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PROGRESS REPORT

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ITRA, Media Lab Asia

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Abbreviations

Sr. No	Abbreviation/Terms	Definition
1	AC	Advisory Council
2	AF	Adjunct Faculty
3	Co-PIs	Co-Principal Investigator
4	DBT	Department of Bio-Technology, Govt. of India
5	EC	Executive Committee
6	EOI	Expression of Interest
7	FP	Full proposal
8	GC	Governing Council
9	IIs	ITRA Institutions –institutions of the research groups that form the teams
10	IPs	Interacting Pyramids – A set of pyramids forming a team working together on different parts of the same problem
11	IT & ICTE	Information Technology & Information and Communication Technologies and Electronics
12	IT-in-X	IT applied to solve problems in an application domain X
13	<i>ITRA-Ag&Food</i>	<i>IT Based Transformations in Indian Agriculture & Food</i> – an IT-in-X focus area of ITRA
14	<i>ITRA-HuSim</i>	<i>ITRA-Human Simulator</i> – the IT-in-X focus area targeted by this RFP
15	<i>ITRA-Mobile</i>	<i>Mobile Computing, Networking and Applications</i> - an IT focus area of ITRA
16	<i>ITRA-Water</i>	<i>IT based Innovations in Water Resources Sustainability</i> - an IT-in-X focus area of ITRA
17	Lead PI	Principal Investigator of the Lead Institution of a pyralet
18	LIN	Lead Institution of a pyralet
19	PI	Principal Investigator – lead of the group from one institution in the pyralet
20	PIN	Partner Institution
21	PRSG	Program Review and Steering Group
22	PSIG	Project Steering and Implementation Group
23	Pyralet	2-layered pyramid of research groups from different institutions
24	R&D	Research and Development
25	RFP	Request for Proposals
26	SFM	Strategy Formulation Meeting
27	TOR	Terms of Reference
28	TOT	Transfer of Technology
29	UG	Under Graduate

Executive Summary

MISSION STATEMENT: Information Technology Research Academy (ITRA) is a national programme aimed at building a national resource for advancing the quality and quantity of R&D in Information and Communications Technologies and Electronics (ICTE, or IT for short) and its applications at a steadily growing number of academic and research institutions across India, while strengthening academic culture of IT based problem solving and societal development. ITRA is currently operating as a division of Media Lab Asia, a section-8 not-for-profit organization of Ministry of Electronics and Information Technology, Govt. of India.

FOCUS AREAS: Focus areas for conducting research and development are chosen based on national and societal priorities, need assessment, and opportunities. To begin the pursuit of a selected focus area, a Strategy Formulation Meeting (SFM) is held to identify and discuss different aspects of the area and evolve a roadmap. Well known researchers, other relevant experts and all stakeholders in the focus area, from India and abroad, are invited to the meeting. Subsequently, multi-institution teams are identified to conduct collaborative projects, each implementing a part of the SFM roadmap in the focus area.

SCALABILITY: ITRA uses a pyramid model to interlink the institutions in the team (called ITRA Institutions, or IIs), wherein each II acts as a Lead Institution (LIN) for a set of Partner Institutions (PINs) in the next lower layer in the pyramid. Each PIN learns from its LIN immediately above, while it simultaneously helps improve the quality of its own PINs at the level immediately below. The pyramid grows after every growth cycle (of a predetermined period of, e.g., 2 years), via each PIN in the lowest layer acquiring a set of new IIs as PINs and serving as a LIN for them. This leads to an exponential growth in the number of ITRA institutions. The coexisting LIN-PIN interactions simultaneously raise quality across the pyramid with time, while fresh, lowest tier institutions are steadily added at the bottom.

TEAM STRUCTURE: A team consists of (i) researchers from academic and research institutions, any additional disciplines needed to pursue the team's objectives. (ii) The node IIs closely collaborate with the translators to add or extend the team capabilities in translating their R&D into societal impact, e.g., through technology transfer to industry, startups, etc. (iii) each team must also include mentors who have agreed to be involved in the project. Mentors are renowned scientists, technologists, industrialists, etc., and an integral part of the team. They mentor the team from the proposal stage through the actual activities, including motivating research groups, planning and conducting research, guiding students and theses supervision, helping with publications, teaching new classes, evaluating status and discussing/implementing changes, if needed, and general professional guidance. Pooling experts from across the world offers the institutions an opportunity for incorporating the best practices from across the world.

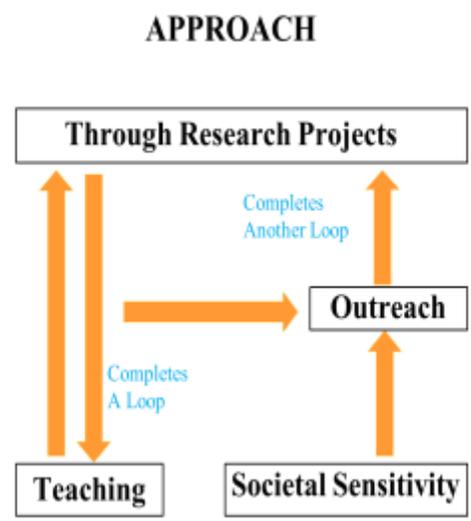
PROPOSAL EVALUATION AND DEVELOPMENT: To maximize the likelihood of a match with ITRA expectations, a two-stage process is used for teams to efficiently develop proposals. In the first stage, a brief Expression of Interest (EOI) statement is submitted by lead institution of a team, containing a small part of the information needed in a full proposal. This helps ITRA arrive at a preliminary assessment of the proposed effort and provides any feedback that may help improve the chances of eventual acceptability of any full proposal that follows. Those teams with acceptable EOIs are invited to submit a full proposal. ITRA may provide inputs about the thrust of team's proposal, potentially useful groupings among selected teams, etc. Second stage is submission of a full proposal. Those full proposals that are considered promising are shortlisted for further development. A Full Proposal Development Workshop is conducted in which shortlisted teams are invited to interact with ITRA, experts and among themselves, to better understand the focus area objectives and what various other teams are doing, and also to identify ways in which they could enhance their proposals so better fit the focus area individually while complementing each other's activities. The enhancements may also include changing thrusts of the proposals, team structures, and team groupings, etc. The teams are then invited to modify and resubmit their proposals accordingly. This is followed by a series of evaluate-

modify steps in which the teams interact with ITRA and experts to iteratively modify the proposals until all identified improvements are incorporated.

POST SELECTION ENGAGEMENT WITH TEAMS: After the teams have been selected, ITRA proactively and continuously works with teams to identify needs and opportunities to maximize performance. ITRA arranges for the necessary resources and mechanisms for pyramid-wide access to them. In addition to two intra-team meetings, all teams also meet every 6 months, once for receiving feedback, and once for being evaluated, in Feedback and Evaluation Workshops. Achievements by teams are recognized through a variety of awards given for quality of their proposals to begin with, to quality of work done by individuals, institutions and teams, at different stages of the work, with respect to all four ITRA quality metrics mentioned earlier.

FOCUS AREAS TO DATE: ITRA began with two focus areas, viz., “Mobile Computing, Networking and Applications (*ITRA-Mobile*)”, “IT based Innovations in Water Resources Sustainability (*ITRA-Water*)” and ‘IT Transformation in Agriculture and Food (*ITRA-Ag & Food*)’. In *ITRA-Mobile*, 9 teams, consisting of 38 groups, in *ITRA-Water*, 5 teams, consisting of 24 groups and in *ITRA-Ag& Food*, there are 6 teams with 36 institutions that are engaged in research and development projects identified in focus area roadmaps. One more focus area “Human Simulator for Amyloids Related Diseases (*ITRA-HuSim*)” is also ready for commencement.

EXPECTED OVERALL IMPACT: The teams working on related problems from a focus area help with: Building R&D Groups in IT and its Applications; Networking them and connecting them to Industry and Society; Producing high quality PhDs for Industry, R&D labs and Academic Institutions; Enhancing societal problem solving skills, and overall, and Enabling innovation. It is expected that ITRA will help produce a large numbers of IT researchers who are well equipped with the latest IT knowledge, educated in relating classroom knowledge to developing solutions, trained to spot problems amenable to IT solutions, motivated to identify societal problems in IT and other domains, and exposed to mechanisms for converting lab solutions to working prototypes. The expected large increase in the national capacity of producing PhDs should help address the shortage of good faculty in academic institutions, and the needs of the industry and society at large.



About ITRA

ITRA was initiated by Ministry of Electronics and Information Technology (MeitY), Government of India, as national programme to help build a national resource for advancing the quality and quantity of R&D in Information and Communications Technologies and Electronics (ICTE, or IT for short) and its applications, in IT and related institutions across India. The core areas of IT lie in various engineering disciplines, notably computer science and engineering, and electrical engineering, although applications may come from almost any discipline. ITRA focuses on strengthening the nation's competitiveness by expanding the R&D base in IT, especially by leveraging the large IT education sector and IT users such as government, industry and other organizations. The enhanced IT R&D capacity created through ITRA will impact the overall ecosystem of Information Technology, to be reflected in the numbers of research groups and labs created, new research areas initiated, scale of PhD graduations, new curricula, innovative solutions to industrial and societal problems, strong linkages with R&D groups, etc.

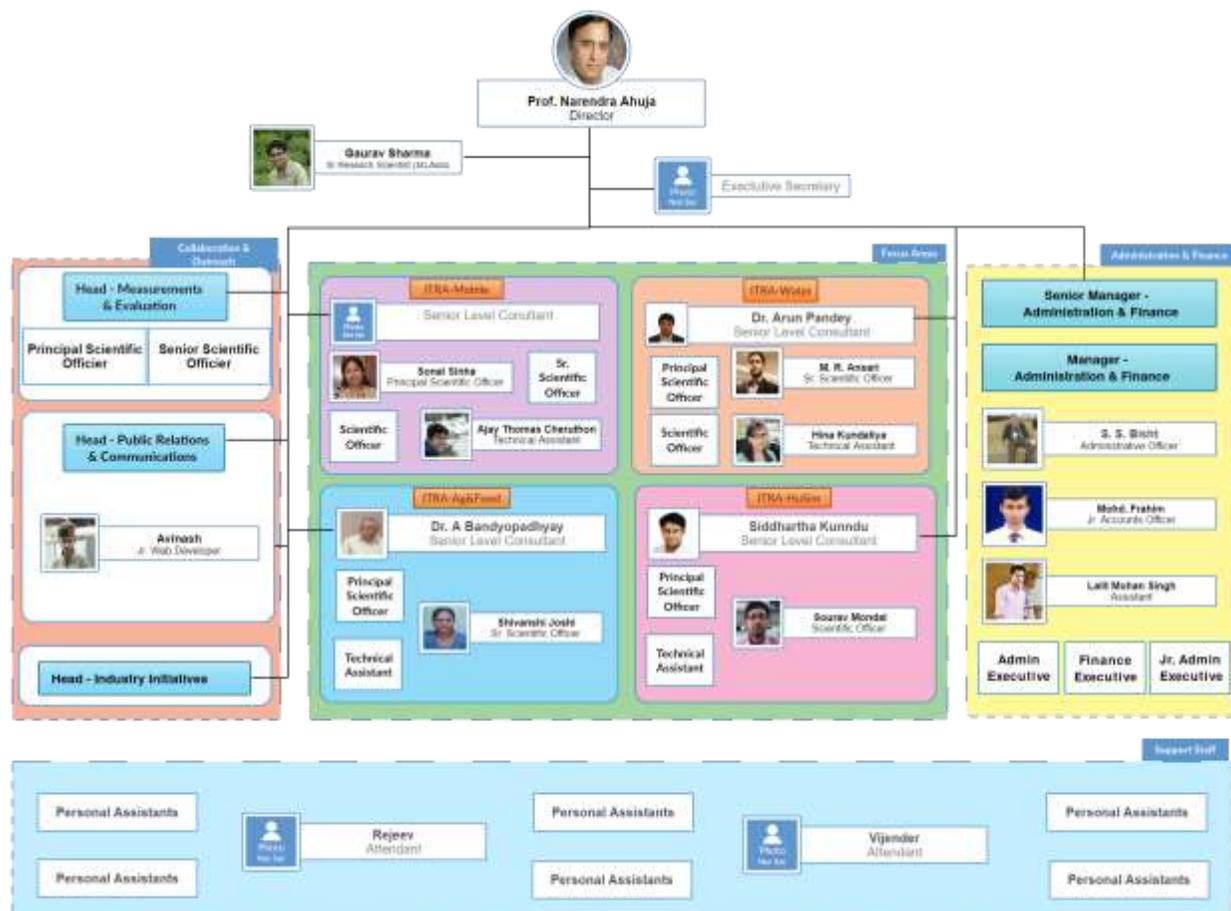
Implementation of the five year 'ITRA project' with a total outlay of Rs. 148.83 Cr was entrusted to Media Lab Asia (MLAsia), a Section-8 not-for-profit organization, by MeitY in November 2010. Initially, ITRA was established for operations through Dec 2015, but this period was subsequently extended till Dec 2018. ITRA is currently operating as a Division of MLAsia.

3.1 GOVERNING STRUCTURES

- a. **Governing Council (GC):** ITRA GC was setup with the approval of Hon'ble Minister of Electronics and IT, and is chaired by the Secretary, MeitY. The GC has representatives from MHRD, Academia, and Industry. ITRA GC provides general guidance and supervision. It has full powers to decide and approve various policy matters of the ITRA.
- b. **Advisory Council (AC):** ITRA AC was setup with the approval of Hon'ble Minister of Electronics and IT and is chaired by Prof. S. V. Raghavan, IIT Madras and ex-Scientific Secretary, Office of the Principal Scientific Advisor to the Government of India. The AC consist of eminent persons and visionaries from IT, IT-in-X and related policy-making areas and from other disciplines of relevance. ITRA AC recommends the high level priorities and agenda for IT research. Any ideas about new focus areas need to be first presented to and recommended by AC.
- c. **Executive Committee (EC):** ITRA EC was setup with approval of ITRA GC and is chaired by Director-ITRA. This committee takes all decisions needed to implement the approved policies. Overall, EC will provide guidance to ITRA for effective execution of the programme.
- d. **Program Review and Steering Group (PRSG):** A 5-member Project Steering & Implementation Group (PSIG) was constituted initially by MeitY for taking necessary steps for the implementation of the starting phase of the ITRA project. On completion of these steps, MeitY replaced PISG with PRSG to oversee the ITRA project. PRSG makes recommendations to the ITRA Programme Division at MeitY on the decisions that have to do with the government functioning and regulations, including those made as per policies recommended by ITRA AC and approved by ITRA GC. PRSG is chaired by Prof U.B. Desai, IIT Hyderabad and co-chaired by the Group Coordinator at MeitY handing ITRA.

The composition and Terms of Reference (TOR) of all committees are placed at ANNEXURE 1

3.2 ORGANIZATIONAL STRUCTURE



The list of ITRA personnel is placed at ANNEXURE 2.

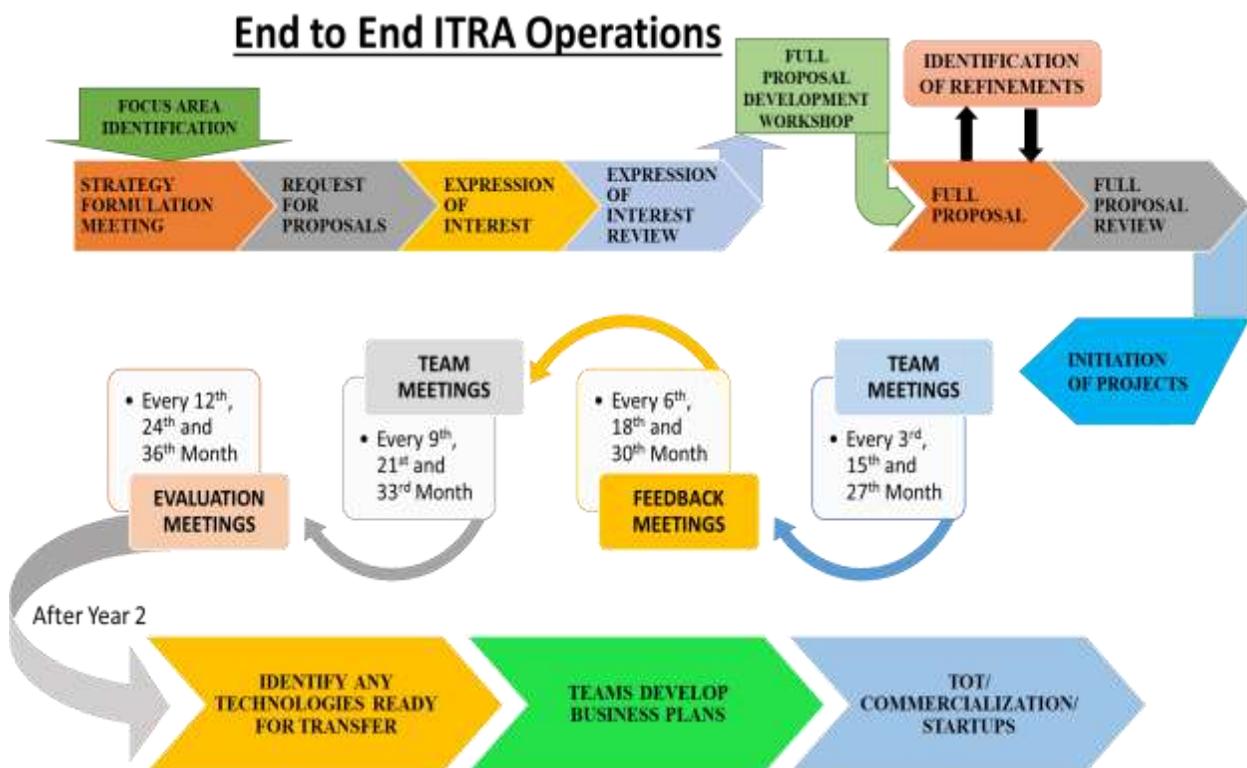
ITRA Model

In pursuit of building a national resource for advancing the quality and quantity of R&D in IT and its applications, ITRA first chooses a Focus Areas with societal relevance for conducting research and development. To begin the pursuit of a selected focus area, a Strategy Formulation Meeting (SFM) with well-known researchers and other relevant experts in the focus area is held to identify and evolve a roadmap for the area. Subsequently through rigorous selection mechanism, multi-institution teams are identified to conduct collaborative projects, each implementing a part of the SFM roadmap in the focus area.

ITRA uses a pyramid model to interlink the institutions in the team. A team consists of (i) researchers from academic and research institutions, any additional disciplines needed to pursue the team’s objectives. (ii) The nodes of pyramid closely collaborate with the translators to add or extend the team capabilities in translating their R&D into societal impact, e.g., through technology transfer to industry, startups, etc. (iii) Each team also include renowned scientists, technologists, industrialists, etc. as mentors who mentor the team from the proposal stage through the actual activities, including planning, publications, theses supervision, and general professional guidance.

After the teams have been selected, ITRA proactively and continuously work with teams to identify needs and opportunities to maximize performance. ITRA arranges for necessary resources and mechanisms and pyramid-wide access to them. Achievements of teams are recognized through a variety of awards given for quality of their proposals to begin with, to quality of work done by individuals, institutions and teams, at different stages of the work, with respect to ITRA quality metrics.

Quality is measured in following four parts: the R&D work itself, aimed at developing skills of problem formulation and solving, as reflected in commonly used metrics (publications, etc.); impact of the R&D on enhancing curriculum and instruction; programs for developing sensitivity to society, so the researchers tend towards routinely spotting societal problems and developing an urge for solving them as targets of their R&D work; and making an impact on society at large through entrepreneurial activity or other ways of transferring technologies and knowledge developed in the R&D work



4.1 MECHANISMS TO SELECT AND INITIATE PROJECT ACTIVITIES IN A FOCUS AREA

Focus Areas with societal relevance are chosen for nurturing research with advice from Advisory Committee (AC) of ITRA. To begin the pursuit of a selected focus area, a Strategy Formulation Meeting (SFM) is held to identify and discuss different aspects of the area. Well known researchers and applications experts in the focus area, from India and abroad, are invited to the meeting. They are selected from the relevant government and nongovernment organizations, industry, etc., so as to represent the viewpoints of all stakeholder communities, including researchers, mentors, sponsors, developers, outreach groups, users, domain knowledge providers, etc. The SFM participants help formulate a comprehensive national research initiative in the area.

The SFM outcomes are used to prepare a Request for Proposals (RFP) to form ITRA teams working on the identified short-term, medium-term and long-term objectives. The RFP embodies ITRA's emphasis on team based work. All proposals are required to be submitted by teams. The team consists of academic institutions or government research labs (together referred to as ITRA institutions, or IIs) and other, collaborating organizations. Each team consists of:

- (a) One or more pyralets (defined as: one lead II and, typically, two partner IIs), and
- (b) Other collaborating organizations, if any, including research labs, industry, government organizations, NGOs, international organizations, etc., to complement the expertise of the IIs to form a well-rounded team that can help improve as many parts of the ITRA quality measure and to as large an extent as possible. These organizations act as translators of the pyralets.

To maximize the likelihood of a match with ITRA expectations, a two-stage process is used for teams to efficiently develop proposals. In the first stage, a brief Expression of Interest (EOI) statement is submitted by the lead institution of a team. This helps ITRA to arrive at a preliminary assessment of the proposed effort and provide any feedback that may help improve the chances of eventual acceptability of any full proposal that follows. Those teams with acceptable EOIs are invited to submit a full proposal. ITRA may provide inputs about potentially useful groupings among the selected teams. The second stage is submission of a full proposal. Submitted full proposals are reviewed and shortlisted by a diverse panel of eminent experts from academia, industry, research laboratories, Government and other organizations as needed. Subsequently, the shortlisted collaborative projects are taken up in the selected focus areas.

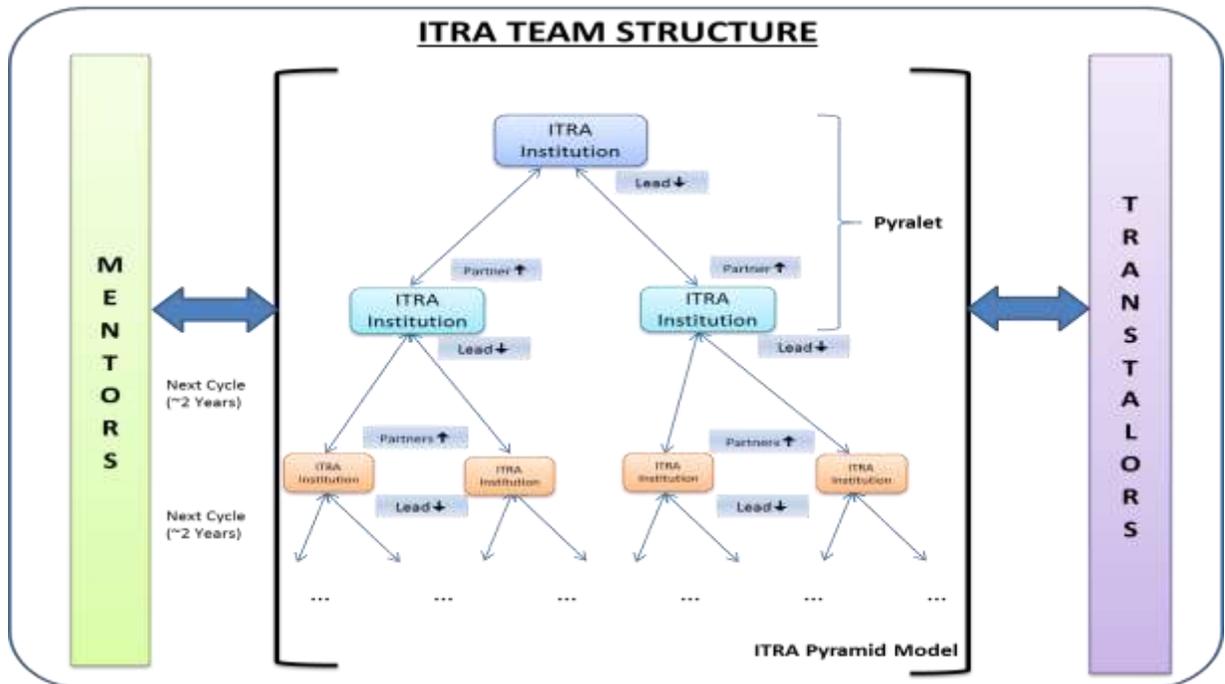
4.2 TEAM STRUCTURE

ITRA plans to enhance the quality of the ITRA institutions (to be referred to as IIs in the sequel) through R&D, by closely interacting teams of researchers and institutions that have expertise in specific IT research areas, or in the use of IT in other engineering and non-engineering domains. To realize effective interaction among increasing number of institutions, ITRA has networked these existing institutions as a pyramid. All IIs are academic institutions or government supported research laboratories and form nodes of a pyramid. These IIs closely collaborate with non-academic institutions, such as research labs, industry, government organizations and NGOs, the latter typically adding or extending the capabilities of the IIs in translating their R&D into societal impact, e.g., through technology transfer to industry, startups, etc. As is well recognized, such translation of technical innovation into societal impact requires much more than the innovation itself. Thus, the participation of non-academic institutions is central to achieving the objectives of ITRA. However, this role will be played by them through collaboration with the IIs in the pyramid as the primary target of ITRA is enhancement of the quality of academic/research institutions. A critical other component of the ITRA teams is the presence of world class scientists, technologists, industrialists, etc., as central players and an integral part of the team, who will mentor the rest of the team from the proposal stage through the actual activities, including planning, publications, these supervision, and general professional guidance.

Each problem (P) in the focus area identified as important is addressed by a set of pyramids. The problems are divided into sub problems, and work on each sub problem (S) is undertaken by N (N being one or more) interacting pyramids (IP). The value of N depends on the size/requirements of S. A

more ambitious S may call for a larger number of IPs. Each IP begins with an initial set of research groups, led by a Lead Institution (LIN) at the root level, with the next level formed by Partner Institutions (PINs), forming a two-level pyramid, called a pyralet. A LIN distributes and carries out the project work jointly with its PINs, in the process bringing up the quality of the PINs. At the end of a cycle of 1.5-2 years after becoming an II, each PIN is required to add a layer of 2-3 new PINs of its own for whom it will act as LIN.

The pyramid thus grows in chunks, each chunk being the new layer of PINs added at the bottom, thus expanding the pyramid. The expansion is done as soon as a PIN is ready, typically every 1.5-2 year cycle. An II may appear in multiple pyramids, associated with different focus areas, represented by II's different research groups. Those IIs with a broader research program tend to appear in the ITRA pyramids more frequently.



An II typically improves its quality in a focus area with help from its LIN, its parent node in the pyramid, while helping raise the quality of its own PINs, its children nodes in the layer below. It is therefore envisioned that the entire pyramid will rise in quality with time, while layers of new PINs are added at the bottom. The rate at which PINs are added to the pyramid itself grows directly with the number of institutions in the pyramid, i.e., the pyramid size will grow exponentially.

Focus areas are either be disciplines within IT itself, or aimed at applying IT to an important problem domain X, referred to as IT-in-X. ITRA helps initiate IPs for each S, by selecting a set of seed pyralets for each S, based on a single proposal jointly submitted by the team. The primary responsibility, accountability and rewards for the improvement in the quality of PINs in a pyralet primarily flows through the PIN itself, its LIN and the mentors. However, collaboration within a team is preferred to be broader, to take advantage of the complementarities in the strengths of all IIs in the team. The teams are established through initial grants. Future layers are added during the same grant, through renewals of these grants or new grants.

4.2.1 Mentors

Mentors are renowned researchers in an area relevant to the team. They are an integral part of a team proposal and are thus involved from the time of the inception of the team. They are entrusted with and duly credited and rewarded for enhancing the team's performance. Types of Interactions between a Mentor and ITRA Teams are as follows:

1. Co-supervision of PhD/Master's student theses
2. Co-authorship of papers
3. Co-teaching of courses
4. Co-development and conduct of labs
5. Co-planning and steering of research agenda and formulating proposals
6. Giving seminars and short courses
7. Working with team collaborators and other stake holders
8. Hosting ITRA faculty and students at mentor's institution for short (~a few weeks) or long periods (~a semester)
9. Help with outreach efforts
10. Guide teams to contribute to national and international professional organizations and activities involving conferences, journals, contests, standards, multinational initiatives, professional societies, etc.
11. Be a member of team feedback panels
12. Be a member of team evaluation panels.

Details of Interactions of Teams with Mentors are available at ANNEXURE 4.

4.2.2 Adjunct Faculty

Adjunct Faculty (AF) are renowned researchers in an area relevant to the team. They may perform most of the functions normally performed by a mentor, but the mentors are an integral part of a team proposal, usually involved from the time of the inception of the team. AF are entrusted with and duly credited and rewarded for enhancing the team's performance. AF may also be invited to complement the mentors from time to time. AF may choose to become mentors if need arises as they work with the teams. Types of Interactions between ITRA Teams and Adjunct Faculty

1. Co-supervision of PhD/Master's student theses
2. Co-authorship of papers
3. Co-teaching of courses
4. Co-development and conduct of labs
5. Co-planning and steering of research agenda and formulating proposals
6. Giving seminars and short courses
7. Working with team collaborators and other stake holders
8. Help with outreach efforts
9. Be an invited member of team feedback panels if needed
10. Be an invited member of team evaluation panels if needed
11. Guide teams to contribute to national and international professional organizations and activities involving conferences, journals, contests, standards, multinational initiatives, professional societies, etc.

Details of Interactions of Teams with Adjunct Faculty are available at ANNEXURE 5.

4.3 POST PROJECT INITIATION ENGAGEMENTS WITH THE TEAMS

ITRA proactively and continuously works with the IIs to identify the needs and opportunities for achieving greater efficiency. ITRA arranges for the necessary resources and mechanisms and pyramid-wide access to them. ITRA and all teams engage in the following periodic exercises to ensure healthy progress.

1. **Quarterly Team Meet for Inter Team Interactions:** PIs and Co-PIs of each team meet every three months, to take stock of the progress and discuss the work that is to follow. After each of these meets, they prepare a quarterly report, to be submitted by the PI to ITRA. The contents of the reports are specified in a report template to be provided to the teams by ITRA.
2. **Semi-Annual Focus Area Meet for ITRA Feedback:** Along with the usual 2nd quarterly meet of the PIs and Co-PIs, there is a focus area meet aimed at providing feedback to the team. Each team, including PI, Co-PIs, PhD students and other researchers, participate in this meet. A subset of the mentors along with other experts provides their comments on the progress made and any suggestions to help enhance the quality of the planned subsequent work.
3. **Annual ITRA Meet for Performance Evaluation, Recognition and Planning:** This meet, coinciding with 4th quarter inter-team meets, is attended by the entire teams, including PI, Co-PIs, PhD students and other researchers, from all focus areas. One objective is to evaluate each team’s performance over the preceding year. Based on performance, a panel of mentors and experts makes decisions about whether in the following year the work plan of the team, participation of an II, the details of an activity, etc., should continue or if changes are needed, e.g., in the budgets, proposed work, etc. As another major objective, the panel recognizes students, IIs, entire teams, etc., for noteworthy performance with respect to the ITRA quality metrics and towards meeting various other ITRA objectives, by presenting various ITRA awards.

4.3.1 ITRA Awards

ITRA projects are fundamentally team oriented. Teamwork is necessary for many large undertakings in general, and it needs particularly strong attention in the Indian academia and research institutions. Towards this end, there is a need to have a performance linked incentive scheme (awards) for the ITRA teams. ITRA Awards are linked to the performance of the ITRA teams with respect to the fundamental objectives of ITRA. The policy for awards was approved in the third meeting of ITRA Governing Council. The summary of the awards is as follows:

Awards Category	Details
PhD Research Award	<ol style="list-style-type: none"> a) The award will have 2 levels – Exemplary and Outstanding, and will be given annually. b) The number of awards will be up to 5 at Exemplary level (i.e. 5% of the total PhD Students in the focus area) and 25 (i.e. 25% of the total PhD Students in the focus area) at Outstanding level. c) Award amounts will be 2 Lakhs at Exemplary level and 1 Lakh at Outstanding level. d) These awards will be given twice i.e. at end of year 1 and year 2 of the project.
PhD Dissertation Award	<ol style="list-style-type: none"> a) ITRA plans to give PhD Dissertation Awards, in the form of a citation only, without any monetary compensation. b) PhD theses of the ITRA students will be evaluated for quality and impact and those theses meeting a quality threshold will be given the award.

	<p>c) A citation along with a gold plated medal will be given to each awardee.</p> <p>d) These awards will be given twice i.e. at end of year 1 and year 2 of the project.</p>
Team Achievement Award Grant	<p>a) The award to the teams will be given in 3 categories, corresponding to the following groupings of the ITRA performance metrics: (i) Research, (ii) Curricular Impact, and (iii) Combined Societal Sensitivity and Outreach.</p> <p>b) Up to 1 team per category per focus area may be selected for the award per year.</p> <p>c) The award will have 2 levels – Exemplary and Outstanding.</p> <p>d) The award grant amount will be either Rs. 10 Lakhs (for Outstanding level) or Rs. 20 Lakhs (for Exemplary level).</p> <p>e) These awards will be given twice i.e. at end of year 1 and year 2 of the project.</p>
Foresight Award Grant	<p>a) Up to 1 team per focus area may be selected for the award.</p> <p>b) The award grant amount will be Rs. 10 Lakhs.</p> <p>c) This award will be given once at the time of approval of projects, i.e. in year 1.</p>
Partnership Achievement Grant	<p>a) The award will have 2 levels – Exemplary and Outstanding.</p> <p>b) The number of LIN-PIN pairs to be selected will be up to 1 at Exemplary level (i.e. 5% of institutions in a focus area), and up to 4 at Outstanding level (i.e. 15% of institutions in a focus area).</p> <p>c) Award amounts will be: Rs. 6 Lakhs at Exemplary level and Rs. 3 Lakhs at Outstanding level.</p> <p>d) These awards will be given twice i.e. at end of year 1 and year 2 of the project.</p>
Interdisciplinary Collaboration Award Grant	<p>a) The award will have 2 levels – Exemplary and Outstanding.</p> <p>e) The number of awardee pairs to be selected will be up to 1 at Exemplary level (i.e. 5% of institutions in a focus area), and up to 4 at Outstanding level (i.e. 15% of institutions in a focus area).</p> <p>b) Award amounts will be: Rs. 6 Lakhs at Exemplary level and Rs. 3 Lakhs at Outstanding level.</p> <p>c) These awards will be given twice i.e. at end of year 1 and year 2 of the project.</p>

Details of ITRA Awards can be seen at ANNEXURE 3.

4.3.2 International Travel of Researchers

The principal objective of ITRA is to catapult the quality and quantity of advanced IT research in India. Integral to this objective is further strengthening the sense of research quality and understanding of research methodology in the ITRA faculty, students and other team members, and building local and global collaborative relationships, including through interactions with mentors and other renowned experts in their domains.

One important way in which this can be realized is by helping Indian researchers present their work at international fora. In addition to the fact that most conferences accept papers under the condition that the each paper is actually presented by an author at the conference site, being at such conferences provides a valuable opportunity for face to face interactions and building relationships with professional colleagues. It is a standard method for the new researchers to connect and succeed. It may lead to closer collaborations and fruitful new research partnerships.

Since many of the major conferences are often held outside India, there is a need for supporting international travel by researchers. ITRA considers attending at least 2 good quality conferences annually to be essential for any research group to enhance the quality metrics by which their performance is to be evaluated. ITRA team members shall therefore be supported to present research papers at international conferences or workshops; etc. that have already been identified or accepted by ITRA as quality venues.

Details of International Travel of Researcher are available at ANNEXURE 6.

4.3.3 Attracting UG and PG students early on to pursue PhD

To enlarge the R&D base, ITRA plans to attract deserving undergraduate/master's students early on, i.e. while they are in the midst of their study programs (2nd year onwards for UGs and 1st year onwards for MS). They will be given an opportunity to be involved in ITRA projects, and thus be exposed to the project's nationwide, growing and dynamic environment, and to world class research practices, fora and researchers. This should lead to a positive change in student's perception of pursuing PhD in Indian institutions.

Student interns on the project will be compensated at the rates used by IITs. The following rates, being used currently at IIT Kanpur shall be adopted:

- i. Interns working full time (during summers):
 1. UGs: Rs. 8k-16k/month for up to 40 hrs/week
 2. PGs: Rs. 12k-24k/month for up to 40 hrs/week
- ii. Interns working part time (during the academic term):
 1. UGs: Rs. 60-100/hr for up to 10hrs/week
 2. PGs: Rs. 100-200/hr for up to 15hrs/week

Students working on part time basis will be given an amount on pro rata basis. The internship awards are planned to be at 3 different levels.

Selection: Identification of student interns will be done via a rigorous evaluation of their achievements as well as research disposition. A committee of faculty from institutions in the team considering offering internship to a student, chaired by Lead PI of the team, will assign a grade to the student. The grade will determine if the student is an acceptable match to the project and a good PhD prospect, and if so, where on the capability scale s/he is placed, and therefore, what the internship award level within the specified range should be.

ITRA Focus Areas

Focus Areas with societal relevance and national priority are chosen by ITRA Advisory Council for conducting research and development. To begin the pursuit of a selected focus area, a Strategy Formulation Meeting (SFM) is held to identify and discuss different aspects of the area and evolve a roadmap. Well known researchers and other relevant experts in the focus area, from India and abroad, are invited to the meeting. Subsequently, multi-institution teams are identified to conduct collaborative projects, each implementing a part of the SFM roadmap in the focus area.

Initially to identify the relevant IT activities, ITRA held discussion with the related MeitY groups and their ongoing and planned or desired activities. Correspondingly several focus areas were identified as possible IT and IT-in-X areas for ITRA to pursue, to begin its activities. ITRA began with two focus areas, viz., “Mobile Computing, Networking and Applications (*ITRA-Mobile*)”, and “IT based Innovations in Water Resources Sustainability (*ITRA-Water*)”. In *ITRA-Mobile*, 9 teams, consisting of 38 groups, and in *ITRA-Water*, 5 teams, consisting of 24 groups, have been selected and are currently engaged in research and development projects identified in their roadmaps. Two more focus areas, “IT Transformations in Indian Agriculture and Food (*ITRA-Ag&Food*)” with 6 teams and 36 institutions, and “Human Simulator for Amyloids Related Diseases (*ITRA-HuSim*)” has also been initiated.

5.1 ITRA-MOBILE: MOBILE COMPUTING, NETWORKING AND APPLICATIONS

This focus area is primarily aimed at work in IT itself, instead of IT-in-X that targets applications of IT to important problems, per our general approach to selecting focus areas described in the plan document. Within IT, it is motivated by simultaneously realizing two desirable properties. First, it involves multiple IT disciplines. This is result of the fact that mobility, networking and applications aspects each impose different constraints on basic formulation of the problems to be solved. Combining these with characteristics of test-bed scenarios relevant to India brings in additional constraints. The result is need for an integrated study of the following disciplines, each traditionally studied in the indicated familiar departments

- Communication Theory – Electrical Engineering
- Network Theory – Electrical Engineering, and Computer Science
- Graph Theory – Electrical Engineering, Computer Science, and Mathematics
- Dependable Systems – Electrical Engineering, Computer Science, Computer Engineering
- Communication Protocols – Computer Science and Computer Engineering
- Operating Systems – Computer Science

The traditional separation of these disciplines is somewhat natural consequence of how they got introduced and evolved as subjects of study. The proposed ITRA structuring of focus areas has the advantage of creating the desired but otherwise uncommon synthesis. This is because, being new, ITRA centers are free of factors that in traditional contexts require realigning of administrative and other organizational boundaries. Proposed ITRA centers would bring together researchers in all of these disciplines under the same unit. This, combined with the encouragement (albeit not a uniform, essential requirement) of team based mode of research can be expected to lead to fundamental advances, normally associated with deeply theoretical work. Simultaneously, the theory would have been motivated by more diverse practical constraints than is normal, combining elegance with applicability. Inter-disciplinarily these days is a much appreciated, but hard to realize, need, we therefore expect the proposed ITRA centers in this focus area will make their worldwide mark right from the start, from their formation itself, and later, of course, through the natural uniqueness of the work they produce.

ITRA focus on mobile devices, in the proposed interdisciplinary way, can therefore be expected to not only put India on the “science” and “fundamental advances” map of the world in related existing areas, but should also translate into unique new hybrid disciplines, teams and entrepreneurial activities.

The Strategy Formulation Meeting (SFM) for the area *Mobile Computing, Networking and Applications* held during October 10-12, 2011. The meeting was organized to identify, discuss and develop a research and development agenda focusing on this area. The meeting was attended by participants from academia, government, industry and NGOs, from India as well as abroad. Based on this meeting a Request for Proposal document was created, following the aforesaid team selection mechanism, 9 team projects consisting of 34 institutions, were identified under the focus area with approval of Hon’ble Minister of Electronics and IT. These nine projects were further classified into three clusters, and they share a theme, of Mobile Computing and Networking applied to one of three different application domains, namely, (i) Transportation, (ii) Healthcare and (iii) Disaster Management. The teams within any of these clusters have domain specific similarities, even though the problems they address are different. Collaboration among teams within a cluster is typically stronger than across clusters although not always as strong as within teams. List of projects in the focus areas is placed at ANNEXURE 7.

Status and achievements made so-far by the teams of *ITRA-Mobile* are as follows:

Summary of the quantitative measures of the progress achieved by eight *ITRA-Mobile* teams:

Area	Total Numbers (Since the project began)
1. Research and Development	240
# of Publications in Peer Reviewed Conferences included in the ITRA List or of the same Calibre	45
# of Publications in Major Peer Reviewed Journals included in the ITRA List or of the same Calibre	135
# of Peer Reviewed Conferences in which Project Personnel are Organizers (e.g., as Chairs, Reviewers, Committee Members, ..)	59
# of Peer Reviewed Journals included in the ITRA List or of the same Calibre in which Project Personnel are involved (e.g., as Reviewers, in editorial duties,)	120
# of invited talks given at major institutions, conferences	98
# of PhD students in the project	147
# of Masters students	166
# of Undergrad students	65
# of students supported to travel to conferences	4
# of Post-Docs	64
# of Tools/Technologies developed	16
# of Technical contests held for solving various technical/other field-relevant challenges organized by professional societies and other organizations from time to time	63
# of World renowned Experts involved with ITRA researchers	55/3442
2. Impact on Curriculum	
# of New Courses/Modules developed with enrolment	

# of New Labs	30
# of Courses/Modules updated in a major way with enrolment	26/1461
# of Labs Updated in a major way	18
# of New Textbooks authored/edited, Book chapters, Magazine, Articles, Case studies	45
3. Combined Outreach and Societal Sensitivity Development	
# of Patents	4
# of Startups formed or in formation	8
# of Summer/Winter/Monsoon Schools and # of Participants	23/406
# of other Short/Long Courses and # of Participants	41/470
# of Tutorials and # of Participants	38/650
# of Distance Education Courses and # of Participants	3/63
# of Seminars/ Seminars Series/Workshops/Conferences and # of Participants	80/1535
# of Open houses where the work being done by the team is exhibited to colleges, schools, public at large, etc., to increase their understanding and appreciation of research in science and engineering	18/200
# of Contests held for solving various outreach and societal sensitivity challenges organized by NGO and other organizations from time to time and # of Participants	38/173
# of Other Institutions in/outside the team impacted by the above	70
# of Major Collaborations with Industry	25
# of Major Collaborations with Government	16
# of Major Collaborations with NGOs	17
# of Major Collaborations with International Organization	9
# of Major Collaborations with Any Others	5
# of Technologies Transferred (Industry/Government/NGOs/ International Organization/ Others)	10
# of Solutions Provided (Industry/Government/NGOs/ International Organization/ Others)	24
# of Services Offered (Industry/Government/NGOs/ International Organization/ Others)	28
# of Licenses Granted (Industry/Government/NGOs/ International Organization/ Others)	1
# of Consultations Offered (Industry/Government/NGOs/ International Organization/ Others)	22
# of Industrial Board Memberships (Industry/Government/NGOs/ International Organization/ Others)	20
# of Other Outreach Activities	29

5.2 ITRA-WATER: IT BASED INNOVATIONS IN WATER RESOURCES SUSTAINABILITY

ITRA-Water is focused on the challenge of sustainable access to water – which is a problem reaching crisis proportions across India. Water will become the bottleneck for economic growth of the country affecting all sectors including food and agriculture, industry, energy, and human health. This is a multifaceted challenge and it involves rapidly declining water quantity and quality in surface and groundwater resources, extremely variable distribution in space and time affecting availability and access, and devastating consequences of floods and droughts driven by uncertainty of strength and timing of monsoon system. The demand for water driven by agriculture, industrial, consumptive and livestock needs is increasing rapidly. This is further compounded by effects of climate change that is increasing glacier melt rates, changing frequencies of floods and droughts, and impacting natural and human demand for water. The solution of water issues requires consideration of water, energy, food and human health as an integrated problem. Human rights and social justice are also an integral part of the solution needs. Significant progress can be made by enabling locally informed, locally relevant and market efficient solutions through empowerment of the community that is blended/overlaid with centrally planned and policy driven solutions.

The Strategy Formulation Meeting (SFM) for *ITRA-Water* held during September 28-30, 2011. The meeting was organized to identify, discuss and develop a research and development agenda focusing on this area. The meeting was attended by participants from academia, government, industry and NGOs, from India as well as abroad. The SFM identified four grand challenges in the area of Water Resources Sustainability using IT:

- i.) Improving hydro-meteorological prediction for economic development,
- ii.) Improving groundwater levels and quality through enhanced water use efficiency in agriculture,
- iii.) Total urban water management to achieve 24/7 availability, and
- iv.) Inter-basin water transfer for integrated water resource management.

These grand challenges are to be addressed using multi-institution collaborative. In this context, IT is interpreted broadly as cyber infrastructure to include communication, computational, and collaborative technologies; sensors and sensor systems; data management and data mining technologies; and knowledge and decision support systems. *ITRA-Water* will serve as a catalyst for developing scientific and IT capacity through a paradigm shift in educational and training modalities, as well as support economic and policy solutions to foster multifaceted, comprehensive and sustainable solutions to present and emerging water challenges. *ITRA-Water* envisions open sharing of data, model and information as a core value for progress; and considers innovative and imaginative inter-disciplinary cross sector collaboration across educational, private and government institutions, NGOs, national laboratories, etc., as being essential for addressing the water challenge.

Based on the SFM report, a RFP document was created. As per the team selection mechanism, 5 team projects consisting of 24 institutions were identified under the focus area with approval of Hon'ble Minister of Electronics and IT. These projects were further classified into four clusters, and each cluster shares a theme of IT based innovation in water resources sustainability, applied to one of two different application domains, namely, (i) Improving groundwater levels and quality through enhanced water use efficiency in agriculture; (ii) Total urban water management to achieve 24/7 availability. The teams within any of these clusters have domain specific similarities, even though the problems they address are different. Collaboration among teams within a cluster typically stronger than across clusters although not always as strong as within teams. List of projects in the focus areas is placed at ANNEXURE 8.

Summary of the quantitative measures of the progress achieved by 5 *ITRA-Water* teams:

Area	Total Numbers (Since the project began)
1. Research and Development	50
# of Publications in Peer Reviewed Conferences included in the ITRA List or of the same Calibre	30
# of Publications in Major Peer Reviewed Journals included in the ITRA List or of the same Calibre	22
# of Peer Reviewed Conferences in which Project Personnel are Organizers (e.g., as Chairs, Reviewers, Committee Members, ..)	43
# of Peer Reviewed Journals included in the ITRA List or of the same Calibre in which Project Personnel are involved (e.g., as Reviewers, in editorial duties,)	125
# of invited talks given at major institutions, conferences	38
# of PhD students in the project	51
# of Masters students	44
# of Undergrad students	24
# of students supported to travel to conferences	0
# of Post-Docs	23
# of Tools/Technologies developed	26
# of Technical contests held for solving various technical/other field-relevant challenges organized by professional societies and other organizations from time to time	47
# of World renowned Experts involved with ITRA researchers	
2. Impact on Curriculum	
# of New Courses/Modules developed with enrolment	17
# of New Labs	22
# of Courses/Modules updated in a major way with enrolment	10
# of Labs Updated in a major way	17
# of New Textbooks authored/edited, Book chapters, Magazine, Articles, Case studies	
3. Combined Outreach and Societal Sensitivity Development	
# of Patents	6
# of Startups formed or in formation	8
# of Summer/Winter/Monsoon Schools and # of Participants	18-283

# of other Short/Long Courses and # of Participants	15-189
# of Tutorials and # of Participants	4-82
# of Distance Education Courses and # of Participants	4
# of Seminars/ Seminars Series/Workshops/Conferences and # of Participants	48-408
# of Open houses where the work being done by the team is exhibited to colleges, schools, public at large, etc., to increase their understanding and appreciation of research in science and engineering	9
# of Contests held for solving various outreach and societal sensitivity challenges organized by NGO and other organizations from time to time and # of Participants	5
# of Other Institutions in/outside the team impacted by the above	42
# of Major Collaborations with Industry	13
# of Major Collaborations with Government	27
# of Major Collaborations with NGOs	7
# of Major Collaborations with International Organization	15
# of Major Collaborations with Any Others	4
# of Technologies Transferred (Industry/Government/NGOs/ International Organization/ Others)	5
# of Solutions Provided (Industry/Government/NGOs/ International Organization/ Others)	48
# of Services Offered (Industry/Government/NGOs/ International Organization/ Others)	10
# of Licenses Granted (Industry/Government/NGOs/ International Organization/ Others)	0
# of Consultations Offered (Industry/Government/NGOs/ International Organization/ Others)	13
# of Industrial Board Memberships (Industry/Government/NGOs/ International Organization/ Others)	28
# of Other Outreach Activities	22

5.3 *ITRA-AG&FOOD*: IT BASED TRANSFORMATIONS IN INDIAN AGRICULTURE AND FOOD

The prime objective of *ITRA-Ag&Food* is to create collaborative, multi-institutional, inter-disciplinary teams to catapult the state of Agriculture & Food (Ag&Food) into a new orbit of productivity using IT. IT here may be interpreted broadly as cyber-infrastructure that would help enable the desired paradigm shift in Ag&Food, by integrating into Ag&Food operations capabilities such as environment and location sensing, communication, data management, modeling, simulation and data mining. The work under this initiative, primarily focused on inter-disciplinary R&D on current and emerging Ag&Food challenges with the necessary cross sector (e.g., among IT, Ag&Food, etc.) collaboration, will be expected to simultaneously impact educational and training modalities, demonstrate that Ag&Food are an important arena for advanced and creative IT activity with much societal returns and satisfaction, and enable a range of entrepreneurial and other outreach activities. Given that a significant fraction of the work in Ag&Food field tends to have high degree of applicability in relatively short term, and given the scale of field, impact can be very significant, the proposals are expected to lay out clearly how the proposed work is going to integrate outreach activities to make a major field impact. The outreach activities include development of IT-driven Ag&Food systems designed by IT and Ag&Food experts, from government, academic, research, industrial, non-governmental and extension organizations. Another important outcome of outreach part is economic and policy approaches conducive to the multifaceted, comprehensive and sustainable solutions targeted by the R&D work. Given two otherwise comparable proposals, the one that has a larger role for IT in it will be given preference.

The following examples of IT based interventions are likely to lead to an increase in Ag&Food productivity: IT can help the average Indian farmer obtain relevant information on markets, inputs, technologies and financing; IT can help in bridging the knowledge gap as it permits geographically distributed organizations to work together more effectively, allowing them to provide mutual mentorship and support; IT can link agricultural producers to increasingly globalized production chains and help develop trade opportunities; and IT can support taking the long-term view, with tools for understanding and planning the future effects of today's economic and land use decisions.

Significant research advances are taking place in IT (data management, information systems, communication, sensor networks, modeling and simulation, data mining, etc.) and agriculture (green house technologies; high yielding, climate resistant and draught resistant varieties; new storage techniques; etc.). IT and agricultural researchers are both making independent and isolated efforts. The current need is to start collaborative projects carried out by interdisciplinary teams consisting of researchers from agricultural and IT sectors.

Succinctly, what is needed is a large number of institutions – faculty and PhD students - collaborating intensely on advanced research and development motivated by specific challenges faced in the field. These teams should simultaneously develop and improve curriculum on a regular basis. For creatively identifying and formulating problems, the team members need to develop an awareness of them in daily life. Finally, there need to be effective mechanisms to enable transfer of the technologies to real world.

SFM for the area *ITRA-Ag&Food* was held during March 15-16, 2013, in collaboration with the Indian Council of Agricultural Research (ICAR). The meeting was organized to develop a plan of research and development towards realizing large scale field use of IT in agriculture and food in India. The meeting was attended by participants from academia, government, industry and NGOs, from India as well as abroad. Based on this meeting a Request for Proposal document was created. The agriculture and food problems were listed under five categories: crop production; soil, water and weather; agriculture education and extension; marketing and agri-business; and livestock and fisheries. In this section we give a brief description of each category and provide a list of corresponding problems.

- (i) **Crop Production:** Under this category we consider production related issues pertaining to cereals, pulses, fruits, vegetables, spices, flowers, oilseeds, etc. The topics under crop production include seed production systems and planting material, crop production systems, protected cultivation, farm mechanization, farm management, precision farming, pest/disease management, biotic stress management, post harvesting management and food processing systems.
- (ii) **Soil, Water, and Weather:** This category covers issues concerning better management of soil, soil mapping, weather forecasting, abiotic stresses, environment management, disaster management, and natural resources management.
- (iii) **Agriculture education and extension:** We must cultivate the next generation of students', scientists', and professionals' practical and advanced research skills. Related goals are extending crop technologies to stakeholders (including farmers), reducing the lab to land gap, improving capacity building/training of stakeholders, and providing real-time advisory to farmers, and establishing farmer expert connectivity.
- (iv) **Marketing and agri-business:** The areas include efficient procurement, storage and supply of quality agricultural produce and processed goods to consumers, sale of produce by farmers, market intelligence, etc.
- (v) **Livestock and fisheries:** This category is about scientific herd/flock management, management of semen stations and information on availability of semen, milk collection, storage and processing; production and availability of fish seed; marketing of fish and aquaculture produce; marine fishing and logistics; fish processing; and production, protection, education, extension, and marketing of animals and animal products.

Activities undertaken from selection of proposals:

- i. Request for Proposals (RFP) was developed and floated in Nov 2014 based on the recommendations of Strategy Formulation Meeting held in Mar 2013. In response of this RFP, ITRA received a total of 219 EOIs.
- ii. These EOIs were reviewed by a panel of domain experts, who shortlisted 26 EOIs and recommended them to be clubbed into 18 Full Proposals (FPs).
- iii. These teams were called for a full proposal development meeting in May 2015 to maximize the quality of the final proposals, and coverage of the RFP topics by the shortlisted teams. The teams were asked to modify their FPs to cover the *ITRA-Ag&Food* focus area well and re-submit.
- iv. The revised FPs were evaluated by a Review Panel who classified them into five categories of merit. Another proposal on post-harvest losses, developed in consultation with ITRA with external funding possibility, was also reviewed and shortlisted.
- v. 12 projects covering top 3 categories were presented during the EC meeting held in Nov 2015, where EC suggested some modifications in 10 proposals and recommended these 10 proposals (including the post-harvest loss proposal) to be processed further. 2 proposals were recommended to be funded under North-East budgetary component.
- vi. Out of these 10 proposals, the 9 proposals that were selected at EOI stage were taken up with the EC again during Feb 2016. EC recommended 8 proposals to be funded under *ITRA-Ag&Food*, if funds were available. One remaining proposal was referred back to the review panel, as it had some change in team structure.
- vii. Due to paucity of funds from MeitY, final 8 proposals along with one proposal which was referred back, were presented before the EC during May 2016 for recommendations for funding. EC noted that the fund flow to ITRA has not been very good, and recommended that ITRA may initiate the 2 proposals which were earlier recommended to be funded under North-East budgetary component. EC also recommended V-Fisheries proposal with the reconstituted team be evaluated by the review panel and then again put before EC for further recommendations.
- viii. 9 proposals including V-Fisheries, after re-evaluation by review panel, was put up before GC during July 2016, for financial recommendations. GC noted that ITRA-Ag&Food proposals

should be implemented as proposed. GC also recommended that MeitY should find a way to fund the selected Ag&Food proposals.

- ix. The 2 North-East proposals were initiated by ITRA, as per the recommendations received from EC. Administrative proposals for these 2 proposals were released during Nov 2016.
- x. ITRA approached ICAR for joint funding of 4 proposals under ITRA-Ag&Food. Multiple meetings were organized between ICAR and ITRA officials. One such meeting was organized during Dec 2016, between DG, ICAR and ITRA, during which unanimously it was decided that ITRA will be submitting an Umbrella project to NASF with an integrated budget. In which, ITRA will be acting as the Lead Institution, with four original proposals acting as integrated components of the umbrella project.
- xi. Now, ITRA has prepared the umbrella project to be submitted to ICAR following proper channel and forwarded by the Head of the Institution for further processing at their end.

5.4 ITRA-HUSIM: HUMAN SIMULATOR FOR AMYLOIDS RELATED DISEASES

ITRA, in coordination with DBT, conducted SFM during January 15-17, 2015, to develop a roadmap for Human Simulator for Amyloids related Diseases. The SFM was conducted with participation of about 50 eminent IT researchers, health scientists and clinicians. SFM identified challenges associated with the understanding of the proteins called amyloids that have been implicated in a variety of diseases, including Neurodegenerative diseases, Type 2 Diabetes, Steatohepatitis and various other diseases. These diseases are expected to be the cause of a significant burden in the coming decades. SFM discussed the impact of amyloids, amyloid precursors and Mallory Body proteins on the human body, and their roles in the aforementioned diseases. These proteins are known to misfold and form plaques and aggregates under certain conditions. The major organs impacted include, brain, liver, kidney, and pancreas. SFM concluded that the understanding of the formation, transport, misfolding and plaque formation mechanisms, and their impact on the organs will vastly increase our ability to successfully treat the diseases caused by proteins. Specifically, the SFM participants were asked to identify the mechanisms and modeling and clinical treatment options that should be investigated under *ITRA-HuSim*. Based on this meeting a Request for Proposal document was created. The basic objective of the focus area of *ITRA-HuSim* is to address the most important challenges being faced by the clinicians today, by furthering therapeutic options available to them and their efficiency at analyzing them. Clinicians must often assemble their reasoning from answers to specific questions that arise along the way. Finding clear answers to some of them may be relatively straight forward but slow. A central objective of the simulators being targeted here is to carry out the corresponding low level tasks, and shoot back the required intermediate information readily as the clinician focuses on the big picture.

With respect to a specific clinician, the simulators will help with a specific type of disease or a family D of diseases. The scope of this RFP is on chronic diseases most associated with amyloid and amyloid-like proteins, and known to have a large burden. Proposals should be directed primarily at the set of diseases $D = \{\text{Alzheimer's, Parkinson's, Frontal Temporal Dementia, Steatohepatitis, Diabetes-II, Amyloids related Nephritis}\}$, which can affect the brain, liver, pancreas and kidney.

A simulator will help a clinician model disease related processes and interventions. It would model a specific body process, and help find answers to questions in silicon without running actual experiments on humans or animals. The process modeled may be of different types. It may: (i) be confined to one or multiple organs; (ii) involve body phenomena of different types, e.g., corresponding to biochemical, pharmacological, anatomical, tissue-geometric and vascular; (iii) have different scopes, e.g., pathways; and (iv) capture body behaviors at the levels of molecule, cell, organ, organism, or an entire population.

With the simulator, a clinician may be able to try out different hypotheses about a process. Since a disease is combination of many types of processes, an appropriately assembled network of simulators will help identify and integrate different types of available information pertaining to a disease and develop a model for its state. The clinician may reconstruct the condition of a particular patient with a specific disease and experiment with it, e.g., with different options available for diagnosis; therapy; prognosis; prevention; and intervention by drugs, novel agents, drug combinations, dose-time protocols and prediction of risks associated with them. The network may thus function as an in-silico clinical trial platform.

Activities undertaken for selection of proposals:

- i. Request for Proposals (RFP) was developed and floated in Mar 2015 based on the recommendations of Strategy Formulation Meeting held in Jan 2015. In response of this RFP, ITRA received a total of 32 EOIs.
- ii. These EOIs were reviewed by a panel of domain experts, who shortlisted 23 EOIs and submit their FPs.
- iii. In response 21 FP/teams were called for a full proposal development meeting in Sep 2015 to maximize the quality of the final proposals, and coverage of the RFP topics by the shortlisted

- teams. The teams were asked to modify their FPs to cover the ITRA-HuSim focus area well and re-submit.
- iv. The revised FPs were evaluated by online reviewers. Based on the reviews, the FPs were classified into two groups. 4 proposals in the first group, which received the best reviews, were decided to be invited for a presentation before a review panel. The second group which had remaining 17 FPs, were asked to resubmit their proposals based on reviewers' comments.
 - v. A teleconference with representatives from the 17 teams was conducted in Feb 2016. Teams were given feedback on their proposals and were asked to revise and resubmit their proposals.
 - vi. 4 teams made presentation before the review panel in Feb 2016. 3 FPs were shortlisted and asked for revisions and resubmission, and the last remaining FP was rejected. All three teams submitted their revised proposals.
 - vii. The 17 revised proposals were discussed by a Review Panel on July 5, 2016. After several rounds of discussions electronic and telephonic, it was decided that 6 proposals may be considered after revision and the other 11 be dropped.
 - viii. These 9 proposals are being reviewed and ITRA is awaiting necessary permissions and grants from MeitY to pursue this initiative.

ITRA Pilot Technologies for Possible Transfer/Start-Ups

ITRA began a new thrust on taking research results towards development and deployment of technologies for major national problems. Robust solutions are being demonstrated by the projects which will extend to the domains of many other societally important sectors. These solutions/technologies are designed to target important problems, they would be well aligned with Hon'ble PM's Digital India, Startup-India-Standup-India, Make-in-India and Skill-India initiatives.

ITRA identified research results that held most promise as deployable solutions and nurtured them towards an independent start-up by:

- a. Working closely with the potential technologies and regularly monitoring and evaluating them with the help of domain experts from industry and academia.
- b. Working out mock drill plans for most of them and motivating them to identify impact of their technologies for key stake holders and in turn to the society.
- c. Holding workshops with stakeholders for promising technologies which not only help to provide critical feedback concerning real time scenario but also create an awareness about the developed technology among the stakeholders from government and industry.

By the result of aforementioned processes, 17 technologies/business plans were identified and possible Start-ups were formed out of them. To nurture these possible start-ups, ITRA has formulated a joint program with NASSCOM, under which NASSCOM will mentor the possible start-ups and connect them with the Venture Capitalists (VCs).

The program began with NASSCOM Product Conclave in October 2016, where 8 of the possible start-ups demonstrated their solutions. In a highly unusual development, two of the possible start-ups were offered on the spot VC funding namely 'S-Mask: A device for monitoring Chronic Obtrusive Pulmonary Disease Patients' and 'Smartways: Smart-phone based solutions for Real Time Bus Information, Accident Detection & Accident Forensics, All start-ups are now in the midst of follow up activities.

Subsequently, NASSCOM had also invited ITRA teams to join its 10,000 start-up program so that ITRA teams may benefit from NASSCOM Warehouse events organized for young start-ups and avail opportunity to connect with investors, mentors, and corporates and be part of trainings, workshops, hackathons conducted by NASSCOM's industry partners. Participation in warehouse events of NASSCOM had given the registered start-ups access to dedicated desks, meeting rooms, event spaces, and a spaces to unwind within the warehouse. Beyond this, start-ups were also given the opportunity to connect with investors, mentors & corporates and be a part of trainings, workshops, hackathons conducted by NASSCOM's industry partners such as Google, Microsoft, IBM, Facebook, Amazon, Digital Ocean and Kotak among others.

In addition to that ITRA is constantly encouraging its start-ups to make presentations to other professional bodies with the aim to constantly refine their technology/product and to achieve a sustainable economic model for their start-ups. Some of the professional bodies which our technologies have approached are:

- 1) **Action for India (AFI) Forum:** AFI Forum is the annual flagship event of Action For India, bringing 100 hand-picked social innovators together with 100 influencers, including donors, IAS officers, technology leaders and impact investors to help those entrepreneurs scale their organizations. The Forum aims to benefit social entrepreneurs working in the following six sectors – agriculture, education, energy, healthcare, financial inclusion and livelihoods. 6th Annual AFI Forum was scheduled during Jan 24-25, 2017 at India Habitat Centre, New Delhi.

- 2) **Industry Innovation Programme on Medical Electronics (IIPME):** IIPME is a collaborative initiative between the "Ministry of Electronics and Information Technology (MeitY)", and "Biotechnology Industry Research Assistance Council (BIRAC)". This programme promotes scientific and technological research in Medical Electronics sector in India to address the pressing challenges associated with the development of innovative medical electronics and makes it available, accessible and affordable to the people at the bottom of the pyramid. The project aims to fund a portfolio of Indian lead pilot Projects that seem to target innovations in the multi - disciplinary areas comprising of electronics, engineering, medical devices, healthcare, software, algorithms and information technology.

BIRAC has identified 4 potential areas which need special attention of government initiatives and have potential of changing Medical Electronics arena, which are: Imaging and navigation, Technologies for chronic diseases, Convergence of medical device and bioinformatics and Increasing the Outreach through Medical electronics. This would offer the Start-ups an opportunity to secure seed grants and early transitions for their start-up teams.

- 3) **Atal Innovation Mission (AIM):** Atal Innovation Mission (AIM) including Self-Employment and Talent Utilization (SETU), which is Government of India's endeavor to promote a culture of innovation and entrepreneurship. Its objective is to serve as a platform for promotion of world-class Innovation Hubs, Grand Challenges, Start-up businesses and other self-employment activities, particularly in technology driven areas.

AIM has two core functions:

1. Entrepreneurship promotion through Self-Employment and Talent Utilization wherein innovators would be supported and mentored to become successful entrepreneurs
2. Innovation promotion: to provide a platform where innovative ideas are generated

Currently AIM has shortlisted 17 established incubation centers (ICs) for scale-up support. These centers would act as focal point to provide necessary and adequate infrastructure along with high quality assistance or services to start-ups in their early stages of growth.

- 4) **Indian Software Product Industry Round Table (iSPIRT):** The iKen program of iSPIRT - A think tank formed by leading practitioners to build a healthy, globally-competitive and sustainable software product industry.

iKen is a boot camp aimed at people planning a start-up or in the early stages of the startup. It is by entrepreneurs for entrepreneur model and based on effectuation model put forth by Prof. Saras Saraswathi and conducted by entrepreneurs who have gone through the same model.

iKen program is conducted in a toastmaster format, one is encouraged to attend the meetings even after the camp gets over. The mandatory part is a 6-week exercise/task oriented course designed at gaining clarity and action plan on the ideas. The participants do most of the work during the week and review of the task happens at 2-hour meet every weekend. The community continues to meet to help each other through their journeys even after the program.

ITRA continuously notifies and encourages all possible start-ups to participate in such events to refine their technologies and find support for all start-up needs.

Examples of ITRA Pilot Technologies for Possible Transfer/Start-ups

1. The technologies listed on the following pages have resulted from the first two focus areas, *ITRA-Mobile* and *ITRA-Water*. Each is the result of collaboration among, in general, several institutions. They are being pursued for possible transfer through start-ups.
2. Some of the startups have already made presentations to the Venture Capitalists, etc. (VCs). They are now in follow up discussions.
3. These as well as all other startups plan to make presentations at other similar conclaves
4. The technologies listed under the third focus area, *ITRA-Agriculture and Food*, are the *expected* results of the selected project activities in the focus area.

1. ITRA-Mobile (Projects Initiated in 2014)	
1.	<p>SmartWays** ++: A smartphone based system for real time bus information, remote collision detection, and pre-collision vehicle path forensics.</p> <p>This technology aims at improving the transit experience of commuters, starting with public buses. A Smartphone Application will in one click provide commuters real time information about transit route, the core of which includes estimated bus arrival time and occupancy level. Monetization will be done through location based advertisements and expanding the application to private bus and cab services. An analysis tool will also be provided to analyze the sensed trajectories of the vehicles to detect collisions among vehicles and analyzing the vehicle movements that preceded them.</p>
2.	<p>e-Homes**: An automated system to sense, analyse, conserve and provide advice for enhancing home energy usage.</p> <p>This solution would detect the need of the various appliances, e.g., by detecting presence of people, temperature, etc., and turning lights, fans and other home appliances on and off accordingly. It is thus expected to reduce the energy footprint of households.</p>
3.	<p>Cardio Watch**: A low-cost, cuff-less, continuous Blood Pressure monitoring solution.</p> <p>A robust, low-cost, calibration-free, continuous and cuff-less blood pressure recording and monitoring system. The data is automatically transmitted to a cloud based service for reporting, analyzing and saving in a medical database.</p>
4.	<p>Cough Analyzer**: A cough and wheeze analysis tool for respiratory health services.</p> <p>A web based tool for lab free monitoring of respiratory diseases such as Asthma, Tuberculosis and Pneumonia with an in-built automatic cough, wheeze analysis and with an ability to generate early diagnosis report or patient recovery report which can be used by physicians, care takers and family members.</p>
5.	<p>S-Mask** ++: A device for quantitative analysis of exhalation useful for monitoring chronic obstructive pulmonary disease patients</p> <p>A low cost device for digital measurement of vital exhalation related parameters such as tidal volume, residual volume, minute ventilation and forced exhalation volume, helpful in treating Asthma patients. It replaces the current system that involves forcefully breathing into a pipe which pushes up a ball at the other end, and noting the height to which the ball rises.</p>
6.	<p>ForkIT: A service to establish ad hoc communication networks at short notice in disaster-struck areas by scatter-deploying mobile phones and interlinking them.</p> <p>Even when conventional communication infrastructure is fully or partially disabled, these quickly established self-sustaining network and services act as a platform for collection, dissemination and map-based visualisation of situational information, to aid rescue-relief</p>

	activities during and after the golden hours of a level 3 kind of disaster.
7.	<p>Smart Phone Lab: A smartphone kit to serve as a LINUX PC and allow experimentation with various theoretical concepts in computing - by allowing freedom to combine different operating systems, hardware interfaces, and applications.</p> <p>One specific application that the technology would have is in raising the average quality of technical education, e.g., in teaching of courses on Embedded Systems, Communication Systems, Mobile Computing and Internet of Things which require matching lab environments. While on the one hand it would provide a versatile pedagogical platform for bridging the gap between teaching/learning of theory and practice of such diverse ICT subjects, the use of ubiquitous mobile devices as the base would make the platform it affordable to institutions where the lab facilities may be lacking, thus significantly broadening the impact on technical education.</p>
8.	<p>Piscean Net Solutions: A service to guide offshore fishing boats with real time information from the shore, and disseminate information collected by the individual boats to all the boats and to the shore.</p> <p>This technology provides an information portal for communication among offshore fishing boats, and between boats and the shore. The portal is accessible to both ends and acts as a continuously updated repository of information extracted by the boats and that available on the shore, e.g., by broadcasting information obtained by individual boats like locations and types and sizes of fish schools, and shore information like latest market demand and prices to help fishermen direct their effort at the best available catches.</p>
9.	<p>Soft Wireless Mesh Nets: A hybrid approach of traditional networking and software defined networking for wireless networks and wireless mesh networks.</p> <p>These technologies enable Software Defined Wireless Networks for fine grain management and performance enhancement of single as well as multihop wireless networks, useful for enterprise wireless LANs, heterogeneous cellular networks, military wireless mesh networks, and rural civilian communication networks.</p>
10.	<p>OffshoreNet: A dynamically configured wireless system to establish communication among small radio units located on off-shore fishing boats, and between boat-clusters and shore.</p> <p>This technology solves the challenging problem of establishing a wireless communication network at sea, among scattered fishing boats, out of the reach of the communication towers present on the shore. It allows the fishermen to talk among themselves, as well as with the shore.</p>
11.	<p>MediCloud: A very affordable solution for remote healthcare delivery.</p> <p>A hardware and software healthcare system for telemedicine kiosks/mobile units, designed to function under rural Indian conditions - with capabilities including communication with remote doctors through cloud, and data entry and extraction interfaces suitable for operation by the unskilled - to take healthcare to the door of every citizen, including in rural areas.</p>
2. ITRA-Water (Projects Initiated in 2014)	
1.	<p>Floodlite**: A service to forecast, analyse the effect of, and manage urban floods, and to design water drainage networks.</p> <p>This service will help guard against flash floods, it would prepare manufacturers, real estate companies, insurance companies and other businesses plan their business operations (inventories, etc.), services, material flow, etc., to minimize adverse impact from the floods.</p>
2.	<p>AgroCast**: A real time 7-30 day drought forecast and its use in the selection of crops to be planted.</p> <p>This technology makes high resolution satellite data to provide real-time conditions and forecast water availability at different spatial (industry, block, district, watershed, and state level) and temporal (daily, weekly, monthly and seasonal) scales.</p>

3.	<p>Drinking Water Management: A system for sensing and wirelessly disseminating consumer water quality (contamination) and flow (leakage) information in large urban water distribution networks.</p> <p>This technology enables remote monitoring of quality and flow rate (quantity) of water in a region of interest (geographical area, high-rise complex, etc.) through a variety of distributed sensors. It includes a decision support system for continuous analysis of this data, and raising alerts through e-mail/SMSs/alerts on discovery of any violations of WHO norms on water safety, and usage and flow patterns, appropriately taking into account any relevant local and application contexts.</p>
4.	<p>SenseTube: A hardware/software device to integrate sensor data, human-provided information, computational models and wireless communications to manage crop resources</p> <p>Senstube collects data from wireless agricultural sensors, integrates it with data and information provided by humans, and from these inputs performs process based modeling for agricultural crop water management, plant diseases, prediction of various related parameters, and yield improvement. The final goal is to provide advice to the growers on weather, irrigation needs and fertilization requirements.</p>
5.	<p>Hydrology & Groundwater Consulting: A service for detecting and estimating the size of ground water resources in hard rock aquifers of India.</p> <p>This service provides consultancy in the fields of hydro-geology and groundwater in hard-rock aquifers of India, at scales ranging from field to watershed, through ElectroResistivity Tomography, Borehole Logging and Aquifer Storage and Recovery.</p>
6.	<p>Ground Water Recharge Consultancy: A service to optimally locate water recharge sites and tube wells.</p> <p>This service is for locating recharge sites for directing ground water flows, while ensuring sustainable and secure development and management of groundwater resources in a participatory manner in different river basins of India. Using a similar analysis and criteria, the technology also provides advice on locating water drawing sites, e.g., tube wells.</p>

** These startups have already made presentations to the Venture Capitalists, etc. (VCs) at the NASSCOM Product Conclave at Bengaluru on October 26-27, 2016.

++ These startups were made on-the-spot offers at the NASSCOM Product Conclave at Bengaluru on Oct 26-27, 2016.

TOP ITRA-AGRICULTURE&FOOD PROJECTS, SELECTED BUT YET TO BE AWARDED

MOST EXPECTED TO LEAD TO TRANSFERRABLE TECHNOLOGIES, E.G., THROUGH STARTUPS

Some Results Expected to Start Emerging Within Year 1

S. No.	Topic
1.	<p>Hyperspectral Imaging Based Soil and Crop Health Monitoring <i>Expected Impact:</i> There are about 1206 soil testing labs operating in the country with an annual analyzing capacity of 12.8 million samples. Government of India has launched soil health card programme in February 2015 to generate soil health cards for 140 million land holdings through testing of 24.8 million soil samples every three years. The existing soil testing facilities and infrastructure in the country cannot provide soil testing results at this pace. Consequently, rapid and in situ assessment of soil properties even in near-real time remains a formidable task despite decades of research and development in soil testing. Similarly, there is hardly any near real time system for monitoring and managing crop condition (biotic and abiotic stress) for optimizing yield. Hyperspectral remote sensing or imaging spectrometry is a most promising, if not the only, alternative to traditional soil testing, for real time crop stress monitoring on very large areas.</p>
2.	<p>Detection of Buffalo in Heat through Electronic Nose and Colorimetric Sensing <i>Expected Impact:</i> With an estimated population of about 55 million buffaloes, and assuming 10 productive years per animal, the approximately 50% miss rate of detecting one heat cycle leads to a loss of no less than 250 million litres of milk per year. Even an improvement of 50% in the detection rate will mean an enhanced yield of 120 million litres of milk per year.</p>
3.	<p>A Tracing System for Safe Pork Production in North-Eastern India <i>Expected Impact:</i> As results of the proposed system: Disease management alone will enhance farm income from pigs by 30%. Direct linkage between producers, processors and consumers will enhance income of the pig farmers by 25%. A piggery database could be developed, to serve as a single source repository of all related information.</p>
4.	<p>Sensor Based Postharvest Management of Selected Agri-Horticultural Commodities of Bihar <i>Expected Impact:</i> Non-availability of adequate storage facilities, existing methods of handling of grains in bags, and CAP storage at centralized locations and inclement weather conditions during post-procurement season contribute to the loss of about 40% of harvested food grains. A distributed storage system, with small silos managed through ICT will reduce the loss substantially. The proposed electrochemical sensors, integrated with packaging material, for evaluation of the ripening stage and quality of mango and litchi during handling, storage, transportation and retailing, will help handlers, transporters and distributors to reorient their marketing strategies to maximize returns from the products. The consumer on the other hand will be assured of quality.</p>
5.	<p>ICT Based Livestock Information, Service and Knowledge Management <i>Expected Impact:</i> Small farmers scattered in rural areas with a few heads each of cattle and buffalo are deprived of services of solution providers because of almost total information</p>

	<p>disconnect. A fraction of the potential of the livestock wealth of the country is realized. A system that integrate data gathered manually by farmers and those provided by the sensors and transmit the data through mobile phones will help connect the farmers and, solution & service providers. The DSS modules developed based on this system of data providing advice & service for timely And proper breeding, nutrition, health care and reproduction. Timely & cost effective services in managing the general health & reproductive health which are related to nutrition too, is estimated to provide a gain of about 2000 crores per year in the country.</p>
6.	<p>Image Based Systems for Identification of Individuals, Breeds and Diseases of Pigs and Goats <i>Expected Impact:</i> Providing insurance cover and services to small farmers will become easy and fool-proof, animal health monitoring and traceability will be feasible for the neglected animals, and conservation of indigenous genetic resources in situ will have a firm footing.</p>
7.	<p>Computer Vision Based Technology for Automating Fish Species Identification and Abundance Information for Biodiversity and Energy Conserving Fishery <i>Expected Impact:</i> Image based real time fish species identification and target species abundance estimation in real time is a technologically nascent field and this project will be counted among the pioneers. The application of the technology, in both the sea and rivers, will enable a drastic reduction in fish biodiversity loss due to catches of non-targeted species, as well as in energy and other associated costs.</p>
8.	<p><i>In Situ Measurement of Active Principles in Chemotypic Diversity in Medicinal Plants</i> <i>Expected Impact:</i> We have very little or no idea about the present status of the availability and diversity of most of the medicinal plants in the wild, and which ecologies yield the best quality plants. The technologies developed in this project will enable large scale and fast surveying of the chemotypic diversity, help in the conservation of diversity, help in breeding, and guide in development of the best agronomy for many species.</p>
9.	<p>Detection and Quantification of Pollutants in Inland Aquatic Ecosystems <i>Expected Impact:</i> Cheap technologies will be available for regular monitoring of pollution levels caused by pesticides, insecticides and endocrine disruptive chemicals in aquatic systems which have recently come into increased focus because of their adverse effects on humans, and on fish health, growth and reproduction.</p>
10.	<p><i>Diagnostic Systems for Pests and Diseases of Crops of Quarantine Importance</i> <i>Expected Impact:</i> A strong quarantine system is a must for protecting India's agriculture and plants against the entry of unwanted alien pests through imported seeds, planting material and plant parts. Identification of the pests today is still fully manual. With the tremendous increase in import of plant material, the chances of failure in detection have therefore been increasing steadily. An IT based system will drastically reduce failures and increase the efficiency of the quarantine system.</p>

ITRA Activities, Milestones and Achievements

7.1 ACTIVITIES UNDERTAKEN BY ITRA: 2010 – 2017

Legend:

	Administrative activities undertaken by ITRA
	Technical activities undertaken by ITRA

Timeline	Activity/ Milestones	Output
Oct 2010	Admin approval for ITRA project, given to MLAsia	→ Admin Approval given to MLAsia, and asked to complete the administrative formalities.
Dec 2010	Release of 1 st installment of funds	→ Rs. 14.33 Crs as 1 st installment was released to MLAsia for ITRA project → Commencement of ITRA project as per DeitY's Admin Approval
Mar 2011	Constitution of Program Steering and Implementation Group (PSIG)	→ PSIG constituted with approval of Hon'ble MCIT with following members: (i.) Prof. N. Ahuja, UIUC USA; (ii.) Dr U.P. Phadke, DeitY (retd.); (iii.) Mr V.B. Taneja, DeitY (retd.); (iv.) Prof. R. Sangal, IIIT Hyd; (v.) Dr G. V. Ramaraju, DeitY Representative. → Terms of appointment were finalized and approved.
Jun 2011	Formal Start of ITRA Technical Activities	→ Technical activities started in ITRA post joining of Prof Ahuja as Member and Co-ordinator of PSIG
Jun - Sep 2011	Technical activities by PSIG	→ PSIG interacted with various DeitY R&D groups to identify the complimentary role that can be played by ITRA in strengthening ICT eco system. → 2 Focus Areas were identified, viz, <i>ITRA-Mobile</i> : Mobile computing, Networking and Architecture, and <i>ITRA-Water</i> : IT Based Innovations in Sustainability of Water Resources.
Jun - Sep 2011	Administrative activities by PSIG	→ Mechanisms to initiate project activities were formulated and implemented → Constitution of the Governing Council (GC) and Advisory Council (AC) finalized and processed for approval → Planning and Actions on administrative matters, viz. Office Space, Recruitment, etc. → Planning of Strategy Formulation Meeting (SFM) for the selected focus areas.
Sep 2011	SFM on <i>ITRA-Water</i>	→ The meeting was attended by 50+ experts from academia, government and industry, from India as well as abroad. This SFM identified the following themes: <ul style="list-style-type: none"> - Improving Hydro-Meteorological Prediction for Economic Development - Improving GW Levels and Quality Through Enhanced Water Use Efficiency in Agriculture - Total Urban Water Management to Achieve 24/7 Availability

		<ul style="list-style-type: none"> - Inter-basin water transfer for integrated water resource management.
Oct 2011	SFM on <i>ITRA-Mobile</i>	<p>→ The meeting was attended by 50+ participants from academia, government and industry, from India as well as abroad. This SFM identified the following themes:</p> <ul style="list-style-type: none"> - Communication Theory - Network Theory - Graph Theory - Dependable Systems - Communication Protocols - Operating Systems
Dec 2011	RFP's floated for <i>ITRA-Water</i> and <i>ITRA-Mobile</i>	→ Requests for Proposals (RFP) for both focus areas were prepared and circulated.
Jan 2012	Constitution of ITRA – GC and AC	<p>→ ITRA GC was setup with the approval of Hon'ble MCIT and is chaired by the Secretary, DeitY. The GC has representatives from MHRD, Academia, and Industry. ITRA GC provides general guidance and supervision. It has full powers to decide and approve various policy matters of the ITRA.</p> <p>→ ITRA AC was setup with the approval of Hon'ble MCIT and is chaired by Prof. S. V. Raghavan, Scientific Secretary, and Office of the Principal Scientific Advisor to the Government of India. The AC consist of eminent persons and visionaries from IT, IT-in-X and related policy-making areas and from other disciplines of relevance.</p>
Feb – Apr 2012	Processing of proposals submitted for <i>ITRA-Mobile</i> and <i>ITRA-Water</i>	<p>→ The last date of receiving Expression of Interests was end of Jan 2012.</p> <p>→ For <i>ITRA-Water</i> – 30 EoIs and for <i>ITRA-Mobile</i> – 64 EoIs were submitted by deadline.</p> <p>→ EoIs were reviewed by experts and shortlisting of teams to submit Full Proposals (FP) was done: for Water 20 Teams; and for Mobile 30 Teams were shortlisted.</p>
Apr 2012	Meeting of ITRA AC	<p>→ Ratification of the areas already initiated: <i>ITRA-Mobile</i> and <i>ITRA-Water</i></p> <p>→ Probable candidates for new focus areas presented</p> <p>→ Food and Agriculture domain was recommended</p>
May – Oct 2012	Processing of proposals submitted for <i>ITRA-Mobile</i> and <i>ITRA-Water</i>	<p>→ FP Submissions were due in late May 2012 for both <i>ITRA-Mobile</i> and <i>ITRA-Water</i></p> <p>→ Review of FPs was done online by experts;</p> <p>→ Teams were asked to incorporate comments of the experts and re-submit their FPs by Oct 2012.</p>
Feb – Sep 2012	Drafting Technical/ Administrative/ Financial guidelines/ policies for ITRA	<p>→ PSIG drafted guidelines for Selection of Focus Areas; Proposal Submission, and Evaluation & Award Processes.</p> <p>→ Policy documents specifying recruitment rules and organizational structure were also drafted.</p>

Jul 2013	Meeting of ITRA AC	<ul style="list-style-type: none"> → 7 new probable focus areas were presented. → AC prioritized those areas → AC suggested that ITRA pick two areas to pursue in the near future, the rest to be considered subsequently.
Sep 2013	Brainstorming meetings on various probable focus areas	<ul style="list-style-type: none"> → Brain storming meeting on <i>Robust Electronics</i> was conducted on Sep 24, 2013 at New Delhi which was attended by 10 domain experts to prepare a white paper on the subject. → Brain storming meeting on <i>Computational Fluid Dynamics</i> was conducted on Sep 27, 2013 at New Delhi which was attended by 10 domain experts to prepare a white paper on the subject.
Sep 2013	Award of Projects	<ul style="list-style-type: none"> → 14 team projects worth Rs. 39 Crs were awarded with the approved of Hon'ble MCIT. → In <i>ITRA-Mobile</i>, 9 teams, consisting of 34 institutions, and in <i>ITRA-Water</i>, 5 teams, consisting of 20 institutions, were awarded projects.
Oct 2013	Release of second installment of funds to ITRA	<ul style="list-style-type: none"> → Rs. 16.27 Crs were released to MLAsia as second installment of funds for ITRA projects.
Nov 2013	Policy for post project award engagement with teams	<ul style="list-style-type: none"> → Meeting to draft framework for post project award engagements with teams was conducted. This was attended by around 10 experts mainly from Govt., and academia. → Subsequently framework was framed for: <ul style="list-style-type: none"> - ITRA Awards for students and teams - Interactions of ITRA Teams with Mentors - International Travel of ITRA Researchers - Adjunct Faculty Scheme - Attracting New Faculty
Dec 2013	Meeting of ITRA AC	<ul style="list-style-type: none"> → Two themes of national significance and need that may run through the detailed topics recommended at the 2nd AC meeting were discussed. → Two overarching focus areas, viz. Human Simulator and Diagnostic Dome, that unify several of the recommended topics, were identified and proposed to be pursued by ITRA.
Dec 2013	Meeting of ITRA EC	<ul style="list-style-type: none"> → 3rd meeting convened to plan ITRA project launch workshop and discuss ITRA's extension.
Jan 2014	Formal launch of <i>ITRA-Mobile</i> and <i>ITRA-Water</i> Projects	<ul style="list-style-type: none"> → 14 team multi-disciplinary, collaborative, multi-institutional R&D projects in the areas of "Mobile Computing, Networking and Applications (<i>ITRA-Mobile</i>)" and "IT based Innovations in Sustainability of Water Resources (<i>ITRA-Water</i>)" were launched. → All teams were briefed about ITRA's objectives, and methodology.

Apr 2014	Meeting of ITRA GC	<p>→ Draft policy for post project award engagement with teams, ITRA extension, and new focus areas, were presented in the 2nd meeting of GC.</p> <p>→ A sub-committee was constituted for formulating the policy for post project award engagement with teams.</p>
May - July 2014	Meeting of Sub-committee of GC	<p>→ Sub-committee drafted the schemes and policies for:</p> <ul style="list-style-type: none"> - UG and PG Student Internships - Performance Based Awards for Students and Teams - Interactions of Teams with Mentors - International Travel of Researchers - Interactions of Teams with Adjunct Faculty <p>→ Approved by Chairman – GC in Aug 2014</p> <p>→ Approval of DeitY was sought for implementation of the same in Aug 2014.</p> <p>→ IFD/DeitY recommended to seek approval in ITRA GC’s next meeting</p>
Aug 2014	Feedback Workshops of <i>ITRA-Water</i> and <i>ITRA-Mobile</i> projects	<p>→ Feedback workshop held in Bangalore to review and provide feedback to <i>ITRA-Water</i> teams.</p> <p>→ Feedback workshop held in Delhi to review and provide feedback to <i>ITRA-Mobile</i> teams.</p>
Oct 2014	Meeting of ITRA GC	<p>→ 3rd meeting of ITRA GC convened to seek approval on various schemes and policies, ITRA extension, plans for initiating two new focus areas, and external funding opportunities</p> <p>→ All schemes and policies were approved.</p> <p>→ Recommended to seek one-time dispensation of Dept. of Expenditure for all international travel.</p> <p>→ Recommended mid-term review of the functioning of ITRA, before seeking extension.</p> <p>→ Approved plans for new focus area.</p> <p>→ Asked ITRA to constitute a committee to formulate policy on external funding.</p>
Oct 2014	Meeting of PRSG	<p>→ PRSG for ITRA project constituted by DeitY under chairmanship of Prof UB Desai, Director, IIT Hyderabad</p> <p>→ 1st meeting convened to oversee the progress of ITRA.</p> <p>→ PRSG recommended the following:</p> <ul style="list-style-type: none"> - Revise targets of PhD students to 250 instead of 480. - Seek approval on international travel of ITRA researchers from PRSG on case to case basis - Release 30 Crs to MLAsia as next installment of GIA to ITRA project.
Nov 2014	Brainstorming Meeting for <i>ITRA-HuSim</i>	<p>→ Brainstorming was conducted to develop an outline of the HuSim initiative of ITRA – in terms of defining its scope, identifying the sciences, engineering disciplines, stakeholders, organizations, individuals, etc., to be involved to best realize that scope. This meeting was attended by around 15 eminent experts from Govt. departments, Research Institutions, Academia and Industry.</p>

Nov 2014	RFP for <i>ITRA-Ag&Food</i>	→ RFP for the focus areas were prepared and circulated.
Dec 2014	Meeting of ITRA EC	→ 4 th meeting convened to discuss (i) Addition of new PINs to the existing teams; (ii) To formalize eligibility criteria for Indian Academic Institutions in line with DeitY's PhD Scheme; (iii) Revisiting permissible budget heads for private institutions → EC recommended the following: - Seek recommendations of Review Panel on New PINs during Evaluation Workshop - Agreed to suggestions as made by ITRA on eligibility criteria with some modifications. - Agreed to release of Contingencies and Misc budget head to private institutions.
Dec 2014 – Jun 2015	Dispensation from Dept. of Expenditure (DOE) for supporting foreign travel of ITRA Mentors	→ As per directions of Governing Council, ITRA worked in tandem with the programme division at DeitY for seeking the dispensation from DOE for supporting foreign travel of 350 ITRA Mentors. → After multiple iterations of notings from DOE, approval for supporting 14 mentor visits till Dec 2015 was accorded.
Jan 2015	Evaluation Workshop for <i>ITRA-Mobile</i> and <i>ITRA-Water</i>	→ The Annual Evaluation Meeting of <i>ITRA-Water</i> and <i>ITRA-Mobile</i> was conducted in January, 2015. → 14 team projects were reviewed by panels of 10 to 15 experts in the respective fields. → Students presented posters for their respective projects. A total of 72 posters (33 for <i>ITRA-Water</i> and 39 for <i>ITRA-Mobile</i> projects) were presented during the course of the workshop.
Jan 2015	SFM for <i>ITRA-HuSim</i>	→ SFM on 'Human Simulator for Amyloids related Diseases' conducted in January, 2015. Participated by 60+ national and international experts, from the fields of Medicine and ICT&E.
Feb – May 2015	Processing of proposals submitted for <i>ITRA-Ag&Food</i>	→ In response to the RFP floated, ITRA received 200+ EOIs by the deadline of Feb 1, 2015. → These EOIs were reviewed by a panel of domain experts on basis of their quality, national importance and readiness of the proposal. → The review panel shortlisted 47 EOIs for further consideration. → An EoI Evaluation Meeting was conducted in April, 2015 during which the panel shortlisted 26 EOIs to be merged into 18 FPs in order to avoid overlapping in topic of importance.
Mar 2015	RFP for <i>ITRA-HuSim</i>	→ RFP for the focus areas were prepared and circulated.
Mar 2015	Release of 3 rd installment to ITRA	→ Rs. 8 Crs were released to MLAsia as third installment of funds for ITRA projects.
Apr 2015	Meeting of PRSG	→ 2 nd Meeting convened to discuss: Status of ITRA project; Modifications in existing <i>ITRA-Mobile</i> and

		<p><i>ITRA-Water</i> teams; ITRA project extension; Interaction and collaboration with UNESCO.</p> <p>→ PRSG recommended the following:</p> <ul style="list-style-type: none"> - Endorsed the recommendations made by Review Panel during Evaluation Workshop 2015 regarding changes/alteration in team structure. - To convene PRSG meeting preferably in May 2015, specifically for review of ITRA activities before recommending ITRA extension - Approved interaction and collaboration with UNESCO
Apr – Aug 2015	Processing of proposals submitted for <i>ITRA-HuSim</i>	<p>→ 32 EOIs received by the deadline of Apr 19, 2015</p> <p>→ Scrutiny of EoIs: 9 EoI teams were rejected as they did not meet one or more RFP criteria, Remaining 23 EOI teams were screened in for further processing</p> <p>→ Review of EoIs: These EOIs were reviewed by a panel of domain experts, who shortlisted 23 EOIs and submit their FPs.</p> <p>→ In response only 21 EoI Teams submitted their full proposals</p>
Apr 2015	Meeting of ITRA EC	<p>→ The fifth executive committee held to discuss: (i) Current status of ITRA; (ii) International travel funding; (iii) Formation of PI committees; (iv) Budgets for new institutions and enhanced budgetary requirements of existing institutions; (v) ITRA's extension</p> <p>→ EC recommended the following:</p> <ul style="list-style-type: none"> - ITRA project be extended up to March 31, 2019. - Approved constitution of ITRA PI Committees for: Inter-Institutional Affairs; Faculty Talent acquisition; International Programs; Technology Transfer; Organization of ITRA Meetings; Development of Societal Sensitivity Programs - Addition of the new PINs, to existing institutions. - Revision in project outlays, due to increase in fellowship amounts and outreach activities, and transfer international travel funds to the teams, of existing institutions may be taken up with competent authority.
May 2015	PRSG Meeting	<p>→ The Third PRSG meeting convened to discuss (i) ITRA's status; (ii) Extension of ITRA term;</p> <p>→ PRSG recommended the extension of ITRA project up to March 31, 2019</p>
May 2015	Governing Council Meeting	<p>→ The fourth GC meeting was convened to discuss: Status of ITRA activities; and Extension of ITRA.</p> <p>→ GC recommended the extension of ITRA up to Dec 31, 2018.</p>
May 2015	Full Proposal Development Meeting for <i>ITRA-Ag&Food</i>	<p>→ ITRA invited 18 teams to the Full Proposal development Meeting for further refining the shortlisted proposals.</p> <p>→ On basis of review panel's recommendations, these teams revised their FP's and re-submitted to ITRA by deadline of 24th July, 2015 for further consideration.</p>
Jul	Mid-Year Review for <i>ITRA-</i>	<p>→ The Mid-Year Evaluation Meeting of <i>ITRA-Water</i> was conducted at Univ. of Hyderabad campus.</p>

2015	<i>Water</i>	<ul style="list-style-type: none"> → 5 team projects reviewed by panels of more than 10 experts in the respective fields. → Students presented posters for their respective projects, and other discussions on Cleaning Ganga, Open Data Access in the Context of ITRA Projects, and Ideas for Outreach were discussed. → The workshop was concluded with the feedbacks from the panel to the teams.
Aug 2015	Mid-Year Evaluation Meeting for <i>ITRA-Mobile</i>	<ul style="list-style-type: none"> → The Mid-Year Evaluation Meeting of <i>ITRA-Mobile</i> was conducted in Delhi. → 8 team projects were reviewed by panels of more than 10 experts in the respective fields. → Students presented posters for their respective projects, and other discussions were held on technical challenges being faced by Ola Cabs, and Role of Mobile Computing and Networking for Disaster Management in the context of ITRA projects, and Ideas for Outreach were discussed. → The workshop was concluded with feedbacks from the panel to the teams.
Aug – Nov 2015	Shortlisting of proposals under <i>ITRA-Ag&Food</i>	<ul style="list-style-type: none"> → The revised 18 FPs were reviewed again during the review panel meeting held on Aug 5-6, 2015. → The review panel shortlisted 11 proposals keeping in view the proposal quality and value of the proposed deliverables
Sep - Oct 2015	Full proposal development meeting for <i>ITRA-HuSim</i>	<ul style="list-style-type: none"> → All 21 FP/teams were called for a full proposal development meeting in Sep 2015, to maximize the quality of the final proposals, and coverage of the RFP topics. → Domain experts reviewed the R&D plans of the teams and gave feedback to modify their respective full proposals and re-submit by end of Oct 2015.
Nov 2015	Meeting of PRSG	<ul style="list-style-type: none"> → The fourth PRSG meeting convened to discuss technical and financial status of ITRA → Based on satisfactory performance by ITRA, PRSG recommended release of next installment of GIA to MLAsia towards ITRA project, and extension of international travel support to ITRA mentors till March 2016
Nov 2015	Meeting of ITRA EC	<ul style="list-style-type: none"> → 6th Executive Committee meeting convened to discuss proposals under <i>ITRA-Ag&Food</i> initiative → EC prioritized them on the basis of their proposal quality and value of the proposed deliverables. EC authorized ITRA to review and revise financials of the proposals.
Nov 2015 – Mar 2016	Processing of proposals submitted for <i>ITRA-HuSim</i>	<ul style="list-style-type: none"> → The revised FPs were evaluated by online reviewers. Based on the reviews, the FPs were classified into two groups: <ul style="list-style-type: none"> - 4 proposals in the first group, which received the best reviews. These teams made presentation before the Review Panel in Feb 2016, where 1 FP was shortlisted for further processing, 2 FPs were asked for revisions and resubmission, and the last remaining FP was rejected. - The second group had remaining 17 FPs, A teleconference with their representatives was conducted in Feb 2016. Teams were given feedback on their proposals and were asked to revise and resubmit their proposals.

Dec 2015	Extension for providing international travel support towards mentorship visits	→ Based on PRSG's recommendations, DeitY accorded extension for supporting international travel of the 14 listed ITRA mentors till March, 2016
Dec 2015	Release of 4 th installment to ITRA	→ Rs. 955.83 Lakhs (including NE) were released to MLAsia as fourth installment of GIA for ITRA projects.
Jan 2016	Evaluation Workshops for <i>ITRA-Mobile</i> and <i>ITRA-Water</i> project	→ The second evaluation meeting of <i>ITRA-Water</i> and <i>ITRA-Mobile</i> projects were conducted in January, 2016. → 14 team projects were reviewed by panels of 15 to 17 experts in the respective fields. Students presented posters for their respective projects. → A total of 103 posters (38 for <i>ITRA-Water</i> and 65 for <i>ITRA-Mobile</i> projects) were presented during the course of the workshop.
Feb 2016	Meeting of ITRA EC	→ 7 th Executive Committee meeting convened to discuss proposals for <i>ITRA-Ag&Food</i> initiative. EC took note of the revisions made by the shortlisted <i>ITRA-Ag&Food</i> proposal teams and found them in line with the suggestions made in its last meeting. After a detailed discussion on each of the proposals, EC recommended 8 teams for funding under <i>ITRA-Ag&Food</i> initiative.
May 2016	Meeting of ITRA EC	→ 8 th Executive Committee convened and ratified all the decisions made in all previous meetings. In view of availability of funds under North Eastern (NE) component of DeitY, EC recommended that ITRA may initiate two projects of NE region under <i>ITRA-Ag&Food</i> focus area.
July 2016	Meeting of ITRA GC	→ The fifth GC meeting was convened to discuss the ongoing projects under <i>ITRA-Mobile</i> and <i>ITRA-Water</i> and also the initiatives under <i>ITRA-Ag&Food</i> and <i>ITRA-HuSim</i> .
July 2016	Mid-Year Review for <i>ITRA-Water</i> and <i>ITRA-Mobile</i>	→ The Third Feedback Meeting of <i>ITRA-Water</i> and <i>ITRA-Mobile</i> was conducted in July, 2016. → 13 team projects were reviewed by panels of 17 to 19 experts in the respective fields. Students presented posters for their respective projects. → Apart from the project reviews, poster presentation sessions by students, session on taking forward technologies ready for transfer were conducted during the course of the workshop.
Sep 2016	Meeting of PRSG	→ The fifth PRSG meeting convened to discuss technical and financial status of ITRA → PRSG recommended that the two NE projects, amongst the nine in Agri & Food, may be started using Year 1 funds already available with ITRA for NE projects. Considering the constraints on funds availability during current financial year PRSG recommended that a few more Ag & Food projects may be processed based on fund availability.

Jan 2017	Evaluation Workshops for <i>ITRA-Mobile</i> and <i>ITRA-Water</i> project	<ul style="list-style-type: none"> → The third evaluation meetings of ITRA-Water and ITRA-Mobile projects were conducted in January, 2017. → 13 team projects were reviewed by panels of 25 to 30 experts in the respective fields. Students presented posters for their respective projects. → A start-up session was also conducted, during which eminent entrepreneurs and angel investors have discussed their success stories and provided critical feedback to the startup teams regarding the seed funding and investment.
Mar 2017	Release of 5 th installment to ITRA	→ Rs. 1.44 Crs. were released to MLAsia as fifth installment of GIA for ITRA projects.

7.2 CURRENT STATUS VIS-A-VIZ DPR TARGETS

Parameters	Final Target (DPR)	Achieved
Participating Institutions	40	60
Large Research Institutions	20	21
Small Research Institutions	40	46
ITRA Faculty	74	136
Adjunct Faculty	51	0
PhD Students (Students and Lecturers)	250*	136

* Targets revised by PRSG from 480 to 250

7.3 ACHIEVEMENTS

To achieve its objectives, ITRA identified the main characteristics of the Indian environment, and designed an R&D model accordingly. This model involves (i) an exponentially growing ecosystem of teams of (ii) tightly interlinked academic institutions, research labs, and government, industrial, international and other organizations; (iii) integrated by the theme of solving problems in an important focus area; (iv) while being mentored by eminent researchers and industry. In the pilot:

- a. ITRA has identified four focus areas of R&D and associated problem solving, three of which have been initiated, and proposals from the fourth are being reviewed.
- b. The initiated focus areas has led to:
 - i. 67 research groups
 - ii. 136 faculty/researchers
 - iii. 136 PhD students (to grow in Year 3 of Mobile and Water projects)
 - iv. 40 Mentors (eminent researchers) from India and abroad, and 10 Translators (research to industry)
 - v. Led to 393 research publications, 174 new/modified courses, 169 workshops/seminars/conferences, 22 researchers deputed abroad for international interactions and exposure
- c. 8 *ITRA-Ag&Food* teams from 49 research groups are ready to be launched as soon as funds are made available.
- d. 16 technologies are in advanced stages of implementation of ToT / Commercialization / Start-ups.

Financials

Grant-in-Aid Received from MeitY towards ITRA Project and Interest Earned (till 31 Dec 2016)

S. No	Sanctioned Heads	Approved Total Budget outlay	Grant in aid Received						Total Receipts (a)
			2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	
1	R&D facilities & Prototyping	6,154.50	557.10	-	-	632.19	325.00	234.56	1,749.32
2	Adjunct Faculty Salary & Fellowships	5,976.00	537.36	-	-	763.58	371.78	524.54	2,262.78
3	ITRA HQ, DIT Coordination & Workshops	1,400.00	205.99	-	-	150.00	175.00	150.00	615.00
4	Misc.& Contingency	1,352.50	132.55	-	-	154.23	87.22	90.90	464.90
	Sub Total	14,883.00	1,433.00	-	-	1,700.00	959.00	1,000.00	5,092.00
I	Interest earned		19.16	109.61	120.66	94.76	95.78	16.82	456.79
Ii	Interest refunded to DeitY					180.62			180.62
Iii	Interest adjusted in grant in aid by DeitY in Grant in aid releases.					73.00	159.00	44.17	276.17

Expenditure Incurred

Sanctioned Heads	Expenditure incurred							Total Expenditure (b)	Balance (a-b)
	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17		
R&D facilities & Prototyping	-	0.17	2.47	554.92	632.19	349.07	383.66	1,922.49	(173.17)
Adjunct Faculty Salary & Fellowships	-	10.55	6.91	612.32	691.27	408.10	402.65	2,188.07	74.71
ITRA HQ, DIT Coordination & Workshops	0.64	62.81	57.16	100.53	187.71	164.92	155.17	672.67	(57.67)
Misc.& Contingency	-	-	132.55	154.23	87.22	90.90	-	464.90	(0.00)
Sub Total	0.64	73.54	199.09	1,422.00	1,598.39	1,012.99	941.48	5,248.13	(156.13)

Conclusions and Next Steps

1. Startups - Taking Results to Society: Meetings with the teams are ongoing to identify field-ready results from among those produced to date by the 13 teams engaged in *ITRA-Mobile* and *ITRA-Water* activities. About 18 of the developed technologies, each addressing a significant national need, have been identified for conversion into products and services. ITRA's interactions with the teams are ongoing, and business plans are being prepared by the teams. The target time for the start-ups to be funded and begin functioning is the second half of 2017.

2. Deepening the Pyramids: One feature of the ITRA model that is yet to be implemented is about the important attribute of exponential growth of the R&D community with time. Since the first set of ITRA projects was initiated on Jan 1, 2014, and will be completed at the end of July 2017, ITRA model calls for addition of the first new layer to the initial pyramids by the end of July 2017.

3. New Focus Areas: There are numerous nationally important problem areas (e.g., overseen by various domain ministries) in which there are well recognized, IT-hungry needs but expert IT attention to them may be lacking. These may be chosen as new ITRA focus areas in collaboration with the domain ministries. ITRA model could thus be used as a cookie-cutter, to develop vibrant communities in all areas of national significance, having quality and attributes mentioned earlier. Our experience of working with ICAR and DBT (see 8) has shown that such domain based intense collaboration is not only very productive but also feasible, and can be made the norm.

4. Efforts under Way Towards (2) and (3): Towards 2, themes to be pursued by the deepened pyramids, in continuation of the current objectives and activities of *ITRA-Mobile* and *ITRA-Water*, are being identified. Towards 3, new focus areas that were already approved by the Advisory Council, or those that have arisen as a result of interest expressed by various stakeholders, are being explored. Discussions are ongoing with, e.g., Ministries of Power, Water Resources, HRD, Petroleum and Gas, Defense, Health, Railways, Textiles and National Disaster Management Authority.

9.1 PILOT GUIDED PROPOSED 5-YEAR PLAN

1. Pilot-Suggested Prospects of Making a Major National Impact

The ITRA model is novel, in part as a natural result of having been custom designed to function under the uncommon Indian conditions. The performance of the pilot with respect to the various metrics identified during the formulation and then implementation of the model reflect the model's unique effectiveness, and therefore, the potential benefits of expanding its reach. Like the four pilot areas, there are numerous other nationally important problem areas X, e.g., in the government, overseen by various domain ministries/departments. The IT needs of these areas are often well recognized by the domain policy makers, but the IT expertise available to them is usually limited. Consequently:

- a. The ITRA model could be replicated in these domains, while also developing vibrant IT-in-X communities with a culture of spotting and solving problems in the areas.
- b. These communities will also serve as think tanks and knowledge banks in the domain that may routinely provide ready answers to unanticipated questions or to find them at short notice.
- c. ITRA's experience in formulating joint initiatives with ICAR and DBT in two focus areas has shown that intra-government collaboration can devise potent joint roadmaps. We have also discovered widespread appreciation of the value IT brings (and much enthusiasm for IT-in-X collaboration with ITRA) in several ministries/departments, e.g., Agriculture, Disaster Management, Power, Water Resources, Transportation, Healthcare, Housing, Education/HRD, ISRO, Petroleum & Gas, Defense, Health, Railways, and Textiles.

2. A Proposed Plan – 20 Focus Areas Over Five Years

We propose the use of ITRA model to launch 20 focus areas over five years - one each quarter. Each will involve formulating an IT-in-X joint initiative with a domain (X) ministry.

3. Expected Impact of the Proposed Plan

The choice and formulation of the detailed technical targets of the focus areas will benefit significantly from the experience of the pilot. Their execution would continue to require broad, interdisciplinary, holistic approach and expertise, and working closely with the teams as the ecosystem takes roots.

- a. With the required support and based on the pilot's results to date, the proposed plan is estimated to yield (beyond the pilot) a minimum of:
 - i. 800 active research groups/institutions
 - ii. 1100 active researchers
 - iii. 500 Mentors
 - iv. 1700 PhDs
 - v. 150 start-up technologies/solutions such as are resulting from the pilot.
- b. The solutions may be expected to form a critical mass, capable of demonstrating the influence IT-in-X research may wield on the state of affairs in many societally important sectors.
 - i. The solutions would help ITRA make a widely felt, national impact.
 - ii. As the applications broaden, the quality of individual solutions and domain knowledge base would grow steadily, and making the next quantum of impact would become easier.
 - iii. Simultaneously, domain ministries would find better solutions to problems in their sectors.
 - iv. Since startups are designed to target important problems, they would be well aligned with Hon'ble PM's *Digital India, Startup-India-Standup-India, Make-in-India* and *Skill-India* initiatives.
- c. As suggested by the quality of pilot activities, the proposed plan may be realistically expected to put a large number of advanced Indian institutions on the world map as centers of excellence in education/research, and more importantly, greatly strengthen a culture of developing and deploying made-in-India solutions to Indian problems, with the graduates becoming job providers instead of job seekers.

The final result will thus be a win-win for ITRA, collaborating ministries, and the nation.

Annexures

10.1 COMPOSITION OF VARIOUS ITRA COMMITTEES AND THEIR TERMS OF REFERENCE

ITRA-Governing Council

Composition of ITRA-GC:

1. Secretary to Government of India, MeitY (Chairman)
2. FA, MeitY
3. Joint Secretary, Higher Education, MHRD
4. Prof. V. Ramgopal Rao, Director, IIT Delhi
5. Prof. Rajeev Sangal, Director, IIT(BHU) Varanasi
6. MD & CEO, MLAsia
7. President, Nasscom
8. Group Coordinator, Handling ITRA at MeitY
9. Director, ITRA (Member Secretary)

Terms of Reference of ITRA GC:

1. Operational/ Administrative Policies
2. Human Resource Policies
3. Finance Policies
4. Policies regarding engaging adjunct faculty and consultants
5. Review and steering of the ITRA programme including moderation of activities and allocations
6. Policies regarding participating institutions and research labs
7. Delegation of administrative and financial powers

ITRA-Advisory Council

Composition of ITRA-AC:

1. Prof. S. V. Raghavan, IIT Madras and ex-Scientific Secretary, Office of the PSA, GoI (Chairman)
2. Secretary, DIT
3. Sh. N.K. Sinha, Secretary, Ministry of Culture
4. Dr. Arabinda Mitra, Head, International Bilateral Cooperation Division, DST
5. Prof. Santanu Chaudhury, Director CEERI Pilani
6. Prof. Bhaskar Ramamurthi, Director, IIT Madras
7. Sh. Ajai Chowdhry, Chairman, HCL Infosystems
8. Sh. Kiran Karnik, Former President, Nasscom
9. Prof. U. B. Desai, Director, IIT Hyderabad
10. Prof. Subhasis Chaudhuri, Dean, IIT Bombay
11. Prof. A. K. Majumdar, Indian Institute of Technology, Kharagpur
12. Prof. H. S. Jamadagni, IISc
13. Dr. C. Murali Krishna Kumar, Sr. Adviser (CIT & I/DBT/UIDAI/ S& T Divn.), NITI Aayog
14. Prof. Pankaj Jalote, Director, IIIT Delhi
15. Prof. Rajeev Sangal, Director IIT(BHU) Varanasi
16. Shri. Abhay Bakre, Joint Development Commissioner, MSME
17. Dr. P Venkat Rangan, Vice Chancellor, Amrita University
18. Prof M.S. Gaur, NIT Jaipur
19. Sh. V. S. Mahalingam, Director, CAIR, DRDO, Bangalore
20. Dr. A.G. Apte, Head, Computer Division, BARC

21. Dr. K. Sethuraman, Engineer-SF, Frequency Management Office, ISRO
22. Dr. G. Venkatesh, CTO, Sasken Communication Technologies
23. MD & CEO, Media Lab Asia
24. Representative of NGO sector (to be decided by Head/DG of ITRA, in consultation with the Chairman)
25. Head/DG ITRA (Member Secretary)

Terms of Reference (ToR) of ITRA-AC:

Advisory Council is motivated by the desire to include various sectors of interest to ITRA such as IITs, IITs, NITs, Private institutions, MHRD, Planning Commission, MSME, DST, CSIR, Strategic Departments (ISRO, DAE, DRDO), MLAsia, industry, industry associations, and NGO's.

ITRA-Executive Committee

Composition of ITRA-EC:

1. Director, ITRA, Chairman
2. Joint Secretary MHRD, Higher Education, or his Representative
3. Ms. Alpana Dey, HOD (ITRA), MeitY
4. Prof. Sanjiva Prasad, IIT Delhi
5. Prof. Vinod Tare, IIT Kanpur
6. Dr. Milind Kulkarni, Scientist G, DST
7. Ms. Rama Vedashree, Vice President NASSCOM
8. Rep NRI Community
9. Rep MLAsia (to be nominated by MD/CEO MLAsia)
10. Finance Officer-ITRA/MLAsia
11. ITRA Officer

Terms of Reference of ITRA-EC:

1. Provide guidance to ITRA for effective execution of the programme.
2. Help prepare implementation plans and review the progress of ITRA activities from time to time
3. Optimize distribution of research foci and resources across the ITRA institutions.
4. Help monitor and coordinate the activities of ITRA institutions.
5. Help interface with researchers in India and abroad, particularly to attract them to ITRA.
6. Help establish and maintain connections with industry, government and non-governmental organizations.
7. Help obtain/channel/approve funds for the ITRA institutions/teams from external sponsors.
8. Formulate necessary policies and proposals, and steer them before the competent authorities for necessary approvals.
9. Recommend R&D project proposals for approval, modification or rejection.
10. Any other matters of relevance in the execution of ITRA programme.

Project Review Steering Group (PRSG)

Composition of PRSG:

1. Prof. U.B. Desai, Director IIT, Hyderabad, Chairman
2. Mr. B.M. Baveja, GC, R&D in IT Group, MeitY, Co-Chairman
3. Prof. Rajeev Sangal, Director, IIT BHU, Varanasi
4. Prof. Pankaj Jalote (expert- S/w Engg.), Director, IIIT, Delhi
5. Prof. Sanjiva Prasad (expert-IT), HoD, CSE, IIT Delhi
6. Dr. G. Venkatesh (expert-mobile), CTO, Sasken Comm, Chennai
7. Ms. Rama Vedashree, VP, e-gov, NASSCOM, Delhi
8. Dr. Prasun Roy (expert-Health), Sr. Prof., NBRC, DBT
9. Ms. Alpana Dey, Scientist F, HoD, R&D in IT, MeitY

Terms of Reference of ITRA PRSG:

1. To review Technical and Financial progress of the project.
2. To steer the project from initiation to completion towards achieving specific output leading to useful outcome as per project objectives.
3. To meet and visit the project site as and when required to assess the progress made by the project and to advise the project executing team on new direction/approach and ensure its smooth progress and link-up with the work going on elsewhere in the country for full utilization of the capabilities available in the country.
4. To examine specific request from Chief Investigator, including re-appropriation of funds, enhancement of project outlay, change in the scope of the project, extension of project duration, change in the posts for project personnel, publication of research papers, provision for foreign travel, project completion report, equipment procurement, revision of bar/PERT chart, any other modifications and suggest remedial actions wherever required and make recommendations for consideration by Ministry of Electronics & Information Technology (MeitY).
5. To advise action regarding completion of the project, establishment of facilities, its utilization and transfer of know how etc.
6. **Roadmap for translation:** PRSG should within 6 months of the commencement of the project, discuss the need and the feasibility of translation/TOT of the proposed output of the project for commercialization. If so feasible, PRSG should hold discussion with experts on the subject from Industry Associations, by inviting them especially to the meetings of the PRSG. PRSG, where possible, shall prepare a roadmap for translation/TOT for commercial production, keeping in view the extant guidelines in the matter.
7. **Cost effectiveness:** PRSG should regularly review & guide the project w.r.t. cost effectiveness of the technologies being developed under the project where relevant. In case the Cost Benefit ratio, where relevant, is likely to be too adverse, PRSG may advise on mid-course correction or pre-closure of the project
8. **Relevance of technology to India:** PRSG should direct the project efforts for development of globally competitive technologies with relevance to the Indian condition & requirements.

Term of the PRSG will be till the Project Completion Report submitted by the implementing agency is reviewed by the PRSG and accepted by MeitY and TOT if applicable.

10.2 LIST OF ITRA PERSONNEL

S.No.	Name	Designation	% of time devoted to this project	Date of Joining	Date of Leaving
1	Prof. Narendra Ahuja	Director, ITRA	100%	02/06/2011	
2	Dr. Arun Pande	Sr. Level Consultant-ITRA	50%	01/02/2014	
3	Dr. A. Bandyopadhyay	Sr. Consultant	50%	05/01/2015	
4	Dr. Siddhartha Kundu	Sr. Consultant	50%	19/01/2016	
5	Mr. Roop Kishan Dave	Head, Government Initiatives	100%	10/03/2015	05/01/2017
6	Mr. Gaurav Sharma*	Sr. Research Scientist	100%	22/12/2010	
7	Ms. Sonal Sinha	Principle Scientific Officer	100%	10/09/2015	
8	Mr. Mohd. Rizwan Ansari	Senior Scientific Officer	100%	15/09/2015	
9	Mr. S. S. Samal	Senior Scientific Officer	100%	17/10/2016	24/04/2017
10	Ms. Shivanshi Joshi	Senior Scientific Officer	100%	7/11/2016	
11	Mr. Ishant Kumar Bajpai	Scientific Officer	100%	16/09/2015	08/03/2017
12	Mr. Sourav Mondal	Scientific Officer	100%	01/06/2016	
13	Mr. Rishabh Gupta	Jr. Network Administrator	100%	21/09/2015	15/02/2017
14	Mr. Avinash	Jr. Web Developer	100%	05/10/2015	
15	Mr. Mohd. Frahim	Jr. Accounts Officer	100%	10/09/2015	
16	Ms. Hina Kundaliya	Executive Assistant	100%	15/12/2014	
17	Mr. Ajay Thomas Cheruthon	Executive Assistant	100%	07/01/2015	
18	Mr. Deepraj Chandra	Technical Assistant	100%	03/01/2017	21/02/2017
19	Mr. Lalit Mohan Singh	Assistant – ITRA	100%	01/04/2013	
20	Dr. U.P. Phadke	Member, PSIG-ITRA	100%	27/04/2011	09/09/2011
21	Dr. Akshai Runchal	Programme Advisor – ITRA	50%	01/02/2015	24/12/2015
22	Dr. P.K. Reddy	Sr. Level Consultant-ITRA	50%	11/11/2013	30/11/2015
23	Dr. Rajeev Shorey	Sr. Level Consultant-ITRA	50%	01/11/2013	31/10/2014
24	Dr. Umesh Chandra Pandey	Co-ordinator (Technical)-ITRA	100%	04/04/2012	31/03/2013
25	Mr. R.G.S Asthana	Consultant	100%	4/6/2012	31/08/2012
26	Mr. Ashok Kumar Katta	Executive Secretary to Director, ITRA	100%	23/09/2013	31/03/2014
27	Ms. Namrata Nagar	Executive Secretary to Director, ITRA	100%	12/05/2014	28/07/2015

28	Mr. Tushar Sharma	Web Developer	100%	25/09/2014	04/12/2014
29	Mr. Aakash Sharma	Web Developer	100%	10/10/2013	15/09/2014
30	Ms. Himani Sharan	Executive Assistant	100%	15/12/2014	29/05/2015
31	Mr. Sanat Kumar Patra	Management Trainee	100%	05/08/2013	08/01/2015

- On loan from Media Lab Asia

10.3 PERFORMANCE BASED AWARDS FOR STUDENTS AND TEAMS

ITRA projects are fundamentally team oriented. Teamwork is necessary for many large undertakings in general, and it needs particularly strong attention in the Indian academia and research institutions. The awards below are linked to the performance of the ITRA teams with respect to the fundamental objectives of ITRA.

1. GENERAL GUIDELINES

- a. All awards are to be given at the end of a year, based on the performance during the year, applicable to only the following, one year.
- b. The awards will be given to either individual Students or to entire Teams of ITRA Institutions.
- c. The awards are based on self-competition, i.e., making noteworthy leaps in capabilities, and not based on performing better than others. Whether an award is even given in a specific year would depend on whether anyone has made award worthy progress with respect to the award criteria.

10.3.1 Student Awards

i. PhD Research Award

Motivation: To keep the PhD students inspired and devoted to the research enterprise, and thus help continuously enhance the quality of their research, ITRA plans to periodically recognize their good work.

Selection: The yearly research performance of each student would be evaluated and assigned a performance grade at the end of each year, by an evaluation panel comprising mainly of technical experts. The selection criteria are the relevant subset from those given in the Measurement Parameters Table. This grade will be translated into an equivalent Award Percentage (AP). AP received by a student at the end of a given year and any preceding years will be used to determine the award amount to be paid to the student over the following year.

Award: The **PhD Research Award** has 2 levels – Exemplary and Outstanding, and is given annually. The number of awards are up to 5 (i.e. 5% of the total PhD students in the Focus Area) at Exemplary level, and up to 25 (i.e. 25% of the total PhD students in the Focus Area) at Outstanding level. Award amounts will be 2 L at Exemplary level and 1 L at Outstanding level.

ii. PhD Dissertation Award

Motivation: To recognize PhD theses in which the individual contributions made in different parts are of high quality and impact, and have high coherence and integrative value.

Selection: The selections of the awardees are done by the evaluation panel, comprising mainly of technical experts.

Award: ITRA gives **PhD Dissertation Awards**, in the form of a citation only, without any monetary compensation. PhD theses of the ITRA students are evaluated for quality and impact and those theses meeting a quality threshold will be given the award. A citation along with a gold plated medal is given to each awardee. It is estimated that the number of the award winning theses would be about 5% of the total number of theses considered, i.e., currently an average of about 1 thesis per focus area per year.

10.3.2 Team Awards Grants

Faculty leadership is central to the success of the ITRA projects. The team awards are aimed at recognizing the leadership of PIs, Co-PIs and other senior personnel for the collaborative achievements made by their teams.

Each award is in the form of a grant to the team. The recipient team will submit a brief statement of work along with a budget for the award amount. The budget will be flexible in that it could be used for any category of expense, e.g., to attend a different type of conference, invite experts, hire extra students for possible new work, etc., as needed. Any use of the award grant money on large equipment or international travel by the researchers will be acceptable, but it will be subject to the pertinent ITRA policies, and therefore, will require prior ITRA approval.

i. Team Achievement Awards Grants

Motivation: ITRA recognizes overall team performance, in areas related to the ITRA quality metrics, i.e., (i) Research (ii) Curricula Impact (iii) Combined Societal Sensitivity Development and Outreach.

Selection: Performance of each team over a year is evaluated for its quality with respect to each of the four metrics by a panel comprising mainly of technical experts. The panel will consider the performance of the team with respect to the relevant parameters listed in Measurement Parameters Table and assign grades.

Award: ITRA is to give the following *Team Achievement Awards*: (i) **Research Achievement Award**; (ii) **Curricular Impact Award** and (iii) **Combined Societal Sensitivity and Outreach Award**. Up to 1 team per category per focus area may be selected for the award per year. The award will have 2 levels – Exemplary and Outstanding. The award grant amount will be Rs. 10 L (for Outstanding level) or Rs. 20 L (for Exemplary level).

ii. Partnership Award Grants

Motivation: This award category singles out a particularly important aspect of ITRA architecture – Partnering Institutions (PINs) in a pyralet advancing their quality with the help of their Lead Institution (LIN), even though such activities may, in part, also be included among the many comprising outreach, and hence recognized by a part of an ITRA Team awards, e.g., *Societal Sensitivity and Outreach Award*. The extra emphasis on this parameter is due to the critical national need for significantly increasing the number of quality institutions, and the high level of importance ITRA associates with it.

Selection: The award is given to a LIN-PIN pair, for their joint work leading to an award worthy enhancement in the PIN's quality, or to an entire pyralet, when all the PINs in a pyralet work closely with the LIN to take advantage of their larger combined scale, and thus derive greater and award worthy enhancement in the quality of all PINs in the pyralet. The award worthiness is judged considering all four quality metrics, using most of the criteria listed in Measurement Parameters Table. While PINs are the intended primary beneficiaries from this joint work, the award will also help LINs to derive well known advantages of mentoring, thus enriching both LINs and PINs. The awardees and the award amounts will be determined by the evaluation panel, comprising mainly of technical experts.

Award: The *Partnership Award* will have 2 levels – Exemplary and Outstanding. The number of LIN-PIN pairs to be selected will be up to 1 at Exemplary level, and up to 4 at Outstanding level (i.e. 5% and 15% of institutions in a focus area). The use of this award amount will be planned jointly by the PIs at the awardee LIN and PIN(s), and directed at further enhancing their partnership activities. Award amounts will be: 6 L at Exemplary level and 3 L at Outstanding level, which amount to 3 L/institution at Exemplary level and 1.5 L/institution at Outstanding level.

iii. **Interdisciplinary Collaboration Award Grants**

Motivation: To recognize major cross-fertilization efforts between IT institutions and X (domain specific) institutions in a team, leading to major interdisciplinary advances in IT-in-X research projects.

Selection: The awardees and the award amounts will be determined by the evaluation panel, comprising mainly of technical experts.

Award: The *Interdisciplinary Collaboration Award* will have 2 levels – Exemplary and Outstanding. The number of awardee pairs will be up to 1 at Exemplary level and up to 4 at Outstanding level (i.e., 5% and 15% of institutions in a focus area). The use of this award amount will be planned jointly by the PIs of the awardee teams, and directed at further enhancing their interdisciplinary activities. Award amounts will be 6 L at Exemplary level and 3 L at Outstanding level, which amount to 3 L/institution for exemplary performance and 1.5 L/institution for Outstanding performance.

iv. **Foresight Award Grants**

Motivation: The number of proposals with high innovation content submitted for funding in India is in general quite low. There is a need to encourage potential ITRA teams to be ambitious and come up with bold new ideas as a part of planning for ITRA project activities, particularly for addressing India specific problems. An opportune time for the brainstorming required for coming up with out-of-the-box ideas is when the team is writing the proposals, which they would of course like to see succeed. Accordingly, the ITRA project proposals need to be recognized on the basis of their innovation content.

Selection: Evaluation of the ITRA proposals includes identifying relevant, novel, high-risk high-reward ideas. Innovative proposals being sought here are to be distinguished from those proposals containing well thought out, organized plans, but whose impact is expected to be incremental, though useful. Those teams whose proposals are found to be refreshing and innovative beyond a threshold, by a panel of reviewers consisting mostly of technical experts, will be given the award.

Award: The *Foresight Award* will be renamed as *Doordarshi Award*, and will be given to a team for submitting a proposal with strategic, innovative, path breaking ideas. Up to 1 team per focus area may be selected for the award. The award grant amount will be Rs. 10 L.

Measurement Parameters for Evaluation of Student/ Team Performance

Area
1. Research and Development
of Publications in Peer Reviewed Conferences included in the ITRA List or of the same Calibre
of Publications in Major Peer Reviewed Journals included in the ITRA List or of the same Calibre
of Peer Reviewed Conferences in which Project Personnel are Organizers (e.g., as Chairs, Reviewers, Committee Members, ..)
of Peer Reviewed Journals included in the ITRA List or of the same Calibre in which Project Personnel are involved (e.g., as Reviewers, in editorial duties,)
of invited talks given at major institutions, conferences
of PhD students in the project
of Masters students
of Undergrad students
of students supported to travel to conferences
of Post-Docs
of Tools/Technologies developed
of Technical contests held for solving various technical/other field-relevant challenges organized by professional societies and other organizations from time to time
of World renowned Experts involved with ITRA researchers
2. Impact on Curriculum
of New Courses/Modules developed with enrolment
of New Labs
of Courses/Modules updated in a major way with enrolment
of Labs Updated in a major way
of New Textbooks authored/edited, Book chapters, Magazine, Articles, Case studies
3. Combined Outreach and Societal Sensitivity Development
of Patents
of Start-ups formed or in formation
of Summer/Winter/Monsoon Schools and # of Participants
of other Short/Long Courses and # of Participants
of Tutorials and # of Participants
of Distance Education Courses and # of Participants
of Seminars/ Seminars Series/Workshops/Conferences and # of Participants
of Open houses where the work being done by the team is exhibited to colleges, schools, public at large, etc., to increase their understanding and appreciation of research in science and engineering

of Contests held for solving various outreach and societal sensitivity challenges organized by NGO and other organizations from time to time and # of Participants
of Other Institutions in/outside the team impacted by the above
of Major Collaborations with Industry
of Major Collaborations with Government
of Major Collaborations with NGOs
of Major Collaborations with International Organization
of Major Collaborations with Any Others
of Technologies Transferred (Industry/Government/NGOs/ International Organization/ Others)
of Solutions Provided (Industry/Government/NGOs/ International Organization/ Others)
of Services Offered (Industry/Government/NGOs/ International Organization/ Others)
of Licenses Granted (Industry/Government/NGOs/ International Organization/ Others)
of Consultations Offered (Industry/Government/NGOs/ International Organization/ Others)
of Industrial Board Memberships (Industry/Government/NGOs/ International Organization/ Others)
of Other Outreach Activities

10.4 INTERACTIONS OF TEAMS WITH MENTORS

Mentors are renowned researchers in an area relevant to the team. They are an integral part of a team proposal and are thus involved from the time of the inception of the team. They are entrusted with and duly credited and rewarded for enhancing the team's performance.

Modes of Interaction

1. Visits to teams
2. Hosting visits of team members
3. Remote interaction via video conferencing, etc.

Modes 1 and 2 involve traditional face-to-face interactions. However, remote engagement of the mentors with the teams is highly desirable, particularly for mentors that are located far off. This is because most mentors tend to be renowned researchers with limited time. Given that they hold regular jobs elsewhere, they will be able to spend only a small number of weeks per year visiting the teams. This time will not be adequate for many mentoring activities. For example, discussions on research problems, writing papers, etc. happen over time and cannot be rushed in a short period of intense activity. The required sustained engagement is, however, possible through remote interactions wherein the mentors may contribute smaller chunks of time more frequently. Indeed, this would be a very effective practical way of making speedy progress towards ITRA objectives under the current constraints on faculty availability in India. This is the reason for having Mode 3. It would apply to most of the activities listed in Sec. A, with exceptions being the last two where physical presence of the panel members is required.

The limit on the number of international mentors per team is 1. The number of domestic mentors may also be up to 1.

All international visits should be discussed with ITRA sufficiently in advance so that ITRA processing is finished and the travel finalized at least one month ahead of the beginning of the travel.

A. Mode 1: Mentor Visits to Teams

1. Mentor visits to the teams are a central and highly encouraged part of ITRA model.
2. All visits should be hosted by the mentor's team. This team may wish to discuss the visit with other teams who may also be interested in the mentor.
3. The host team's PI should discuss an outline of the plans with ITRA at least two months before the visit is to begin and get ITRA's go-ahead before proceeding with the plans.
4. On approval by ITRA, the host team may work out a detailed tentative plan, and ask all other teams if they would like to participate in the activities, organize some by hosting the mentor, etc., and if it suits the mentor, work out a final plan that caters to the needs of all other interested teams. The objective should be to maximize ITRA-wide benefit from the activities.
5. Those activities, of value to other ITRA teams and possibly beyond, e.g., lectures, courses, discussion, etc., may be streamed, e.g., via NKN, other video conference means, etc.
6. The host team PI should inform all other teams, etc., about the plans through direct email, ITRA website, etc.
7. Mentor's role in ITRA team activities is obviously very valuable. The host PI should ensure an efficient and smooth visit, including the interface with any other teams that the mentor may visit.

That the activities are useful, efficient and a pleasant experience for all involved, particularly the mentor, is an important duty of the host PI.

8. The organization and execution of a mentor trip are the responsibility of the host team PI.

Guidelines for ITRA's support towards Mentorship Mode 1:

- i. Each domestic mentor should visit ITRA/teams for a total of at least 3 weeks per year, with no visit of less than 3 days. The honorarium given to them will be Rs. 15K/week. A maximum of 3 visits per year will be supported by ITRA.
- ii. International mentors will visit for at least 3 weeks, over at most 2 trips, with no trip of less than a week. The honorarium paid for a trip will be equivalent of US \$1000 in Indian rupees for the first week's stay in India, and equivalent of US \$250 in Indian Rupees for each subsequent additional week's stay, up to a maximum of 4 weeks' stay in India for execution of the joint project in India. When the international travel of a mentor is not supported by ITRA, s/he will be treated as a domestic mentor.
- iii. Air travel will be as per MLAsia air travel rules [*Annexure 7 of Minutes of the GC Sub-Committee Meeting*].
- iv. Local hospitality including boarding, lodging and local travel will be provided by the host institution.

B. Mode 2: Team Members Visiting Mentors

Mode 2 activities will be an obvious subset of those under Mode 1 as they will be carried out at the mentor's location. They will provide a greater amount of mentor time, but of course only to those team members visiting the mentor. An added advantage of this mode will be the broader exposure of the visiting member to the different culture of research, etc. prevalent at the mentor's institution.

Guidelines for ITRA's support towards Mentorship Mode 2:

- i. Visits of up to 2 student researchers per institution per year, each for up to 1 semester (up to 135 days), may be supported by ITRA.
- ii. Visiting a Domestic Mentor:
 - a) Living and travel expenses to be given as per team member's parent institution's norms.
 - b) Compensation to Mentor: Since this activity involves engagement of the mentors without going to the mentored institutions, it is comparable to the remote activities under Mode 3. The compensation for Mode 2 is therefore discussed under Mode 3.
- iii. Visiting an International Mentor:
 - a) Per diem Allowances, Accommodation charges and Local Transport: \$1750 per month (all inclusive). This will be limited to DA = \$35/day, and Accommodation Charges (on submission of bills) = \$700/mo.
 - b) Air travel will be as per MLAsia international air travel rules [*Annexure 7 of Minutes of the GC Sub-Committee Meeting*]
 - c) Host Institution Costs = \$1000
 - d) Compensation to Mentor: Since this activity involves engagement of the mentors without going to the mentored institutions, it is comparable to the remote activities under Mode 3. The compensation for Mode 2 is therefore discussed under Mode 3.

- e) Other Expenses (Travel Insurance, medical etc..) = up to Rs. 15,000

C. Mode 3: Mentors Interacting Remotely

Effective remote interaction can be had for most of the activities listed in Sec. A, except for the last two where physical presence of the panel members is required.

The overall design of the proposed mechanism for assessing the time spent by the mentors remotely, and for compensating mentors for this time, is given in the table “Computation of the Hours Spent by a Mentor in Interaction Modes 2 and 3” [*Annexure 9 of Minutes of the GC Sub-Committee Meeting*]. The design should be carefully refined by incorporating the experience gained in the early stages of implementation. ITRA may pay an honorarium to the mentors for Mode 2 and Mode 3 activities as described in the guidelines below.

Guidelines for ITRA’s support towards Mentorship Mode 3:

- i. **Domestic Mentors:** Based upon time spent on activities involving visiting student researcher(s), as estimated using applicable parts of the method given in *Annexure 9 of Minutes of the GC Sub-Committee Meeting*. The compensation will be Rs. 15K/week, subject to the constraint that the total compensation to a mentor for Modes 1, 2 and 3 activities does not exceed Rs. 1.2 L/year.
- ii. **International Mentors:** Based upon time spent on activities involving visiting student researcher(s), as estimated using the applicable parts of the method given in *Annexure 9 of Minutes of the GC Sub-Committee Meeting*. The compensation will be equivalent of US \$1000/week in Indian rupees, subject to the constraint that the total compensation to a mentor for Modes 1, 2 and 3 activities does not exceed US \$7,500/year.

10.5 INTERNATIONAL MENTORS FOR ITRA-WATER AND ITRA-MOBILE PROJECTS

S.No.	Name of the Mentor	Affiliation	ITRA-Institutions associated with	Focus Area
1.	Prof. Praveen Kumar	Univ. of Illinois at Urbana Champaign, IL, USA	1. IIT, Bombay 2. IIT, Hyderabad	<i>ITRA-Water</i>
2.	Dr. Dev Niyogi	Purdue Univ., Indiana, IN, USA	1. IIT, Bombay 2. IIT, Hyderabad 3. IISc Bangalore 4. BITS Pilani, Hyderabad	<i>ITRA-Water</i>
3.	Prof. Binayak P. Mohanty	Texas A&M Univ., College Station, TX, USA	1. IIT, BBSR 2. IIT, Kharagpur 3. IISc Bangalore 4. BITS Pilani, Hyderabad	<i>ITRA-Water</i>
4.	Prof. V. Sridhar	Virginia Tech, Roanoke, VA, USA	1. IIT, Kharagpur 2. IIT, Gandhinagar	<i>ITRA-Water</i>
5.	Prof. James Phillip King	Mexico State Univ., Las Cruces, USA	1. IIT, Bombay 2. IIT, Hyderabad	<i>ITRA-Water</i>
6.	Prof. Adit Singh	Auburn Univ., Auburn, AL, USA	1. Univ. of Hyderabad 2. IIT, Hyderabad 3. IIT Delhi 4. IIIT Delhi	<i>ITRA-Mobile and ITRA-Water</i>
7.	Prof. Sajal K Das	Missouri University of Science and Technology	1. I.I.T. Kharagpur 2. I.I.M. Calcutta 3. N.I.T. Durgapur 4. Jadavpur University 5. University of Calcutta 6. Amrita Vishwa Vidyapeetham, Kerala	<i>ITRA-Mobile</i>
8.	Prof. Sukumar Ghosh	Univ. of Iowa, Iowa City, IA, USA	1. I.I.T. Kharagpur 2. I.I.M. Calcutta 3. Jadavpur University 4. University of Calcutta	<i>ITRA-Mobile</i>
9.	Prof. K. K. Ramakrishnan	Univ. of California, Riverside, CA, USA	1. IIT, Bombay 2. PEC University of Technology,	<i>ITRA-Mobile</i>

			Chandigarh 3. IIT, Madras	
10.	Prof. Supratik Mukhopadhyay	Louisiana State Univ., LA, USA	1. Jadavpur University 2. University of Calcutta 3. NIT, Durgapur	<i>ITRA-Mobile</i>
11.	Prof. Prashant Pillai	Univ. of Bradford, UK	1. IIT, Madras 2. Inst. of Mathematical Sciences, Chennai 3. I.I.T. Kharagpur 4. I.I.M. Calcutta	<i>ITRA-Mobile</i>
12.	Prof. Archan Misra	Singapore Management Univ., Singapore	1. IIIT Hyderabad 2. I.I.T. Kharagpur 3. I.I.M. Calcutta	<i>ITRA-Mobile</i>
13.	Prof. Nitin Vaidya	Univ. of Illinois, Urbana, IL, USA	1. HIT, Delhi 2. Amrita Vishwa Vidyapeetham, Kerala 3. IIT, Delhi 4. Institute of Radio Physics & Electronics, Kolkata	<i>ITRA-Mobile</i>
14.	Prof. Sumit Roy	Univ. of Washington, Seattle, USA	1. IIIT, Delhi 2. IIT, Delhi 3. Amrita Vishwa Vidyapeetham, Kerala	<i>ITRA-Mobile</i>

10.6 INTERACTIONS OF TEAMS WITH ADJUNCT FACULTY

Adjunct Faculties (AF) are renowned researchers in an area relevant to the team. They may perform most of the functions normally performed by a mentor, but the mentors are an integral part of a team proposal, usually involved from the time of the inception of the team. AF are entrusted with and duly credited and rewarded for enhancing the team's performance. AF may also be invited to complement the mentors from time to time. AF may choose to become mentors if need arises as they work with the teams.

An AF coming from an academic institution will be compared with and classified by ITRA Executive Committee into one of three categories of equivalent IIT faculty: Assistant Professor, Associate Professor, and Professor. An AF coming from a non-academic institution will also be mapped onto one of the same categories by ITRA Executive Committee.

Unlike mentors, Adjunct Faculty (AF) will not be involved regularly and integrally in the projects. However, when engaged, the impact of AF on the teams will be comparable to that of the mentors. Typically, involvement of AF will be triggered by their chance availability, for longer periods such as during sabbatical or other leaves. The proposed modes of interaction include visits to teams and sometimes remote interactions. The maximum number of AFs supported by ITRA, as provisioned in ITRA EFC, is 51.

Modes of Interaction

1. Visits to teams
2. Remote interaction via video conferencing, etc.

A. Adjunct Faculty Visits to Teams

1. AF visits to the teams are encouraged.
2. Any team may host an AF. This team may also wish to discuss the visit with other teams who may also be interested in the AF.
3. The host team's PI should discuss an outline of the plans with ITRA at least two months before the visit is to begin and get ITRA's go-ahead before proceeding with the plans.
4. On approval by ITRA, the host team may work out a detailed tentative plan, and ask all other teams if they would like to participate in the activities, organize some by hosting the AF, etc., and if it suits the AF, work out a final plan that caters to the needs of all other interested teams. The objective should be to maximize ITRA-wide benefit from the activities.
5. Those activities, of value to other ITRA teams and possibly beyond, e.g., lectures, courses, discussion, etc., may be streamed to all interested, e.g., via NKN, other video conference means, etc.
6. The host team PI should inform all other teams and any others about the plans through direct email, ITRA website, etc.
7. The host PI should ensure an efficient and smooth visit, including the interface with any other teams that AF may visit. That the activities are useful, efficient and a pleasant experience for all involved, particularly the AF, is an important duty of the host PI.
8. The organization and execution of an AF trip are the responsibility of the host team PI.

B. Guidelines for ITRA's support towards an Adjunct Faculty for Visiting Teams

1. When visiting an institution engaged in an ITRA project, an AF will be typically engaged not only in ITRA project activities but also in other institutional activities, such as teaching, course/lab development, etc. Since most institutions in India are in serious need of quality faculty, and may be expected to happily avail of the opportunity of having a quality researcher as visiting faculty, ITRA will act only as a facilitator of these opportunities; the host institution will need to compensate the AF for salary, local hospitality including boarding, lodging and local travel.
2. Towards the interaction of the AF with an ITRA team at a host team institution, ITRA will support travel of the AF if the visit is for at least a month. For shorter visits, the travel will also have to be supported by the host institution.
3. Travel of an international AF will be supported by ITRA as per MLAsia international air travel rules [*Annexure 7 of Minutes of the GC Sub-Committee Meeting*]. The total cost will be limited to Rs. 1 L, for round trip economy air fare by shortest route between AF's place of stay/work and the place of host institution.
4. Travel support for a domestic AF will be limited to Rs. 25,000, for round trip economy air fare by shortest route between AF's place of stay/work and the place of host institution will be provided by ITRA.
5. All international visit plans should be finalized by the host team PI working with ITRA at least one month before the beginning of the travel.

10.7 INTERNATIONAL TRAVEL OF RESEARCHERS

The principal objective of ITRA is to catapult the quality and quantity of advanced IT Research in India. Integral to this objective is further strengthening the sense of research quality and understanding of research methodology in the ITRA faculty, students and other team members, and building local and global collaborative relationships, including through interactions with mentors and other renowned experts in their domains.

One important way in which this can be realized is by helping Indian researchers present their work at international fora. In addition to the fact that most conferences accept papers under the condition that the each paper is actually presented by an author at the conference site, being at such conferences provides a valuable opportunity for face to face interactions and building relationships with professional colleagues. It is a standard method for the new researchers to connect and succeed. It may lead to closer collaborations and fruitful new research partnerships.

Since many of the major conferences are often held outside India, there is a need for supporting international travel by researchers. ITRA considers attending at least 2 good quality conferences annually to be essential for any research group to enhance the quality metrics by which their performance is to be evaluated. ITRA team members shall therefore be supported to present research papers at international conferences or workshops; etc. that have already been identified or accepted by ITRA as quality venues.

The decision for supporting travel to present papers at conferences shall be made using predetermined criteria by a committee duly constituted by ITRA. The general guidelines for the committee shall include the following:

1. The total number of visit slots for ITRA researchers per year per focus area will be 50.
2. Support to only one author per paper will be provided by ITRA.
3. All international visits should be discussed and finalized with ITRA at least one month before the beginning of the travel.
4. The paper must have been submitted at least 3 months after the beginning of project, and no later than 3 months after the end of the project.
5. The quality of the paper, the reputation of the conference, frequency of recent travel supported by ITRA, the standing of the author's institution will be considered, along with whether the paper and the conference represent good research achievement and/or adequate improvement by the author over an appropriate period just preceding the current conference. ITRA will form a list of reputable conferences for each focus area.
6. Students need to be particularly encouraged, e.g., to present their research findings at conferences, so they get exposed to the latest developments in their field of interest and develop confidence that they can also publish and lead the way like others who they may otherwise have only heard of or read about. The faculty should also be supported to participate in international conferences. Following is the high to low priority order for providing travel support to the eligible ITRA researchers: PIN student researchers, PIN faculty researchers, LIN student researchers, and LIN faculty researchers. Also, first time authors may be given extra encouragement. Specifically, the available international travel support will be distributed among students, PIN faculty and LIN faculty in the proportion 5, 3 and 2. Exceptions will be possible if there are not enough candidates to maintain the proportions.
7. Each conference visit slot will be for up to 5 days, excluding travel days.
8. A common structure of ITRA support to faculty as well as students for attending the conference shall be provided, and this support shall be for costs under the following common heads: Air

Travel, Visa, Hotel accommodation, DA, Taxi, Registration and Travel Insurance. Reimbursement will be made on production of actual bills. [Annexure 10 of Minutes of the GC Sub-Committee Meeting]

9. Whenever travel to an international mentor or adjunct faculty is otherwise planned in the general time frame of the international conference, merging of the two may be explored to economize on the total cost.

LIST OF ITRA-MOBILE PROJECTS

Start date of Project: Jan 1, 2014

Duration: 3 Years

S.No.	Name of the Project
1.	HumanSense: Towards Context Aware Sensing, Inference and Actuation for Applications in Energy and Healthcare
2.	DISARM: Post-Disaster Situation Analysis and Resource Management Using Delay-Tolerant Peer-to-Peer Wireless Networks
3.	Remote Health: A Framework for Healthcare Services using Mobile and Sensor-Cloud Technologies
4.	CARTS: Communication Assisted Road Transportation Systems
5.	Virtual Assistant for mobile devices using voice and gesture technologies for mobile devices using voice and gesture technologies
6.	De-congesting India's transportation networks using mobile devices
7.	Mobile Broadband Service Support over Cognitive Radio Networks
8.	MICRONet : Mobile Infrastructure for Coastal Region Offshore Communications & Networks
9.	Uncoordinated, Secure and Energy Aware Access in Distributed Wireless Networks

Summary of the Quantitative Measures of the Progress Made by Eight Mobile Teams

Area	Total Numbers (Since the project began)
10. Research and Development	240
# of Publications in Peer Reviewed Conferences included in the ITRA List or of the same Calibre	45
# of Publications in Major Peer Reviewed Journals included in the ITRA List or of the same Calibre	135
# of Peer Reviewed Conferences in which Project Personnel are Organizers (e.g., as Chairs, Reviewers, Committee Members, ..)	59
# of Peer Reviewed Journals included in the ITRA List or of the same Calibre in which Project Personnel are involved (e.g., as Reviewers, in editorial duties,)	120
# of invited talks given at major institutions, conferences	98
# of PhD students in the project	147
# of Masters students	166
# of Undergrad students	65
# of students supported to travel to conferences	4
# of Post-Docs	64
# of Tools/Technologies developed	16
# of Technical contests held for solving various technical/other field-relevant challenges organized by professional societies and other organizations from time to time	63
# of World renowned Experts involved with ITRA researchers	55/3442
2. Impact on Curriculum	
# of New Courses/Modules developed with enrolment	30
# of New Labs	26/1461
# of Courses/Modules updated in a major way with enrolment	18
# of Labs Updated in a major way	45
# of New Textbooks authored/edited, Book chapters, Magazine, Articles, Case studies	
3. Combined Outreach and Societal Sensitivity Development	
# of Patents	4
# of Startups formed or in formation	8
# of Summer/Winter/Monsoon Schools and # of Participants	23/406
# of other Short/Long Courses and # of Participants	41/470
# of Tutorials and # of Participants	38/650

# of Distance Education Courses and # of Participants	3/63
# of Seminars/ Seminars Series/Workshops/Conferences and # of Participants	80/1535
# of Open houses where the work being done by the team is exhibited to colleges, schools, public at large, etc., to increase their understanding and appreciation of research in science and engineering	18/200
# of Contests held for solving various outreach and societal sensitivity challenges organized by NGO and other organizations from time to time and # of Participants	38/173
# of Other Institutions in/outside the team impacted by the above	70
# of Major Collaborations with Industry	25
# of Major Collaborations with Government	16
# of Major Collaborations with NGOs	17
# of Major Collaborations with International Organization	9
# of Major Collaborations with Any Others	5
# of Technologies Transferred (Industry/Government/NGOs/ International Organization/ Others)	10
# of Solutions Provided (Industry/Government/NGOs/ International Organization/ Others)	24
# of Services Offered (Industry/Government/NGOs/ International Organization/ Others)	28
# of Licenses Granted (Industry/Government/NGOs/ International Organization/ Others)	1
# of Consultations Offered (Industry/Government/NGOs/ International Organization/ Others)	22
# of Industrial Board Memberships (Industry/Government/NGOs/ International Organization/ Others)	20
# of Other Outreach Activities	29



HumanSense



TOWARDS CONTEXT AWARE SENSING, INFERENCE AND ACTUATION FOR APPLICATIONS IN ENERGY AND HEALTHCARE

PROJECT TEAM

Recent advances in mobile computing and networking have resulted in low cost pervasive sensing, ubiquitous communications networks and mobile platforms with more on-device computation than ever before. This allows large scale connectivity while leveraging cloud computation. Although, much of the sensing and mobile devices have become part of everyday life, their relevance and applicability towards developing interdisciplinary solutions for critical application domains like energy and healthcare, is yet untapped, due to several technical and contextual limitations.

HumanSense project is applying the aforesaid advancements to address domains of energy and healthcare by empowering users with information that helps them in decision making and thus optimizing on the limited available resources. Relevant interdisciplinary solutions are being developed using a distributed cyber physical infrastructure to collect high resolution data about user activity and its associated context (e.g. environmental, social, economic, cultural and educational). Collected data, after suitable processing, establishment of data quality and understanding of the context in which the data is collected, will help in achieving optimal decisions both at the individual and the system level.

A system comprising hardware platforms, mobile middleware, distributed server software and algorithms will be developed that can measure personalized energy impact

and provide personalized recommendations towards energy conservation. Similarly, a scalable system to provide efficient, integrated and affordable healthcare services will be developed. This system comprising mobile based health kit, GIS integrated modular server side software, and related algorithms, will be test deployed in some hospitals.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 42 papers have been published in conferences/ journals, out of which, 17 were presented in ITRA approved conferences/journals of international repute.

PATENTS: Submitted TWO Patents (i) A Smart phone builder kit; & (ii) Smart phone based remote monitoring & alerting system.

IMPACT ON CURRICULUM

TEN Courses Developed/ Modified.

OUTREACH OUTCOMES

FOUR Summer/ Monsoon/ Winter Schools Conducted.

TWENTY THREE Workshops/ Conference/ Seminars Conducted.

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

Heart health monitoring Cardio watch; Smartphone kit to serve as LINUX PC; and System to sense, analyse and enhance home energy usage are few technologies that may lead to a Commercialization/ Startup

INSTITUTIONS

- i. IIT Delhi - Lead Institution
- ii. Shiv Nadar University, Gr. Noida - Partner Institution
- iii. Indira Gandhi Delhi Technical University for Women, Delhi - Partner Institution

INVESTIGATORS

- i. Dr Pushpendra Singh, IIT Delhi - Lead Investigator
- ii. Dr Debopam Acharya, SNU
- iii. Dr S.R.N. Reddy, IGDTUW
- iv. Dr Vinayak Naik, IIT Delhi
- v. Dr Sanjit Kaul, IIT Delhi
- vi. Dr Sujay Deb, IIT Delhi
- vii. Dr Angshul Majumdar, IIT Delhi
- viii. Dr Amarjeet Singh, IIT Delhi
- ix. Dr Vikram Goyal, IIT Delhi
- x. Dr Prasad Pathak, SNU
- xi. Dr Divya Lohani, SNU
- xii. Dr Seema Sehrawat, SNU

MENTORS

- i. Prof. Sumit Roy, University of Washington, USA
- ii. Dr. Shivkumar Kalyanaraman, IBM Research, Melbourne
- iii. Dr. Venkat Padmanabhan, Microsoft Research, Bangalore

COLLABORATORS

Dr. Mona Duggal, PGIMER, Chandigarh

PH.D STUDENTS

FOURTEEN PhD students are working on the project

PROJECT ADVANCEMENTS

- i. A context aware, Android based smart phone ad hoc sensing system that senses parameters (like temperature, humidity, CO, CO₂) from indoor environment and analyzes it in real time has been developed.
- ii. IoT prototype to sense and monitor outdoor pollution from smoke, CNG, CO and particulate matter has been developed.
- iii. A smartphone accessory kit to watch heart health has been developed.
- iv. A system to sense, analyze and enhance home energy usage has been developed.
- v. A middleware for efficient management and retrieval of collected data has been developed.
- vi. IVR platform for delivering healthcare information has been developed.
- vii. New advanced algorithms have been developed and tested for anomaly detection in energy data.

GALLERY



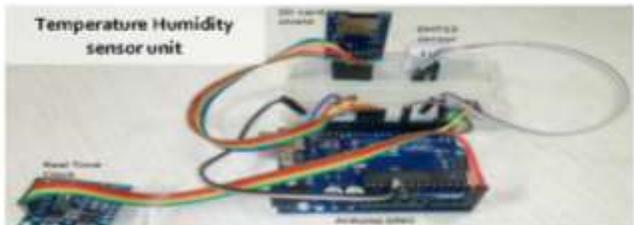
Experimental set up for diagnostic information like BP and HR is extracted using ECG and PPG



IOT Prototype for sensing outdoor pollution data from various sources



Non-intrusive Load Monitoring using Smart Meter



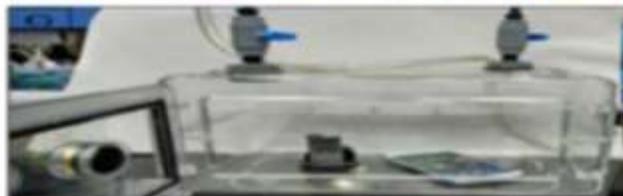
Temperature Humidity sensor unit



(A)



(B)



(C)



(D)

Experimental setup: (A, B) Co₂ incubator (Eppendorf) to maintain cell lines (C) Chamber for maintaining Co₂ concentrations and take the reading by sensor drone (D) Nikon Fluorescence Microscope for imaging the endothelial cells.



DISARM



POST-DISASTER SITUATION ANALYSIS AND RESOURCE MANAGEMENT USING DELAY-TOLERANT PEER-TO-PEER WIRELESS

PROJECT TEAM

During post disaster recovery period communication services are either not available or partially available. In times of limited communication services like these, innovative wireless networking applications can be helpful for systematizing chaotic situations.

Disarm project aims in providing service and network level solutions for tackling various challenges related to the Post-Disaster Situation. The project is about developing a 4-tier, low cost, fast deployable and disaster-tolerant wireless communication infrastructure. A robust framework will be investigated and developed that will lead to a global need assessment from the piecewise localized views of the rescue teams and victims.

Disarm's major innovation lies in the construction of a coherent picture for overall situation analysis from different, partial, inflated, multi-modal information and development of distributed methods for post-disaster service management in presence of uncertainty that may range from unreliable (wireless) network links to diverse background of the victims as well as volunteers. This will also provide a coordination system to guide resource distribution among disaster victims. Experience gained from this project will enhance the preparedness

of relief agencies and the first responder which will improve the use of smart devices for better coordination of relief efforts.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 52 papers have been published in conferences/ journals. Out of which, 37 papers were in ITRA approved conferences/journals of international repute.

IMPACT ON CURRICULUM

FOURTEEN Courses Developed/Modified.

OUTREACH OUTCOMES

TWENTY THREE Workshops/ Conference/Seminars Conducted.

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

A technology to establish ad hoc communication networks at short notice in disaster-struck areas is under advance stage of development which may lead to a ToT/ commercialization/ startup.

INSTITUTIONS

- i. IIT Kharagpur - Lead Institution
- ii. IIM Calcutta - Lead Institution
- iii. IEST Shibpur - Partner Institution
- iv. NIT Durgapur - Partner Institution
- v. KGEC, Kalyani - Partner Institution
- vi. HIT, Kolkata - Partner Institution

INVESTIGATORS

- i. Prof. Niloy Ganguly, IIT KGP – Lead Investigator
- ii. Dr. Somprakash Bandyopadhyay, IIM Calcutta – Lead Investigator
- iii. Dr. Sipra Das Bit, IEST
- iv. Dr. Sujoy Saha, NIT Durgapur
- v. Dr. Indrajit Bhattacharya, KGEC
- vi. Dr. Siuli Roy, HIT
- vii. Dr. Bivas Mitra, IIT KGP
- viii. Dr. Animesh Mukherjee, IIT KGP
- ix. Dr. Sandip Chakraborty, IIT KGP
- x. Dr. Indranil Bose, IIM Calcutta
- xi. Dr. Saptarshi Ghosh, IEST
- xii. Dr. Tamaghna Acharya, IEST
- xiii. Dr. Subrata Nandi, NIT Durgapur
- xiv. Dr. Pranay Chaudhuri, HIT
- xv. Dr. Partha S Banerjee, KGEC

MENTORS

- i. Dr. Sajal K. Das, Missouri S&T, USA
- ii. Dr. Sukumar Ghosh, University of Iowa, USA
- iii. Dr. Subir Biswas, Michigan State University, USA
- iv. Dr. Arjun Katoch, United Nations Disaster Assessment and Coordination & NDMA

COLLABORATORS

- i. Dr. Romit Roy Choudhary, University of Illinois, USA
- ii. Dr. Pradipta De, SUNY, Korea.
- iii. Industry: Flipkart, Google and Microsoft
- iv. NGO: SPADE and Indian Red Cross Society

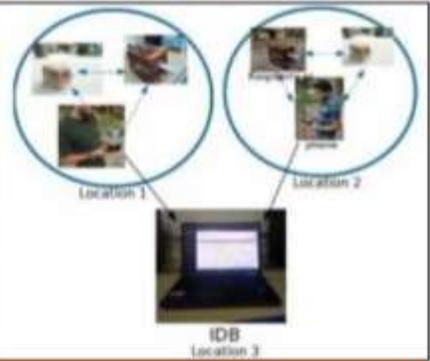
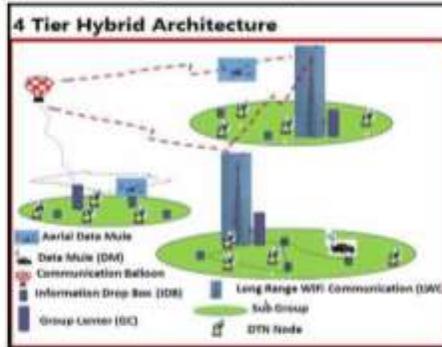
PH.D STUDENTS

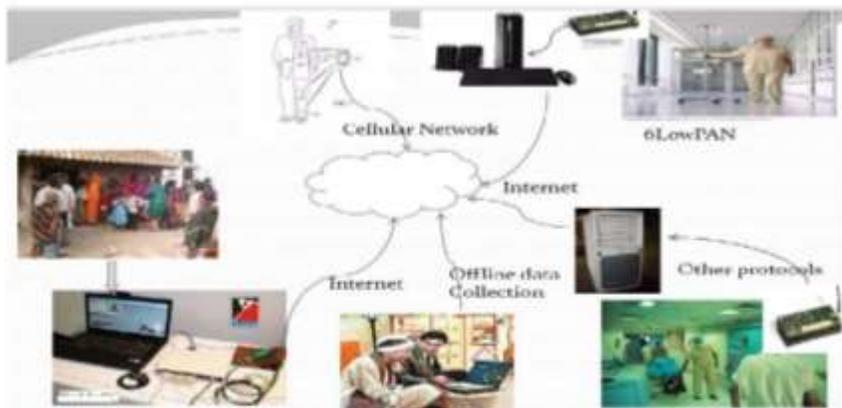
FIFTEEN PhD students are working on the project

PROJECT ADVANCEMENTS

- i. Wireless MeshBox: Ultra low-cost, plug-and-play wireless mesh network has been developed that spreads an Internet connection in a specific area has been developed.
- ii. A DTN-based P2P sync tool for post-disaster applications called pSync has been developed.
- iii. Android application for collecting typing activity and predicted emotion using machine learning techniques has been developed.
- iv. A situational analysis tool for situational information aggregation, filtering and integration during propagation through the tiered architecture has been developed.
- v. Developed an Android application for navigation and alerting user in a public transport
- vi. Developed a system to generate an annotated city traffic map using crowdsourcing
- vii. Developed an intelligent bus route recommendation system
- viii. Designed density based clustering algorithms for outdoor landmark identification from vehicular traces.

GALLERY





A FRAMEWORK FOR HEALTHCARE SERVICES USING MOBILE AND SENSOR-CLOUD TECHNOLOGIES

The economically weaker and marginalized sections of people, particularly those living in remote villages of India have very limited and often no access to proper healthcare services. Due to tremendous shortage of trained manpower and huge cost for setting up state-of-the-art facilities, it is often not possible to deliver proper healthcare services in the rural and remote areas. Lack of accurate and timely information further adds to the problem. The advancements of the internet, wireless mobile computing, sensor networking and cloud computing technologies have led to cutting-edge research in a wide variety of applications that can significantly improve our daily lives, including healthcare systems.

Remote Health project is about creating a service provision framework and deploying suitable healthcare services through integration of state-of-the-art technologies like smart-mobile devices, sensor networking and cloud computing. Remote Health research work is distributed around three central themes: (1) developing sensor-cloud infrastructure for providing remote healthcare services, (2) delivering efficient solutions for pervasive healthcare services over wireless networks while ensuring the quality of service (QoS) requirements, and (3) developing knowledge extraction techniques for mobile healthcare applications.

Major technical contribution of the project will be a healthcare service framework in a sensor-cloud

architecture having secure and seamless communication. Low-cost, portable device for bridging this gap towards integration of sensor data from multiple patient sensors will be developed. Finally, knowledge extraction techniques and application of this knowledge for efficient diagnosis, prognosis and delivery of healthcare services will be another important contribution of the project.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 72 papers have been published in conferences/ journals. Out of which, 16 were presented in ITRA approved conferences/journals of international repute.

IMPACT ON CURRICULUM

TWELVE Courses Developed/Modified.

OUTREACH OUTCOMES

SEVEN Summer/ Monsoon/ Winter Schools Conducted.

THIRTY Workshops/ Conference/ Seminars Conducted.

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

(i) Communication, analysis and interaction system for telemedicine kiosks operated by unskilled personnel; and (ii) A device for monitoring Chronic Obtrusive Pulmonary Disease Suffers; are being developed and has the potential to lead to a startup / ToT / commercialization.

RemoteHealth



PROJECT TEAM

INSTITUTIONS

- i. Jadhavpur University, Kolkata - Lead Institution
- ii. Calcutta University, Kolkata - Lead Institution
- iii. IEST, Shibpur - Partner Institution
- iv. KIIT, Bhubaneswar - Partner Institution
- v. NIT, Durgapur - Partner Institution
- vi. FGIET, Raebareli - Partner Institution

INVESTIGATORS

- i. Prof. Nandini Mukherjee, JU - Lead Investigator
- ii. Prof. Nabendu Chaki, CU Kolkata
- iii. Prof. Jaya Sil, IEST Shibpur
- iv. Dr. Monideepa Roy, KIIT
- v. Dr. Anirban Sarkar, NIT Durgapur
- vi. Dr. Rakesh K. Misra, FGIET
- vii. Dr. Samiran Chattopadhyay, JU
- viii. Dr. Sarmistha Neogy, JU
- ix. Dr. Sankhayan Choudhury, CU

MENTORS

- i. Prof. Sukumar Ghosh, The University of Iowa, USA
- ii. Prof. Sajal Das, Missouri Univ. of S&T, USA
- iii. Prof. Nabanita Das, Indian Statistical Institute, Kolkata

COLLABORATORS

- i. Dr. Satadal Saha, JSV Innovation Pvt. Ltd.
- ii. Dr. Arijit Mukherjee, TCS Innovation Lab
- iii. Foundation for Innovations in Health (NGO)

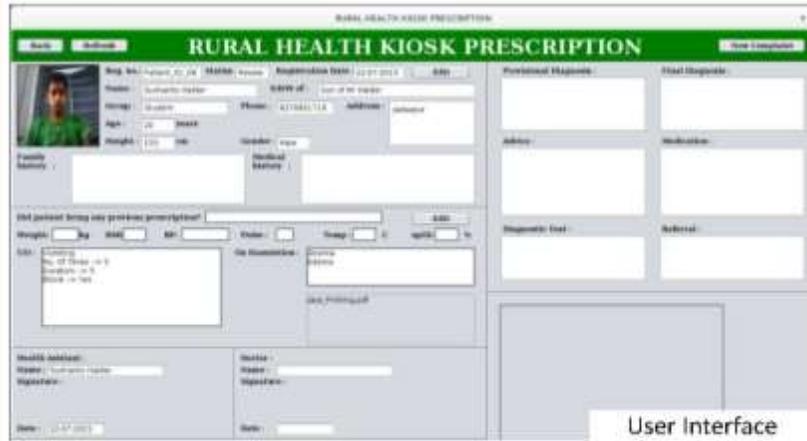
PH.D STUDENTS

EIGHTEEN PhD students are working on the project

PROJECT ADVANCEMENTS

- i. Developed a test bed with E-health sensor kits with the manual and Healthcare e-learning modules.
- ii. Health kiosk has been set up and is operational t i) Barrha in Birbhum district, ii) Bally, Sundarban and iii) Siuri in Birbhum
- iii. An android based application has been developed and tested with test data consisting of JSON tree.
- iv. JSON based on SaaS applications for ontology driven data model suitable for cloud based NoSQL or SQL Databases has been developed.
- v. A generic interface has been created for allocating, de-allocating and managing virtual sensors at IaaS level.
- vi. A sensor-cloud infrastructure has been implemented for management of sensors as remote resources.
- vii. A prototype has been developed for continuous monitoring of patients on top of SensIaaS architecture.
- viii. An algorithm has been implemented for immediate reservation of sensing resources to the SaaS applications on demand basis.
- ix. Lab prototype of ontology based autonomous disease diagnosis system developed with case studies "Abdominal Pain" and "Diarrhoea".
- x. NeSen – a tool for cross layer feedback on network connection stability and link stability developed
- xi. S-MASK – a prototype device for monitoring the COPD patient is developed and demonstrated at NPC 2016.

GALLERY



User Interface



Outreach Activities

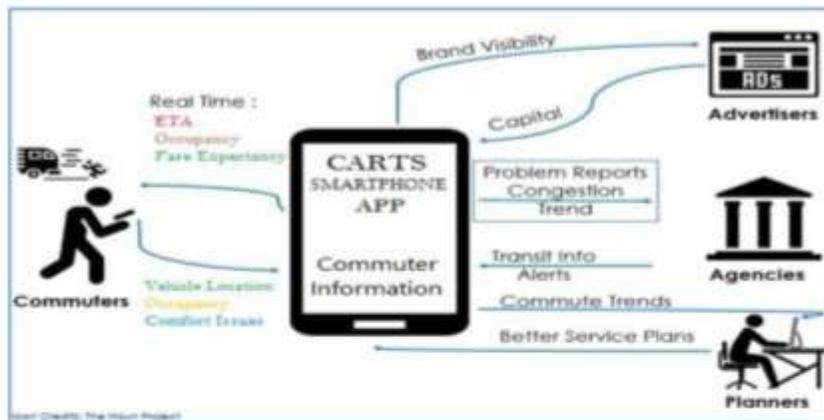


Telemedicine Kiosk at Bali



A-Mobile App: Child Immunization Register

A-Mobile App: DOTS Program for Children



CARTS



COMMUNICATION ASSISTED ROAD TRANSPORTATION SYSTEMS

PROJECT TEAM

Road traffic congestion is a world-wide issue, especially, severe in the developing world which needs specific attention because of the contrasting nature of traffic as compared to developed countries. Traffic in developing countries, like India, is often chaotic with ineffective lane systems and much higher variability in size and speed of vehicles. While the use of public transportation is highly desirable, but uncertainty and overcrowding hinders its effectiveness. This calls for the need of Intelligent Transportation Systems especially designed for developing countries, like India.

The project aims to construct an overarching communication framework that can help ease congestion, while also making it much easier for commuters to use public transportation, by harnessing the capabilities of wireless communication and mobile devices.

In the project mobile-phone based sensing techniques are being developed and tested under various chaotic road conditions, and are being optimized for metrics such as the mobile's power consumption. On-road static sensing techniques are also being developed and enhanced. A flexible and scalable Information gathering & dissemination framework is being developed, to collect the (crowd-sourced) information centrally, via Mobile internet, WiFi & SMS, as well as

disseminate it to interested users. Machine learning techniques are being used to deduce information from the gathered sensor data, and also to develop techniques for identification and elimination of noise/malicious data in crowd-sourced information. Example applications using the CARTS system, will be developed for Android & iOS based smart phone and also for basic phones.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 5 papers have been published in ITRA listed journals and conferences of international repute

IMPACT ON CURRICULUM

SIX Courses Developed/Modified.

OUTREACH OUTCOMES

FOUR Workshops/ Conference/ Seminars Conducted

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

(i) A real time bus information system using crowd sourcing; (ii) A smartphone signal based pothole and bump detection system; and, (iii) A Content-Centric Networking framework providing road traffic state classification, using smart-phone sensors; are few smartphone based systems/ technologies which are under advanced stages of development and has a potential of ToT/ Commercialization / Startup

INSTITUTIONS

- i. IIT Bombay - Lead Institution
- ii. PEC Chandigarh - Partner Institution
- iii. UIET Chandigarh - Partner Institution

INVESTIGATORS

- i. Prof. Bhaskaran Raman, IIT Bombay - Lead Investigator
- ii. Dr. Divya Bansal, PEC Chandigarh
- iii. Dr. Naveen Aggarwal, UIET Chandigarh

MENTORS

- i. Prof. K. K. Ramakrishnan, U.C Riverside, USA

COLLABORATORS

- i. Indian Computer Emergency Response Team
- ii. Transport authority, Chandigarh
- iii. Mathematical Sciences Research Institute
- iv. Bangalore Metropolitan Transport Corporation
- v. MHRD: Design & Innovation Center at UIET

PH.D STUDENTS

SIX PhD students are working on the project

PROJECT ADVANCEMENTS

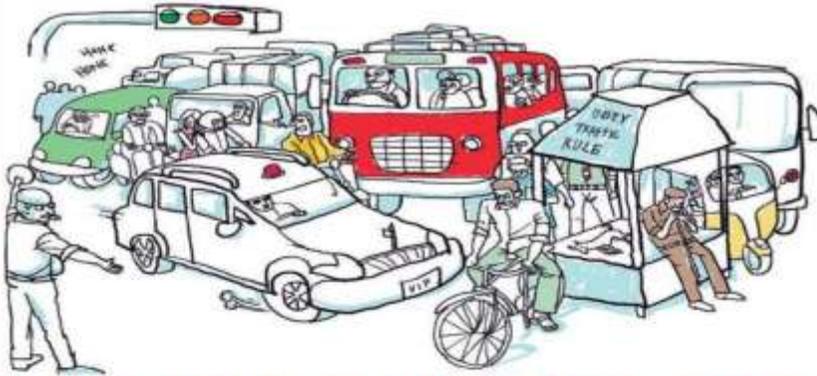
- i. Smart phone apps for pothole and bump detection, and real time bus information app using crowd sourcing, have been developed.
- ii. Road Safety: Incident Detection and Forensics using Mobile Sensors has been developed.
- iii. Urban Traffic Planning: Automated Turning Movement Monitoring: improved intersection and signal behaviour analysis.
- iv. Developed an android and an IoT App for Road Accident Detection
- v. RoadSphygmo: Traffic Congestion Detection using Barometer Sensor done
- vi. Driving behaviour has been characterized to accuracy rate of 90% (approx) for turns and 97% (approx) for braking and sudden acceleration. Road conditions detected at accuracy: 90% (approx) for bump and potholes.
- vii. Design of content-centric networking framework providing road traffic state classification, using smartphone sensors has been completed.
- viii. Developed algorithms for GSM based positioning for public transportation commuters.
- ix. Developed algorithms for efficient and accurate localization of cell-phones using crowdsourced data
- x. An Android App developed for Real time traffic analysis using acoustics

Pothole and Bump Detection App

Crowd Sourced Real Time Bus Information App

GALLERY





DE-CONGESTING INDIA'S TRANSPORTATION NETWORKS USING MOBILE DEVICES

Road congestion in India is a massive problem that is steadily getting worse. This calls for an urgent need to estimate congestion and traffic patterns on urban roads. Although much work has already been done by developed nations, but solutions for Indian cities need specific attention as the nature of traffic in India is fundamentally different from that of developed nations.

This project envisages the use of mobile phones to estimate congestion and traffic patterns on urban roads. Based on the congestion metrics thus obtained, the project is developing algorithms and tools for traffic planning and management, using mobile phone as a service platform. The proposed solution strategy consists of two distinct focus areas. The first focus area deals with the problem of estimating mobile phone densities to measure prevailing congestion and traffic patterns. The second focus area involves developing algorithms for traffic routing, control and prediction, based on the estimated congestion.

This work has enormous potential for applications such as dynamic

route planning, peak hour rush control, routing of emergency vehicles to and from disaster affected areas, evacuation planning and traffic prediction. In addition, this work shall shed new conceptual insights into the general problem of controlling complex networks by bringing together ideas from several technical disciplines. The project also plans to do a techno-economic evaluation of the system so as to understand and appreciate the extent of avoidable social costs caused by congestion.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 5 papers have been published in ITRA approved conferences/journals of international repute.

IMPACT ON CURRICULUM

SEVEN Courses Developed/Modified.

OUTREACH OUTCOMES

FIVE Workshops/Conference/Seminars Conducted.

De-congesting



PROJECT TEAM

INSTITUTIONS

- i. IIT Madras - Lead Institution
- ii. IMSc Chennai - Partner Institution
- iii. Dept. of Physics, Calcutta University - Partner Institution
- iv. NIT Trichy - Partner Institution

INVESTIGATORS

- i. Dr. Krishna Jagannathan, IIT Madras - Lead Investigator
- ii. Prof. Sitabhra Sinha, IMSc - Chennai
- iii. Dr. Ramakalyan Ayyagari, NIT Trichy
- iv. Prof. Subinay Dasgupta, Calcutta University
- v. Dr. Gaurav Raina, IIT Madras
- vi. Dr. Gitakrishnan Ramadurai, IIT Madras

MENTORS

- i. Prof. P. R. Kumar, Texas A&M University, USA
- ii. Prof. D Manjunath, IIT Bombay

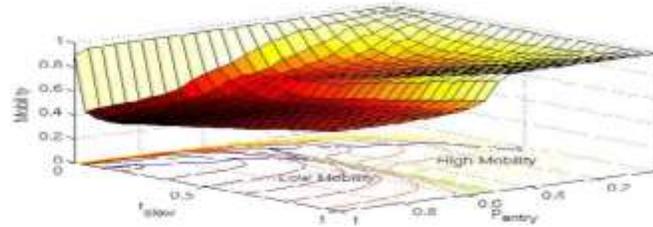
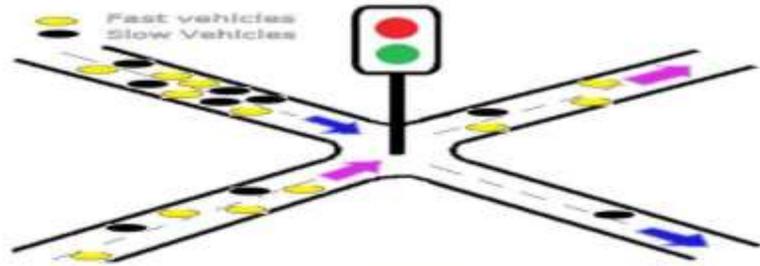
COLLABORATORS

- i. Aditya Gopalan, IISc, Bangalore
- ii. OLA Cabs, Hyderabad

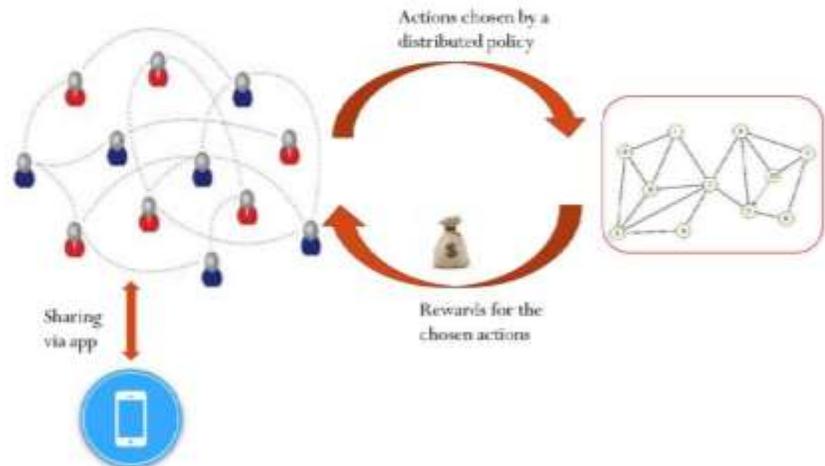
PH.D STUDENTS

FOUR PhD students are working on the project

- i. Developed a methodology to derive marginal and total cost of traffic congestion in Delhi
- ii. Quantitatively characterized the impact of slow-moving traffic on throughput, using a cell- automata model.
- iii. Developed an intricate understanding of stability of car following models with delayed feedback.
- iv. Developing a distributed route learning framework based on a bandit problem with shared samples through a social network.
- v. Development of a distributed system to automatically schedule movements of vehicles in such a way that no collision occurs and no vehicle is ever required to deviate from its pre-specified route.



Cellular Automata Model



Distributed Route Learning Model



Virtual Assistant



VIRTUAL ASSISTANT FOR MOBILE DEVICES USING VOICE AND GESTURE TECHNOLOGIES

PROJECT TEAM

The current interfaces on a mobile phone are based on alpha-numeric keys and touch technologies, which expects a human being to operate over a tiny area and are extremely sub-optimal & restricted for literate/illiterate and differently-abled. Although, some Virtual Assistants (VAs) have made inroads into the mobile space, but current state-of-the-art VAs suffer from severe limitations including lack of multimodal communication, support for Indian languages and differently-abled individuals.

Virtual Assistant project is trying to overcome this limitation and build a rich interface using voice and gesture based technologies for a multi-modal mobile interaction and computing. This project is developing various techniques to augment speech application with dialogue and gesture based interaction in order to improve system performance among patients (users) suffering from various ailments that may impair normal speech. The research work encompasses speech signal processing, acoustic modeling, language modeling, dialog modeling, natural language generation and speech synthesis. This system will act as the baseline for next versions of Virtual Assistant health care system. The overall system will be made to successfully work in real-time for

Indian languages even on low-end Android mobile.

KEY OUTCOMES

RESEARCH OUTCOMES

Publications: 18 papers have been published in conferences/journals, out of which, 5 were presented in ITRA approved conferences/journals of international repute.

IMPACT ON CURRICULUM

TWO Courses Developed/ Modified.

OUTREACH OUTCOMES

FIVE Summer/ Monsoon/ Winter Schools Conducted.

TWO Workshops/Conference/ Seminars conducted

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

A technology for providing a Respiratory Digital Health Services (V-Health); and, Smartphone based analysis of cough characteristics; are being developed and has the potential of ToT/ commercialization/ start-up.

INSTITUTIONS

- i. IIIT Hyderabad – Lead Institution
- ii. VNRVJIT, Hyderabad - Partner Institution

INVESTIGATORS

- i. Dr. Manish Srivastava, IIIT Hyderabad -Lead Investigator
- ii. Dr. Padma Sai, VNRVJIET-Hyderabad
- iii. Dr. Radhika Mamidi, IIIT Hyderabad
- iv. Dr. Anoop Nambodri, IIIT Hyderabad
- v. Dr. Snehasis Mukherjee, IIIT Hyderabad

MENTORS

- i. Prof. Thomas Binford, Chairman and CTO, Read-Ink Technologies Pvt. Ltd.
- ii. Dr. Archan Misra, SMU, Singapore
- iii. Prof. Aloknath De, CTO, Samsung Engineering Pvt. Ltd.

COLLABORATORS

- i. Shreshtha Nursing Home
- ii. Vivekanand Hospital
- iii. Sri City Medical Center

PH.D STUDENTS

THREE PhD students are working on the project

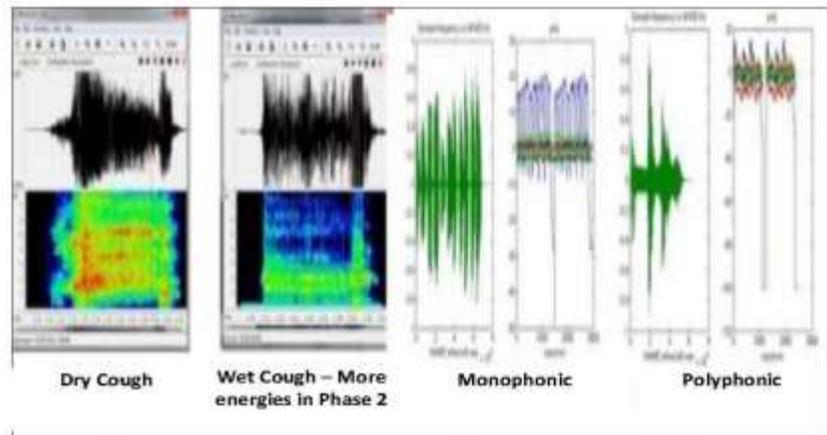
PROJECT ADVANCEMENTS

- i. Working prototype for event detection (like speech, cough and wheeze) has been developed.
- ii. Built adaptive dialogue modelling engine for rapid dialogue integration.
- iii. Built dialogue models for disease diagnosis and advisory.
- iv. Built VA gesture and vision based identification for bites/cuts and lacerations from images for providing first aid advise.
- v. A smartphone based Cough Analyzer App which can be executed on any Android device to classify cough signals either as Wet Cough Signal or Dry Cough signal has been developed. The application takes the cough signal as input and classifies as wet or dry.
- vi. Stress Analysis system is under final stage of development.
- vii. The Acoustic and Language models trained using the Kaldi toolkits are integrated into the developed speech recognition application.
- viii. Completed event detection logic for separating speech, cough and wheeze events
- ix. Built an Adaptive Dialogue model for rapid dialogue integration in multiple languages

GALLERY



Diagnose symptoms dialog flow



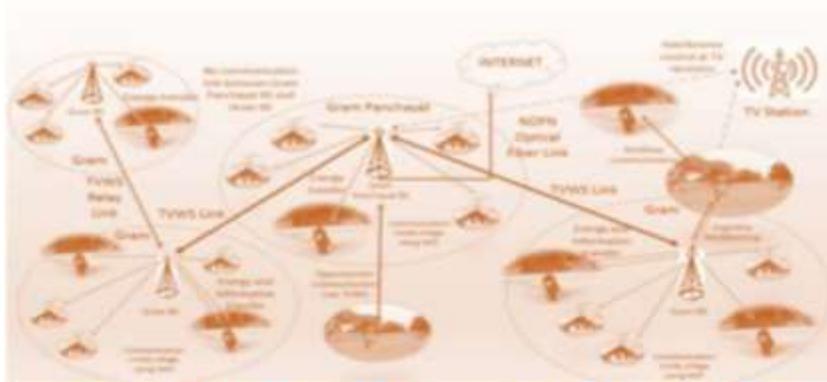
Acoustic Signal Analysis



Gesture Data



Writing Data



MOBILE BROADBAND SERVICE SUPPORT OVER COGNITIVE RADIO NETWORKS

The large population of connected devices imposes a great demand on spectrum resource, which is now crowded with most frequency segments being statically and exclusively allocated to specific types of wireless devices. On the other hand, at any given time and place, less than 10 percent of the allocated spectrum is being utilized. Cognitive Radio is the next generation technology option further increase availability of spectrum by using these unused spectrum (white spaces/ spectrum holes) efficiently, opportunistically, and dynamically without causing any unacceptable interference to the licensed primary user. While the cognitive sensing has been investigated in recent years, there is a need to develop sophisticated methods that are reliable at low SNRs. There has been relatively less work on upper layer issues, such as the effects of distributed transmit power control, packet error rate and quality of service guarantee, as well as device level issues, such as energy constraints. Further, studies on the usage of cognitive radios for mobile medical health-care support are quite nascent.

This project envisages a comprehensive approach to the design issues related to architectural

planning, physical layer alternatives and their impact, medium access protocols and network layer processing including dynamic spectrum coordination, energy efficiency, individual and group mobility support, and broadband service provisioning on low-power flexible cognitive radio platform. In view of an urgent need for technologies for national-level mobile health-care support, and the fact that there has been no significant ongoing effort in the country on such technology development, application areas in this research project would fill this gap.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 59 papers have been published in conferences/ journals, out of which, 30 papers are in ITRA approved conferences/ journals of international repute.

IMPACT ON CURRICULUM

SIXTEEN Courses Developed/Modified.

OUTREACH OUTCOMES

FIVE Workshops/ Conference/ Seminars Conducted.

Cognitive Radio



PROJECT TEAM

INSTITUTIONS

- i. IIT Delhi -Lead Institution
- ii. LNMIIT, Jaipur -Partner Institution
- iii. IRPE-CU, Kolkata - Partner Institution
- iv. NERIST, Itanagar - Partner Institution

INVESTIGATORS

- i. Prof. Shankar Prakriya, IIT Delhi – Lead Investigator
- ii. Prof. Ranjan Gangopadhyay, LNMIIT – Jaipur
- iii. Prof. Abhirup Das Barman, IRPE-CU – Kolkata
- iv. Dr. Ningrinia Marchang, NERIST – Itanagar
- v. Dr. Swades De, IIT Delhi

MENTORS

- i. Dr. R Chandramouli, NSF SAvI: Institute for Cognitive Networking, New Jersey
- ii. Dr. Mainak Chatterjee, University of Central Florida, Orlando
- iii. Dr. Chitrabrata Ghosh, Intel Corporation, Santa Clara
- iv. Prof. Sridhar Varadharajan, IIIT Bangalore
- v. Dr. R Ramjee, Microsoft, Bangalore

COLLABORATORS

- i. ISI Kolkata
- ii. SAMEER Kolkata

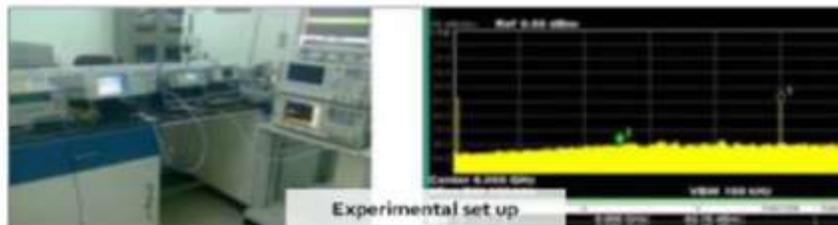
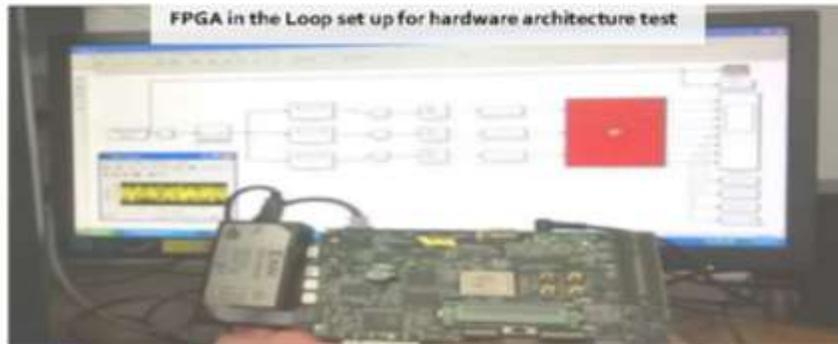
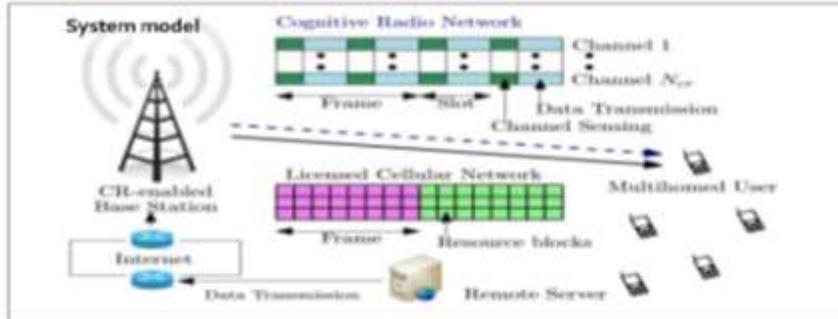
PH.D STUDENTS

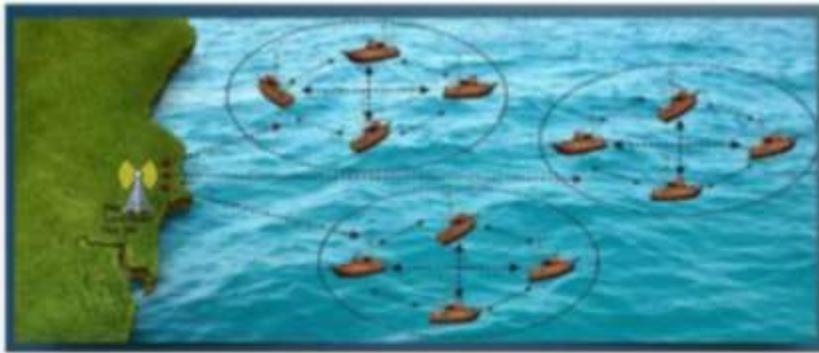
SEVENTEEN PhD students are working on the project

PROJECT ADVANCEMENTS

- i. Developed a finite state machine based optimized system on chip architecture for spectrum sensing.
- ii. Developed a bio inspired optimization based algorithm for dynamic threshold in energy based spectrum sensing.
- iii. Analyzed spectrum sensing system using Boltzmann machine for extremely low SNR scenarios under shadow fading channels.
- iv. Spectrum measurement at different location has been carried out. Machine learning Algorithms are being developed for spectrum occupancy prediction and cooperative spectrum sensing by using such data.
- v. Single on-chip FPGA implementation of genetic algorithm and evolutionary optimization based spectrum sensing algorithm development has been done.
- vi. Real Time Spectrum Occupancy Prediction Analysis using Time Series Models and Machine Learning

GALLERY





MICRONET



MICRONET – MOBILE INFRASTRUCTURE FOR COASTAL REGION OFFSHORE COMMUNICATIONS & NETWORKS

PROJECT TEAM

Presently, the fishing community in India is facing technology challenges due to lack of efficient and low-cost communication, accident reporting systems and the fact that cellular network is not able to provide sufficient coverage beyond 15 Km from the shore.

The MicroNet project's primary objectives are to provide low cost Mobile Infrastructure for Coastal Regions of India to enable Offshore Communications and to solve the technology challenges faced by the fishermen community. This project is investigating into femtocell based building blocks and developing effective algorithms required for co-operative beamforming mobile infrastructure for coastal region offshore communications and networks for distances greater than 40km using peer-to-peer communication between various boats at sea.

In the MICRONet architecture, Transmission High Site (THS) located on land will have an antenna array consisting of several antenna elements. THS transmits space-time encoded data streams to the remote femtocell radio units at sea which are situated on boats. At the receiving end, radio nodes on the clusters of boats, will form several independent groups to undertake coordinated uplink beam forming to the THS. LED indicators/alarm indicators will help to alert maritime boundary violations, disseminate the weather warnings and

also help in collision avoidance – mutual collision & collision with other larger ships. The increasing network coverage contributed by this architecture would bolster chances of effective disaster relief during emergencies.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 42 papers have been published in conferences/ journals. Out of which, 15 were presented in ITRA approved conferences/journals of international repute.

PATENTS: Submitted ONE patent on low power antenna design.

IMPACT ON CURRICULUM

FOURTEEN Courses Developed/ Modified.

OUTREACH OUTCOMES

ONE Summer/ Monsoon /Winter Schools Conducted.

FIVE Workshops/ Conference/ Seminars Conducted.

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

System to establish communication among off-shore fishing boats and with shore; A real time information service to guide offshore fishing and disseminate offshore information to boats; and a directional antenna design for low power communication from offshore boats, are few technologies under development which may lead to startups / ToT / commercialization.

INSTITUTIONS

- i. Amrita Vishwa Vidyapeetham, Coimbatore – Lead Institution
- ii. IIST, Trivandrum – Partner Institution
- iii. IIITM, Trivandrum – Partner Institution

INVESTIGATORS

- i. Prof. Maneesha Ramesh, Amrita – Lead Investigator
- ii. Prof. BS Manoj, IIST
- iii. Dr. Elizabeth Sherly, IIITM
- iv. Prof. Sethuraman Rao, Amrita
- v. Prof. Balaji Hariharan, Amrita
- vi. Dr. Venkat Rangan, Amrita

MENTORS

- i. Prof. Nitin Vaidya, UIUC, USA
- ii. Prof. Sajal Das, MissouriS&T, USA
- iii. Prof. Prasant Mohapatra UC Davis, USA
- iv. Prof. G. Venkatesh, IITM Madras & Sasken Technologies, Chennai
- v. Prof. Seshaiiah Ponnekanti, NEC, UK
- vi. Dr Dilip Krishnaswamy, IBM, Bangalore

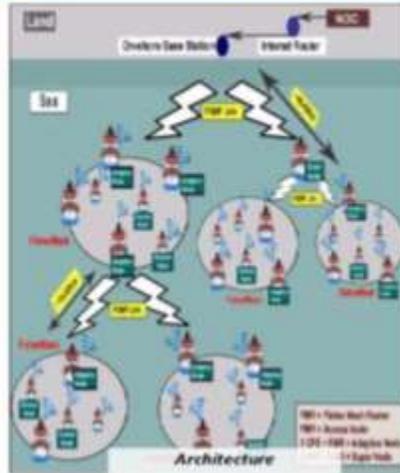
COLLABORATORS

- i. Prof. A Jayasumana, CSU, USA
- ii. Dr. Nagabhushana Sindhushayana, Qualcomm, USA
- iii. Embracing the World (NGO)
- iv. Department of Fisheries, Govt. of Kerala

PH.D STUDENTS

TWELVE PhD students are working on the project

- i. Wireless mesh network for intra-boat communications has been developed
- ii. Developed algorithm for "Location based Information Predictive System for Deep Sea communication".
- iii. Developed directional antenna design for low power communication from offshore boats.
- iv. Developed an adaptive, demand driven and energy efficiency algorithm for provisioning of the back-haul network.
- v. Designed and implemented an optimization scheme for backhaul utilization.
- vi. Created a novel software-defined wireless mesh network architecture based on OpenFlow.
- vii. Mobility prediction algorithm for finding missing boats developed.
- viii. Designed and developed Pentagonal Patch single antenna & antenna array.
- ix. Developed a hierarchical control plane architecture and associated protocols specific to FisherMesh2.0



9.Uncoordinated, Secure and Energy Aware Access in Distributed Wireless Networks

Team Institutions:

1. Indian Institute of Technology (IITB), Bombay - Lead Institution
2. Tata Institute of Fundamental Research (TIFR), Bombay
3. National Institute of Technology (NITK), Surathkal, Karnataka
4. National Institute of Technology (NITD), Durgapur

Lead PI: Prof. Bikash Kumar Dey, IIT Bombay

Objectives: This project proposal envisages the design of communication strategies in uncoordinated network settings, e.g. military networks/vehicular networks with the following three main features. (i) Efficient multi-user distributed strategies for maximizing the data-rates under communication constraints on power/bandwidth/delay, while coordinating the participating users with limited information exchange; (ii) Enhanced secure data access in distributed wireless systems where information dissemination to unwanted entities should be guarded against. (iii) Protocols and fundamental limits of data rate transmission in uncoordinated networks with renewable energy sources, e.g. solar/wind energy.

Outlay Rs.: 182.52 lakhs for 3 Years

LIST OF *ITRA-WATER*
PROJECTS

Start date of Project: Jan 1, 2014

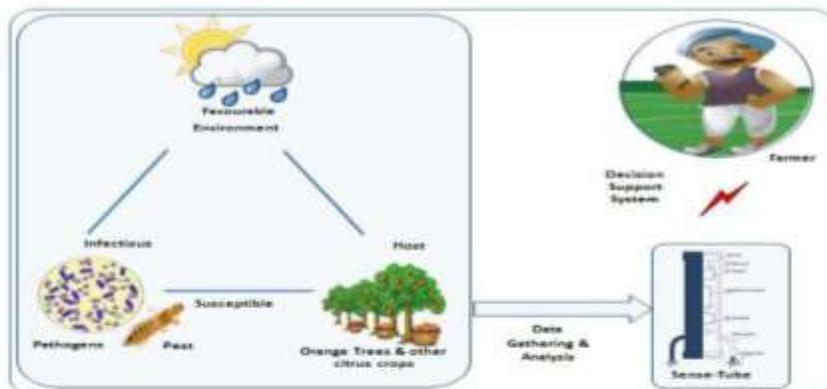
Duration: 3 Years

S. No.	Name of the Project
1.	GridSense (Groundwater-Irrigation-Disease Sensing System) : ICT in Water and Pest/Disease Management for Yield Improvement in Horticulture (Citrus)
2.	Improving Groundwater Levels and Quality through Enhanced Water Use Efficiency in Eastern Indian Agriculture
3.	Measurement to Management (M2M): Improved Water Use Efficiency and Agricultural Productivity through Experimental Sensor Network
4.	Integrated Urban Flood Management in India: Technology-Driven Solutions
5.	AquaSense : Development of Effective Wireless Sensor Network System for Water Quality and Quantity Monitoring

Summary of the Quantitative Measures of the Progress Made by Five Water Teams

Area	Total Numbers (Since the project began)
1. Research and Development	
# of Publications in Peer Reviewed Conferences included in the ITRA List or of the same Calibre	50
# of Publications in Major Peer Reviewed Journals included in the ITRA List or of the same Calibre	30
# of Peer Reviewed Conferences in which Project Personnel are Organizers (e.g., as Chairs, Reviewers, Committee Members, ..)	22
# of Peer Reviewed Journals included in the ITRA List or of the same Calibre in which Project Personnel are involved (e.g., as Reviewers, in editorial duties,)	43
# of invited talks given at major institutions, conferences	125
# of PhD students in the project	38
# of Masters students	51
# of Undergrad students	44
# of students supported to travel to conferences	24
# of Post-Docs	0
# of Tools/Technologies developed	23
# of Technical contests held for solving various technical/other field-relevant challenges organized by professional societies and other organizations from time to time	26
# of World renowned Experts involved with ITRA researchers	47
2. Impact on Curriculum	
# of New Courses/Modules developed with enrolment	17
# of New Labs	22
# of Courses/Modules updated in a major way with enrolment	10
# of Labs Updated in a major way	17
# of New Textbooks authored/edited, Book chapters, Magazine, Articles, Case studies	
3. Combined Outreach and Societal Sensitivity Development	
# of Patents	6
# of Startups formed or in formation	8
# of Summer/Winter/Monsoon Schools and # of Participants	18-283
# of other Short/Long Courses and # of Participants	15-189
# of Tutorials and # of Participants	4-82

# of Distance Education Courses and # of Participants	4
# of Seminars/ Seminars Series/Workshops/Conferences and # of Participants	48-408
# of Open houses where the work being done by the team is exhibited to colleges, schools, public at large, etc., to increase their understanding and appreciation of research in science and engineering	9
# of Contests held for solving various outreach and societal sensitivity challenges organized by NGO and other organizations from time to time and # of Participants	5
# of Other Institutions in/outside the team impacted by the above	42
# of Major Collaborations with Industry	13
# of Major Collaborations with Government	27
# of Major Collaborations with NGOs	7
# of Major Collaborations with International Organization	15
# of Major Collaborations with Any Others	4
# of Technologies Transferred (Industry/Government/NGOs/ International Organization/ Others)	5
# of Solutions Provided (Industry/Government/NGOs/ International Organization/ Others)	48
# of Services Offered (Industry/Government/NGOs/ International Organization/ Others)	10
# of Licenses Granted (Industry/Government/NGOs/ International Organization/ Others)	0
# of Consultations Offered (Industry/Government/NGOs/ International Organization/ Others)	13
# of Industrial Board Memberships (Industry/Government/NGOs/ International Organization/ Others)	28
# of Other Outreach Activities	22



GridSense

Groundwater Irrigation Disease Sensing System



ICT IN WATER AND PEST/DISEASE MANAGEMENT FOR YIELD IMPROVEMENT IN HORTICULTURE (CITRUS)

PROJECT TEAM

Vidarbha region experiences severe climatic uncertainties thereby giving rise to citrus crop failure. In absence of right information, farmers do not follow right irrigation practices based on stage-wise crop water requirements, and tend to overexploit ground water resources. Improper/excessive irrigation results in water logging, which has a strong correlation with diseases which adversely effects the quantity and yield of citrus. This warrants for efficient water management in the region.

GridSense project had tried to address water sustainability problem by providing technological, economical and behavioral solutions to the most critical water related problems in citrus agriculture. The combined effects of Hydro-geology, Irrigation, and Crop pest/diseases are being investigated in the project. Field scale experiments are conducted for developing 'soil-water-crop' models with detailed representation of aquifer composition, material characteristics, groundwater divide, and structural boundaries at field scale. Methods are being developed for quick and real time system for measurement of groundwater draft. Wireless Sensor Network has been developed and deployed to monitor the agrometeorological parameters from the citrus farms and further develop models for early detection of crop diseases.

Consequently, GridSense project will assist water managers and farmers with region specific crop & disease models and information through various ICDT, which in-turn will help them in optimizing the irrigation and increasing the citrus productivity.

KEY OUTCOMES:

RESEARCH

PUBLICATIONS: 14 papers have been published in conferences/journals, out of which, 5 papers are in ITRA approved conferences/ journals of international repute.

PATENT: Filed **TWO** patents (i) on Wireless Sensing System for Precision Agriculture (ii) A Prototype Crowd Sourcing System.

IMPACT ON CURRICULUM

SIX Courses Developed/Modified.

OUTREACH

THREE Summer/ Monsoon/ Winter Schools Conducted.

SIX Workshops/ Conference/ Seminars Conducted.

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

(i) A wireless platform to sense and manage crop resources; and, (ii) A solutions for identifying, delineating, managing and developing ground water resources in hard rock aquifers of India; are under advanced stage of development which may lead to ToT/commercialization/ start-ups.

INSTITUTIONS

- i. IIT Bombay-Lead Institution
- ii. IIT Hyderabad -Partner Institution
- iii. PDKV, Akola -Partner Institution

INVESTIGATORS

- i. Prof. J. Adinarayana, IIT- Bombay Lead Investigator
- ii. Dr. K.B.V.N Phanindra, IIT- Hyderabad
- iii. Prof. Rajendra Gade, PDKV-Akola
- iv. Prof. Surya Durbha, IIT- Bombay

MENTORS

- i. Prof. James Phillip King, New Mexico State University, USA
- ii. Prof. Praveen Kumar, Univ. of Illinois at Urbana-Champaign, USA
- iii. Prof. U. B. Desai, IIT Hyderabad
- iv. Prof. S.N. Merchant, IIT Bombay

COLLABORATORS

- i. Dr. P. S. Shirgure, National Research Centre for Citrus, Nagpur
- ii. Mr. Rafael Thomas, Datamatrix Infotech Pvt. Ltd., Pune
- iii. Dr. Bhushan Jagyasi, Ms. Yogita Karale, Mr. Jayant Mohite, Mrs. Sonali Kulkarni, TCS Innovation Labs
- iv. Maharashtra Orange Growers Association, Warud

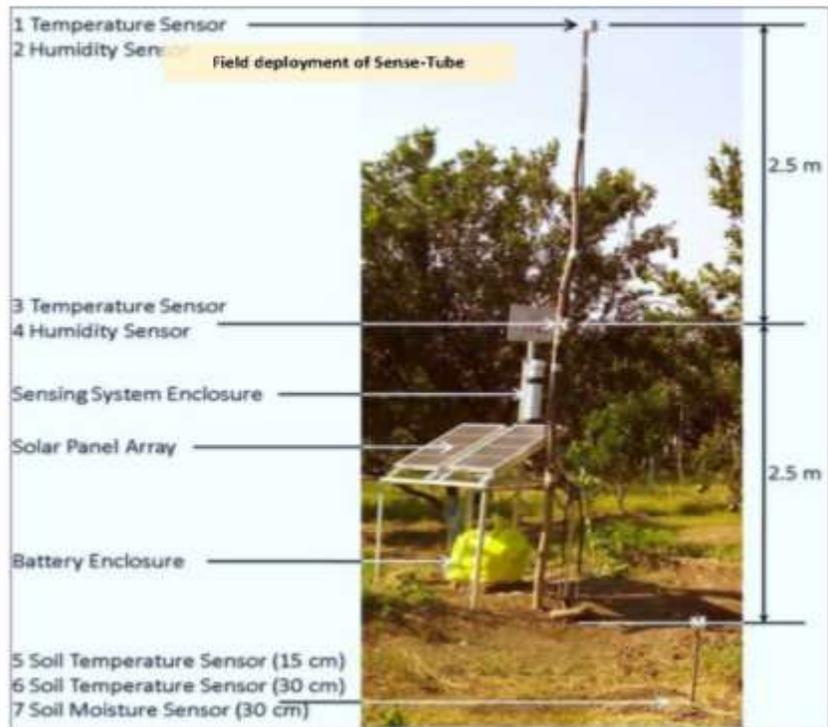
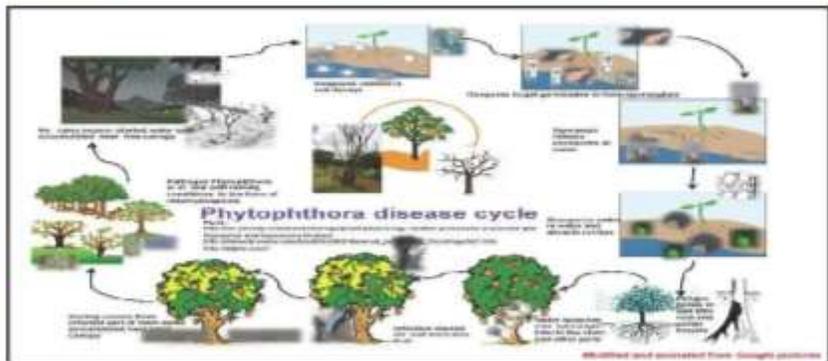
PH.D STUDENTS

FIVE PhD students are working on the project

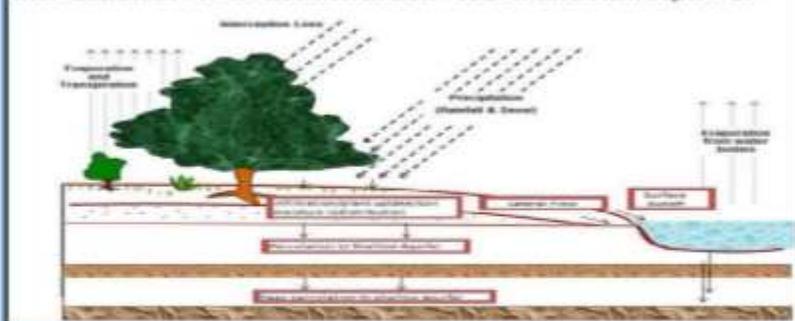
PROJECT ADVANCEMENTS

- i. Developed an Open Source Hardware and Software Sensing System for Citrus (Sense Tube). The technology is being tested for citrus growers in Warud area near Nagpur.
- ii. Configured and calibrated Soil Water Plant Atmosphere (SWAP) model for soil moisture and soil temperature estimation using datasets from AWS Lab and SenseTube observations.
- iii. Developed an Aquifer Mapping Technology, which has been tested in couple of villages of Telangana and Maharashtra.
- iv. Developed a Remote Sensing platform for acre and sub-acre agricultural field (RapidSense).
- v. Developed Stage II Gummosis disease Prediction model on Nagpur mandarin to determine exact severity of the disease in Warud tehsil.
- vi. Developed Stage III Integrated Prediction model including weather-soil-plant-disease parameters.
- vii. Developed a Lasso Regularization based regression model using remote sensing and watershed parameters for predicting Gummosis disease severity.
- viii. Deployed low-cost low-power soil moisture sensor network on selected fields to study the moisture patterns.
- ix. Developed a protocol to monitor 3-D soil moisture distribution beneath a healthy and declined orange tree using ERT survey.

GALLERY



Interaction of Plantations with Soil –Water and Atmosphere:



IMPROVING GROUNDWATER LEVELS AND QUALITY THROUGH ENHANCED WATER USE EFFICIENCY IN EASTERN INDIAN AGRICULTURE

Many parts of India are already water stressed and this may worsen due to climate variability impacts. Therefore it is important to increase the efficiency of water use, explore options to augment water supply in critical areas, and ensure more effective management of water resources. Ground water, the most dependable source, is under tremendous stress in the form of rapidly declining quantity and quality due to non-judicious overuse mainly by the Indian agriculture. Accurate assessment of water balance across various hydrologic reservoirs is essential to understand and tackle water related issues. This warrants better predictive tools for root zone soil moisture at field-scale where water management decisions are made.

This project targets development of representative digital watersheds/catchments and underlying aquifers in eastern India for better understanding of their characteristic spatio-temporal dynamics and water balance across various hydrologic reservoirs and their underlying cause/effect relationships. Soil water balance and aquifer recharge and recovery are being monitored at different spatial and temporal scales. Innovative storm-water management, agricultural water management, conjunctive use and aquifer recharge techniques are being evaluated for reversing the declining trend of groundwater quantity and quality.

This project will provide a unifying global scheme/ technique for forecasting daily root zone soil moisture status maps at the field-scale by using various satellite/ insitu data, and will develop efficient agricultural water management scheme for improving the water use efficiency and recharge of aquifers. Finally, a Decision Support System will be developed for determination of best practices for existing and proposed scenarios of water resources management in eastern India.

KEY OUTCOMES:

RESEARCH OUTCOMES

PUBLICATIONS: 14 papers have been published in conferences/ journals, out of which, 4 papers are in ITRA approved conferences/journals of international repute.

IMPACT ON CURRICULUM

TEN Course Developed/Modified.

OUTREACH OUTCOMES

FIFTEEN Workshops/ Conference/ Seminars Conducted.

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

(i) A system to point out the best water recharge sites and the best digging sites for tube wells; and (ii) Designs of micro irrigation system for enhancement of water use efficiency, and, protected cultivation structures are under advanced stage of development which have the potential for TOT/ Commercialisation/ Startup.

IGWL

Improving Groundwater Levels and Quality



PROJECT TEAM

INSTITUTIONS

- i. IIT Bhubaneswar - Lead Institution
- ii. IIT Kharagpur - Partner
- iii. KIIT University, Bhubaneswar- Partner
- iv. CAET, Orissa Univ. of Agri. & Tech, Bhubaneswar - Partner

INVESTIGATORS

- i. Prof R K Panda, IIT Bhub - Lead Investigator
- ii. Prof K N Tiwari, IIT Kharagpur
- iii. Prof B Das, KIIT University, Bhub
- iv. Dr B C Sahoo, OUAT, Bhub
- v. Prof S Tripathy, IIT Bhub

MENTORS

- i. Prof. Binayak Mohanty, Texas A&M University, USA
- ii. Dr. P K Mishra, Indian Institute of Soil and Water Conservation, Dehradun

COLLABORATORS

- i. Prof. Suranjan Panigrahi, University West Lafayette, USA
- ii. Dr. Ajay Pradhan, C252 New Delhi
- iii. Mr. G. P. Pattanaik, Ex. Engg. Agg. Dept. Odisha
- iv. Mr. S. K. Pattnaik, Asst Er., GW Survey & Invst., Govt. of Odisha
- v. Odisha State Agriculture Dept.
- vi. Directorate of Groundwater Survey & Investigation, Bhubaneswar
- vii. Dr. A. K. Behera, Overseas Proj & Services, Bhubaneswar

PH.D STUDENTS

Seven PhD students are working in the project

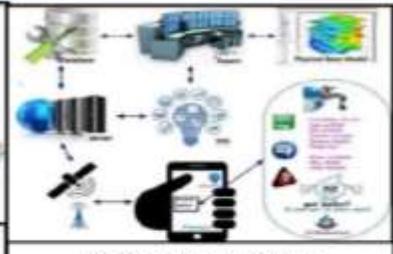
PROJECT ADVANCEMENTS

- i. Groundwater Flow simulation model for the study basin using Visual MODFLOW has been developed been translated to numerical model with different boundary and initial conditions and finite difference grids in visual mudflow flex 2014.2 environment.
- ii. Mapping of groundwater potential zones using remote sensing, GIS and multi-criteria decision analysis techniques based on analysis of geological, geomorphological, land use/ land cover information and water table fluctuations at 46 locations has been completed.
- iii. Disaggregation/downscaling of L-band Radiometer (SMAP, NASA satellite) derived brightness temperature (36 km scale) at finer scales (1, 3 and 9 km) using C-band SAR data (RISAT-1, ISRO satellite) has been completed.
- iv. Computed Spatio-temporal variation of groundwater recharge through Hydrologic Evaluation of Landfill Performance model.
- v. Daily soil moisture data are being monitored at an interval of 10 cm up to 160 cm depth for eleven micro watersheds using FDR. A set of soil moisture data has been analysed for developing soil moisture retention curves for different depths under different plantation crops.
- vi. Recharge estimation by water level fluctuation methods and different empirical methods has been completed.
- vii. Grid-based soil moisture and hydraulic properties data at 0.5, 3 and 9 km are monitored periodically using theta probes.
- viii. An Eddy covariance system has been installed for evaluating the carbon dioxide, water vapour and heat fluxes across the different boundary layers of the atmosphere for precession estimation of the evapotranspiration from crop fields.
- ix. Digital map of watersheds in middle catchment of Mahanadi Basin have been prepared using Arc GIS 10.1

GALLERY



Study Area: Middle Catchment of Mahanadi River Basin, Approx 50,000 km²



Decision Support System



A view of Surface Rice Field

Monitoring of Aquifer Recharge



Field Deployments and Outreach



In-Situ Test-beds for Continuous Monitoring using Sensors



IMPROVED WATER USE EFFICIENCY AND AGRICULTURAL PRODUCTIVITY THROUGH EXPERIMENTAL SENSOR NETWORK

Unsustainable exploitation of surface and groundwater resources for irrigation with inefficient management practices has resulted in alarming groundwater depletion in many agriculture-dominated watersheds/regions across India. Furthermore, climate variability (episodic droughts and heat waves) and climate change may further increase irrigation water demands while reducing crop yields in future. Improved agricultural productivity via increased efficiency in farm practices, choice of crops, and improved irrigation practices are needed to ensure food and fresh water security for growing population.

M2M project is developing an integrated system to quantify agricultural water demands at farm to regional scales and to improve irrigation water use efficiency to enhance groundwater quantity/quality and agricultural productivity. An experimental sensor network has been setup for measuring weather parameters, soil moisture, and soil temperature at a field scale. These measurements are combined with historic, remote sensing based monitoring of vegetation and soil conditions, and near real time hydrologic monitoring, to evaluate the actual crop water requirements and for optimizing irrigation water requirements through an irrigation scheduling and water management system.

This project will help in evaluating the sensitivity of crop yield towards varying

soil, water, and climate conditions taking information of key variables that can provide an assessment of potential changes in crop yields and water availability under climatic change conditions.

KEY OUTCOMES

RESEARCH OUTCOMES

PUBLICATIONS: 32 papers have been published in conferences/ journals, out of which, 17 papers are in ITRA approved conferences/ journals of international repute.

PATENTS: Submitted **TWO** patents on (i) Autonomous cleaning mechanism for distributed Solar cell based application; and, (ii) UAV based agricultural sensor data transfer.

IMPACT ON CURRICULUM

FIVE Courses Developed/Modified.

OUTREACH OUTCOMES

THREE Summer/ Monsoon/ Winter Schools Conducted.

SIX Workshops/ Conference/ Seminars Conducted.

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

Technology for prediction of rainfall over a 7-30 day period and its use in the crops selection for plantation is under advanced stage of development and has the potential for ToT/ Commercialization/ Startup.

M2M Measurement to Management



PROJECT TEAM

INSTITUTIONS

- i. IIT Kharagpur - Lead Institution
- ii. IIT Gandhinagar - Lead Institution
- iii. IGKV, Raipur - Partner Institution
- iv. CAET, Anand Agri. Univ., Godhra, Gujarat - Partner Institution
- v. NERIST, Itanagar - Partner Institution

INVESTIGATORS

- i. Prof. N. S. Raghuvanshi, IIT Kharagpur - Lead Investigator
- ii. Prof. Vimal Mishra, IIT GN
- iii. Prof. M.P. Tripathi, IGKV Raipur
- iv. Prof. M.K. Tiwari AAU, Godhra
- v. Dr. A. Bandyopadhyay, NERIST
- vi. Prof. R. Singh, IIT Kharagpur
- vii. Prof. C. Chatterjee, IIT Kharagpur
- viii. Prof. A. Mishra, IIT Kharagpur
- ix. Prof. S. Misra, IIT Kharagpur
- x. Prof. A. Bhadra, NERIST, Itanagar
- xi. Prof. M.L. Gaur, AAU, Godhra

MENTORS

- i. Dr. V. Sridhar, Virginia Tech, USA
- ii. Dr. A. K. Sikka, IWMI, New Delhi

COLLABORATORS

- i. Dr. Chris Funk, USGS, USA
- ii. CGWB, Raipur
- iii. Dept. of Water Resource & Dept. of Agriculture, Govt. of Chattisgarh
- iv. Govt(s). of Uttar Pradesh and Madhya Pradesh
- v. Sardar Sarovar Narmada Nigam Limited, Gujarat

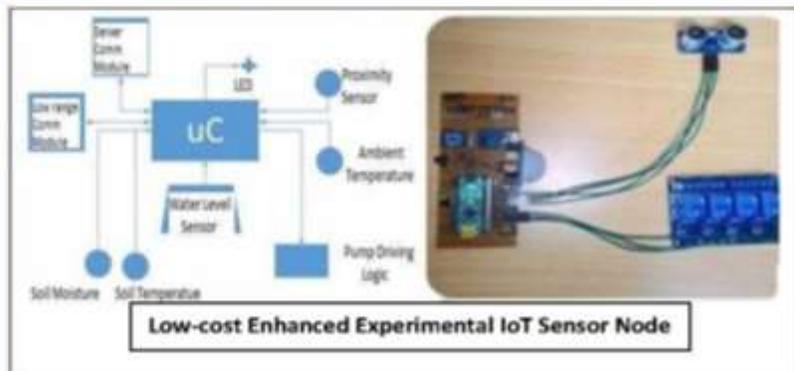
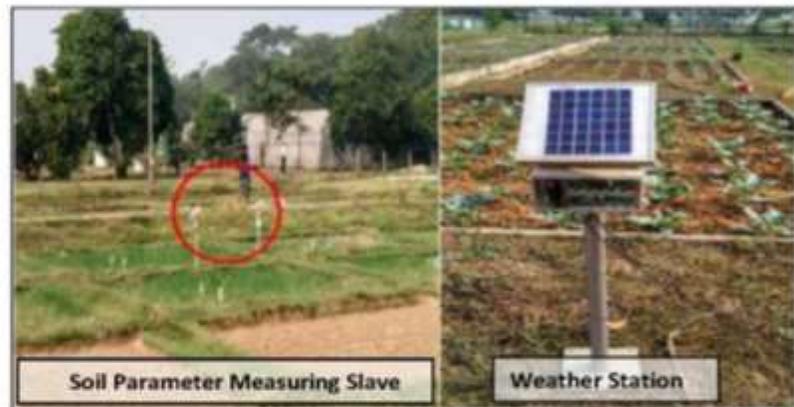
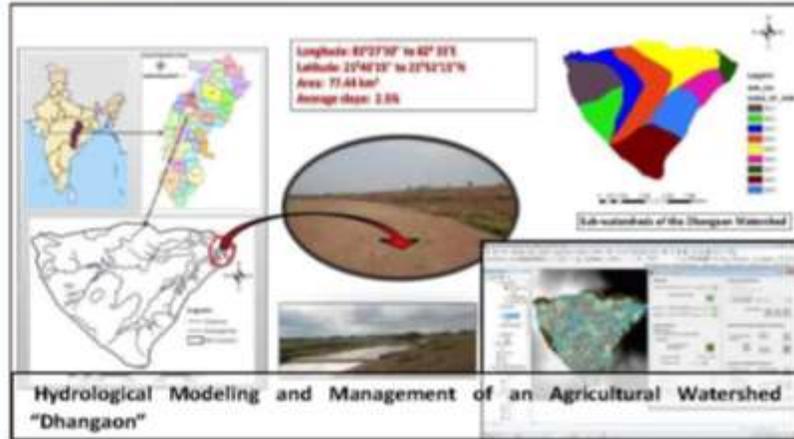
PH.D STUDENTS

TWELVE PhD Students are working on the project

PROJECT ADVANCEMENTS

- i. "Drought Monitoring System" and "Statistical Model to predict Vegetation Anomaly" has been developed.
- ii. Hydrologic framework for 45 days lead drought forecast has been developed.
- iii. An Irrigation Scheduling and Water Management System has been developed.
- iv. A ground-based visual UAV tracking and guidance system has been developed.
- v. SWAT, Noah LSM and VIC models based hydrologic modeling framework has been developed.
- vi. Characterization of basin parameters using hydrological, geomorphological, soil resources and satellite data in the environment of GIS has been completed.
- vii. Identification and prioritization of critical sub-watersheds and Hydrologic Response Units on the basis of estimated runoff, sediment yield and nutrient losses using ArcSWAT have been completed.
- viii. Server-side utilities for blind identification of sensor and nodes in absence of node identifiers; and identification of faculty data.
- ix. Automated link error detection system has been incorporated into the cloud, which classifies the incoming readings to the server into error and error-free classes
- x. Water management studies undertaken on Maize and Finger Millet in midland situation of Chhattisgarh Plains.
- xi. HEC-HMS Hydrological model setup is completed in the Panam watershed and obtained results are very useful for methodology selection and for field engineers to different watershed planning and management.

GALLERY





Urban Flood



INTEGRATED URBAN FLOOD MANAGEMENT IN INDIA

PROJECT TEAM

Rapid urbanization coupled with unplanned land use and increasing intensities of rainfall, has in recent years contributed to a significant flooding in Indian urban areas. The problem is aggravated by aging infrastructure and lack of scientific capabilities in forecasting and managing the urban drainage systems. The flood-damage potential in urban areas is also high due to population and property concentration in relatively small areas. Recent catastrophic floods in Indian cities have highlighted the importance of urban flood management in the country.

This project is developing an end to end integrated flood warning system with focus on urban areas. This will enhance the scientific capabilities for interactive operational management of urban drainage systems integrated with real-time flood forecasts with data from automatic weather stations, water level sensors, control systems, satellite products, Geographic Information Systems driven based data, urban numerical weather forecast, hydrologic models, communication networks and computer technologies.

A three stages solution comprising monitoring, modeling, and management is being proposed. Real-time flood forecasting models based on data and information from satellite products, automatic weather stations

and state-of-the-art numerical weather prediction and hydrological models are being developed. Methodologies for communicating the forecasts to different levels of decision making mechanisms is being integrated. GIS based operational models for real-time management of urban drainage systems using water level sensors and control systems algorithms are being developed.

KEY OUTCOMES:

RESEARCH OUTCOMES

PUBLICATIONS: 19 papers have been published in conferences/ journals, out of which, 10 papers are in ITRA approved conferences/journals of international repute.

IMPACT ON CURRICULUM

FOUR Courses Developed/Modified

OUTREACH OUTCOMES

FIVE Summer/Monsoon/Winter Schools Conducted.

FIVE Workshops/Conference/Seminars Conducted

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

A service to forecast, analyze the effect of, and manage urban floods is under advanced stage of development and has the potential of ToT / commercialization / start-up.

INSTITUTIONS

- i. IISc Bangalore - Lead Institution
- ii. BITS Hyderabad - Partner
- iii. NIT Warangal - Partner
- iv. C-DAC, Trivandrum - Partner

INVESTIGATORS

- i. Prof. P.P. Mujumdar, IISc Bangalore - Lead Investigator
- ii. Prof. N.V. Umamahesh, NITW
- iii. Prof. K. Srinivasa Raju, BITS Hyd.
- iv. Dr. R. Valsalam, C-DAC Triv.
- v. Prof. M.S. Mohan Kumar, IISc Bangalore

MENTORS

- i. Prof. Dev Niyogi, Purdue University, USA
- ii. Dr. Bhanu Neupane, UNESCO, Paris

COLLABORATORS

- i. Dr. G S Reddy, Karnataka State Natural Disaster Monitoring Centre
- ii. UNESCO, Paris
- iii. University of Baroda, Vadodara
- iv. M/S Geokno (Industry)
- v. Foundation for Innovations in Health (NGO)

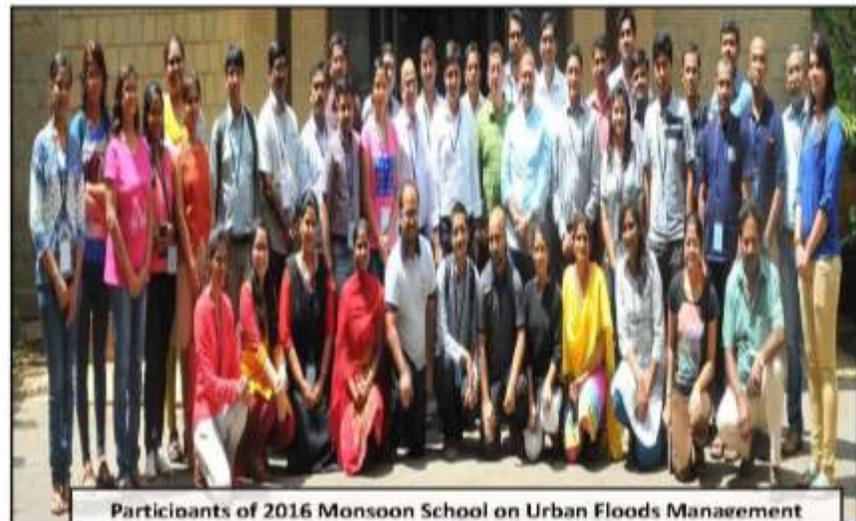
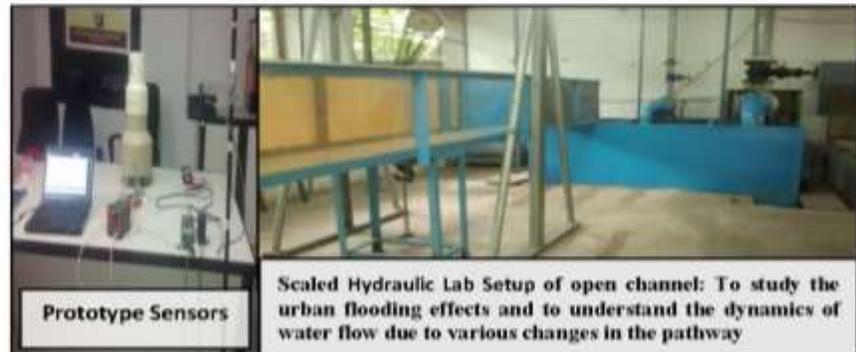
Ph.D STUDENTS

FIVE PhD students are working on the project

PROJECT ADVANCEMENTS

- i. IISc, Bangalore is developing a model to disaggregate daily precipitation time series to hourly precipitation.
- ii. A Hydro meteorological forecasts and hydrologic models for "Estimating Drainage Adequacy" in urban area for flood forecasting and management has been developed. The technology is being tested in Bengaluru city.
- iii. A Prototype of low cost water level sensor and Rainfall sensor has been developed.
- iv. LiDAR survey was conducted for high resolution surface representation in IISc Campus. The data is been processed and will be incorporated into the 2D Overland Flow Model.
- v. HEC-RAS Steady flow analysis was carried out is completed for flood plain mapping at Hyderabad City. This helped in locating the extent of flooding for a critical rainfall event; analyzing the buffer zones; and analyzing connectivity between major water bodies of Hyderabad City.
- vi. A Sensor Network Based Cyber Physical Infrastructure for Continuous Monitoring of Water Distribution Networks has been developed at IISc to study the flow behavior as well as the quality degradation in the water network.
- vii. Storm Water Management Model (SWMM) modelling is completed for Hyderabad City.

GALLERY





AquaSense



DEVELOPMENT OF EFFECTIVE WIRELESS SENSOR NETWORK SYSTEM FOR WATER QUALITY AND QUANTITY MONITORING

PROJECT TEAM

India suffers from problems of decreasing per capita water availability, inequitable water access and unaccountable urban water supply due to leakages, thefts, metering inaccuracies and losses. Another major challenge in water sector is deteriorating water quality which is witnessed by the rising levels of Biochemical oxygen demand and bacteriological contamination often due to mixing with sewage. Thus, it is very necessary to have adequate methods and equipment for water protection and drinking water quality monitoring is an important aspect for the purpose.

AquaSense project is developing an indigenous, intelligent and adaptive decision support system for on-line remote monitoring of the water flow and water quality across the wireless sensor zone to generate data pertaining to utilization of water and raising alerts in terms of mails/messages/ alarm following any violation in the safety norms for the drinking water quality.

Wireless Sensor Network system is being developed to monitor water quality and quantity in urban supply distribution network consisting of water pipeline distribution network, storage in different water bodies like overhead tanks, water sumps, water reservoirs to quantify the water utilization and also to detect the abnormality in water quality and source of pollution. The sensor nodes

consists of different sensors/probes to measure the hydraulic and quality parameters, which are crucial to determine the quantity & quality of potable water.

KEY OUTCOMES:

RESEARCH OUTCOMES

PUBLICATIONS: 1 paper has been communicated to conferences/journals of international repute.

PATENTS: Submitted **TWO** patents on (i) Integrated handheld device for water body profiling system; & (ii) Water level monitoring and early warning system.

IMPACT ON CURRICULUM

TWO Courses Developed/Modified

OUTREACH OUTCOMES

SIXTEEN Workshops/Conference/Seminars Conducted

POTENTIAL TOT / COMMERCIALIZATION / STARTUPS

A system for sensing and wirelessly disseminating consumer water quality and quantity information is under advanced stage of development which has the potential for ToT/ Commercialization/ Startup.

INSTITUTIONS

- i. University of Hyderabad - Lead Institution
- ii. IIIT Hyderabad - Lead Institution
- iii. VNRVJET Hyderabad - Partner
- iv. SUIIT Sambalpur - Partner
- v. SCCE Karimnagar- Partner
- vi. SCIT Karimnagar- Partner

INVESTIGATORS

- i. Prof Siba Udgata, Univ. of Hyd, Lead Investigator
- ii. Dr. Neelima Satyam, IIITH- Lead Investigator
- iii. Dr. Nihar Satapathy, SUIIT
- iv. Prof C.D.Naidu, VNRVJET
- v. Dr. RVRK Chalam, SCCE
- vi. Dr. A Prasad Raju, SCIT
- vii. Prof K S Rajan, IIIT Hyderabad
- viii. Dr. Samrat Sabat, Univ. of Hyd.

MENTORS

- i. Prof. Adit Singh, Auburn University, USA
- ii. Prof. Vinod Tare, IIT Kanpur

COLLABORATORS

- i. Institute of Health Science, Bhubaneswar
- ii. Karim Nagar Municipality Water Board, Karimnagar, Telangana
- iii. LightMotif Automation Sensors and Systems Pvt. Ltd. Hyderabad
- iv. Micro Systems Pvt Ltd., Hyderabad

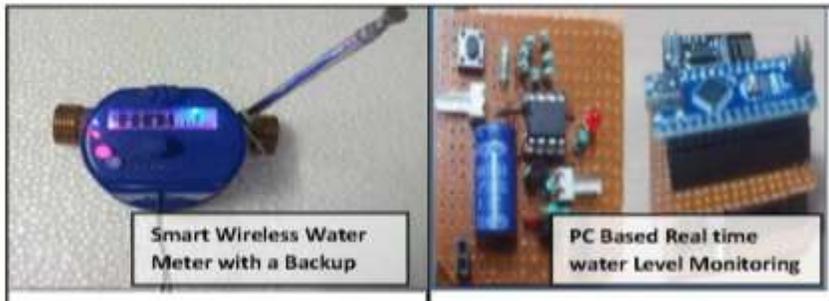
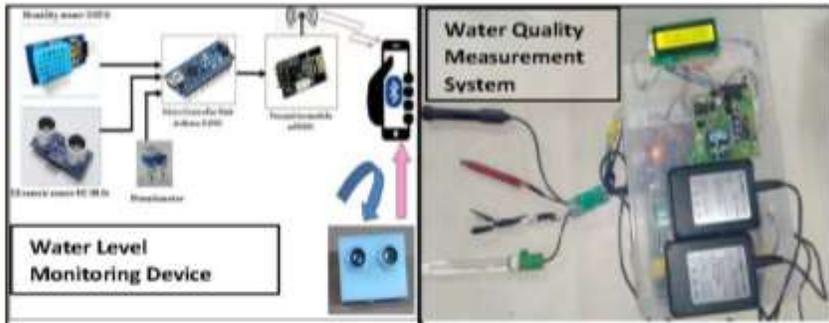
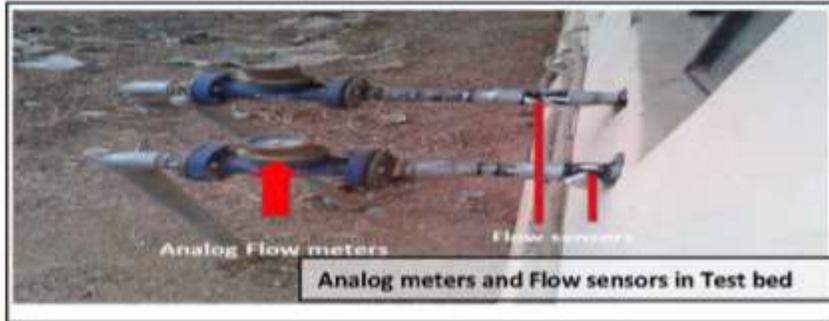
PH.D STUDENTS

NINE PhD students are working on the projects

PROJECT ADVANCEMENTS

- i. Flow measuring unit, self-power generating unit for the smart flow meter and different communication modules, like (RF module, GSM module) has been developed.
- ii. A Handheld device for E.Coli bacteria detection using spectrometry principle has been developed.
- iii. Android App for informing/ sending images of water leakages/ Complaints of water leakages in the pipe lines to sever by the general public has been developed.
- iv. Wireless Sensor Nodes for Over Head Tanks and water pipe line with real time data logging to the server has been developed and this data to be monitored remotely through website.
- v. An indigenous, intelligent, human-assisted and adaptive decision support system for on-line monitoring of the remote water quality and quantity has been developed.
- vi. A software model to measure the water quantity and in the process of developing algorithm for detecting leakage in supply pipe has been developed.
- vii. A machine learning model using SVM (Support Vector Machine) to identify patterns for alert notification has been developed. Developed an optimum sensor placement algorithm for monitoring water quality.
- viii. A model using Advection-diffusion Equation for River Mahanadi has been developed. It is implemented using MATLAB and validated with secondary Data.
- ix. A machine learning algorithm for alert finger print capture and classification has been developed. The model was tested with both real data and synthetic data.

GALLERY



**Technical & Financial Summaries of Shortlisted *ITRA-Ag&Food* proposal
under North-Eastern India**

S.No.	Prop. No.	Proposal Name
1.	1	Image based systems for identification of individuals, breeds and diseases of pigs and goats
2.	3	E-Varaha: Information System for Safe Pork Production in North Eastern India
Overall Summary of Budgets for <i>ITRA-Ag&Food</i> Proposals under North-Eastern India		

Sr.#	Prop#	Project Summary
1	01	<p>Title: Image based systems for identification of individuals, breeds and diseases of pigs and goats</p> <p>Team: (i) Kalyani Government Engineering College (KGEC), Kalyani, Nadia, West Bengal; (ii) ICAR - National Research Centre on Pig (NRCP), Guwahati, Assam; (iii) Indian Institute of Technology (IIT), Guwahati, Assam; (iv) ICAR Research Complex for NEH Region (RCNEHR-T), Tripura; (v) ICAR Research Complex for NEH Region (RCNEHR-M), Umiam, Meghalaya; (vi) Assam University,(Central University), Silchar, Assam; (vii) Uttar Banga Krishi Viswavidyalaya (UBKV), Cooch Behar ,West Bengal</p> <p>PI: (i) Prof. Satyendra Nath Mandal, KGEC, WB (ii) Dr. N.H.Mohan, NRCP, Assam</p> <p>Objectives: (i) Identification of trait(s) suitable for unique identification of individual animals (ii) Image and DNA based classification of animals into breed level clusters (iii) Image based behavioral indications and symptoms of epidemiologically important diseases</p> <p>Deliverables: (i) Trait(s) for uniquely identifying individual animals, (ii) Imaging system for the identified trait(s) (iii) Imaging system for identification with minimal optical facilities (iv) Efficient transmission of imaging data (v) Mobile based disease identification system</p> <p>Outcomes: (i) Service delivery including insurance will be efficient and feasible for these neglected animals (ii) Status of breeds of goats and pigs in the NEH (iii) Sooner than later these systems will be adapted for more animals in the country</p> <p>Abstract: Animal identification is the basis for keeping accurate production records of the herd/flock as important as animal management. Accurate records provide the farmer with enough information to make individual or whole herd/flock management decisions. Identification helps claiming insurance and other benefits in case of the death of the animal. In Indian context, with large number of animals, many of the breeds of domesticated species are yet to get a distinct identity.</p> <p>Traditional animal identification methods such as ear notching or methods like radio frequency IDs are not able to provide accurate and secure animal identification due to possibilities of damage, theft, falsification and duplication especially for small animals like pigs and goats with highly scattered distribution of ownership in very small herds. These animals are extremely valuable for the livelihood and nutritional security in the North Eastern India. Also any method used to apply a marker to an animal entails some degree of stress and tissue damage. There is demand of a method which would identify the individual animals reliably and permanently with no adverse effects even in remote scattered herd.</p> <p>Biometric methods which are non-invasive, economical and not amenable to any change are ideal for these needs. In the present proposed project, unique morphological trait(s) most suitable biometric markers will be identified in pigs (<i>Sus scrofa domesticus</i>) and goats (<i>Capra circus</i>). Some leads are available in animals like rabbits. Necessary algorithms will be developed for unique identification. A database will be established for storing and quick retrieval of the images on a regional basis for use by all relevant agencies.</p> <p>There are quite a few goat and pig population groups in the NE India with unique features and which represent our unique genetic wealth but have been not properly identified, described and documented and so is highly vulnerable to loss of claims of right, lack efforts for conservation and use in genetic improvement. There are so far, only two officially described and accepted breeds each of pig (Ghungroo and Niang Megha) and goat (Black Bengal and Assam hill goat) in the Eastern and North Eastern Region of India. This project will develop image based morphometric database these animal groups and with suitable algorithms classify into hierarchical groups up to the level of breeds and these will be authenticated by DNA markers. It is expected to develop tools for image based real time map of the indigenous goats and pigs, their distribution, emergence, diversity and migration patterns.</p> <p>Creation of image of based warning systems for diseases with visible external symptoms</p>

and/or behavioural for timely clinical intervention at the farmers' level in remote and difficult to approach regions will also be attempted in this project. This will be a very useful tool in veterinary public health management system.

The individual animal identification methods for animals will be useful in census and accurate documentation of livestock wealth for planning, protection and implementation of various schemes.

Outlay (in INR Lakhs):

Institutions	1st Yr	2nd Yr	Total
KGEC, West Bengal	28.39	17.24	45.63
NRCP, Assam	25.35	19.30	33.24
IIT Guwahati	21.52	11.72	25.47
ICAR-RCNEHR-T, Tripura	14.45	8.70	44.65
ICAR-RCNEHR-M, Meghalaya	12.20	10.20	23.15
AUS, Silchar	23.43	12.17	22.40
UBKV, West Bengal	17.06	8.41	35.60
Total	142.4	87.74	230.14

Title: E-Varaha: Information System for Safe Pork Production in North Eastern India

Team: (i) Indian Institute of Technology(IIT), Guwahati (ii) ICAR-National Research Centre on Pig(NRCP), Guwahati (iii) Tezpur University, Assam(TUA) (iv) ICAR-Research Complex for North Eastern Hilly Region, Meghalaya (v) Manipur University, Manipur(MUM) (vi) College of Veterinary Sciences & Animal Husbandry, Central Agricultural University(CVS), Aizwal, Mizoram (vii) Veterinary College, Karnataka Veterinary, Animal and Fisheries Sciences University(KVAFSU), Karnataka

PI: (i) Dr. Sukumar Nandi, IIT Guwahati (ii) Dr. Girish Patil, S., ICAR-NRCP, Guwahati

Objectives: (i) Study of the routes of pig- to- pork in the north eastern region (ii) Development of IT based systems for examining health status of slaughter purpose pigs and post mortem examination of carcasses (iii) Development of tools for identification and traceability of pork (iv) Development of piggery information management system for traceability and pork safety

Deliverables: (i) Tools for data collection and visualization, (ii) Understanding marketing channel of pork within NER (iii) Rapid techniques for examining slaughter pig (iv) Rapid technique for examining pig fecal matter (v) System for traceable labeling of retail pork

Outcomes: (i) Detailed status report containing information and quantitative analysis of routes of pig-to-pork movement in north eastern India (ii) Technologies for rapid examination of pig health at the source and abattoirs to ensure safe pork production (iii) An efficient traceability system to trace back the origin of pig/ pork (iv) An information system for assessment and management of pig health and pork quality (v) Enhanced marketability and profitability in piggery in north eastern region due to quality assurance in pork

Abstract: Pigs are the most important livestock of the North Eastern Region (NER) of India which has 8% of geographical area and 4% of population of the country but 38.38% of the country's pig population. One of the biggest challenges facing piggery sector in India especially in NER is ensuring 'safe pork production'. Most of the pigs are reared by small/ marginal farmers with only few animals and very little inputs in terms of feed and health management. Also, pigs are slaughtered, processed and marketed under unhygienic conditions. Safe pork means meat free from physical, chemical, microbiological and parasitical hazards. Chemical hazards are minimal in NER because of less use of therapeutic drugs, pesticides, growth promoters etc. Challenges to safe pork production in NER are multifarious: varied sources of pigs ranging from locally reared to those moved from across the borders, lack of quick health examination methods both at the level of animal selection at villages/ markets and antemortem (AM) examination, dearth of aids for post mortem (PM) examination of carcasses, non-availability of quick pork borne pathogen detection methods and absence of traceability system for systematic identification & maintenance of livestock records.

To address the issue of developing AM and PM aids it is proposed to develop Infrared (IR) imaging based techniques. Two types of IR interventions are planned, viz, IR thermal measurements and IR spectral imaging. Infrared thermal imaging techniques will help in detecting the general wellbeing of the animals while IR spectral imaging can be used for specific disease identification. At the level of selection of pigs for slaughter and at AM point, IR based techniques will help in examining general well-being, detection of febrile & septicemic diseases, stress level etc while at PM point IRT spectral imaging can help in detection of muscular dystrophies, presence of cysts, worm infestations, enumeration of total viable counts etc. By triangulating IRT images at animal selection level, AM level and PM level informed decision can be taken for acceptance/ rejection of the carcasses. These techniques will help in efficient AM & PM examination even in high throughput abattoirs.

To aid in selection of healthy animals free from parasitic infestation, attempt will be made to develop an IR based technique for detecting parasites, parasitic eggs, blood etc in fecal samples. For detecting meat borne pathogens in carcasses and in slaughter premises a biosensor based on impedance and surface plasma resonance will be developed. Pathogens commonly encountered in pork e.g. Coliforms, Streptococci, Salmonella, Listeria etc will be targeted in the project.

Pathogen detection techniques will help in implementation of HACCP protocols.

An online database e-Varaha will be designed for storing and managing traceability information along with Decision Support System based on Correspondence Analysis of Data generated through the novel IT-based tools for monitoring health of slaughter pigs and evaluating microbial quality at Critical Control Points in the abattoir. e-Varaha would be accessible by farmers and other stakeholders through mobiles (cell-phones). After designing of database components, work stations will be established with all four AF partners and pilot scale enrollment (500 pigs/ centre/ year) will be undertaken to validate the system. Traceability backed quality assurance systems.

Outlay (in INR Lakhs):

Institutions	1st Yr	2nd Yr	Total
IIT Guwahati	40.50	27.00	67.50
TUA, Assam	15.05	11.05	26.10
MUM, Imphal	14.75	10.50	25.25
ICAR-NRCP, Guwahati	48.67	26.87	75.54
ICAR-RCNEHR-M, Barapani	7.76	6.76	14.52
CVS, Aizwal	8.15	6.98	15.13
KVAFSU, Karnataka	10.29	6.54	16.83
Total	145.17	95.70	240.87

Overall Summary of Budgets for shortlisted *ITRA-Ag&Food*

Proposals under North-Eastern India

Sr. No.	Proposal No.	Year 1 Budget	Year 2 Budget	Total Budget
1.	1	142.40	87.74	230.14
2.	3	145.17	95.70	240.87
Grand Total		287.57	183.44	471.01

48	SREE CHAITANYA CE, KARIMNAGAR														P			1
49	SREE CHAITANYA IT, KARIMNAGAR														P			1
50	VNRVJIEET HYDERABAD						P								P			2
51	KGEC West Bengal															L		1
52	ICAR – NRCP GUWAHATI															L	L	2
53	IIT GUWAHATI															P	L	2
54	ICAR-RCNEHR TIPURA															P		1
55	ICAR-RCNEHR MEGHALAYA															P	P	2
56	ASSAM UNIVERSITY (AUS)															P		1
57	UBKV WEST BENGAL															P		1
58	TEZPUR UNIVERSITY (TUA)																P	1
59	MANIPUR UNIVERSITY (MUM)																P	1
60	CVS AIZAWL																P	1
61	VC-KVAFSU KARNATAKA																P	1
	No. Research Groups in the Project	3	6	6	5	3	3	5	3	4	5	4	4	5	6	7	7	76

Legend:

Abbreviation	Meaning
M1	<i>ITRA-Mobile Project</i> - HUMANSENSE: Towards Context Aware Sensing, Inference And Actuation For Applications In Energy And Healthcare.
M2	<i>ITRA-Mobile Project</i> - DISARM: Post Disaster Situation Analysis And Resource Management
M3	<i>ITRA-Mobile Project</i> - REMOTE HEALTH: A Framework For Healthcare Services Using Mobile And Sensor Cloud Technologies
M4	<i>ITRA-Mobile Project</i> - DECONGESTING: De-Congesting India's Transportation Networks
M5	<i>ITRA-Mobile Project</i> - CARTS: Communication Assisted Road Transportation Systems
M6	<i>ITRA-Mobile Project</i> - VIRTUAL ASSISTANT For Mobile Devices Using Voice And Gesture Technologies
M7	<i>ITRA-Mobile Project</i> - COGNITIVE RADIO: Mobile Broadband Service Support Over Cognitive Radio
M8	<i>ITRA-Mobile Project</i> - MICRONet: Mobile Infrastructure For Coastal Region Offshore Communications & Networks
M9	<i>ITRA-Mobile Project</i> - UNCOORDINATED: Uncoordinated Secure Energy Aware Access In Distributed Wireless Networks
W1	<i>ITRA-Water Project</i> - GRIDSENSE: Groundwater Irrigation Disease Sensing System
W2	<i>ITRA-Water Project</i> - IGWL: Improving Groundwater Levels & Quality And Quality Through Enhanced Water Use Efficiency In Eastern Indian Agriculture
W3	<i>ITRA-Water Project</i> - URBANFLOOD: Integrated Urban Flood Management In India: Technology Driven Solutions
W4	<i>ITRA-Water Project</i> - MEASUREMENT TO MANAGEMENT: Improved Water Use Efficiency And Agricultural Productivity Through Experimental Sensor Network
W5	<i>ITRA-Water Project</i> - AQUASENSE: Development Of Effective Wireless Sensor Network System For Water Quality And Quantity Monitoring
AF1	<i>ITRA-Ag&Food Project</i> – ImageIDGP: Image based for identification of Individuals. Breeds and Diseases of Pigs and Goats.
AF2	<i>ITRA-Ag&Food Project</i> – e-Varaha: Information System for Safe Pork Production in North Eastern India.
L	LEAD INSTITUTION
P	PARTNER INSTITUTION

