of purification of recombinant proteins from soluble and insoluble fractions, the team has employed an indigenously developed patented BacSec technology for the production of Synthetic Nanobodies. BacSec technology does not require bacterial cell lysis as the protein is directly secreted into the surrounding media. As an advantage, any toxins or unwanted biochemical components is completely avoided, thereby ensuring a clean starting material for the downstream processing. These novel potential therapeutic entities could also be delivered by nasal inhalation (nebulizer), as treatments and prophylactics, so that hospital visits can be prevented and it can easily be administered at home. The team is in the process of applying for a full patent after which they plan to publish the work in an international journal.

5. Ivermectin for Treatment of COVID-19

Sadhana Sathaye
Institute of Chemical Technology, Mumbai

Kamalesh K. Rao
Lifescient, Inc., San Francisco

Objectives

The team proposes an inhalable combination formulation of FDA approved medications - ivermectin and theophylline that can be delivered directly via a nebulizer to the lung epithelial cells of the COVID-19 patient both in the hospital and at home. Ivermectin, an antiparasiticide has shown significant antiviral activity against COVID-19 virus. Theophylline, a bronchodilator used to treat asthma is known to reduce inflammation and improve respiration.

Progress thus far

The team developed a range of formulations and tested a suspension formulation in vivo for pharamacokinetic (PK) and tolerability evaluation and *in vitro* for antiviral activity. They observed that the combination of formulation resulted in a lung concentration of ivermectin that is almost 100% greater than a formulation consisting of ivermectin alone with high lung-to-plasma ration; the formulation is well-tolerated in animals and is safe; and the formulation exhibited EC50 (half maximal effective concentration) that is more than three orders of magnitude as compared to what was earlier reported.

Ignition Stage-II Awardees

1. Reducing mortality due to COVID-19 with a simple, non-electric pressure ventilator

V Sashi Kumar
Phoenix Medical Systems, Chennai

Stephen John
Advanced Innovative Medical Technologies, LLC, Ann Arbor

Objectives

NeoVent delivers non-electric, visually intuitive, non-invasive positive pressure ventilation to support patients in respiratory distress. With these clinicians can support patient oxygenation and ventilation through independently controlling the upper level of pressure, lower level of pressure and cycles per minute. The patent-pending, award-winning technology is non-electric, non-invasive, easy to setup and operate and costs less than 1/10th the cost of conventional ventilators.

Progress thus far

The U.S. partner shared the design files and technical know-how necessary to build NeoVent with the Indian partner. Based on all this information, the Indian partner built a functional prototype of NeoVent. Reliability tests were conducted with this device, where it was was left running continuously for extended periods of time. Subsequently, the design was modified to improve the "look and feel" and manufacturability. To ensure adequate device performance, traces of the delivered pressures and videos of the device in operation were shared with the U.S. team. Throughout this process, feedback from clinicians in both India and the U.S. was sought, from which it became evident that clinicians wanted a complete suite of technologies for the non-invasive treatment of infants in respiratory distress. Based on this, the team worked to develop a complete package, as well as an instructional manual and video. Formal usability studies were completed with this set up with physicians and nurses in an Indian neonatal intensive care unit. This complete NeoVent set up was shipped to the U.S. where it was tested at their in-house lung simulator lab where acceptable performance was demonstrated in a variety of simulated lung conditions.

Patents

- Indian Application No. 202017045883 (NeoVent)
- U.S. provisional patent 63/181,990 (novel modifications to NeoVent for supporting larger patients)

2. Wearable sensor to monitor and track COVID-19 like signs and symptoms

Vaidy Narayanan
Bionic Yantra, Bengaluru

Arun Jayaraman
Northwestern University, Chicago

Objectives

Molecular testing (RT-PCR) is the current gold-standard for diagnosing COVID-19, but test availability and response time still do not meet the required demand. The team aims to investigate the use of soft-wearables to develop a rapid-screening tool for diagnosing COVID-19 infections. They will leverage on the availability of a new class of skin-mounted devices, which conform to the body and can non-invasively record high resolution data on temperature, cardiac, respiratory and physical activity. The physiological signals data will be used to train an algorithm for assessing the risk of an individual presenting symptoms suggestive of a COVID-19 infection.

Progress thus far

The team employed a novel body-conforming, soft, wearable sensor placed on the suprasternal notch to capture data on physical activity, cardio-respiratory function, and cough sounds. A pilot study was undertaken in the United States on a cohort of individuals who tested positive for COVID-19 and the team detected altered heart rate, respiration rate and heart rate variability, relative to a group of healthy individuals with no known exposure. Logistic regression classifiers were trained on individual and combined sets of physiological features (heartbeat and respiration dynamics, walking cadence, and

cough frequency spectrum) at discriminating COVID-positive participants from the healthy group. The results obtained suggest that a sensor-based snapshot paradigm may be a promising approach for non-invasive and repeatable testing to alert individuals that need further screening.

3. ENCEESPRAY – An electrostatic disinfection machine comprising of electrostatic sprayer and electro hypo generator – an ideal solution for surface disinfection against covid19

Abhijeet Gan
Rite Water Solutions (I) Pvt. Ltd., Nagpur

Pratap Pullammanappallil
University of Florida, Gainesville

Objectives

ENCEESPRAY is an Electrostatic Disinfection Machine comprising of electrostatic spraying unit and onsite disinfectant generator. Electrostatic disinfection is one of the most efficient and effective methods to apply the disinfectant and sanitizing agents to living and non-living surfaces. It offers a favourable approach to increase spray deposition to hidden areas with reduced usages of chemicals and natural resources. The project aims to test, validate and introduce various models of electrostatic disinfection machines.

Progress thus far

As part of the USISTEF project, the team has developed three air-assisted devices - a trolley model which was modified based on user feedback to a suitcase model that was compact and easy to carry, with a capacity of upto 5000 sq ft area coverage per refill (2x1L capacity). Version 3 was a vehicle mounted unit with a large compressor that can power four nozzles at a time. Functional prototypes for two pressure-based models - a backpack model and a cordless model (with a Lithium ion battery) are ready.

The technology for the evaluation of the efficacy of the spray disinfection machine for the removal of microbial contamination from different surfaces has been validated through an NABL (National Accreditation Board for Testing and Calibration Laboratories) accredited lab for Enceespray. The first few customers validating the technology include Pune Municipal Corporation, Hero Honda, IRCON (PSU), Smart Coat India Pvt. Ltd., and some Gram Panchayats. The technology can be expanded for use against other hospital-acquired infections (HAIs) that would help the device remain market-relevant even beyond COVID.

4. A Rapid Point-of-Care Fiber-optic Biosensor (P-FAB) Device for Early Detection of COVID-19 using Saliva

V.V. Raghavendra Sai
Indian Institute of Technology-Madras

Himanshu Bhatia
Ricovr Healthcare Inc., Princeton

Objectives

This collaborative research project is set to simplify and expedite COVID-19 testing while making the cost of such an activity attainable for a broader range of usage. The plasmonic fiberoptic absorbance biosensor (P-FAB) technology is a point-of-care (PoC) device with a unique disposable fiber optic cartridge technology to detect SARS-CoV-2 antigens and virus particles directly in saliva (with minimal sample pre-processing).

Progress thus far

Towards realization of the COVID-19 PoC device, significant progress has been made in the opto-electro-mechanical instrumentation for the U-bent fiberoptic sensor probe fabrication as well as the design and fabrication of the disposable probe cartridge and a suitable optical readout device. The team has successfully demonstrated a detection limit for COVID N Nucleoprotein down to 0.37 ng/m. The device has been tested on samples obtained from Indian Council of Medical Research (ICMR) and have shown detection down to 1:80 dilutions. Experimental evaluation of the probe fabrication scale-up as well as the device and probe cartridge designs are under progress.

Patents

1. Devices And Methods for Detection of Severe Acute Respiratory Syndrome Coronavirus 2 Application No: PCT/IN2021/05047

   Filed on: 17 May 2021

5. A Non-Invasive High Frequency Nasal Cannula Ventilation (vibratory Ventilation to address the COVID conditions)

Prasad Muddam
Heamac Healthcare Pvt. Ltd. (Indian Institute of Technology), Hyderabad

Morarji Peesay
MedStar Georgetown University Hospital, Washington DC

Objectives

The team's Innovation High-Frequency Nasal Cannula (HIFINC) is a vibratory, high frequency, non-invasive ventilation for COVID conditions. This device is affordable, portable, long-lasting and reusable. The team is repurposing this patent-pending technology to match the requirements of the COVID associated respiratory issues such as ARDS, Pneumonia etc. The device will contain variable volume and frequency adjustments addressing neonatal/paediatric and adult ventilation. As it is low-cost, non-invasive technology, it can be adapted to major resource constrained settings; the automated design modifications will enable even low skilled staff to operate with ease.

Progress this far

After developing the proofs-of-concept, multiple iterations were done - developed, tested, redesigned until one device was identified for neonatal/paediatric and adult needs. The team has been able to achieve high-frequency nasal cannula ventilation for variable lung volumes.

Patents

1. U.S. Patent Application for System and Method for Vibratory, High Frequency Ventilation of Neonates and Infants

   Application #20170087317

6. Development of Monoclonal antibody therapeutics for COVID-19

Maloy Ghosh

Zumutor Biologics Private Limited, Bengaluru

Shiladitya Sengupta

Brigham and Women's Hospital, Harvard Medical School, Cambridge

Objectives

The team aims to develop monoclonal antibody therapeutics against spike protein of the SARS-CoV-2 from unique and versatile human antibody libraries. The project proposes a combination of antibody library screening technology and in silico approach to identify and validate novel monoclonal therapeutic antibodies. Additionally, they aim to develop novel monoclonal antibodies to counter appearance of mutated viral strains using in silico approach.

Progress thus far

The team has completed phage panning of human antibody library with Spike protein of SARS-CoV-2. The panning ensured more than a million human antibody clones are transferred for subsequent rounds of screening. They also completed multiple rounds of Yeast surface display to enrich clones with higher affinity against the SARS-CoV-2 spike antigen. The team has carried out in silico analysis of crystal structure of the spike-ACE2 complex and identified 19 amino acids at the 4Å of the receptor ACE2. Multiple lead clones were identified based on analysis of single yeast cell lines.

Section IV: Research and Development

Research and Development

IUSSTF supports a broad portfolio of R&D programs in key strategic areas that are of mutual interest to both countries. The current portfolio includes flagship programs like the **Joint Clean Energy Research and Development Centre (JCERDC)** on **Smart Grid and Energy Storage; PACEsetter Fund** and the DST-Intel® **Real Time River Water and Air Quality Monitoring Initiative.**

Indo-U.S. Joint Clean Energy Research and Development Center (JCERDC)

The **Indo-U.S. Joint Clean Energy R&D Centre (JCERDC)** is a joint initiative of the Ministry of Science and Technology, Govt. of India and the U.S. Department of Energy. The aim of the program was to facilitate joint research and development on clean energy technologies that may be deployed rapidly with the greatest impact. The JCERDC is based on a public-private partnership model of funding and is a first-of-its-kind initiative.

Phase I of the program began in the year 2012 with IUSSTF as the implementing agency. It brought together more than 100 Indian and U.S. academic and industrial partners to work jointly in the space of clean energy research.

Under Phase II of the program, the consortium titled ***"UI-ASSIST: U.S.-India collAborative for smart diStribution System wIth Storage"*** led in India by Suresh C. Srivastava from the Indian Institute of Technology (IIT) Kanpur, and in the United States by Noel Schulz from Washington State University, Pullman, was selected and awarded in September 2017.

Objective: UIASSIST Project

The overall objective of this project is to evolve the future distribution grid that will allow the continuing increase of Distributed Energy Resources (DER) penetration towards a sustainable electricity system. The research proposed will lead to the fully conceptualized smart distribution grid that optimally utilizes energy storage and distributed generation supported by workforce development and policy recommendation. The developed solutions are being validated on six different unique lab test beds in India and five in the U.S. Also, the developed solutions are being deployed at ten different field demonstration pilot sites, five each in the U.S. and India.

UI-ASSIST: Institutional Engagement

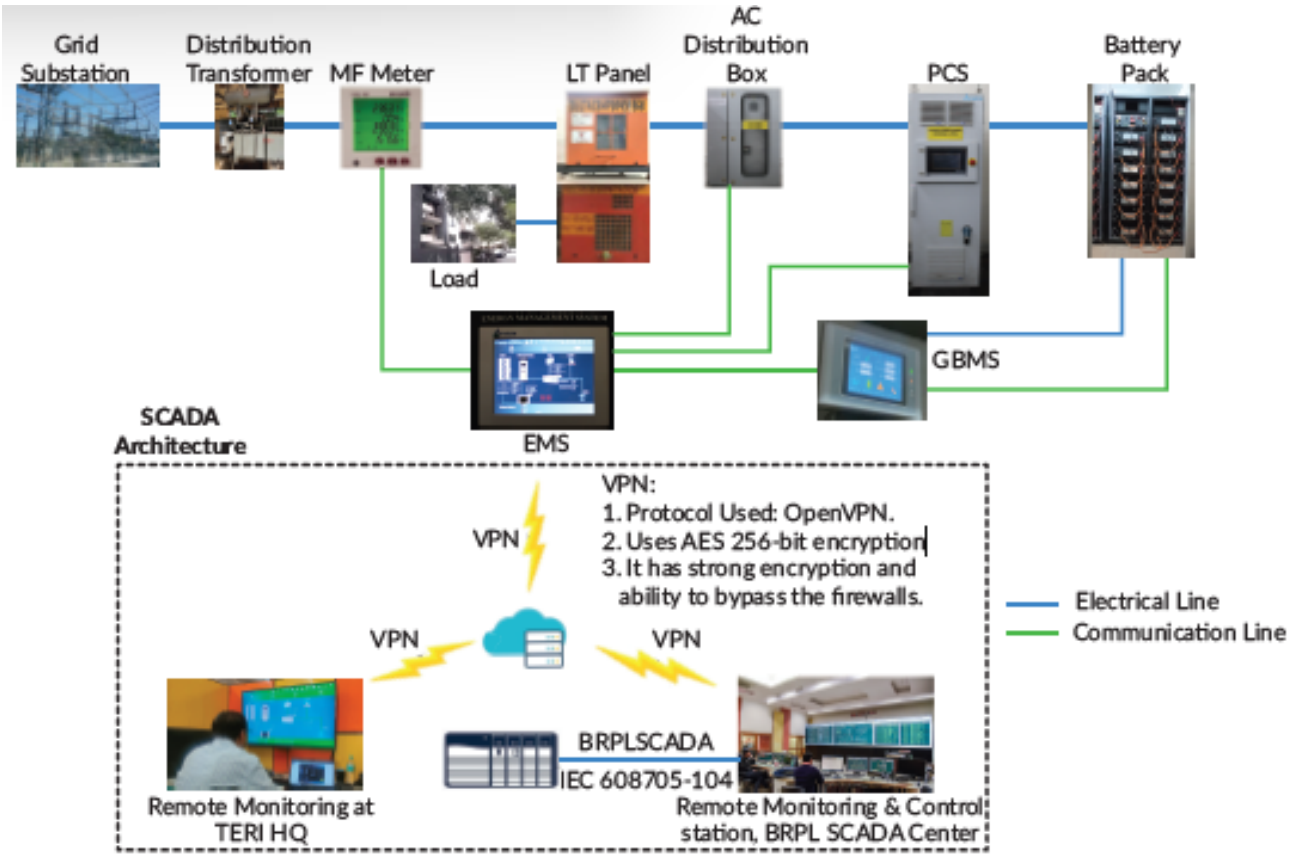
India	USA
• **Indian Institute of Technology Kanpur** • Indian Institute of Technology Delhi • Indian Institute of Technology Roorkee • Indian Institute of Technology Madras • Indian Institute of Technology Bhubaneswar • The Energy and Resources Institute (TERI), New Delhi • NTPC Energy Technology Research Alliance (NETRA), Greater NOIDA • Power Grid Corporation of India Limited (PGCIL), Gurgaon • UP Power Corporation Limited (UPPCL), Lucknow • BSES Rajdhani Power Ltd., New Delhi • Synergy Systems and Solutions, Gurgaon • Customized Energy Solution (CES), Pune • Panasonic India Pvt. Ltd., Gurgaon • GE Global R & D, Bengaluru • Shramik Bharti Foundation	• **Washington State University, Pullman, WA** • West Virginia University (WVU) • Massachusetts Institute of Technology, Cambridge, MA (MIT) • Texas A&M University, College Station, TX (TAMU) • Hawaii Natural Energy Institute, Honolulu, HI (HNEI) • National Renewable Energy Laboratory (NREL) • Lawrence Berkeley National Lab, Berkeley, CA (LBNL) • Snohomish County Public Utility District No 1., Everett, WA (SnoPUD) • Burns and McDonnell, Kansas City, MO (Burns & Mc) • ETAP, Operation technology, Inc., Irvine, CA (ETAP) • National Rural Electric Cooperative Association, Arlington, VA (NRECA) • AVISTA Utilities, Spokane, WA (AVISTA) • Venkata Consulting Solutions Inc. • GE Grid Solutions (GE) • Pacific Northwest National Laboratory (PNNL)

UI-ASSIST: Highlights

The UI-ASSIST project activities are divided into eleven theme areas 1) Finalizing Overall Project Management Architecture, 2) Distribution System Modelling and Benchmark System Development, 3) Energy Storage, 4) Microgrid and Active Distribution System, 5) Cyber Security, 6) DSO Functions/ Energy Management, 7) DSO- Market and Regulatory Issues, 8) Lab Testing and Validation, 9) Field Demonstration, 10) Impact Analysis and Policy Recommendations, and 11) Workforce Development.

The project is being managed through above 11 distinct themes, with interlinked activities. The research work related to all the themes is under advance stage and implementation of the pilot projects ongoing. Some highlights under the project are:

- **Benchmark Systems:** A field pilot /utility data driven, benchmark of semi-urban and rural benchmark is developed by IIT Kanpur, IIT Roorkee, IIT Madras, and WSU which is capable of simulating grid connected solar inverters. It will be implemented in IIT Kanpur lab-testbed for further testing and co-verification of field data. It is in addition to the modified CIGRE model developed for co-simulation and synthetic model being developed at WSU.



TERI Field Pilot-A for DT Overload Management with Energy Time Shift

- **Energy Storage:** TERI has developed the Battery Energy Storage System (BESS) sizing and control algorithm for all applications identified under the three pilot sites within the BRPL licensee area. Also, secondary applications have been identified under all three categories to maximize the utilization of BESS since primary applications may exist only for few days/months. During the remaining period, BESS may be utilized for other applications. TERI has also developed a non-linear autoregressive with exogenous inputs (NARX) model via an artificial neural network for short-term load forecasting. The results obtained from the proposed method will be used in the pilot site' EMS controller for defining the BESS' charging/discharging shave level on a day-ahead basis to minimize the transformer loss of-life. A parametric variation-based robust controller has been proposed and validated in real-time via Typhoon HIL emulator at IIT Kanpur in AC microgrids (MGs) for DC link voltage regulation of BESS to achieve voltage and frequency control of islanded MG. Peak shaving and energy management system using BESS is also developed. IIT Bhubaneswar has developed a BESS optimal charge/ discharge scheduling scheme to minimize both battery and grid net-energy utilization. Further, multi-cell configuration and behavioral analysis of multi-cell modules are also done.

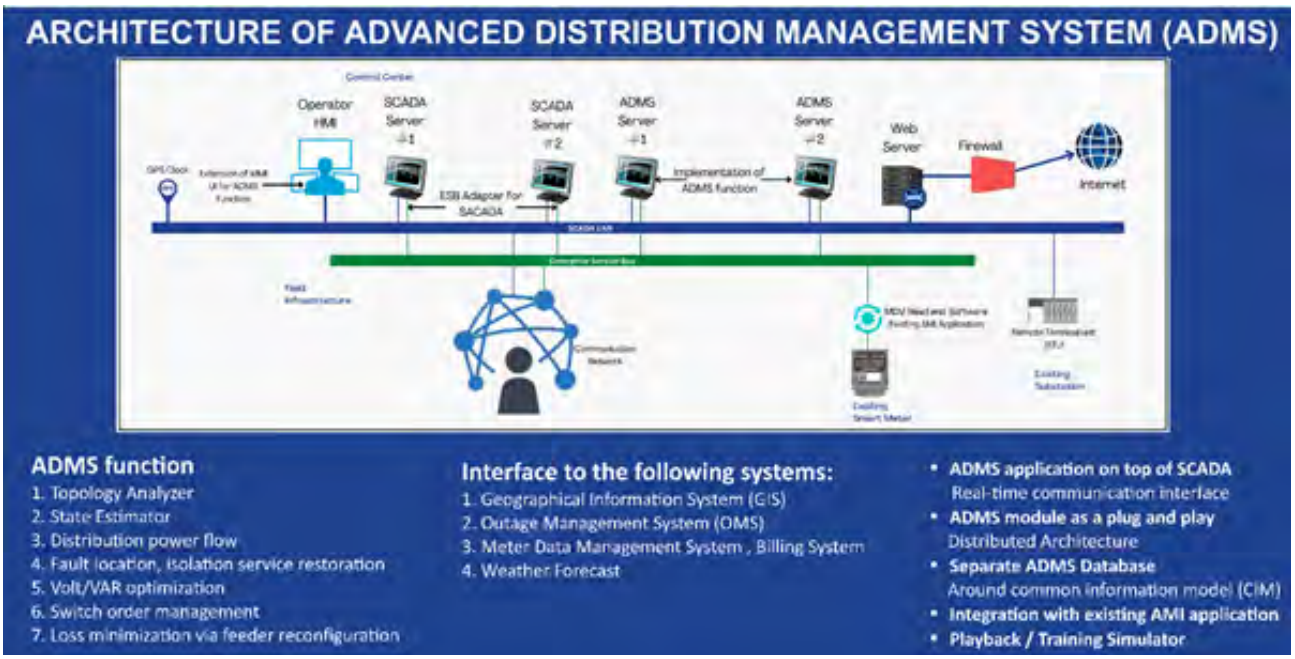
- **Microgrid and Active Distribution system:** The development of primary, secondary controllers for MGs and various protection mechanism for with energy storage systems have been studied. A novel islanding detection scheme for hybrid distributed generation is developed by IIT Kanpur. Impact of unintentional islanding on inverter-based resources enabled with reactive power allocation and frequency dependent active power curtailment services are studied by IIT Delhi. Power management schemes for DC MGs are also developed by IIT Delhi. IIT Bhubaneswar has developed a relaying

scheme, which can differentiate between fault conditions in grid connected and islanded modes of MGs.

- IIT Madras has proposed the enhanced-PLL (EPLL) structure, which integrates an inverter, emulating the behaviour of an alternator, to unbalanced grid. Also, as part of primary controller, an adaptive power management algorithm is developed for a multi-source DC MG system, which considers wide variations in weather conditions like zero wind velocity, zero solar irradiation, wind gust, and dynamic load changes at the dc bus. As part of primary controller, IIT Madras has developed a battery and supercapacitor combination to effectively achieve DC link voltage restoration in inverters for MGs.

- IIT Roorkee has developed a controller hardware in loop platform for testing cyber resilient operation of DC MG clusters considering global energy consensus. A compensation strategy using harmonic components of nonlinear load current, and harmonic components of voltage as the feedback variables has been developed at IITR for inverter rich DERs in weak grid environment. Secondary controller design for current sharing and low voltage regulation are developed by IIT Kanpur.

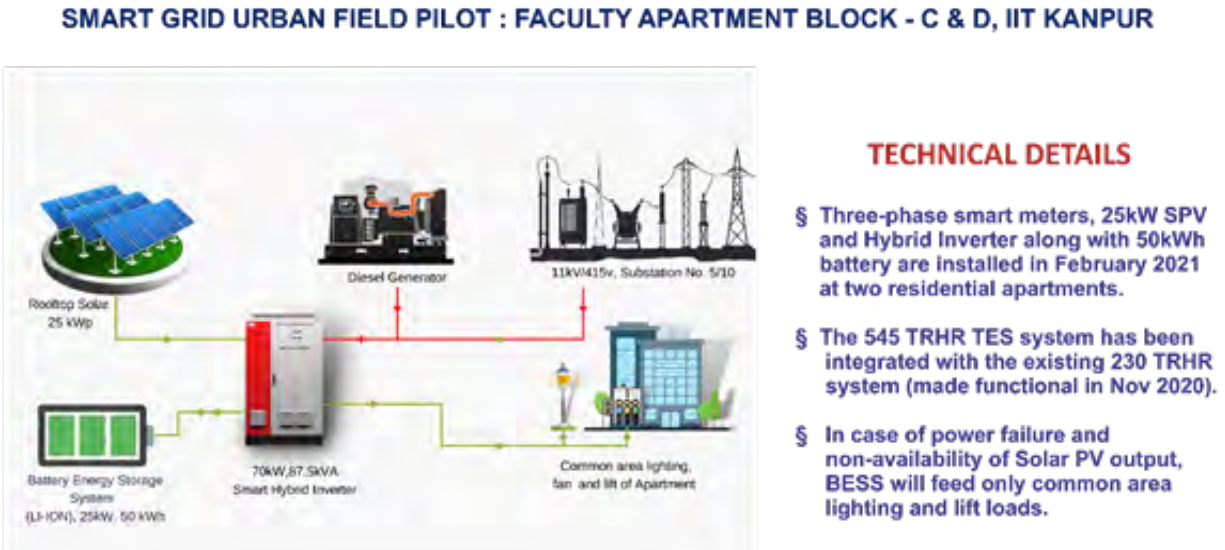
- **Cyber Infrastructure and Security:** Jamming impact in free space optical (FSO) link and effect of relay jamming in the decode-and-forward protocol based cooperative communication system is studied in detail at IIT Delhi. Ergodic capacity is studied for an FSO system in presence of a rational jammer. Thereafter, a non-cooperative game is used to improve the power performance by 74%. The effect of pulse jamming is studied for an aperture averaged FSO system. The effect of asynchronous jamming is also considered. The optical space shift keying (OSSK) is studied for mitigating the effect of jamming in a MISO-FSO system. Research work carried out at IIT Delhi has found out that the existence of an optimal power to be transferred by the central controller (CC) in a wireless powered sensor network (WPSN) that maximizes its probability of detecting false data injection (FDI) attack. Further IIT Delhi and IIT Kanpur have carried out study on GPS spoofing, anomaly detection, physical layer attack prevention. A feasibility study of communication technologies for MGs was performed by IIT Kanpur.



Architecture of ADMS being developed at IIT Kanpur

Smart Grid Rural Field Pilot at Kanpur

- **DSO Functions and Energy Management:** This theme deals with DSO function, optimal scheduling, and demand management system. New methods for State Estimation, Load Flow, Network Reconfiguration and Volt-Var Control are developed by IIT Kanpur and IIT Roorkee. Also, algorithms for Islanding detection, optimal operation of MG, RES and Storage in Distribution Networks are developed. Apart from this, a new inertia estimation technique is developed using PMU measurements. IIT Kanpur and IIT Roorkee have developed energy efficient management algorithm by merging load shifting and conservation voltage reduction techniques. The optimization framework aims to simultaneously minimize both true and conditional risk or conditional value at risk values of the expected energy cost under uncertain solar power generation, load demand, and upper grid energy price, using successive mixed integer linear programming. Also, a new real-time optimization framework for advanced energy-efficient management of active radial distribution networks is developed. IIT Delhi has developed a linearized optimal power flow framework for balanced active distribution system. Case studies are performed on radial and meshed distribution network. A new model is also developed for TSO-DSO interactions. Synergy Systems and Solutions



Smart Grid Urban Field Pilot at Kanpur

and IIT Kanpur are jointly working on the inhouse development of Active Distribution Management System (ADMS) platform, where the testing of a few developed algorithms is already done.

- **DSO Market and Regulatory Issues:** IIT Delhi, TERI and IIT Kanpur have carried out a state of art study and proposed four feasible alternatives of institutional framework considering the prevailing structure of the Indian power sector and relevant learning from the international practices for introducing DSOs in India, are proposed.
    - At IIT Delhi, the need for the local level electricity market, different models, local-level market design, and possible phase-wise implementation have been studied in the Indian context. A four-pillar-based local level market design is proposed.
    - TERI, IIT Delhi, and IIT Kanpur also reviewed the existing legal/regulatory provisions relevant to the promotion of DSOs in India and highlighted the opportunities in legal/regulatory systems to adapt to the emergence of DSO. The modifications/addition of provisions and functions that require new regulations concerning DSO functions are also examined.
    - I**IT Delhi, TERI, and IIT Kanpur are working on a joint white paper that covers a wide range of aspects related to the creation of DSOs in India.** It covers policy and regulatory elements, market design, technological issues, and institutional framework, thus catering to a large cross-section of stakeholders' knowledge and information needs.
    - TERI has carried out a state of art study and proposed a DSO model in India. At IIT Kanpur, study is performed about energy trading in decentralized market. At IIT Delhi, an energy market framework using TSO-DSO coordination is developed by utilizing the resources available in distribution system.
- **Lab Testing and Validation:** Development of all the test-beds are complete. All partnering IITs have tested their R & D results in these test-beds.
    - IIT Kanpur is working with TERI to develop a battery inverter which will be part of TERI's testbed. The prototype was demonstrated to TERI researcher in March 2021. The prototype is being fine-tuned to improve its connection to the testbed at TERI. The rural benchmark is being implemented at IIT Kanpur testbed. Test bed has been configured and key decision-making parameters are being monitored using NI cRIO and developed the program for Distribution transformer overload management system in LABVIEW.
    - IIT Roorkee has developed test-beds for investigation of various parameters affecting the stability of grid connected inverters. Also, DC MG coupled DFIG system has been developed.
- **Field Demonstration:** Progress on setting up three field pilots, under Theme-9 viz. rural pilot by IIT Kanpur and UPPCL/DVVNL, Semiurban and Urban pilots inside IIT Kanpur campus, are as following
    - Installation of Urban Pilot with Thermal Energy Storage System (TESS) in CESE building, and Solar PV with Hybrid Inverter and BESS in Faculty towers has been completed.
    - All the installation work in Semi-Urban pilot including EV charging station is completed.
    - Installation of Rural pilot and overall integration of all three pilots with DSO/ADMS installed at Smart Grid Control Centre is delayed and expected by end of May 2022.
    - TERI in association with partner utility (BRPL) are undertaking the installation of BESS at three

different locations (Cat- A, Cat-B and Cat-C) within the distribution licensee area of BRPL in NCT of Delhi. Under Cat-A, BESS has been installed at site adjacent to existing LT feeder panel. SAT has been conducted and site is undergoing SACDA integration to complete site handover. Under Cat-B, drawing layout has been approved to start the work at site and under category C, BESS has been installed and site is undergoing pre-testing (SAT) of the system. Parallelly, site is undergoing SCADA integration work for remote monitoring & controlling. NETRA is implementing semi-urban pilot inside their Greater-Noida campus in place of rural pilot originally planned at Rihand, UP, after getting due approval from DST and IUSSTF.

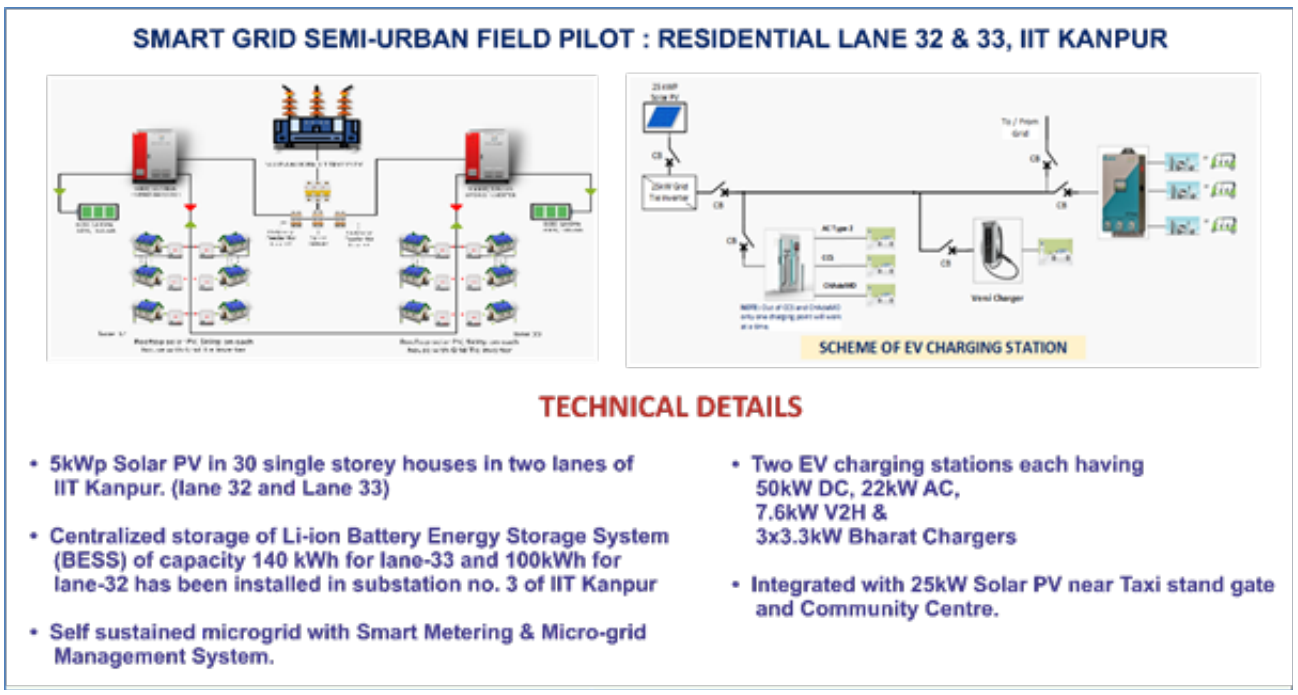
- **Impact Analysis and Policy Recommendation:**
    - The social survey and data analysis to assess the 'baseline' socio-economic conditions in the two village hamlets in Kanpur Nagar, selected for the rural pilot were carried out by IIT Kanpur along with a local NGO Shramik Bharati. Review of Policy and Regulations across the States of India covering Mini grid/Micro Grid, Smart Grid and DSM Policies was also conducted as a part of Social Issues and Policy Recommendations.
    - TERI examined the policy issues (in respect of theme 3, 4, 5, 6 & 7) based on discussion with thematic leads to get an update in regard to policy issues in particular theme. Policy issues, existing policy landscape key policy provisions, measures, initiatives, and provisions in the context of smart distribution system with storage in regard to themes 3,4,5,6 and 7 was analysed in detail by TERI.
- **Workforce Development:** Most of the planned conferences, workshops and meetings have been cancelled, postponed or moved online because of the Covid-19 pandemic.
    - Various webinars and meetings were conducted on Distribution System Operator (DSO) by TERI and IIT Delhi in the reporting year.
    - To improve collaboration, many student webinars and expert talks are being organized on monthly basis.
    - In March 2021, a two-day virtual student e-conference was conducted by IIT Kanpur, which was attended by all the students involved in the project in Indian Consortia.
    - Online webinar was conducted in Sept 2021 by TAMU and IIT BBS students on internship research work. In September 2021, a smart grid technology workshop was organised at IIT Kanpur.
    - In March 2022, a dissemination webinar was conducted in March 2022 for all the stakeholder and PMC members. Five days virtual workshop was conducted for India and US students during Feb-March 2022.

Outputs and Outcomes of the Project:

Applied Research (More Focus)			
1.	No of Ideas Developed (TRL 1-3)		2
2.	No of Prototypes Developed (TRL 4-5)		2
3.	No of Prototypes Validated (TRL 6-7)		1
Fundamental Research			
1.	No of Publications	International	237
		National	22
2.	No of Journals	International	237
		National	8
3.	No of Conferences	International	-
		National	14
4.	No of Patents filed	International	-
		National	4
5.	No of Research Fellows Trained	M. Techs	20
		Ph. Ds	48
		Others	150 research staff, 64 students, 90 professionals in training workshops, 35 ITI professionals
R&D Facilities			
1.	No of Research Facilities / Test beds Created		6
Societal Impact			
1.	No of locational Challenges Addressed		4
2.	No of People Benefitted		Approx. 3000

Project Review:

- The Fourth Project Monitoring Committee Meeting of the UIASSIST Project was conducted virtually. The Indian members of the consortium were asked to prepare presentations summarizing the work accomplished and corrections/actions taken based on the feedback shared as part of the Third PMC, as well as a short video that included footage of the deployment sites/lab experiments etc.
- The Department of Science and Technology, Government of India and the U.S. Department of Energy conducted a joint mid-term review of the UI-ASSIST project, virtually on 5th October 2021. The goal of the mid-term review was to critically assess the consortium's strategic vision and goals, scientific/technical accomplishments, unique aspects of the bi-national consortium model, and the overall impact of the project. A Joint Expert Panel (JEP) comprising leading experts from both countries was convened to evaluate the progress of the consortia and provide feedback on course corrections and next steps. The Lead PIs were asked to submit a joint review document and prepare a presentation. The meeting was organized by the Indo-U.S. Science and Technology Forum (IUSSTF), the Indian Secretariat for the project.



Smart Grid Semi-Urban Field Pilot at Kanpur

Indo-U.S. PACEsetter Fund

The Ministry of New and Renewable Energy (MNRE), Government of India and the U.S. Embassy support the PACEsetter Fund (PSF) that is an INR 50 crore (USD 7.9 million) fund jointly capitalized by the Governments of India and the United States of America. The Fund's main purpose is to improve the viability of off-grid renewable energy businesses that sell small scale (under 1 megawatt) clean energy systems to individuals and communities without access to grid-connected power or with limited/ intermittent access (less than 8 hours per day). The bi-national Indo-U.S. Science and Technology Forum (IUSSTF) is the administrator of this Fund. The following four projects have been supported under the PACEsetter Fund-Round II.

1. **Rural enterprise model for branded packaged diced and dehydrated vegetables and other dried products using hybrid biomass and solar energy led by M/s Centre for Technology & Development, Society for Economic and Social Studies (SESS), New Delhi**

The project aims to develop a self-sustaining commercial enterprise model for a variety of dehydrated vegetable and fruits based on Biomass driers and solar driers in combination, followed by vacuum packing. Under this project three dehydration unit using Solar and Biomass energy with a capacity to dry about 250 kg of sliced vegetables/batch for about 8 hours would be developed and installed at three satellite location in the state of Uttarakhand and one nodal center equipped with facility of vacuum packaging would be set-up.

2. **Solar dryer-based self-employment model for rural tribal communities, women, and differently abled persons led by The Energy & Resources Institute (TERI), New Delhi (Lead Partner) and M/s Society for Energy, Environment and Development (SEED), Hyderabad (Partnering Team).**

The project seeks to develop innovative solar energy-based hybrid drying technologies that will create sustainable self-employment opportunities for women and *Divyang* (differently-abled) individuals in tribal/rural communities. The team has proposed a community-based implementation approach where 5 solar dryer systems would be placed in one community/village to create a sustainable and cost-efficient business model for marketing dried products in urban markets.

3. **Intelligent solar charge controller for increasing energy output & life cycle batteries and revival of under-performing old SPV & their batteries led by M/s Customized Energy Solutions India Private Limited, Pune.**

The aim of the project is to develop an intelligent solar charge controller that includes an algorithm for understanding, initiating, controlling, and terminating issues with a lead acid battery in off grid solar plant. The new charge controller will be able to improve energy output by 20%-50% in operating off-grid solar plants and expect to revive around 70% of the non-functioning solar batteries, not more than 6-7 years old.

4. Development of Unglazed Transpired Solar Air Dryer (UTSAD) with thermal management system led by M/s Raghavendra Suntech Private Limited, Bengaluru

The goal of the project is to develop unique 1000 kg unglazed transpired solar air dryer with energy management system for dehydrating fruits and vegetables. This solar dryer is expected to be more cost efficient when compared to traditional freeze drying and vacuum drying technologies used in high-volume drying processes.

The four projects were evaluated by a standing Techno-Financial Expert Committee (TFEC) comprised of subject Experts, representatives from the MNRE, and the US Embassy, along with the IUSSTF team. In accordance with the project milestones, they were evaluated twice during the year. The first TFEC was held on June 30th, 2021, and the second on February 10th, 2022, respectively. All the projects have successfully completed their first milestone. However, "Development of Unglazed Transpired Solar Air Dryer (UTSAD) with thermal management system" was unable to demonstrate significant progress, and thus it was pre-closed. In addition to the mid-term TFEC reviews, a site visit was also carried out at the TERI site on October 22, 2021, to look at the products and the processes developed by the teams. Feedback from experts was provided to the teams to undertake some course corrections for the better execution of the projects.

TERI Field Pilot-A for DT Overload Management with Energy Time Shift

Research Initiative for Real-time River Water and Air Quality Monitoring (WAQM)

Recognizing the importance of developing online River Water and Air Quality Monitoring (WAQM) systems, the Department of Science and Technology (DST), Government of India and Intel® had collaborated to jointly initiate the **Research Initiative for Real-time River Water and Air Quality Monitoring.** The intent was to develop tools and constituent blocks than will enable end-to-end water and air quality monitoring systems on smart, networked, low cost, low power sensor nodes with large-scale cloud-based data analysis. The program is administered by the Indo-U.S. Science and Technology Forum. Under the WAQM call the following four projects were awarded in 2017.

WAQM Program: Awardees				
S. No.	Project Title	Lead Indian PI	Other Partner(s)	U.S. Partner(s)
Air Quality Monitoring				
1.	"Streaming Analytics over Temporal Variables from Air quality Monitoring (SATVAM)".	**Sachchida Nand Tripathi** Indian Institute of Technology Kanpur (IITK)	Indian Institute of Technology Bombay (IITB) Indian Institute of Science (IISc) Bangalore Respirer Living Sciences Pvt. Ltd., Mumbai	Duke University, Durham
2.	"High resolution air quality monitoring and air pollutant data analytics".	**Amrutur Bharadwaj** Indian Institute of Science (IISc), Bangalore	CSIR-Central Electronics Engineering Research Institute (CEERI), Pilani	University of Southern California

WAQM Program: Awardees				
S. No.	Project Title	Lead Indian PI	Other Partner(s)	U.S. Partner(s)
Water Quality Monitoring				
3.	"Design and Development of Aquatic Autonomous Observatory (Niracara Svayamsasita VedhShala - NSVS) for in situ Monitoring, Real Time Data Transmission and Web based Visualization".	**Bishakh Bhattacharya** Indian Institute of Technology Kanpur (IITK)	Kritsnam Technologies, Kanpur	Woods Hole Oceanographic Institution (WHOI)
4.	"Integrated low cost water sensors for real- time river water monitoring and decision-making".	**Arun Kumar** Indian Institute of Technology Delhi (IITD)	National Institute of Science and Technology (NIST), Berhampur National Environmental Engineering and Research Institute (NEERI) Nagpur Centre for Materials for Electronics Technology (CMET), Pune University of Hyderabad, Hyderabad Asiczen Technologies India Pvt. Ltd., Bhubaneswar SunMoksha Pvt. Ltd., Bangalore	University of California (UCR), Riverside Michigan State University (MSU), East Lansing Stanford University (SU), Palo Alto New Jersey Institute of Technology (NJIT) Newark

Year 2021 marked the completion of Phase I of the WAQM projects. A snapshot of the research accomplishments of the program is presented below:

- 25 SATVAM air quality monitoring devices have been deployed at Indian Institute of Technology Kanpur (IITK). These include indigenously developed sensor interface circuit boards, low-power data communication technologies, renewable-energy based autonomous power sources for the monitoring network, and real-time machine learning calibrations and spatial and temporal analytics

dashboards to create the SATVAM air quality monitoring devices. This low- powered sensor network is the first of its kind in India.

- The Indian Institute of Science (IISc) Bangalore team focused on developing the CO, NOx and SO2 sensors while the Central Electronics Engineering Research Institute (CEERI) team worked on Volatile Organic Compound (VOC) sensors and USC team on an Ozone sensor. IISc team deployed the calibrated sensor boxes in two different pollution monitoring sites of the Karnataka State Pollution Control Board (KSPCB), one in Hebbal and another in Jayanagar. The purpose of this field study was to understand the behavior of IISc's fabricated sensors, in comparison with the gold-standard instrument, under field conditions. The CEERI team designed, fabricated, packaged and lab-characterized three metal-oxide based sensors for VOCs: Benzene (C6H6), Toluene (C7H8), and Formaldehyde (HCHO). The USC team fabricated a 1.3 GHz Film Bulk Acoustic Resonators (FBARs) with quality factors (Q) of 220 – 3,000 and explored various techniques to deposit CCO (Chromium Copper Oxide) 5 which is sensitive to ozone.
- The NSVS system of the IIT K water project is now functional on the river Ganga at Bithoor. The system has the ability to measure important health parameters like Dissolved Oxygen, pH and conductivity continuously through the autonomous observatory. This information can be used to estimate Total Dissolved Solid (TDS), specific gravity and the presence of metallic ions in water. The system autonomously collects data every fifteen minutes and reports it through a wireless network to the Institute. The system has an open platform architecture allowing for other institutes developing sensors to integrate it with the IIT-K system in a collaborative mode.
- The Indian Institute of Technology Delhi (IITD) water project focused on providing solutions to issue of lack of field-adjusted low –cost and energy sufficient sensors for measuring water quality parameters [primarily Chemical Oxygen Demand (COD), microbial indicators, temperature, turbidity, nitrogen content and water resource-related parameters (primarily water flow rate, depth, etc.) which are important for water-related decision-making process. The project team achieved this goal by developing sensors and solar cells, standardizing method for pathogen detection and developing models for prediction purposes which can be used now in developing a buoy for getting real-time data from river water on water pollution.

WAQM Accomplishments: In Numbers	
Research Publications	• 28 Publications • 14 Conference Proceedings
Patents	• Two patents – Filed
Manpower Trained	• B.Tech/ Undergraduate students: 4 • M. Tech/M. Sc./M. Phil students: 8 • Doctoral students: 18 • Post-Docs: 4 • Others: 49 • Technical Manpower trained (employees/fellows deputed for training/participation in workshops etc.): 42

WAQM Accomplishments: In Numbers	
Beneficiary Institutions	**A. Public sector – 8 organizations** • Indian Institute of Technology (IIT) Delhi • Indian Institute of Technology (IIT) Kanpur • Indian Institute of Science (IISc) Bangalore • CSIR-Central Electronics Engineering Research Institute (CEERI), Pilani • National Institute of Science and Technology (NIST), Berhampur • National Environmental Engineering and Research Institute (NEERI) Nagpur • Centre for Materials for Electronics Technology (CMET), Pune • University of Hyderabad, Hyderabad **B. Private sector – 4 organizations** • Respirer Living Sciences Pvt. Ltd., Mumbai • Kritsnam Technologies, Kanpur • Asiczen Technologies India Pvt. Ltd., Bhubaneswar • SunMoksha Pvt. Ltd., Bangalore

Details about the four projects and their accomplishments are given below:

I. Streaming Analytics over Temporal Variables from Air quality Monitoring (SATVAM)

Lead Indian PI (Name & Institute): Sachchida Nand Tripathi, Indian Institute of Technology Kanpur

R&D Priority Area: Air Quality Monitoring

Background: Phase-I of the SATVAM project aimed to fundamentally redefine how air quality monitoring is done in India. At the time when the project started in 2017, India had under 200 continuous air quality monitoring stations across the country. All of the equipment used by the regulatory agencies that time was imported from the United States or Europe with the regulatory-grade $PM_{2.5}$ and PM_{10} BAM (Beta Attenuation Monitoring) monitors costing upwards of $15,000 per BAM and for all the notified gas pollutants analyzers at US $200,000 per monitoring site. There was a recognized need for continuous air quality monitoring in the 7000+ census cities and towns of India. By thoroughly analyzing low-cost air quality sensor devices and networks in difficult resource restricted conditions, the SATVAM team set out to develop India's first scientifically validated and calibrated air quality monitoring network for pollutant $PM_{2.5}$, PM_{10}, NOx, and O_3 pollutants. The SATVAM team brought together expertise on several research vectors indicated in the RFP that are required to design and execute a large-scale air quality network in India.

Project Objectives:

Sensing & Sense-Making:

- To Calibrate Low-cost $PM_{2.5}$, PM_{10}, O_3 and NO_2 sensors.
- To develop edge analytics for auto-calibration, feature/event-based classification

Energy-harvesting:

- To develop a stand-alone power system based on photovoltaic panel and battery back-up.
- To improve the efficiency of the photovoltaic energy harvesting systems through Fresnel lens-based concentrator and thermoelectric generators

Low-power networking & protocols:

- To develop ultra-low power long range communication.
- To establish standards-compliant multi-hop LP WAN network protocols.

Analytics on Edge & Cloud:

- To develop spatial & temporal predictive models using deep learning/ML models.
- To achieve distributed analytics on edge devices and Cloud using fast-data platforms and network health analytics

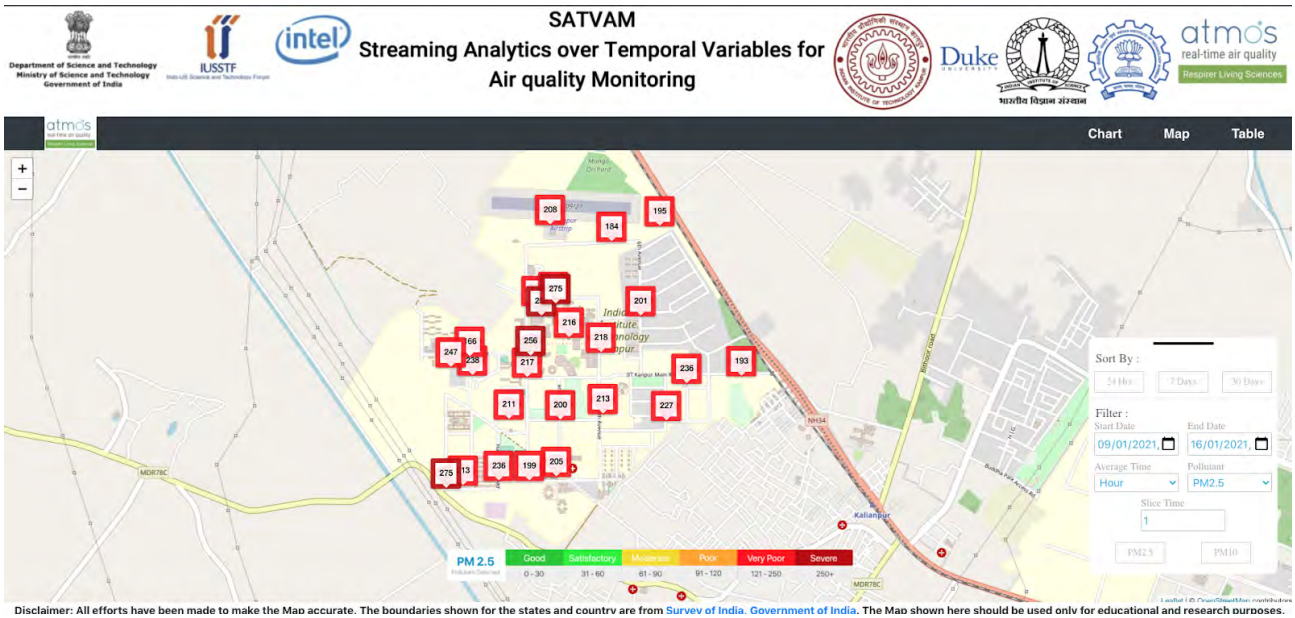
India-U.S. Collaborative Aspects: To understand the correction functions for the NO_2, O_3, $PM_{2.5}$, and PM_{10} sensors, the IIT Kanpur team collaborated with teams from IIT Bombay, IISc Bangalore, and Duke University in the United States. Data was collected using low-cost air quality monitoring sensors and analysed at IIT Kanpur in India as part of a collaborative project. The data from IIT Kanpur was shared with Duke University for further drift estimation in PM sensors. The Gaussian Process Regression (GPR) model, which was created by the U.S. team for dynamically calibrating wireless low-cost PM sensors in Delhi, was applied to data from IIT Kanpur over a five-month period. U.S. and Indian sides have collaborated to assess the performance of the sensors in the field.

Achievements: The ***SATVAM*** air quality monitoring devices were developed using indigenously developed sensor interface circuit boards, low-power data communication technologies, renewable-energy based autonomous power sources for the monitoring network, and real-time machine learning calibrations and spatial and temporal analytics dashboards. The team observed that with co-located calibration, the low-cost air quality ***SATVAM*** sensors "can measure $PM_{2.5}$ concentrations within ~10 % of ambient values". This study was amongst the very first papers published globally on this topic and is widely recognized as having established the global benchmark of $PM_{2.5}$ sensor data calibrations. The team also developed a new method for a Gaussian process based on the fly calibration. The PM_{10} concentrations from the un-calibrated ***SATVAM*** devices were evaluated in New Delhi and the correlation was found to be up to 0.8. The use of very low-powered wireless network solutions using peer-to-peer 6LoWPAN technology and energy harvesting powered IoT systems have been deployed in the real-world in India for the first time. The team has also conducted extensive calibration evaluation of NO_2 and O_3 ***SATVAM*** and built machine learning based models which have found R^2 coefficients of up to 0.9 for O_3 and up to 0.8 for NO_2 pollutants. Comprehensive field deployment preparedness has been accomplished by the team for building calibration models developed in one city and applied and utilised in a different city of India.

SATVAM Air Quality Monitoring Device

The Maharashtra Pollution Control Board (MPCB) commissioned a project to IIT Kanpur for rigorous field validation of PM2.5 and PM10 based monitors designed by four top Indian startups based on all of the work done in the ***SATVAM*** project. The project was completed in May 2021. The field study results in 15 separate locations in Mumbai were exceedingly encouraging, prompting the Maharashtra regulator to contemplate deploying this sensor technology in thousands of locations across the state.

The Steering Committee for the **National Clean Air Programme (NCAP)** was formed on May 20, 2021, by the Ministry of Environment, Forests, and Climate Change (MoEFCC). The PI of ***SATVAM*** has been appointed as expert member of NCAP steering committee, the central government's flagship Clean Air Initiative in India, since June 2019. The Chairman of the Central Pollution Control Board (CPCB) has requested the PI as a member of the NCAP expert group to outline the technological standards for city-scale sensor-based air quality monitoring networks. Based on the scientific studies and ***SATVAM*** project results presented to the committee, there is now widespread agreement among NCAP policymakers to apply this sensor-based technology in five more Indian cities.



Real-time air quality analytics from IIT Kanpur view on a live dashboard

The **National Health Systems Resource Centre (NHSRC)**, which is part of the Ministry of Health and Family Welfare (MoHFW), has commissioned IIT Kanpur, led by ***SATVAM's*** principal investigator and industry partner Respirer Living Sciences, to deploy a variant of ***SATVAM*** monitors to assess the health effects of changing air quality for **Pradhan Mantri Ujjwala Yojana (PMUY)** beneficiaries. Almost a hundred air quality monitors have been put in six Indian states, covering 12 areas with varied levels of PMUY beneficiaries, ranging from the highest to the lowest density. The monitors were installed for few months, and the data is currently being gathered and analysed.

II. High resolution air quality monitoring and air pollutant data analytics

Lead Indian PI (Name & Institute): Amrutur Bharadwaj, Indian Institute of Science, Bangalore

R&D Priority Area: Air Quality Monitoring

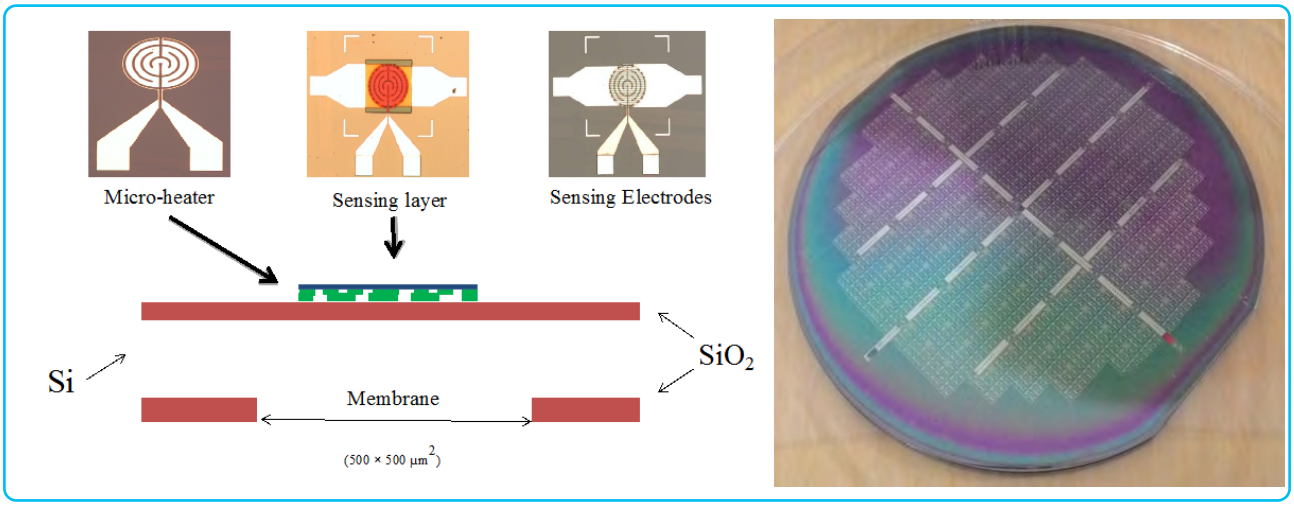
Background: The United Nations has created a blueprint for a greener and sustainable planet via the formulation of 17 Sustainable Development Goals, made up of 169 targets. Air pollution and air quality form a key part for many of these targets and goals. A key requirement to achieving good air quality is to be able to measure it at all the places people live and work. To achieve such a large scale of coverage for measurement, there is a need for low-cost sensor technology that will measure all the important pollutants. A related goal for India is to develop the capacity for designing and manufacturing such sensors locally, as part of the government's vision of a Self-Reliant India.

Project Objectives: The aim of the project was to design and fabricate low-cost sensors for common pollutants like CO, NOx, SO_2, Ozone and certain Volatile Organic Compounds (VOC), and do field testing of these to understand their quality and reliability.

India-U.S. Collaborative Aspects: The IISc team focused on developing the CO, NOx and SO_2 sensors, while the team from CEERI worked on the Volatile Organic Compound (VOC) sensors and the USC team on an Ozone sensor. Commercially available low-cost gas sensors are typically electrolyte based, with a drawback that they need frequent maintenance (replacement every few months) as the electrolyte degrades over time. In this project, the team explored an alternative technology based on Metal-Oxide Semiconductors – where specific metal-oxide semiconductors are deposited to create variable resistors. The metal-oxide material is carefully chosen to selectively adsorb specific pollutants, which in turn changes their resistivity. The resistivity change is related to the pollutant concentration and hence it provides a way to measure their concentration. The potential benefit of this approach is that these sensors can be fabricated using standard integrated circuits manufacturing processes and hence promise low-cost mass manufacturing. On the other hand, these sensors do show much more cross-sensitivity to other pollutants as well as a strong dependence on humidity and temperature. IISc and CEERI teams' sensors directly measured the resistance change via measuring the current generated by applying a fixed voltage across the resistors, while the USC team measured the change in resonant frequency via a novel miniaturized mechanical structure, which holds good promise for high sensitivity.

Achievements: Once fabricated and assembled, calibrating these sensors at different humidity levels becomes especially important. A regular humidity chamber provides a fixed humidity, but there is a practical challenge in maintaining this during the gas purge. Since the volume of most humidity chambers are large, having a fixed humidified gas concentration for sensor calibration is a major challenge. The IISc team developed a novel methodology for maintaining humidity at various levels using saturated salts. Over the course of this project, the IISc team has learnt to fabricate the CO Sensor and master the lab calibration methodology. The team has streamlined the fabrication process for metal-oxide sensors for

CO, CO2 and NO, and NO2 with yields for functional devices exceeding 60%. The team has also created a generic electronic interface to be able to integrate any Chemiresistive Sensors.



Design of the IISc and CEERI gas sensor (The silicon wafer is etched below the sensor to create a thin membrane on which a heating element as well as the sensor film (consisting of specific metal-oxides) are deposited. The sensor's sensitivity to pollutants is high only for specific temperatures – which is obtained by pulsing a current through the heating element. The membrane is thinned down to allow for efficient and quick heating. The photograph on the right shows an array of sensors that are fabricated on a single silicon wafer at IISc.

The silicon wafer is then diced to get individual chips which are wire bonded to a substrate and then mounted onto a small PCB with some other components inside a package. The package is then sealed with a sieve on top to allow the gas and pollutants to diffuse onto the sensor. The IISc team then assembles these sensors, along with the associated electronics onto a custom-designed printed circuit board and mounts them into a custom-designed box. The sensor in the box is then calibrated against specific gas concentrations in the laboratory.

After calibration, the IISc team deployed these boxes in two different pollution monitoring sites of the Karnataka State Pollution Control Board (KSPCB), one in Hebbal and the other in Jayanagar. The purpose of this field study was to understand the behaviour of IISc's fabricated sensors, in comparison with the gold-standard instrument, in field conditions.

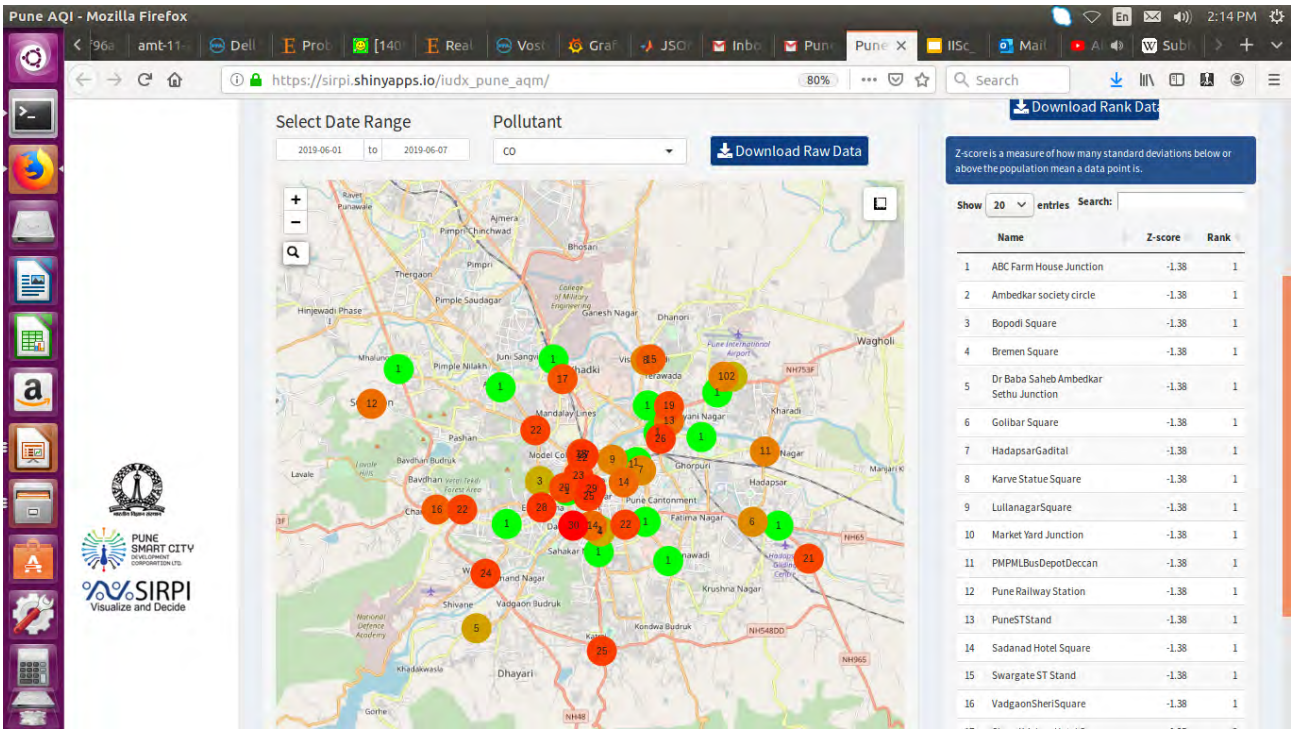
The IISc team experimented with various models. It found that due to high seasonality, AQM data should be handled using window lengths of 1 to 2 hours of data, for data collected every 1-15 minutes. The team also found that prediction models based on the modern LSTM (Long Short-Term Memory) and GRU (Gated Recurrent Units) based deep learning architectures significantly outperform those based on simple linear/polynomial regression and classify-and-regress approach. The accuracy of these models increases for average readings for longer duration, reaching to about 90% accuracy for 12 hourly predictions. Since the AQI (Air Quality index) is calculated using data across 4hr or 8hr windows, the approach of using raw data from such long blocks and then predicting the concentration values is quite appropriate for this application.

The CEERI team has designed, fabricated, packaged and lab-characterized three metal-oxide based sensors for VOCs: Benzene (C6H6), Toluene (C7H8), and Formaldehyde (HCHO). The CEERI team has

also developed a low-cost wearable sensor module (that they call social sensing node) which can be used for crowd sourcing of pollutant data.

The USC team has fabricated a 1.3 GHz Film Bulk Acoustic Resonators (FBARs) with quality factors (Q) of 220 – 3,000 and explored various techniques to deposit CCO (Chromium Copper Oxide) which is sensitive to ozone. The USC team has also assessed low-cost sensors, especially for black carbon aerosol measurements, by comparing to a high accuracy sensor for black carbon (i.e., single-particle soot photometer, SP2). They did this study in Los Angeles and compared it to data from a low-cost micro aethalometer.

IISc and USC teams have developed and deployed data streaming technologies. IISc team also conducted a hackathon in the city of Pune, with participants developing machine learning based algorithms to estimate pollution values in areas without pollution sensors. This is especially important to get complete spatial coverage for pollutant measurements, while using only fewer sensors deployed at a few carefully chosen locations.



The USC Team has explored how data from large-scale IoT applications such as air quality monitoring sensors deployed in cities can be integrated and provided to third parties in the form of online data marketplaces. The code for USC's I3 IoT data marketplace is made available as open source for the research community at: https://github.com/anrgusc/i3-core

III. Design and Development of Aquatic Autonomous Observatory (Niracara Svayamsasita VedhShala - NSVS) for in situ Monitoring, Real Time Data Transmission and Web based Visualization

Lead Indian PI (Name & Institute): Bishakh Bhattacharya, Indian Institute of Technology Kanpur

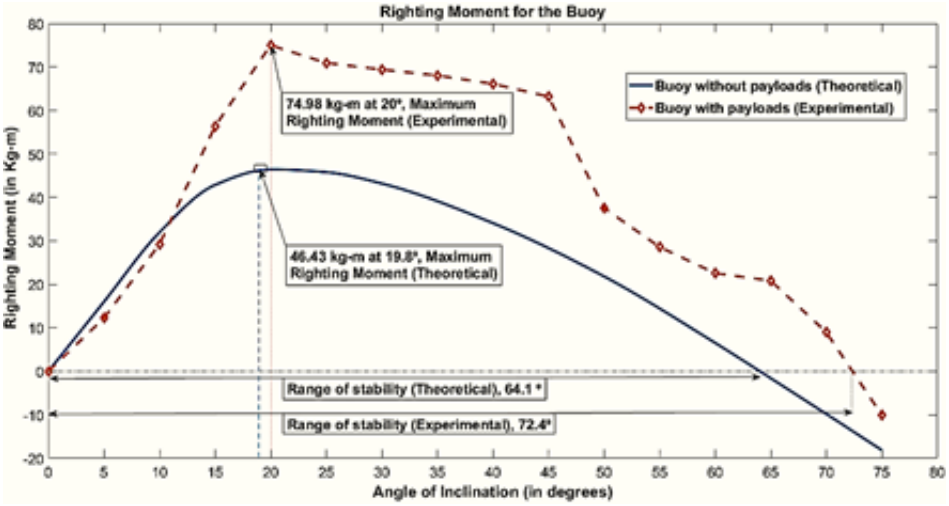
R&D Priority Area: Water quality monitoring

Background: Research initiative of real-time monitoring of river water was conceived keeping in mind the environmental impact of polluted bodies on the entire world. Of all ecosystem impacts, the quality of water is a serious concern as it not only provides water security to billions of people, but also supports marine species. In the Indian subcontinent, cleaning and rejuvenating the health of the River Ganga and other major rivers is the focal point of all river basin management plans for both government and non-government entities. Thus, for real-time monitoring of contaminant levels in the Ganges, an Autonomous Aquatic Observatory (AAO) was developed. A fully functional prototype developed in the project is shown in the figure below.

Autonomous Aquatic Observatory (AAO) with Solar panels deployed in River Ganga (Kanpur, India)

Project Objectives: One of the key components of the project was to develop a suite of low-cost and miniaturized *in-situ* water quality sensors and an auto-sampler for deployment on the proposed observing platform in river systems. The strengths of this system are that it can remain partially submerged in water continuously for long periods of time in a stable mode without human interference (range of stability shown in the figure below), which will aid in real-time monitoring of the rivers. The system is modular in nature; hence it can be assembled and dismantled at any place with ease. It can withstand forces that it will encounter at its deployment sites in rivers like Ganga as confirmed from the structural analysis. The system has been designed and analyzed to integrate energy harvesting systems to make it self-reliant in terms of power generation. The system provides robustness to the integrated sensors and components through self-cleaning arrangement.

The health monitoring sensors can make high-resolution measurements in real-world conditions underwater, including important water quality parameters of dissolved oxygen (DO; measure how 'breathable' water is for organisms), pH (measure of acidity), conductivity (measure of total ions concentration), total carbon dioxide (CO_2) (measure of a major greenhouse gas), and dissolved trace metals (toxic to human). The DO sensor is based on the fluorescence quenching method and is designed and engineered to be small in size (sensing part ~1 cm^3), low power, and deployable underwater.



Comparison between the restoring moment of the buoy without payloads and the buoy with payloads, with respect to different tilt angles.

India-U.S. Collaborative Aspects: The conductivity sensor is developed from a micro-mechanoelectrical system (MEMS) for *in-situ* measurements of conductivity, and the sensing part is printed on a ~3×3 cm2 circuit paper, which makes it compact and easy to integrate with other sensing components. pH sensor consists of a conventional glass type pH sensor but is engineered to cost only a fraction of commercial pH sensors. A newly developed in-situ sensing system, Channelized Optical System II (CHANOS II, shown in the figure below) by WHOI, will also be integrated into the sensing package for this project. It is designed for in-situ high-frequency measurements of total CO_2 and trace metals (e.g. copper) based on spectrophotometric principles.

(left) Sensor calibration and in-lab testing, (right) CHANOS II by WHOI, USA

Achievements: AAO, when deployed collects the water sample and analyses it for water quality and sends the data to the command centre in real-time without human interference. AAO energy requirements are fulfilled through solar panels of appropriate capacity, which provide enough energy to keep AAO running for 24x7. To improve the reliability of sensor measurements, team further upgraded the sample collection technique. This method is called vertical closed loop sample collection technique.

Low power communication technologies form the backbone of this real-time monitoring system. The ability of the system to provide accurate water quality measurements in real-time and with minimal or human assistance holds the key to making the approach scalable. The LoRaWAN protocol is considered for enabling the communication between the sensors and the cloud.

Due to AAO's large size and weight, it is difficult to transport it to the location where it has to be deployed. Hence, team has designed the AAO with a retractable wheel assembly. This assembly makes it convenient for deployment as when the buoy on land it will be easy to push or transfer to boat or vehicle and when deployed in water the legs can be easily retracted by releasing the pin at leg locks and lock it at retract position.

AAO real life deployment in Ganges River - Kanpur

Prof. Bishakh Bhattacharya and his team has successfully obtained an **Indian patent** on, "Apparatus and Method for Real -Time, In-Situ Monitoring of Water Quality by Pawandeep Singh Matharu, Bishakh Bhattacharya, July 2021". Eleven graduate and post-graduate students have also been trained on the inter-disciplinary aspects of this project.

IV. Integrated low cost water sensors for real- time river water monitoring and decision- making

Lead Indian PI (Name & Institute): Arun Kumar, Indian Institute of Technology Delhi

R&D Priority Area: Water quality monitoring

Background: This project focused on providing solutions to the issue of lack of field-adjusted low – cost and energy-sufficient sensors for measuring water quality parameters (primarily COD, microbial indicators, temperature, turbidity, nitrogen content) and water resource-related parameters (primarily water flow rate, elevation, depth, pH etc.) which are important for water-related decision-making processes. The Indo-US team aimed to achieve this goal using four interconnected work packages which focus on following research vectors: sensor development, energy harvesting system, wireless networking, and analytics.

Project Objectives:

- Develop sensors for chemical oxygen demand (COD), microbial indicators and water flow which can be used for determining water quality parameters as well as water flow characteristics in river; and
- Integrate commercial sensors for obtaining water quality parameters such as conductivity, pH etc. with above developed sensors using integrated Application -Specific Integrated Circuit (ASIC) chip.

India-U.S. Collaborative Aspects: Following institutes actively interacted in the duration of the project:

(a) IIT Delhi-MSU-UCR (for pathogen and COD sensor development)

(b) IIT Delhi-MSU (for pathogen monitoring)

(c) IIT Delhi-CMET (for including sensors in the Low-Temperature Co-fired Ceramic (LTCC) framework)

(d) IIT Delhi-Stanford (for EHS part)

(e) All institutes (for ASIC chip platform development)

(f) IIT Delhi-UoH-NIST (for sensor networking and handheld probe platform communication)

Achievements: The consortium developed following commercializeable components and patents in addition to peer-reviewed publications:

a) COD chip

b) On-chip PCR

c) Impedimetric cytosensor

d) Power conditioning unit

e) NiOX based novel carrier-selective silicon solar cells

f) High-efficiency (>30%) and low-cost silicon/transition metal dichalcogenide (TMD) tandem solar cell

g) Soft sensor model for predicting water quality parameters

The products developed in this project need field testing and validation of values with conventional values before they can be used in the field. In energy harvesting system, the power conditioning unit is ready to be used. The heterojunction solar cells and high-efficiency and low-cost silicon/transition metal dichalcogenide (TMD) tandem solar cells need upscaling in manufacturing and then field testing

is needed. The soft sensor model has been validated by the NIST and University of Hyderabad team and is ready to be used.

The developed products of this project can be used by city and State Water Boards and Pollution Control Boards, Ministry of Jal Shakti (India), USEPA, and Environmental companies. These products are currently not available in market and thus each of these products can be taken to TRL6 and upwards towards commercialization.

Section V: Visitations and Fellowships

Visitations and Fellowships

It has been unambiguously demonstrated that providing students and young scientists an exposure to cutting-edge scientific research experiences at a formative stage not only broadens their intellectual horizons but also leads to increased engagements in scientific and technological research careers.

IUSSTF collaborates with several Federal Agencies, Industry, Academic Institutions, Professional Bodies and Not-for-profit organizations to administer Visitation Programs, across various domains and stakeholder levels.

IUSSTF- Viterbi Program

An important aspect of engineering education in the 21st century is to provide the experience of international research to young scholars. This provides them an array of experiences, both academic and social, that helps them gain a global perspective and proves invaluable in their professional careers through a cross-cultural exposure.

To address the need for human resource development and capacity building in the field of computer sciences and electrical engineering, IUSSTF and the Viterbi School of Engineering at the University of Southern California partnered to support the ***IUSSTF-Viterbi Program*** - a dynamic student internship program that creates long-term, sustainable and vibrant linkages between the two nations. The program provides an opportunity for Indian students pursuing a Bachelors or Master's degree in Electrical and Electronics Engineering, Computer Engineering and Computational Sciences at a recognized institution of higher education and learning in India to undertake summer internship at the Viterbi School of Engineering.

A total of 15 students were selected for a virtual internship in 2021-22 due to travel restrictions owing to the COVID-19 pandemic.

S.No.	Name	Institution	Research Topic & Mentor
1	 **Abhishek Mukherjee**	Birla Institute of Technology and Science, Hyderabad	2-D Material based Photonic Emitters ***Mentor: Michelle Povinelli***
2	 **Anish Mondal**	Indian Institute of Technology, Kharagpur	Silicon Photonics ***Mentor: Hossein Hashemi***
3	 **Asha Nandi**	National Institute of Technology, Hamirpur	Smart Doorbell System for Face Recognition and Gesture Classification using different Body Landmarks ***Mentor: Laurent Itti***

S.No.	Name	Institution	Research Topic & Mentor
4	 **Gaurav Gupta**	Indian Institute of Technology, Bhubaneshwar	Transactional Memory and Concurrent Programming ***Mentor: Srivatsan Ravi***
5	 **Ishika Bhattacharya**	Birla Institute of Technology and Science, Hyderabad	Hardware Accelerators for Spiking Neural Networks (SNNs) leveraging Sparsity in Weights and Inputs ***Mentor: Peter Beerel***
6	 **Madhav Agarwal**	National Institute of Technology, Tiruchirapalli	Optimising Personalized Pagerank ***Mentor: Viktor Prasanna***
7	 **Pooja Ganesh**	SRM University, Kanchipuram	Illegal Wildlife Trafficking Analysis ***Mentor: Bistra Dulcina***
8	 **Pruthvi Trinadh Gudivada**	Indian Institute of Technology, Bhubaneshwar	Pain Responsive Synthetic Neuron ***Mentor: Alice Parker***
9	 **Sagnik Mukherjee**	Indian Institute of Technology, Kanpur	Natural Language Processing – Entity robustness of Question Answering Models ***Mentor: Xiang Ren***

S.No.	Name	Institution	Research Topic & Mentor
10	 **Sai Sumedh Ravindra Hindupur**	Indian Institute of Technology, Mumbai	Software simulation of NeuRoBot network- a spiking neural network which performs learning without forgetting ***Mentor: Alice Parker***
11	 **Sakib Malik**	Indian Institute of Technology, Kanpur	Type Inference for Python ***Mentor: Mukund Raghothaman***
12	 **Satyaki Ghosh**	Indian Institute of Technology, Guwahati	Improved Higher Order Bias-correction for Brain-Age estimation using Magnetic Resonance Imaging and Gaussian Process Regression ***Mentor: Andrei Irimia***
13	 **Shaunak Ashish Halbe**	College of Engineering, Pune	Invariance in Machine Learning ***Mentor: Meisam Razaviyayn***
14	 **Siba Smarak Panigrahi**	Indian Institute of Technology, Kharagpur	Explanation Based Learning in Language Models ***Mentor: Xiang Ren***
15	 **Sumanth Varambally**	Indian Institute of Technology, Delhi	Influence of Planning Complexity on Multi-Agent Path Finding performance in Warehouses ***Mentor: Sven Koenig***

Feedback received from the Interns suggest that they found the virtual experience quite fulfilling. The well-structured work plans along with support from doctoral students at USC helped the interns mitigate remote working challenges.

American Society for Microbiology (ASM) - IUSSTF Professorships in Microbiology

Under an arrangement between IUSSTF and the American Society for Microbiology (ASM), the Indo-U.S. Professorship Awards in Microbiology were instituted in 2003 with the aim to foster scientific cooperation, education, training and capacity building at individual and institutional levels through an exchange program. In January 2020, the ASM-IUSSTF Review Committee awarded grants to five candidates, however, due to the COVID-19 pandemic, the selected candidates could not commence their professorships award in 2020. Eventually during 2021-22, the following four (out of the five) awardees completed their Professorships either virtually or in-person:

S. No.	Name	Parent Institution	Host Institution	Research Topic & Host
1	 **Pratik Jagtap**	University of Minnesota, Twin Cities	CSIR - Institute of Microbial Technology, Chandigarh	Bioinformatics analysis of functions expressed by microbiomes ***Host: Manoj Kumar***
2	 **Abani Pradhan**	University of Maryland, College Park	Nitte University, Bangalore	Microbiological risk assessment ***Host: Iddya Karunasagar***
3	 **Abhishek Sharma**	Amity University, Noida	Michigan State University, east Lansing	Fabrication of gold nanoparticles-oligonucleotide conjugate based nanosensor for early and accurate detection of Fusarium oxysporum f. sp. cubense tropical race 4 (Foc TR4) ***Host: Brad Day***

S. No.	Name	Parent Institution	Host Institution	Research Topic & Host
4	 **Mirza Baig**	Indian Institute of Technology, Indore	University of California, San Francisco	Identification of the novel TIRAP-mediated inflammatory mechanism during Streptococcus (pneumococcus) infection ***Host: Mallar Bhattacharya***

An online workshop on **"Analysis of Functions Expressed by Microbiomes"** was organized from November 15 to 24, 2021 by **Pratik Jagtap,** Research Assistant Professor at the University of Minnesota in collaboration with CSIR-IMTech Chandigarh (Indian Host Institution) and Galaxy-P team, Minneapolis under the ***ASM-IUSSTF Indo-U.S. Professorship in Microbiology*** program. The workshop offered open access to talks by microbiome experts. Eight scientists from across the world presented talks on introduction to microbiome research, microbiome research in India, antimicrobial resistance, metatranscriptomics research, viromics, ocean metaproteomics, translational metaproteomics and predictive metagenomics.

NITTE (Deemed to be University; DU) and the University of Maryland jointly delivered an ASM-IUSSTF virtual course on **"Microbiological Risk Assessment in Food Safety".** An ***ASM - IUSSTF Professorship*** was awarded to **Abani Pradhan,** Director, Graduate Program in Nutrition and Food Science, University of Maryland to deliver this course in collaboration with **Iddya Karunasagar**, Advisor (Research and Patents), NITTE (DU) and **Indrani Karunasagar,** Director, DST Technology Enabling Center, NITTE (DU). Food is a highly traded commodity internationally and as per the World Trade Organization (WTO) Sanitary and Phytosanitary (SPS) Agreement, food safety standards should be based on risk assessment carried out according to protocols established by the Joint FAO/WHO Codex Alimentarius Commission. Food safety risk assessment involves use of various statistical tools to obtain probabilistic assessment of the risk and to assess the impact of risk management measures. The ASM-IUSSTF sponsored course consisted of lectures on risk assessment models, Monte Carlo simulations and development of risk estimates. This course was important for faculty and students in the area of food technology, microbiology, public health and food safety. The course attracted 324 registered participants that included faculty and students from NITTE (DU), Pondicherry University, Indian Agricultural Research Institute, Indian Council of Agricultural Research, State Fisheries Universities in Tamil Nadu and Kerala, National Aquatic Resources Research and Development Agency (NARA) Sri Lanka, Food Safety and Standards Authority of India and a number of other academic institutions in India.

Section VI: Money Matters

Money Matters

IUSSTF receives funding from three broad channels:

- Direct support from the U.S. government
- Direct support from the Indian Government
- Extra Mural Programs (EMPs)

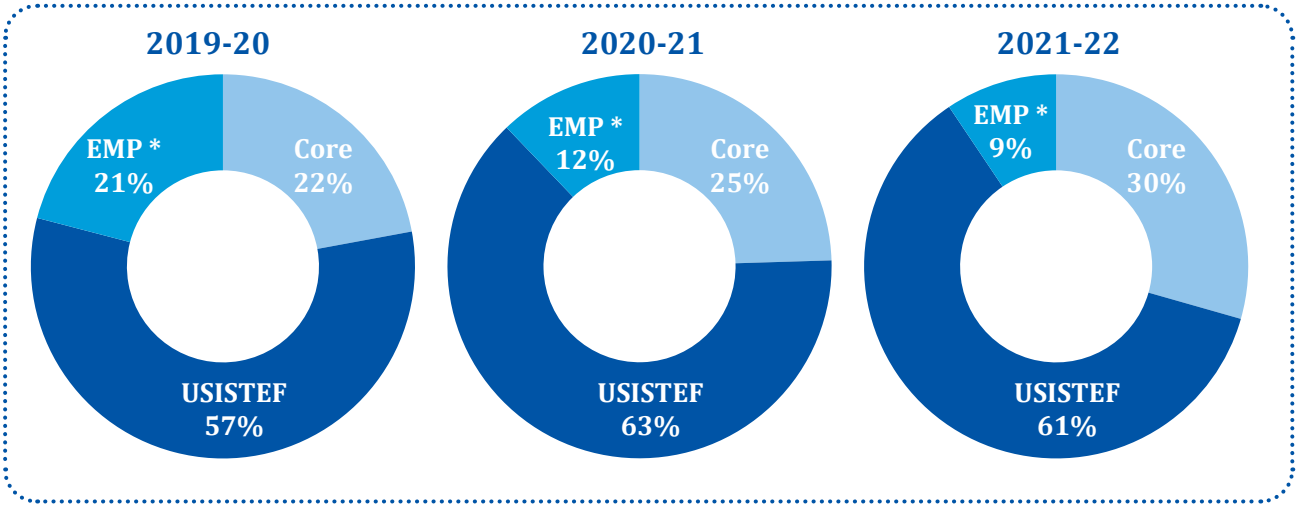
The support from the U.S. Government comes by way of annual interest on two separate Endowments (IUSSTF and USISTEF), to which the Indian Government provides matching grants annually.

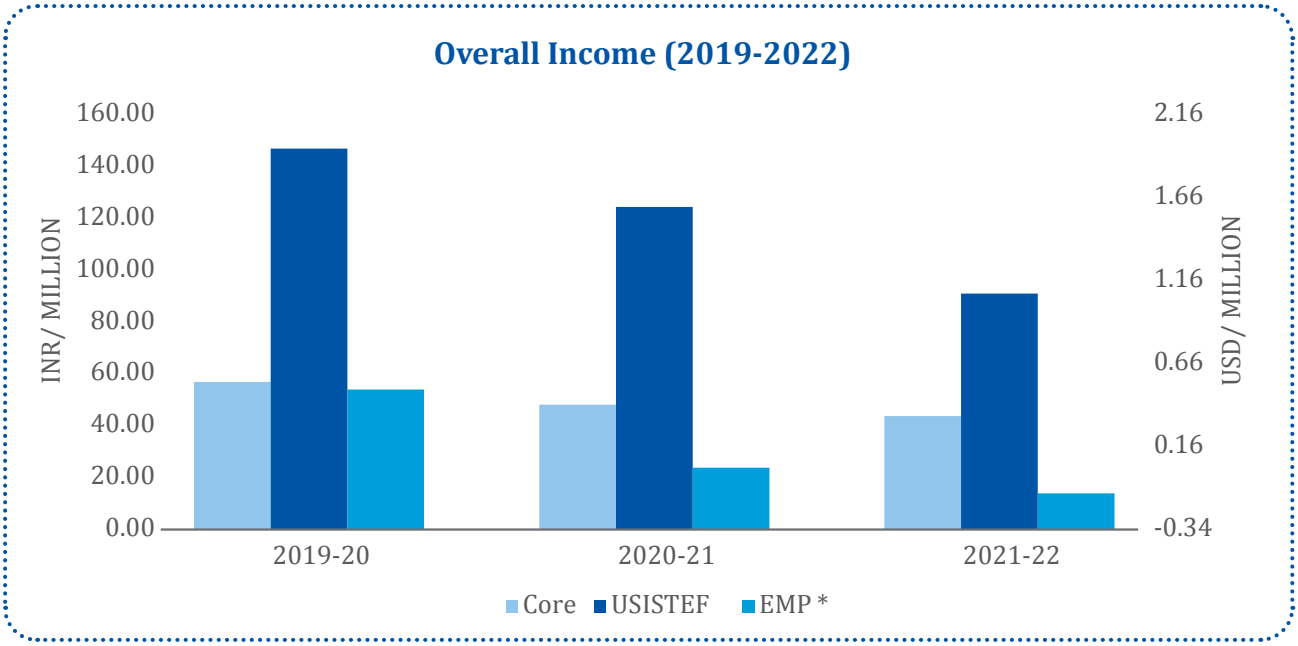
Support for the EMPs is received from various federal agencies such as DST, DBT, MNRE, SERB and Industry. Such support is provided in project mode for the implementation of specific program(s), against a nominal Manpower cost and overheads.

(A) Overall Income

S.No	Head	2019-20		2020-21		2021-22	
		(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)
1	Core	57.05	0.77	48.22	0.65	43.84	0.59
2	USISTEF	147.10	1.99	124.54	1.68	91.20	1.23
3	EMP *	54.07	0.73	23.93	0.32	14.03	0.19
TOTAL		**258.22**	**3.49**	**196.69**	**2.66**	**149.07**	**2.01**

** EMP income exclude targeted funds received from the funding agencies*
IUSD= 74 INR

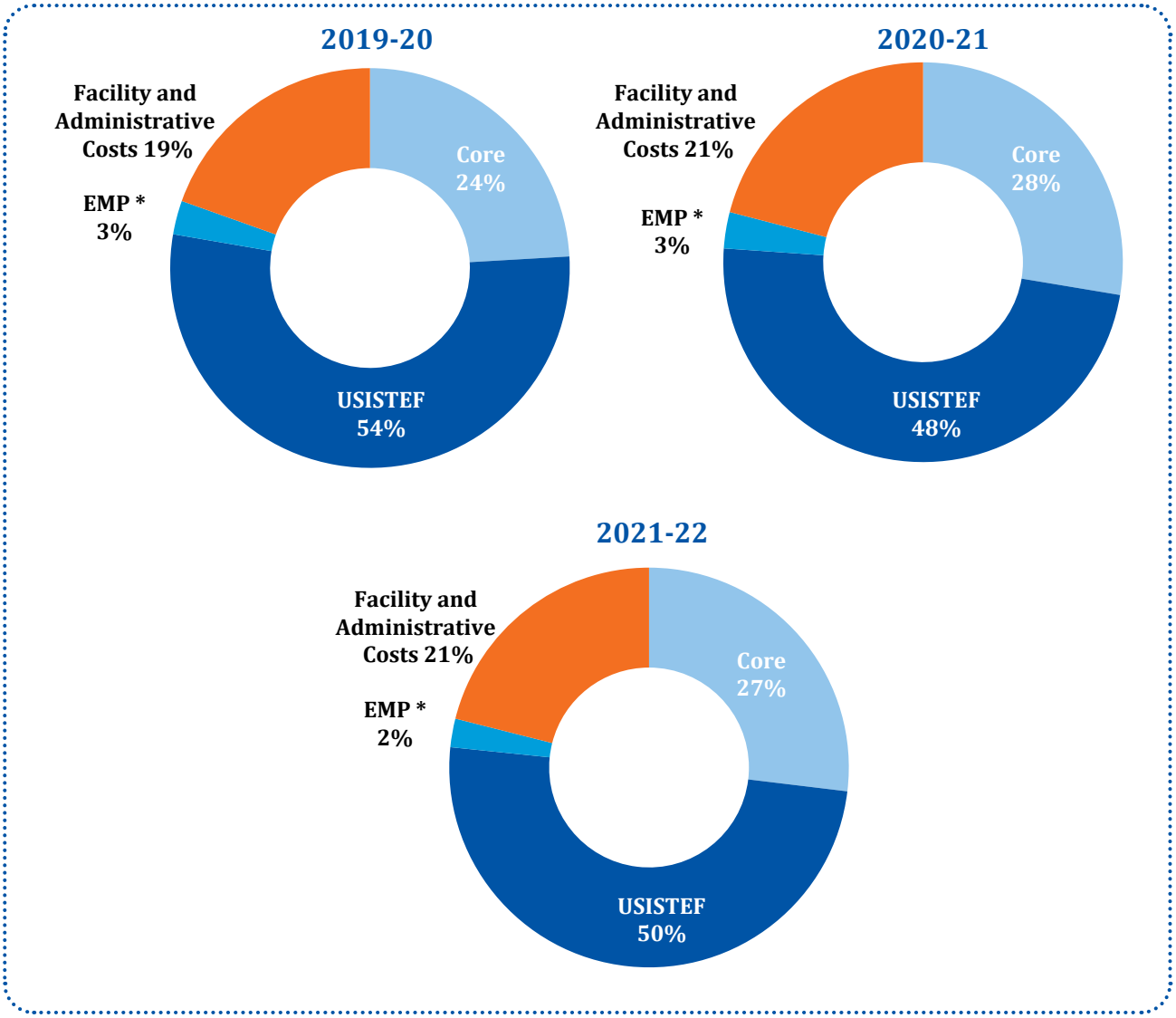


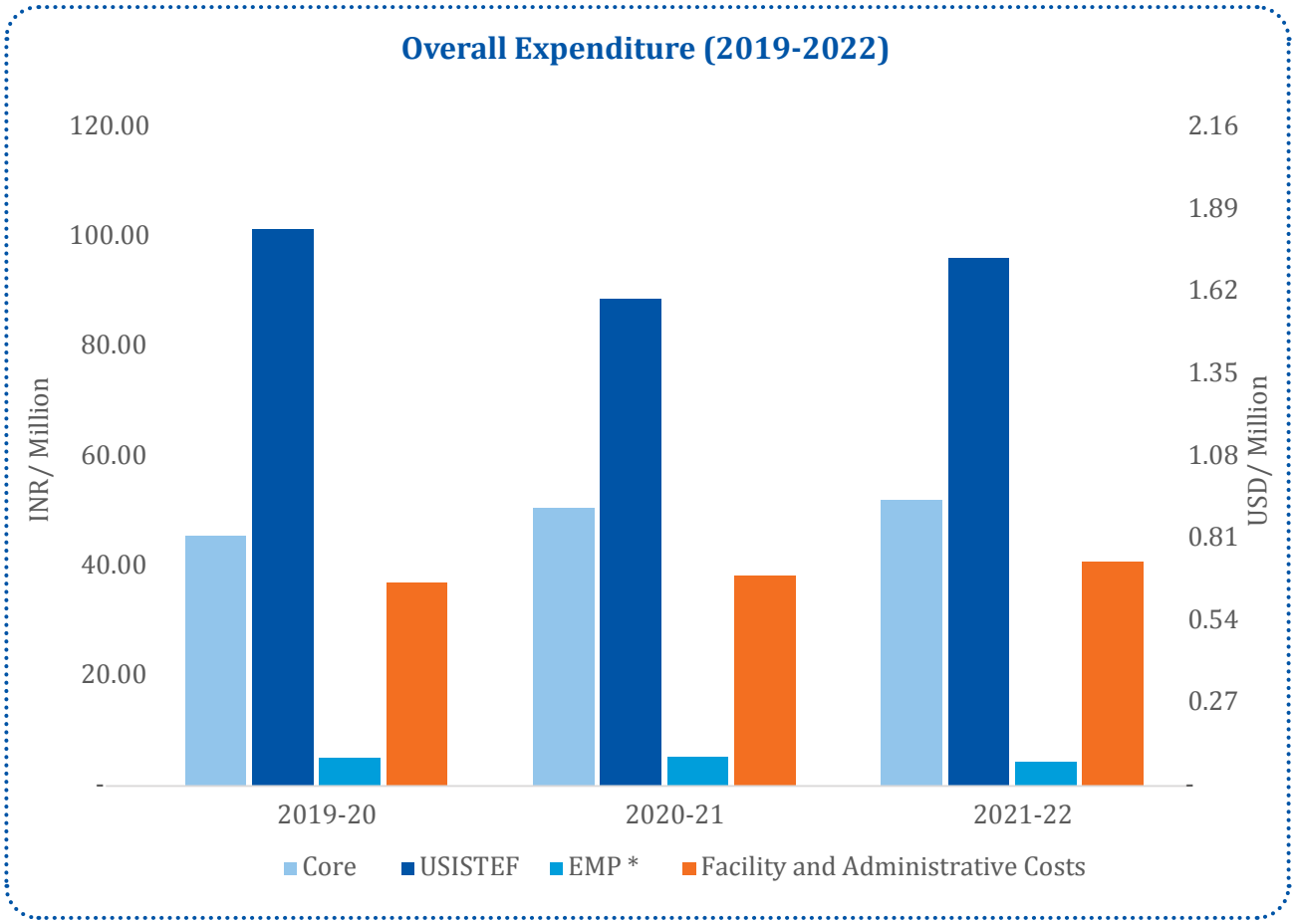


(B) Overall Expenditure

S. No	Head	2019-20		2020-21		2021-22	
		(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)
1	Core	45.59	0.62	50.67	0.68	52.14	0.70
2	USISTEF	101.54	1.37	88.91	1.20	96.33	1.30
3	EMP *	5.18	0.07	5.39	0.07	4.48	0.06
4	Facility and Administrative Costs	37.03	0.50	38.44	0.52	40.82	0.55
TOTAL		**189.34**	**2.56**	**183.40**	**2.48**	**193.76**	**2.62**

** EMP expenditure includes direct expenditure on management of targeted grants received from the funding agencies*
IUSD= 74 INR



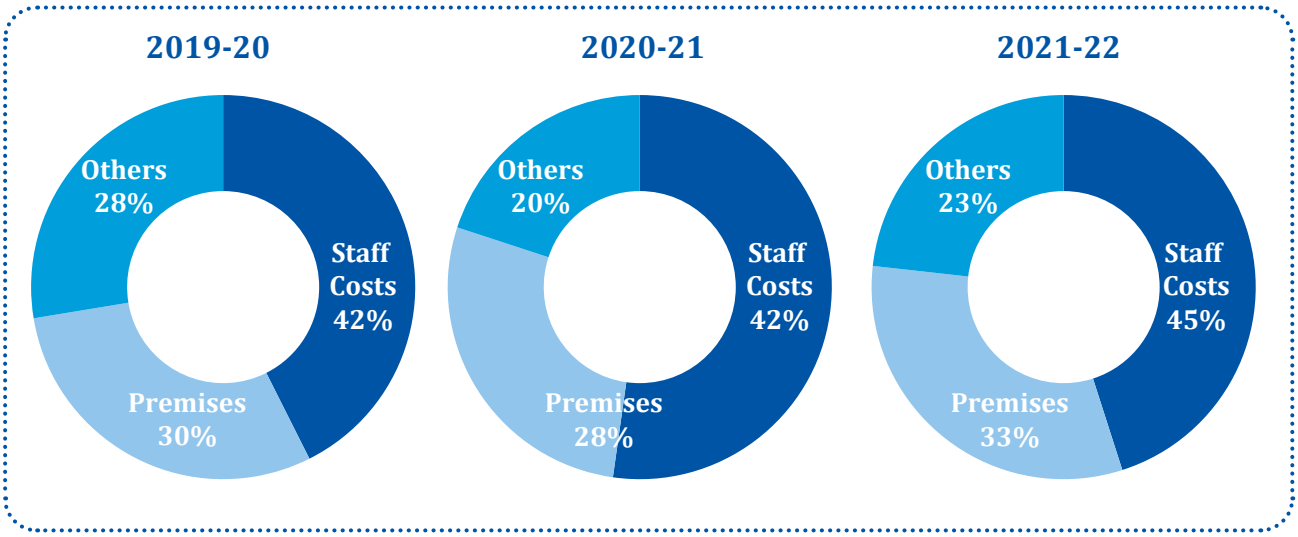

Overall Expenditure (2019-2022)
120.00
100.00
80.00
60.00
40.00
20.00
-
INR/ Million
2.16
1.89
1.62
1.35
1.08
0.81
0.54
0.27
-
USD/ Million
2019-20
2020-21
2021-22
Core
USISTEF
EMP *
Facility and Administrative Costs

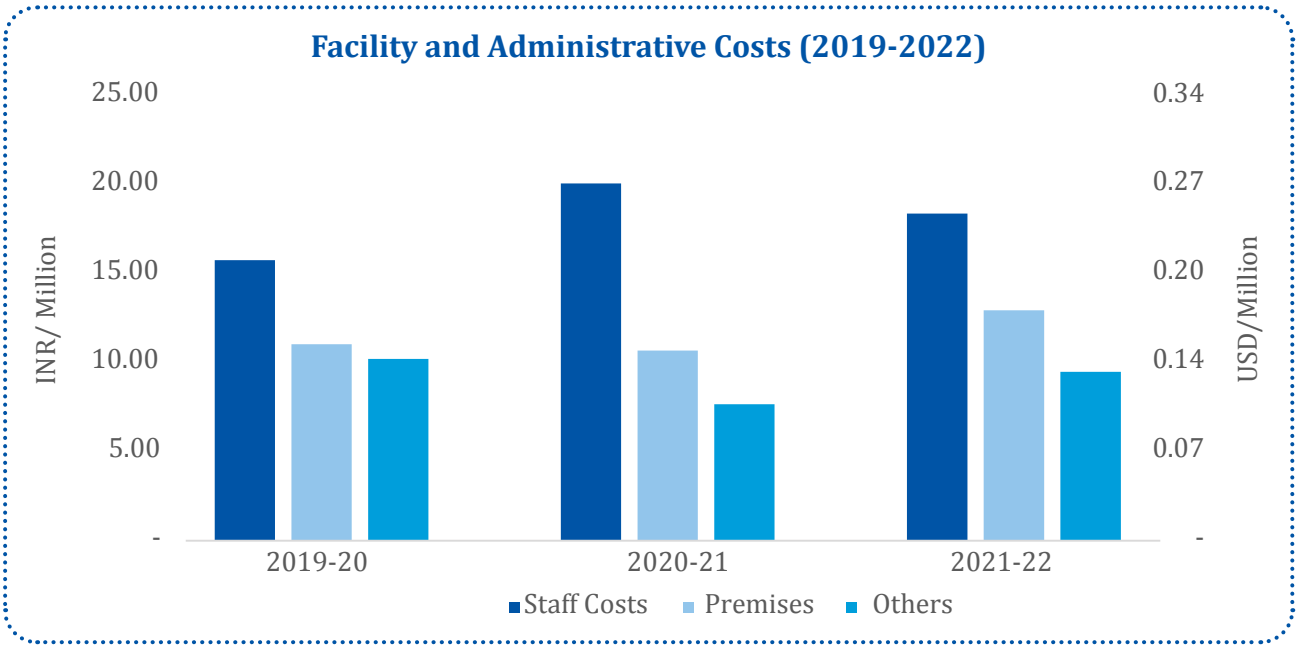

3,690.47
29,140.36
19,580

(C) Facility and Administrative Costs

S.No	Head	2019-20		2020-21		2021-22	
		(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)
1	Staff Costs	15.77	0.21	20.08	0.27	18.39	0.25
2	Premises	11.04	0.15	10.69	0.14	12.94	0.17
3	Others	10.22	0.14	7.68	0.10	9.48	0.13
TOTAL		**37.03**	**0.50**	**38.44**	**0.52**	**40.82**	**0.55**

I USD= 74 INR

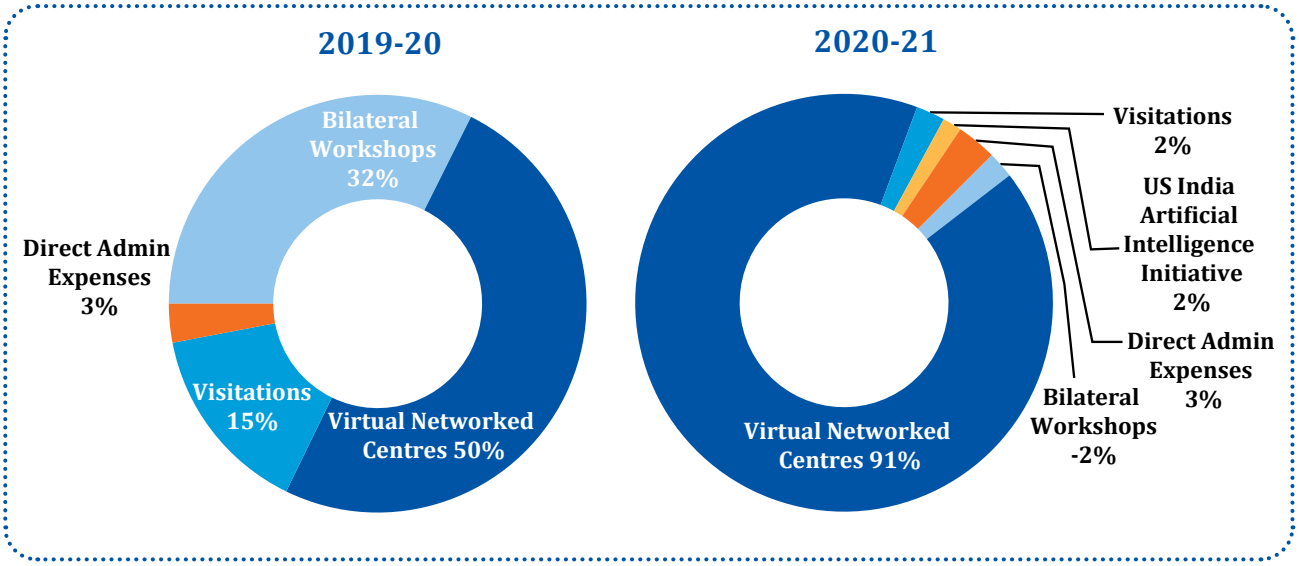


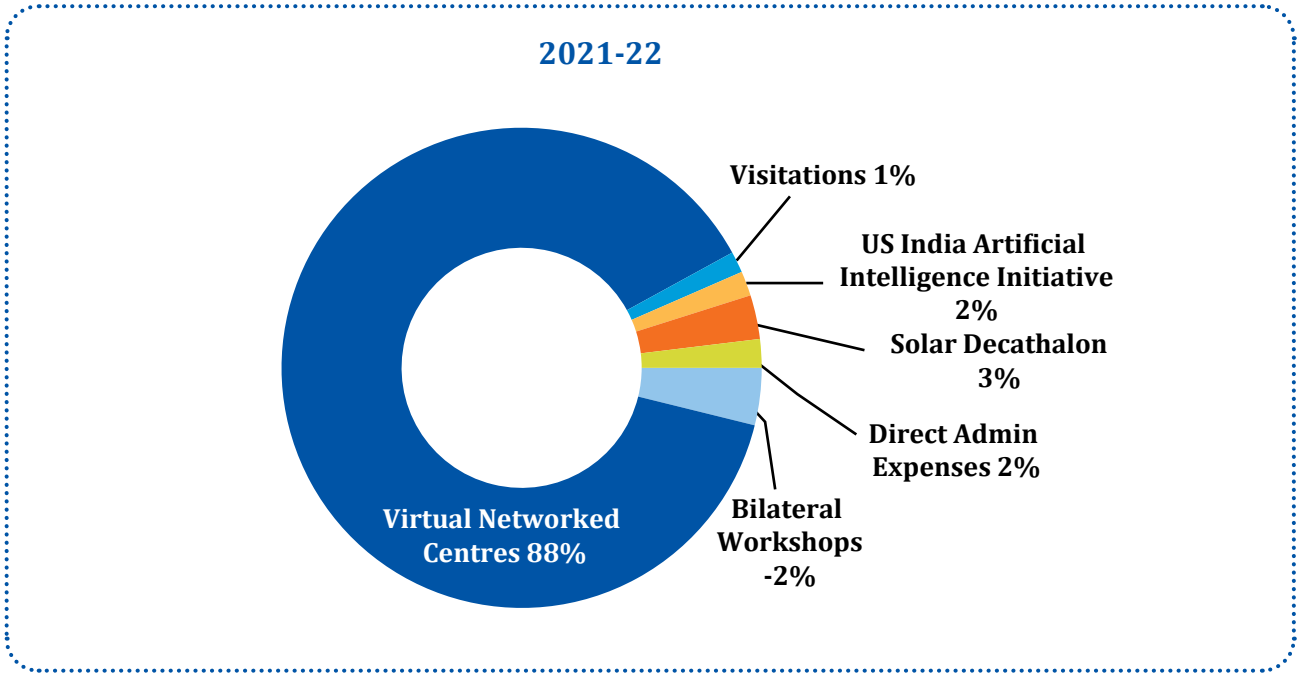


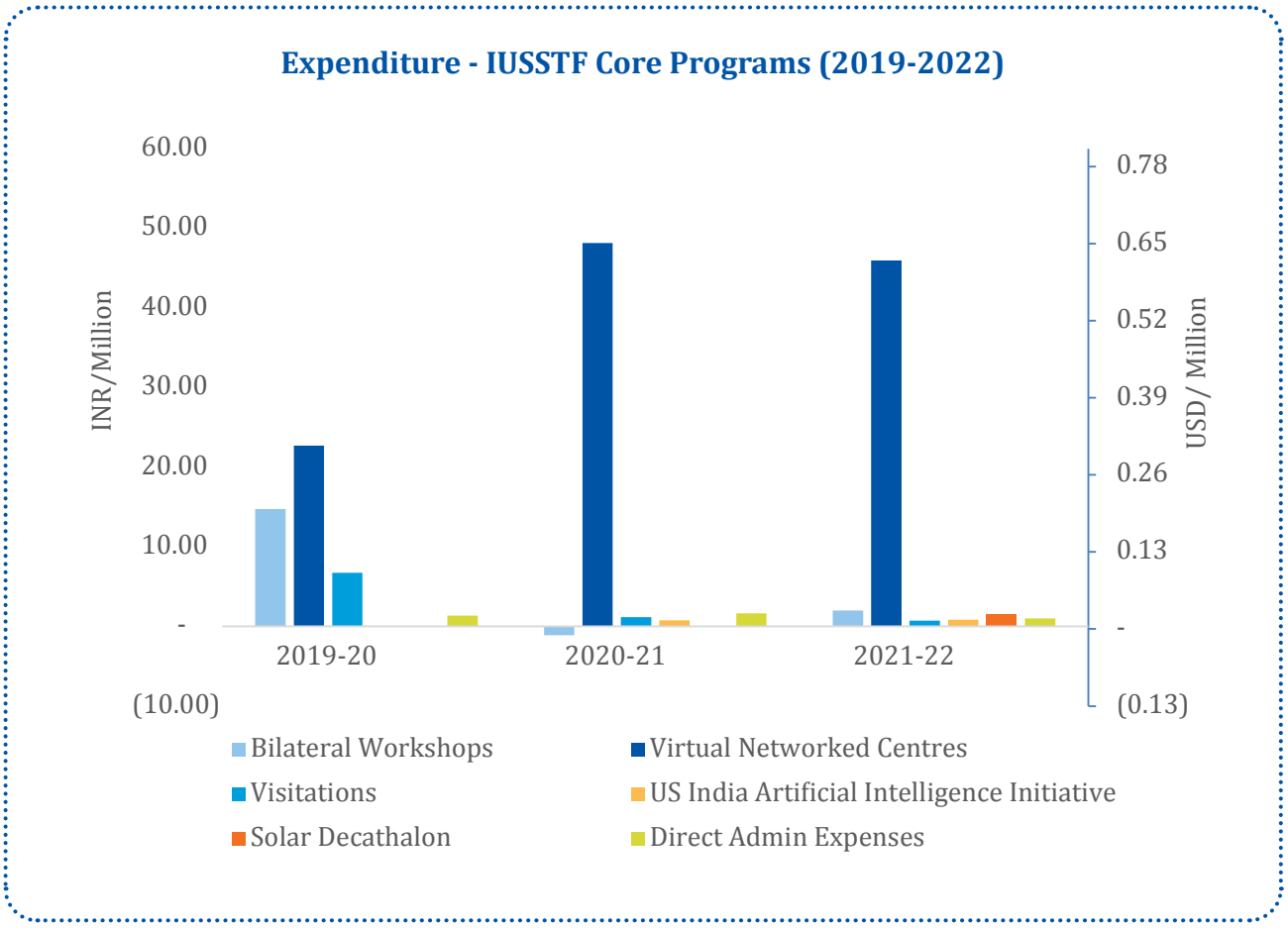
(D) Expenditure - IUSSTF Core Programs

S. No	Head	2019-20		2020-21		2021-22	
		(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)
1	Bilateral Workshops	14.76	0.20	-1.09	-0.01	2.01	0.03
2	Virtual Networked Centres	22.72	0.31	48.16	0.65	45.97	0.62
3	Visitations	6.74	0.09	1.18	0.02	0.75	0.01
4	USIAI Initiative	-	-	0.78	0.01	0.86	0.01
5	Solar Decathalon	-	-	-	-	1.54	0.02
6	Direct Admin Expenses	1.37	0.02	1.64	0.02	1.00	0.01
	a) Governing Body Meetings	0.74	0.01	0.36	0.00	-	-
	b) Outreach Expenses etc	0.63	0.01	1.27	0.02	1.00	0.01
TOTAL		**45.59**	**0.63**	**50.67**	**0.68**	**52.14**	**0.70**

IUSD= 74 INR



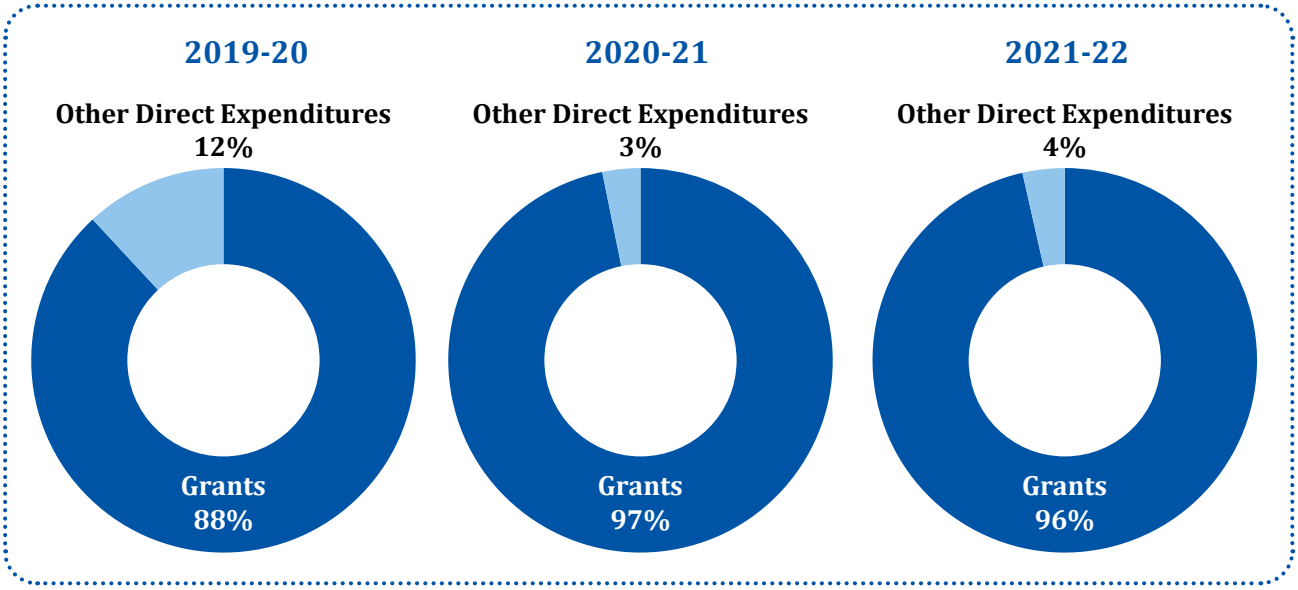

2021-22
Visitations 1%
US India Artificial Intelligence Initiative 2%
Solar Decathalon 3%
Direct Admin Expenses 2%
Bilateral Workshops -2%
Virtual Networked Centres 88%

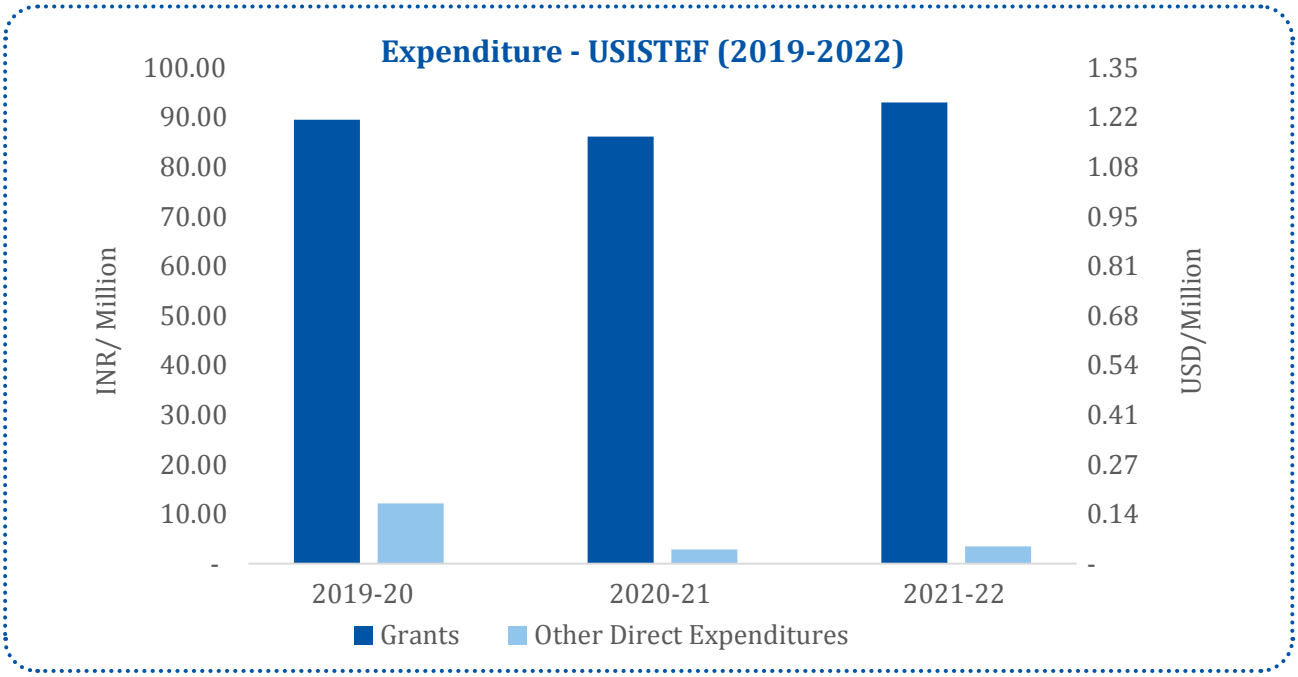

Expenditure - IUSSTF Core Programs (2019-2022)
INR/Million
USD/ Million
60.00
50.00
40.00
30.00
20.00
10.00
-
(10.00)
0.78
0.65
0.52
0.39
0.26
0.13
-
(0.13)
2019-20
2020-21
2021-22
Bilateral Workshops
Virtual Networked Centres
Visitations
US India Artificial Intelligence Initiative
Solar Decathalon
Direct Admin Expenses

(E) Expenditure - USISTEF

S.No	Head	2019-20		2020-21		2021-22	
		(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)
1	Grants	89.45	1.21	86.07	1.16	92.93	1.26
2	Other Direct Expenditures	12.09	0.16	2.84	0.04	3.41	0.05
TOTAL		**101.54**	**1.37**	**88.91**	**1.20**	**96.33**	**1.30**

I USD= 74 INR

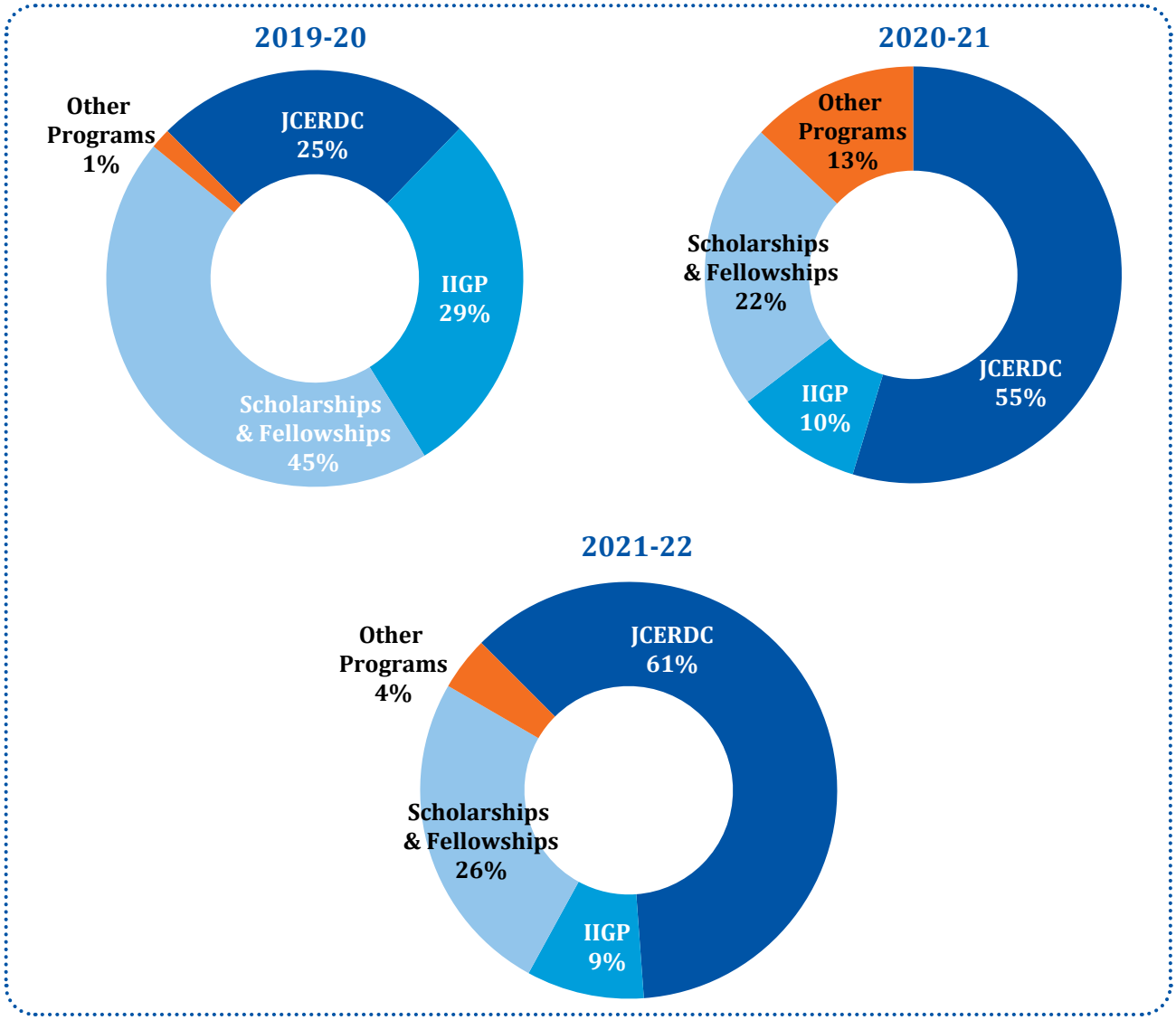


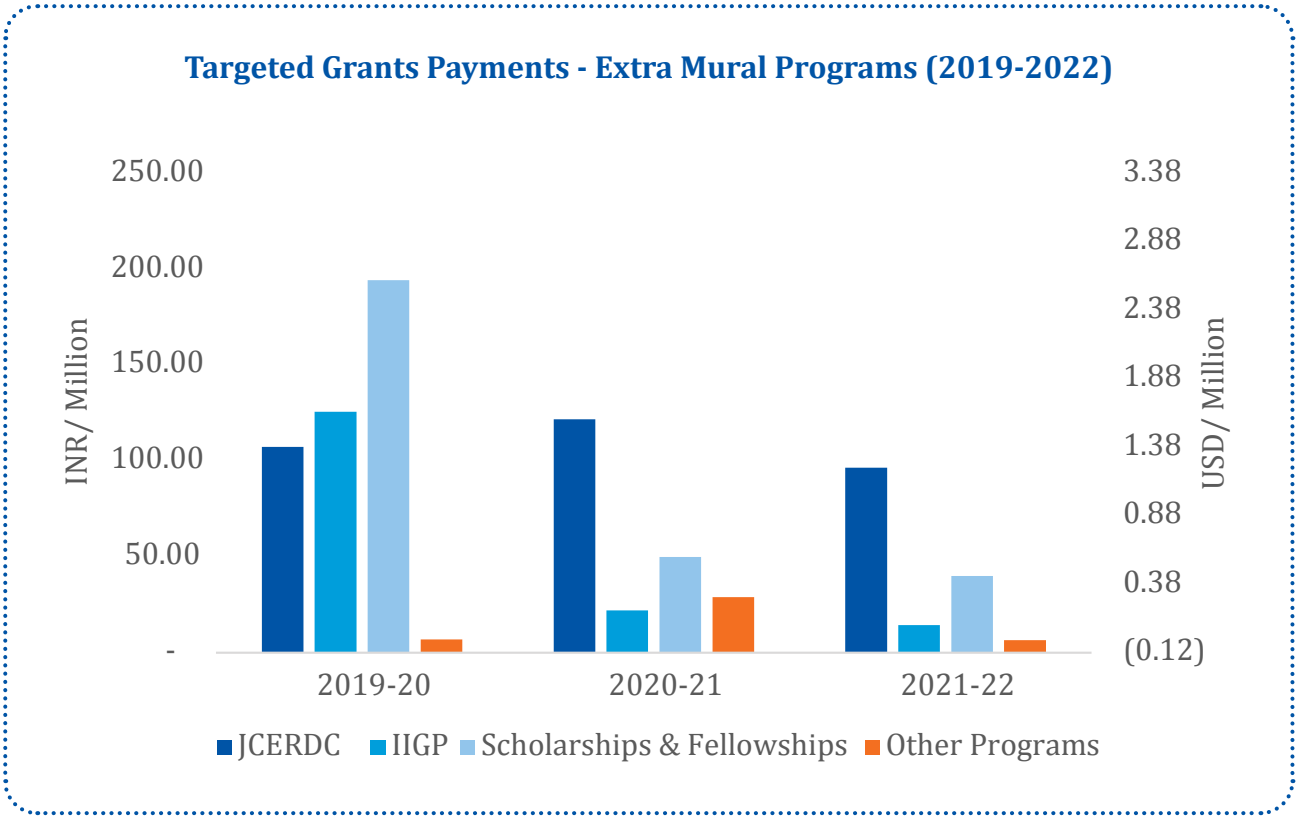


(F) Targeted Grants Payments - Extra Mural Programs

S. No	Head	2019-20		2020-21		2021-22	
		(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)
1	JCERDC	107.29	1.45	121.70	1.64	96.43	1.30
2	IIGP	125.62	1.70	22.07	0.30	14.35	0.19
3	Scholarships & Fellowships	194.15	2.62	49.80	0.67	39.89	0.54
4	Other Programs	6.85	0.09	28.97	0.39	6.53	0.09
TOTAL		**433.91**	**5.86**	**222.53**	**3.01**	**157.21**	**2.12**

I USD= 74 INR

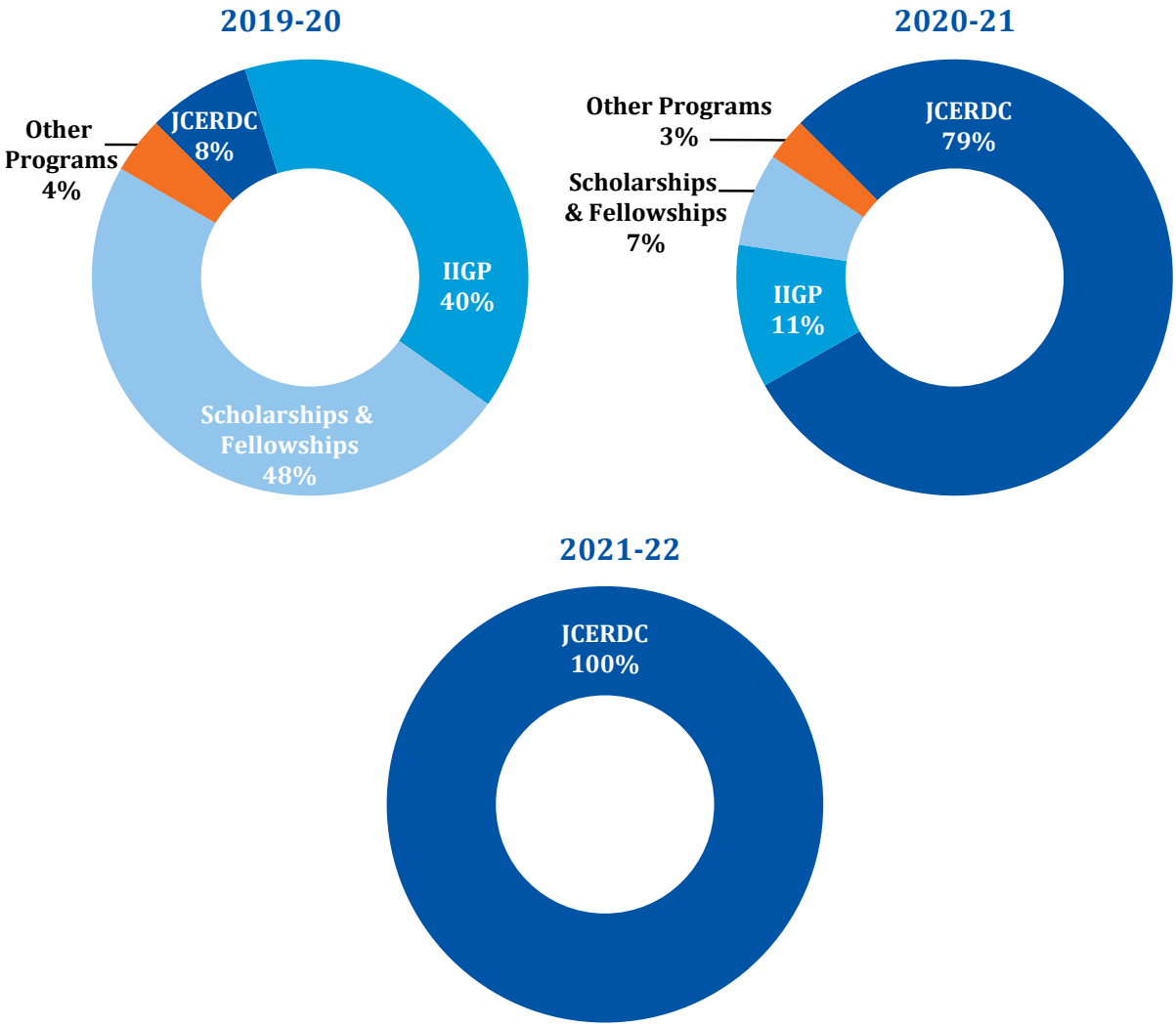




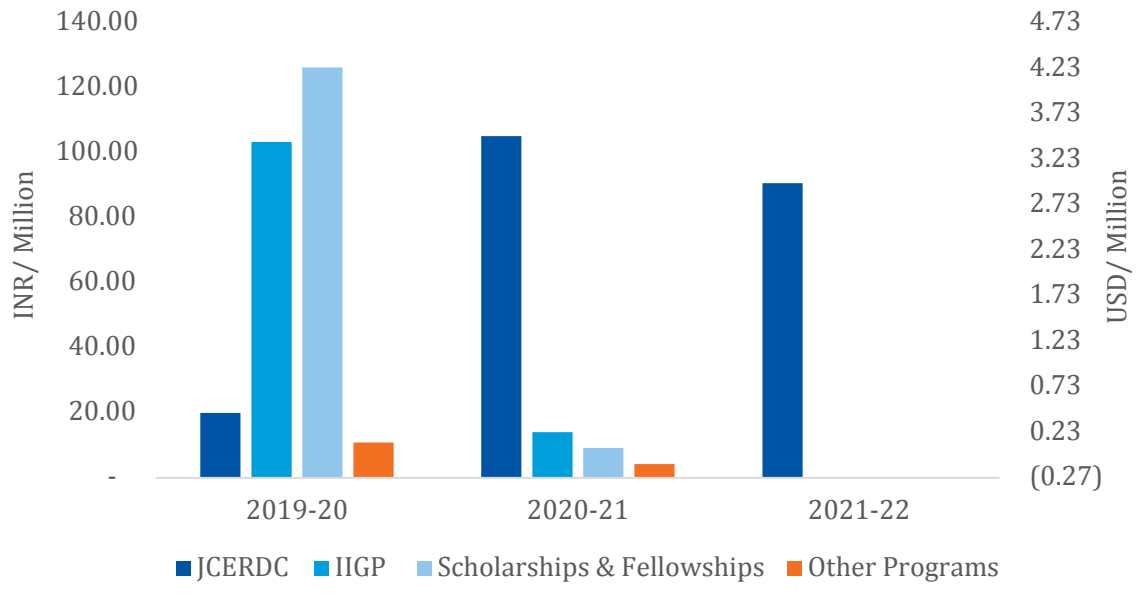
(G) Targeted Grants Receipts - Extra Mural Programs

S. No	Head	2019-20		2020-21		2021-22	
		(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)	(INR/ Million)	(USD/ Million)
1	JCERDC	20.01	0.27	105.14	1.42	90.69	1.23
2	IIGP	103.42	1.40	14.10	0.19	-	0.00
3	Scholarships & Fellowships	126.29	1.71	9.17	0.12	-	0.00
4	Other Programs	10.93	0.15	4.21	0.06	-	0.00
TOTAL		**260.66**	**3.52**	**132.63**	**1.79**	**90.69**	**1.23**

I USD= 74 INR



Targeted Grants Receipts - Extra Mural Programs (2019-2022)



Notes

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