INDIAN NATIONAL ACADEMY OF ENGINEERING

INAE Monthly E-News Letter Vol. VII, Issue 7, July 1, 2016

From the Editor's Desk

The Indian National Academy of Engineering (INAE) is happy to launch the INAE Letters, a quarterly journal, to provide a medium for rapid publication of new research and invited review articles across different domains of engineering science and technology. The Edito Read more...

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Chief Editor of Publications

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ACADEMY ACTIVITIES

Creation of Data for INAE Expert Pool

INAE Expert Pool was created with the aim of identifying domain experts in various disciplines of engineering. There has been a good response from the Fellows and Young Associates in uploading their particulars on the INAE Expert Pool website. The INAE Fellows and Young Associates who have not uploaded their particulars are requested to submit their profile details online at the link http://inae.in/expert-search/index.php/inae-members-form

The details of the INAE expert Pool have since been shared with DST, TIFAC, Niti Aayog and Office of PSA. The creation of the website on Expert Pool has been appreciated by all the agencies and the data would be used by them in identifying suitable domain experts and involve the experts in their activities.

Round Table Meeting on "Regional Transport Aircraft Development"

A Round Table meeting on "Regional Transport Aircraft Development" coordinated by Dr BN Suresh, President, INAE was held on June 14, 2016 at NIAS, Bangalore. The meeting was chaired by Prof. Roddam Narasimhan, an eminent expert in the field and Dr BN Suresh, President, INAE; Dr Baldev Raj, Director, NIAS; Chairman, HAL; DG

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Round Table on "Clean Coal Technologies in India: Current Status, Demands and Aspirations – Pathways to Achievements" held on June 10, 2016 at New Delhi

DST requested INAE to provide engineering interventions required in the field of 'Clean Coal Technologies'. Accordingly, a Round Table meeting on "Clean Coal Technologies in India: Current Status, Demands and Aspirations – Pathways to Achievements" under the chairmanship of Dr. Baldev Raj, Immediate Past President, INAE was conducted on June 10, 2016 wherein about 35 domain experts from Industry, Academia and R&D participated. The proceedings and the recommendations emanated based on the deliberations and to be progressed further are being finalized. With this, INAE would be able to provide inputs to the DST on the existing state of technologies in the country, technologies available internationally and the short-term and long-term plans for adoption of technologies in the field of Clean Coal Technologies.

10th National Frontiers of Engineering (NatFoE) Symposium

The 10th National Frontiers of Engineering (NatFoE) Symposium was held on Jun. 23-25, 2016 at Indian Institute of Technology (IIT) Kanpur. Prof Sanjay Mittal, FNAE was the Coordinator of the event along with Prof Yogesh Joshi and Prof Kantesh Balani of IIT Kanpur. The four themes of the Symposium were on "Flexible Electronics"; "Laser Engineering and Technology"; "Multifunctional Biomaterial Technology" and "Smart Cities". About 30 young engineers from academia, R&D and industry participated in the event. A Panel Discussion on International Collaboration was held preceding the Valedictory Function.

Engineers Conclave 2016

INAE has been making efforts to present the recommendations on important themes of National importance to the appropriate agencies. Engineers Conclave 2016 is being held at Indian Institute of Technology Madras during Sep 1-3, 2016. Prof. Bhaskar Ramamurthi, FNAE, Director, IIT Madras and Dr BN Suresh, President, INAE are the Co-Chairs of the Engineers Conclave 2016. The themes of the Conclave are "Engineering Education" to be coordinated by IIT Madras and "Smart Cities" to be coordinated by INAE. Prof. MS Ananth, FNAE is the Coordinator from IIT Madras for Theme I on "Engineering Education". Theme I on Engineering Education shall have the following

sub-themes: Industry Expectations; Curriculum and Flexibility; Pedagogy; Start ups; Research Excellence; Quality Control; Skill Development and International Comparisons. Prof Prem Krishna, FNAE is the Coordinator of Theme –II on "Smart Cities" which shall have the following sub-themes- e-Governance/ICT Enabling; Urban Water Management; Healthcare/Sanitation; Transportation & Infrastructure and Energy & Ecology.

Annals of INAE

The soft copy of the Annals of the INAE Volume XIII, April 2016 containing the text of the lectures delivered by Life Time Contribution Awardees; Professor Jai Krishna and Prof. SN Mitra Memorial Awardees, newly elected Fellows of the Academy and INAE Young Engineer Awardees during the year; can be downloaded from the link https://www.dropbox.com/s/b3vyi5d029krakf/Annals%202016.pdf?dl=0

Research Journal -INAE Letters

The Agreement for publishing the Research Journal "INAE Letters" has been concluded with M/s Springer as approved by the Governing Council. The website for the Research Journal "INAE Letters" to include facility for submission of papers online has been launched. The first issue of the Research Journal "INAE Letters" will be released shortly and can be viewed at the link http://www.springer.com/engineering/journal/41403

Opening of Facebook and Twitter Accounts by INAE

The Department of Science and Technology (DST) has recommended enhancing Social Media Optimization through creation of Facebook and Twitter accounts. Accordingly a Facebook page and Twitter Handle for INAE have been created. All INAE Fellows are requested to visit the page and post their comments, if any. The Facebook page of INAE can be viewed at https://www.facebook.com/pages/Indian-National-Academy-of-Engineering/714509531987607?ref=hl and Twitter handle at https://twitter.com/inaehq1

Important Meetings held during June 2016

- INAE Governing Council Meeting was held on June 16, 2016
- Finance Committee Meeting was held on June 16, 2016
- General Body Meeting was held on June 17, 2016
- Sectional Committee Meetings were held on June 17, 2016

International Conferences/Seminars being organized by IITs/other Institutions

To view a list of International Conferences/Seminars being held in the month of July 2016 click here.

News of Fellows

1	Prof DN Singh, FNAE, Department of Civil Engineering, IIT Bombay has authored a book on Fly Ash Zeolites, Innovations, Applications, and Directions published by M/s Springer.
2	Dr V Ramachandran, FNAE, Emeritus Scientist, National Aerospace Laboratories, Bangalore has authored a book on "Failure Analysis of Engineering Structures: Methodology and Case Histories" published by ASM International.

International Conference on Innovative Research in Electrical, Electronics, Civil, Computer Science, Information Technology and Mechanical Engineering (ECIM-2016) on July 3, 2016 at New Delhi
http://www.conferencealerts.com/show-event?id=172407

2016 IEEE First International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES 2016) on July 4-6, 2016 at New Delhi
http://www.conferencealerts.com/show-event?id=163029

IEEE Sponsored 3rd International Conference on 'Microelectronics, Circuits and Systems', Micro-2016, on 9-10th July 2016, Kolkata, India.
http://www.conferencealerts.com/show-event?id=165919

International Conference on Advances in Materials and Manufacturing Applications (IConAMMA) on July 14-16, 2016 at Bangalore
http://www.conferencealerts.com/show-event?id=165582

IEEE 2nd International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT - 2016) on July 21-23, 2016 at Bangalore
http://www.conferencealerts.com/show-event?id=168532

Civil Engineering

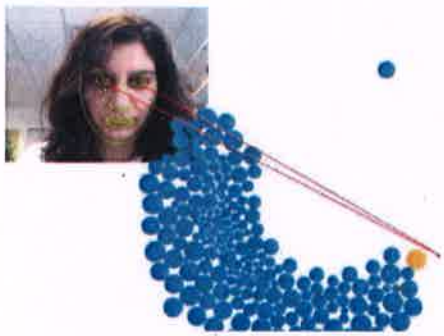
1. Futuristic Dubai Office Showcases 3D Printing's Potential

Dubai's functional office building made using 3D printer technology.

There are office printers that print out documents and there those that make the office itself. A small group of employees in Dubai is starting to move into a new workspace that the emirate says is the world's first functional office building made using three-dimensional (3D) printer technology. Looking like a mashup of a "Jetsons" abode and an Apple Store, the compact office was printed out layer by layer over 17 days at a cost of $140,000, said Saif al-Aleeli, the CEO of a government initiative called the Dubai Future Foundation that is behind the project. Features include a tree-shaded outdoor garden deck and LED lights that automatically adjust to the brightness outside. "Why 3D printing? Because it makes sense in terms of cost, in terms of time-saving, in terms of efficiency," the 29-year-old al-Aleeli said. "We really believe that this technology will revolutionize the construction, the development sector as well as other sectors, including the medical sector and consumable products."Products made using 3D printing are first designed on a computer and then printed out using a variety of materials, including metal, plastic and concrete. Developers are finding a growing number of uses for the technology as it evolves. European aeronautics giant Airbus just unveiled a lightweight electric printed motorcycle made from aluminum alloy particles. The technology has been used in other construction projects too, including a Dutch canal house being raised in Amsterdam. But the foundation says its Dubai office is the first "fully functional 3D printed building," constructed with full services and meant for daily use. The Chinese company WinSun Global used a 20-foot tall printer squirting out cement and other materials to produce the 17 building modules for the new Dubai office, according to the foundation. The pieces were then shipped from China to the Gulf port city, where it took workers two days to piece them together. Further work, including the installment of the interiors and landscaping, took another three months. Designers left open part of the finishing in the foyer so visitors can see how the 3D printed layers came together, row after row. The site will serve as the temporary offices for between 12 and 20 foundation staff members for now. Dubai has an ambitious goal of using 3D printing in a quarter of all buildings by 2030. "The future will be 3D printed," al-Aleeli predicted. "I won't be surprised if in 20 years down the road whole cities will be 3D printed."

Source http://timesofindia.indiatimes.com/home/science/Futuristic-Dubai-office-showcases-3D-printings-potential/articleshow/52533090.cms

2. Software Turns Webcams into Eye-Trackers



Eye-tracking helps web developers make better websites, but it's expensive to do. New software, which can be embedded in any website, turns webcams into eye trackers.

New software created by Brown University computer scientists could help website owners and developers easily determine what parts of a page are grabbing a user's eye. The software, called WebGazer.js, turns integrated computer webcams into eye-trackers that can infer where on a webpage a user is looking. The software can be added to any website with just a few lines of code and runs on the user's browser. The user's permission is required to access the webcam, and no video is shared. Only the location of the user's gaze is reported back to the website in real time. "We see this as a democratization of eye-tracking," said Alexandra Papoutsaki, a Brown University graduate student who led the development of the software. "Anyone can add WebGazer to their site and get a much richer set of analytics compared to just tracking clicks or cursor movements." The use of eye tracking for web analytics isn't new, but such studies nearly always require standalone eye-tracking devices that often cost tens of thousands of dollars. The studies are generally done in a lab setting, with users forced to hold their heads a certain distance from a monitor or wear a headset. "We're using the webcams that are already integrated in users' computers, which eliminates the cost factor," Papoutsaki said. "And it's more naturalistic in the sense that we observe people in the real environment instead of in a lab setting." When the code is embedded on a website, it prompts users to give permission to access their webcams. Once permission is given, the software employs a face-detection library to locate the user's face and eyes. The system converts the image to black and white, which enables it to distinguish the sclera (the whites of the eyes) from the iris. Having located the iris, the system employs a statistical model that is calibrated by the user's clicks and cursor movements. The model assumes that a user looks at the spot where they click, so each click tells the model what the eye looks like when it's viewing a particular spot. It takes about three clicks to get a reasonable calibration, after which the model can accurately infer the location of the user's gaze in real time. Papoutsaki and her colleagues performed a series of experiments to evaluate the system. They showed that it can infer gaze location within 100 to 200 screen pixels. "That's not as accurate as specialized commercial eye trackers, but it still gives you a very good estimation of where the user is looking," Papoutsaki said. She and her colleagues envision this as a tool that can help website owners to prioritize popular or eye-catching content, optimize a page's usability, as well as place and price advertising space. A newspaper website, for example, "could learn what articles you read on a page, how long you read them and in what order," said Jeff Huang, an assistant professor of computer science at Brown and co-developer of the software. Another application, the researchers said, might be evaluating how students use content in massive open online courses (MOOCs). As the team continues to refine the software, they envision broader potential applications down the road -- perhaps in eye-controlled gaming or helping people with physical impairments to navigate the web. "Our purpose here was to give the tool both to the scientific community and to developers and owners of websites and see how they choose to adopt it," Papoutsaki said.

Source https://www.sciencedaily.com/releases/2016/06/160601152015.htm

Mechanical Engineering

3. Flying Cars Just Took a Big Step Closer to Being Legal

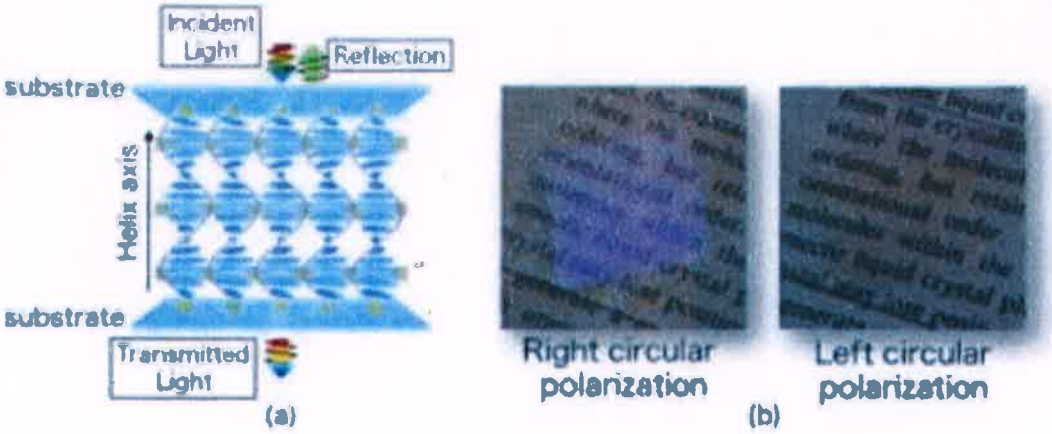
The Terrafugia Transition received an exemption from the Federal Aviation Administration to be classified as a "light sport" aircraft. (Terrafugia)

It looks like a mosquito, its cockpit shoving through the wind while aloft, its wings folded up like a dragonfly while grounded. And it marks the biggest step toward a real, commercial flying car. The Terrafugia Transition earned an exemption recently from the Federal Aviation Administration, USA as a "light sport aircraft," meaning the federal government is on track to legalize the first flying car. Terrafugia can commercially produce the aircraft without repeated burdensome federal airworthiness tests. Flying car industry executives say their products should enter the consumer market -- albeit at a high price -- in the next decade. With its wings folded, the Transition can be driven at highway speeds. Light sport aircrafts should weigh no more than 1,320 pounds, seat two people, have non-retractable landing gear and strict speed limitations. The Transition gained exceptions to be heavier, caused by federal automobile safety requirements, and to exceed the speed limits, because a heavier airplane has to fly faster. Pilots can operate the aircraft with a "sport" license, which requires 20 hours of lessons. Terrafugia designed the vehicle so those with basic drivers licenses can use it on roadways, pending the approval of federal auto regulators. The Transition® brings a new level of freedom, flexibility, and fun to personal aviation by combining driving and flying in one state-of-the-art vehicle. Glass cockpit avionics, carbon fiber construction, and innovative mechanisms make the Transition® easy and fun to fly, drive, and convert. A steering wheel and gas and brake pedals on the ground make it familiar to drive while a stick and rudder pedals provide responsive control in flight. Being able to land and drive not only solves the "last mile problem" but inclement weather will no longer stop your trip. Running on premium unleaded automotive gasoline, the same engine powers the propeller in flight or the rear wheels on the ground. Converting between flight and drive modes is comparable to putting down the top on your convertible and you can keep the Transition® at home in the garage: flying has never been so convenient!

Source https://www.washingtonpost.com/news/the-switch/wp/2016/06/20/flying-cars-just-took-a-big-step-closer-to-being-legal/

Chemical Engineering

4. Liquid Crystals Open New Route to Planar Optical Elements



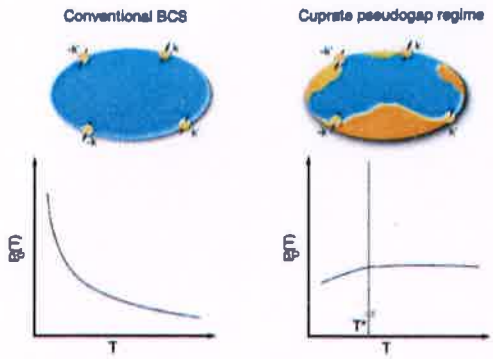
Schematic illustration (left) and photos (right) of a standard cholesteric liquid crystal device. The green bars in the left figure are guides indicating positions with the same helix phase. Cholesteric liquid crystals reflect circularly polarized light with the same handedness as the helical structure and with wavelength fulfilling the Bragg condition. In the right figure, purple light with right circular polarization is reflected.

Researchers at Osaka University developed a technology to control the light wavefront reflected from a cholesteric liquid crystal -- a liquid crystal phase with a helical structure. Although known for their ability to Bragg-reflect light, cholesteric liquid crystals could only be used as flat mirrors, reflecting light at the same angle as the incident angle. The new technology enables planar optical components to be made with functionality by design, contributing to the miniaturization of catoptrics devices. The cholesteric liquid crystal is a liquid crystal phase in which the constituent rod-like molecules spontaneously form a helical structure. Owing to its structure, cholesteric liquid crystals exhibit Bragg-reflection for circularly polarized light with the same polarization handedness as the helix, over a wavelength range determined by the refractive index and the helical pitch. Their characteristic optical properties, as well as the fact that structure is formed by self-organization, have made cholesteric liquid crystals attractive for use as circular polarizers, light reflectors, and electronic papers. However, their ability to function only as a flat dielectric mirror in which light must follow the law of reflection posed a limit on the performance they could achieve, and hence usage of devices based on these materials. Researchers at Graduate School of Engineering, Osaka University discovered that the optical phase reflected from a cholesteric liquid crystal varied depending on the phase of the helical structure. The distribution of optical phase (also known as the wavefront) determines how the light propagates; for example, light propagating along a straight line has a flat profile, whereas light that converges has a curved (parabolic) profile. On the other hand, the helix phase defines the relative orientation of the helical structure at a particular position in space, and can easily be controlled by defining the orientation of the liquid crystal molecules on a substrate. Therefore, by patterning the orientational easy axis in a standard, slab-like cholesteric liquid crystal device, the reflected wavefront can be designed arbitrarily. The image illustrates a planar lens device based on this concept; the parabolic distribution of the helix phase converts an incident planar wavefront to a parabolic profile that converges at a single point. The device shows high circular polarization selectivity even when the helix phase is patterned; the technology thus provides a platform to develop unique optical devices that can be tuned from being fully reflective to transmissive, depending on the incident polarization.

Source https://www.sciencedaily.com/releases/2016/06/160616105731.htm

Electrical Engineering

5. Titan Shines Light on High-Temperature Superconductor Pathway



In conventional, low-temperature superconductivity (left), so-called Cooper pairing arises from the presence of an electron Fermi sea. In the pseudogap regime of the cuprate superconductors (right), parts of the Fermi sea are "dried out" and the charge-carrier pairing arises through an increase in the strength of the spin-fluctuation pairing interaction as the temperature is lowered

High-temperature superconductors are materials that can transport electricity with perfect efficiency at or near liquid nitrogen temperatures (-196 degrees Celsius). Though their operating temperature may seem cold, they're a summer afternoon in the tropics compared to their previously known brethren, so-called conventional superconductors, which operate at temperatures near absolute zero (-273.15 degrees Celsius). Hyperefficient electricity transmission could revolutionize power grids and electronic devices, enabling a wide range of new technologies. That future energy economy, however, is predicated on advancements in the understanding of how high-temperature superconductors work at the microscopic level. Since this discovery, scientists have been working to develop a theory that explains the essential physics of high-temperature superconductors like copper oxides, called cuprates. A team led by Thomas Maier of the US Department of Energy's (DOE's) Oak Ridge National Laboratory (ORNL) used the Titan supercomputer at ORNL to simulate cuprates on the path to superconductivity. Maier's team focused on a pivotal juncture on the cuprates' path called the pseudogap phase, an in-between phase before superconductivity in which cuprates exhibit both insulating and conducting properties. Under these conditions, the conventional pathway to superconductivity is blocked. Maier's team, however, identified a possible alternative route mediated by the magnetic push-and-pull of cuprates' electrons. Simulating a 16-atom cluster, the team measured a strengthening fluctuation of electronic antiferromagnetism, a specific magnetic ordering in which the spins of neighboring electrons point in opposite directions, as the system cooled. The findings add context to scientists' understanding of the pseudogap and how superconductivity emerges from the phase. At extremely cold temperatures, electrons in certain materials pair up, overcoming their natural repulsion toward one another, and gain the ability to flow freely between atoms without resistance. In conventional low-temperature superconductors such as mercury, aluminum, and lead, the explanation for this phenomenon -- called Cooper pairing -- is well understood. This theory, however, doesn't seem to apply to cuprates and other high-temperature superconductors, which are more complex in their composition and electronic structure. Cuprates consist of two-dimensional layers of copper and oxygen. The layers are stacked on top of each other with additional insulating elements in between. To set the stage for superconductivity, trace elements are substituted between the copper and oxygen layers to draw out electrons and create "holes," impurities in the electrons' magnetic ordering that act as charge carriers. At sufficiently low temperatures, this process, called hole doping, results in the emergence of a pseudogap, a transition marked by electronic stops and starts, like a traffic jam struggling to pick up speed. According to the team's simulations, the antiferromagnetic fluctuations of electrons' own spin is enough to form the glue. "These spin fluctuations become much stronger as the material cools down," Maier said. "The interaction is actually very similar to the lattice vibrations, or phonons, in conventional superconductors -- except in high-temperature superconductors, the normal state of electrons is not well-defined and the phonon interaction does not become stronger with cooling." Maier's team approached the problem with an application called DCA++, calculating a cluster of atoms using a two-dimensional Hubbard model -- a mathematical description of how electrons behave in solid materials. DCA++, which stands for "dynamical cluster approximation," relies on a quantum Monte Carlo technique involving repeated random sampling to obtain its results. With Titan, Maier's team possessed the computing power necessary to solve the Hubbard model realistically and at low enough temperatures to observe pseudogap physics.

Source https://www.sciencedaily.com/releases/2016/06/160620112823.htm

6. Threading the Way to Touch-Sensitive Robots

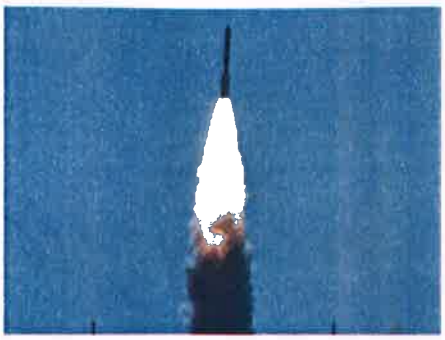
The twisted smart threads developed by KAUST researchers can be woven into pressure-sensitive 'electronic skin' fabrics for use in novel clothing, robots or medical prosthetics.

Smart threads can be woven into pressure-sensitive electronic skin for robots or medical prosthetics. Fabrics containing flexible electronics are appearing in many novel products, such as clothes with in-built screens and solar panels. More impressively, these fabrics can act as electronic skins that can sense their surroundings and could have applications in robotics and prosthetic medicine. Researchers at King Abdullah University of Science and Technology (KAUST), Saudi Arabia, have now developed smart threads that detect the strength and location of pressures exerted on them. Most flexible sensors function by detecting changes in the electrical properties of materials in response to pressure, temperature, humidity or the presence of gases. Electronic skins are built up as arrays of several individual sensors. These arrays currently need complex wiring and data analysis, which makes them too heavy, large or expensive for large-scale production. Researchers have found a different approach. They built their smart threads from cotton threads coated with layers of one of the miracle materials of nanotechnology: single-walled carbon nanotubes (SWCNTs). "Cotton threads are a classic material for fabrics, so they seemed a logical choice," said researchers. "Networks of nanotubes are also known to have piezoresistive properties, meaning their electrical resistance depends on the applied pressure." The researchers showed their threads had decreased resistance when subjected to stronger mechanical strains, and crucially the amplitude of the resistance change also depended on the thickness of the SWCNT coating. These findings led the researchers to their biggest breakthrough: they developed threads of graded thickness with a thick SWCNT layer at one end tapering to a thin layer at the other end. Then, by combining threads in pairs -- one with graded thickness and one of uniform thickness -- the researchers could not only detect the strength of an applied pressure load, but also the position of the load along the threads. "Our system is not the first technology to sense both the strength and position of applied pressures, but our graded structure avoids the need for complicated electrode wirings, heavy data recording and analysis," said researchers. They have used their smart threads to build two- and three-dimensional arrays that accurately detect pressures similar to those that real people and robots might be exposed to. "We hope that electronic skins made from our smart threads could benefit any robot or medical prosthetic in which pressure sensing is important, such as artificial hands," said researcher Lubineau.

Source https://www.sciencedaily.com/releases/2016/06/160617114017.htm

Aerospace Engineering

7. 20 Satellites in 26 Minutes! ISRO Makes Space History

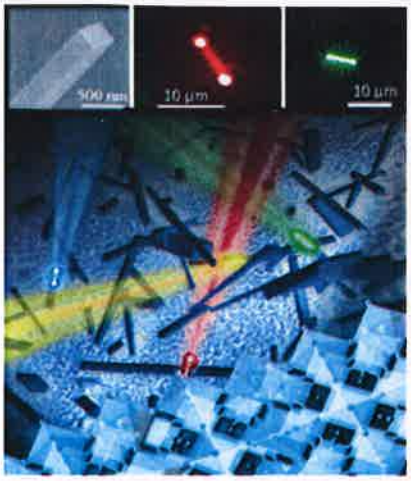


Panoramic View of Fully integrated PSLV-C34 with all the 20 Spacecrafts being moved to second launch pad (SLP).

Creating a record, India last month successfully launched 20 satellites including 17 foreign and its earth observation satellite in a single mission in 26 minutes from Sriharikota, in a crucial step to become a key player in the multi-billion dollar space launch market. In a precision launch, Indian Space Research Organisation workhorse Polar Satellite Launch Vehicle (PSLV-C34) took off in clear skies from the second launch pad of Satish Dhawan Space Centre, about 110 kilometre from Chennai, at 9.26 am and placed the new generation earth observation satellite(Cartosat-2 Series) and 19 others in the designated polar Sun Synchronous Orbit 26 minutes later. Thirteen of the satellites are from the United States including the 12 earth imaging Dove satellites from Planet Labs organisation, each of which weighs just 4.7 kg, and a 110-kg earth imaging satellite called SkySat Gen-2 made by a Google-owned company. There are two Canadian satellites and one each from Germany and Indonesia.Launching 20 satellites in a single payload was like "allowing birds to fly in space", ISRO Chairman Kiran Kumar said, adding, "PSLV C-34 has done its job." Earlier, ISRO had sent 10 satellites into orbit in a single mission in 2008. The record for the most number of satellites launched in a single mission belongs to Russia, which sent up 37 satellites in 2014. The US space agency NASA launched 29. The payload included devices ranging in weight from more than 700 kg to as little as 1.5 kg. "We have the current generation of earth observation satellite of Cartosat 2 series," he said, adding ISRO had done a "wonderful job". Cartosat also has strategic applications. Prime Minister Narendra Modi while hailing ISRO's feat said, "Twenty satellites in a go! @isro continues to break new barriers. Hearty congratulations to our scientists on the monumental accomplishment". "Our space programme has time and again shown the transformative potential of science and technology in people's lives", he said. "Over the years, we developed expertise and capability to help other nations in their space initiatives. This is the skill of our scientists", he said in another tweet. The 727.5 kg Cartosat-2 series satellite will provide regular remote sensing services with its panchromatic and multispectral cameras and its imagery will be of multiple use.

Source http://www.rediff.com/news/report/twenty-satellites-in-26-minutes-isro-makes-space-history/20160622.htm

8. World's Most Efficient Nanowire Lasers



Perovskite-based nanowire lasers are the most efficient known. A topological image of a nanowire is shown (left insert). Room temperature emission images above the lasing threshold for two nanowires composed of different halides, iodide (red in center) and bromide (green on the right), are shown in top inserts.

Known for their low cost, simple processing and high efficiency, perovskites are popular materials in solar panel research. Now, researchers demonstrated that nanowires made from lead halide perovskite are the most efficient nanowire lasers known. Efficient nanowire lasers could benefit fiber optic communications, pollution characterization, and other applications. The challenge is getting the right material. These ultra-compact wires have a superior ability to emit light, can be tuned to emit different colors, and are relatively easy to synthesize. The development of these perovskite wires parallels the rapid development of the same materials for efficient solar cells. Semiconductor nanowire lasers, due to their ultra-compact physical sizes, highly localized coherent output, and efficiency, are promising components for use in fully integrated nanoscale photonic and optoelectronic devices. Lasing requires a minimum (threshold) excitation density, below which little light is emitted. A high "lasing threshold" not only makes critical technical advances difficult, but also imposes fundamental limits on laser performance due to the onset of other losses. In searching for an ideal material for nanowire lasing, researchers at Columbia University and the University of Wisconsin-Madison investigated a new class of hybrid organic-inorganic semiconductors, methyl ammonium lead halide perovskites ($CH_3NH_3PbX_3$), which is emerging as a leading material for high-efficiency photovoltaic solar cells due to low cost, simple processing and high efficiencies. The exceptional solar cell performance in these materials can be attributed to the long lifetimes of the carriers that move energy through the systems (electrons and holes) and carrier diffusion lengths. These properties, along with other attributes such as high fluorescence yield and wavelength tunability, also make them ideal for lasing applications. Room temperature lasing in these nanowires was demonstrated with:

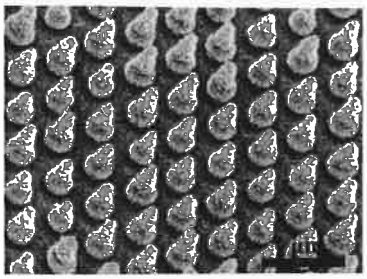
- The lowest lasing thresholds and the highest quality factors reported to date
- Near 100% quantum yield (ratio of the number of photons emitted to those absorbed)
- Broad tunability of emissions covering the near infrared to visible wavelength region.

Specifically, the laser emission shifts from near infrared to blue with decreasing atomic number of the halides (X=I, Br, Cl) in the nanowires. These nanowires could advance applications in nanophotonics and optoelectronic devices. In particular, lasers that operate in the near infrared region could benefit fiber optic communications and advance pollution characterization from space.

Source https://www.sciencedaily.com/releases/2016/06/160616141636.htm

Energy Engineering

9. Researchers Find New Ways to Make Clean Hydrogen, Rechargable Zinc Batteries



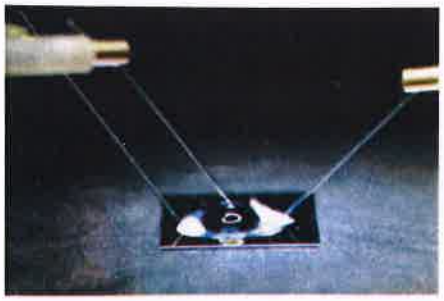
Stanford engineers created arrays of silicon nanocones to trap sunlight and improve the performance of solar cells made of bismuth vanadate (1?m=1,000 nanometers).

A Stanford University research lab has developed new technologies to tackle two big energy challenges -- clean fuel for transportation and grid-scale energy storage. Unlike gasoline-powered vehicles, which emit carbon dioxide (CO_2,), hydrogen cars themselves are emissions free. Making hydrogen fuel, however, is not emission free: today, making most hydrogen fuel involves natural gas in a process that releases CO_2 into the atmosphere. To address the problem, researchers have focused on photovoltaic water splitting. This consists of a solar-powered electrode immersed in water. When sunlight hits the electrode, it generates an electric current that splits the water into its constituent parts, hydrogen and oxygen. Finding an affordable way to produce clean hydrogen from water has been a challenge. Conventional solar electrodes made of silicon quickly corrode when exposed to oxygen, a key byproduct of water splitting. Several researchers have reduced corrosion by coating the silicon with iridium and other precious metals. Cui and his colleagues presented a new approach using bismuth vanadate, an inexpensive compound that absorbs sunlight and generates modest amounts of electricity. "Bismuth vanadate has been widely regarded as a promising material for photoelectrochemical water splitting, in part because of its low cost and high stability against corrosion," said Cui. "However, the performance of this material remains well below its theoretical solar-to-hydrogen conversion efficiency." Bismuth vanadate absorbs light but is a poor conductor of electricity. To carry a current, a solar cell made of bismuth vanadate must be sliced very thin, 200 nanometers or less, making it virtually transparent. As a result, visible light that could be used to generate electricity simply passes through the cell. To capture sunlight before it escapes, Cui's team turned to nanotechnology. The researchers created microscopic arrays containing thousands of silicon nanocones, each about 600 nanometers tall. "Nanocone structures have shown a promising light-trapping capability over a broad range of wavelengths," Cui explained. "Each cone is optimally shaped to capture sunlight that would otherwise pass through the thin solar cell." In the experiment, Cui and his colleagues deposited the nanocone arrays on a thin film of bismuth vanadate. Both layers were then placed on a solar cell made of perovskite. When submerged, the three-layer tandem device immediately began splitting water at a solar-to-hydrogen conversion efficiency of 6.2 percent, already matching the theoretical maximum rate for a bismuth vanadate cell. "The tandem solar cell continued generating hydrogen for more than 10 hours, an indication of good stability," said Cui. The tandem device has room for significant improvement in the future. **Rechargeable zinc battery:** In a second study the researchers proposed a new battery design that could help solve the problem of grid-scale energy storage. "Solar and wind farms should be able to provide around-the-clock energy for the electric grid, even when there's no sunlight or wind," Cui said. "That will require inexpensive batteries and other low-cost technologies big enough to store surplus clean energy for use on demand." Cui, and co-workers designed a novel battery with electrodes made of zinc and nickel, inexpensive metals with the potential for grid-scale storage. A variety of zinc-metal batteries are available commercially, but few are rechargeable, because of tiny fibers called dendrites that form on the zinc electrode during charging. Theses dendrites can grow until they finally reach the nickel electrode, causing the battery to short circuit and fail. The research team solved the dendrite problem by simply redesigning the battery. Instead of having the zinc and nickel electrodes face one another, as in a conventional battery, the researchers separated them with a plastic insulator and wrapped a carbon insulator around the edges of the zinc electrode. The zinc ions are reduced and deposited on the exposed back surface of the zinc electrode during charging. Therefore, even if zinc dendrites form, they will grow away from the nickel electrode and will not short the battery. To demonstrate stability, the researchers successfully charged and discharged the battery more than 800 times without shorting and the design could be applied to a wide range of metal batteries.

Source https://www.sciencedaily.com/releases/2016/06/160617160352.htm

Interdisciplinary Engineering and Special Fields

10. Engineers Develop a New Biosensor Chip for Detecting DNA Mutations



The biosensor chip -- consisting of a double stranded DNA probe embedded onto a graphene transistor -- electronically detects DNA SNPs.

Bioengineers at the University of California, San Diego have developed an electrical graphene chip capable of detecting mutations in DNA. Researchers say the technology could one day be used in various medical applications such as blood-based tests for early cancer screening, monitoring disease biomarkers and real-time detection of viral and microbial sequences. "We are at the forefront of developing a fast and inexpensive digital method to detect gene mutations at high resolution--on the scale of a single nucleotide change in a nucleic acid sequence," said Ratnesh Lal, professor of bioengineering, mechanical engineering and materials science in the Jacobs School of Engineering at UC San Diego. The technology, which is at a proof-of-concept stage, is a first step toward a biosensor chip that can be implanted in the body to detect a specific DNA mutation--in real time--and transmit the information wirelessly to a mobile device such as a smartphone or laptop. The team developed a new technique to detect the most common genetic mutation called a single nucleotide polymorphism (SNP), which is a variation of a single nucleotide base (A, C, G or T) in the DNA sequence. While most SNPs have no discernable effect on health, some are associated with pathological conditions such as cancer, diabetes, heart disease, neurodegenerative disorders, autoimmune and inflammatory diseases. Current SNP detection methods are relatively slow, expensive and require the use of cumbersome equipment. The team is developing a fast, easy, inexpensive and portable way to detect SNPs using a small chip that can work with a cell phone. The chip consists of a DNA probe embedded onto a graphene field effect transistor. The DNA probe is an engineered piece of double stranded DNA that contains a sequence coding for a specific type of SNP. The chip is specifically engineered and fabricated to capture DNA (or RNA) molecules with the single nucleotide mutation--whenever these pieces of DNA (or RNA) bind to the probe, an electrical signal is produced. The chip essentially works by performing DNA strand displacement, the process in which a DNA double helix exchanges one strand for another complementary strand. The new complementary strand--which, in this case, contains the single nucleotide mutation--binds more strongly to one of the strands in the double helix and displaces the other strand. In this study, the DNA probe is a double helix containing two complementary DNA strands that are engineered to bind weakly to each other: a "normal" strand, which is attached to the graphene transistor, and a "weak" strand, in which four the G's in the sequence were replaced with inosines to weaken its bond to the normal strand. DNA strands that have the perfectly matching complementary sequence to the normal strand--in other words, strands that contain the SNP--will bind to the normal strand and knock off the weak strand. Researchers engineered the chip to generate an electrical signal when an SNP-containing strand binds to the probe, allowing for quick and easy SNP detection in a DNA sample. Researchers pointed out that a novel feature of their chip is that the DNA probe is attached to a graphene transistor, which enables the chip to run electronically. "A highlight of this study is we've shown that we can perform DNA strand displacement on a graphene field effect transistor. This is the first example of combining dynamic DNA nanotechnology with high resolution electronic sensing. The result is a technology that could potentially be used with your wireless electronic devices to detect SNPs," said researchers. The use of a double stranded DNA probe in the technology developed by Lal's team is another improvement over other SNP detection methods, which typically use single stranded DNA probes. Next steps include scaling up the technology and adding wireless capability to the chip. They also envision that the technology could lead to a new generation of diagnostic methods and personalized treatments in medicine.

Source https://www.sciencedaily.com/releases/2016/06/160614121538.htm

Engineering Innovation in India
Gandhi Young Technological Innovation (GYTI) 2016 Awards

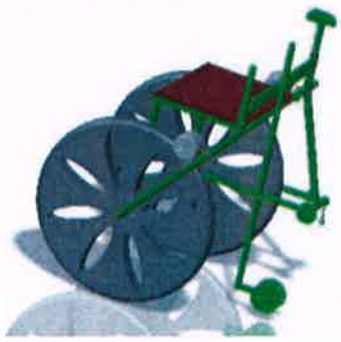
The Gandhi Young Technological Innovation (GYTI) 2016 Awards were conferred on 13th March 2016 at Rashtrapati Bhavan. Brief details of two award winning projects are given below.

Design of an Innovative Retrofitted Tricycle for a Disabled Person

Innovator: Shri Pushkaraj Sonawane **Guide:** Prof. Dr. Sandip T. Chavan **College :** Maharashtra Institute of Technology, Pune

Transportation is one of the important sources for increasing mobility of human beings. Today, various hand driven tricycles, wheelchairs, retrofitted vehicles etc. are available for disabled people but these are designed primarily for the basic functional use for moving on road without considering many important aspects of safety, ergonomics and aesthetics. Existing tricycles demand that the handicapped person dismount from the wheelchair. To address this limitation the team designed and fabricated a retrofitted tricycle which allowed the disabled person to drive the tricycle without dismounting from the wheelchair. This was achieved by providing a specifically designed platform and automated ramp, which allowed the wheelchair to be wheeled up or down. The tricycle is designed to accommodate a disabled person along with the wheelchair with ease and convenience. It is hoped that this new design will ease and improve mobility. This prototype was designed using computer-aided design (CAD) which helps to increase productivity by allowing the visualization of the desired component through the use of a large array of tools for analysis and design. The finalization of the design of the tricycle is done by performing safety tests given by ARAI scheme. An attempt has been made to provide unique, cost-effective, purpose serving motorized retrofitted tricycle for disabled persons.

Design and Development of Multipurpose Electric Cycle



Innovator: Shri Patel Krunal **Guide:** Shri Sandip Godse
College : Shri Satasangi Saketdham

The concept is to create the cycle and convert it into wheel chair. Wheel chair is useful for hospital purposes. The cycle is also run by electric power. In this cycle, two electric motors are fixed into the wheels. The cycle is converted into wheel chair in few minutes without help of any tools. Wheel chair is useful for emergency and rescue. Cyclists can use it to move injured people quickly when no another help is provided at that time. It can be easily converted and take a less than 1 minute. It can be folded into a very compact size for easy transportation and parking. It can be run manually when the battery is down.

Source http://gyti.techpedia.in

Harnessing Science and Technology for Development: A Governance Challenge in Indian Context.

Anil Kakodkar

Introduction

There are several components to India growth story. Some are dependent on our demography, size of youth/work force, market potential, growing aspirations and factors like that. The others are driven by the increasing role of knowledge and technologies in economic activities. With the highly competitive world, that we live in, becoming increasingly knowledge dependent, the balance of trade is strongly dependent on our ability to leverage knowledge to value add or even better, to create new technological products that have competitive market appeal both in India and abroad. Thus our ability to leverage S&T to create innovative products and processes and to nurture a right innovation ecosystem to translate them to the market place assumes greater importance now than any time before. Creating and nurturing people capable of doing so in large numbers and empowering institutions that host them to deliver on this count are the two most important governance challenges in contemporary India.

Today, our total expenditure in R&D in India is comparable to or larger than similar expenditure in countries like Israel, Canada, Sweden, UK, Switzerland, Finland etc..[1] Further a simple back of the envelope calculation would indicate that our spending per full time equivalent in R&D is also comparable with most of the high performing countries. Considering the large population and the size of our economy, there is clearly a strong case to significantly enlarge our investment in S&T. However, with the level of current investment, clearly, India should have been a power house for new technologies that leverage the latest in research at least on par with the countries mentioned above. Our economy however is still very dependent on other countries, including some of those listed here, for its technology needs. Further, there is a serious disconnect by and large, in terms industry investment and engagement in S&T system in the country. Under such conditions, we end up doing what others have already done, in our laboratories as well as in our industries. While as compared to importing products, making them here is decidedly

a superior option, developing competitive technologies here and leveraging them for manufacture of products in the country considerably adds to our competitive advantage both in terms of sustaining competitiveness in our manufacture as well as bringing out new products ahead of others.

Innovation ecosystem

For this purpose, as mentioned earlier, we need to enhance excellence in our R&D as well as its deeper engagement with industry and entrepreneurship. This requires a conducive innovation ecosystem that picks up and encourages a potentially promising idea and facilitates its translation to a successful commercial product. Such an eco---system must support high quality teaching that takes a student all the way up to the current frontiers of knowledge, supports research that pushes these knowledge frontiers forward, supports translation of that research into new and robust technology products and nurtures entrepreneurship that commercialises the newly developed products. An important characteristic of such an ecosystem is the freedom for participants to interact with potential collaborators across different domain boundaries to translate research to business in a win---win mode.

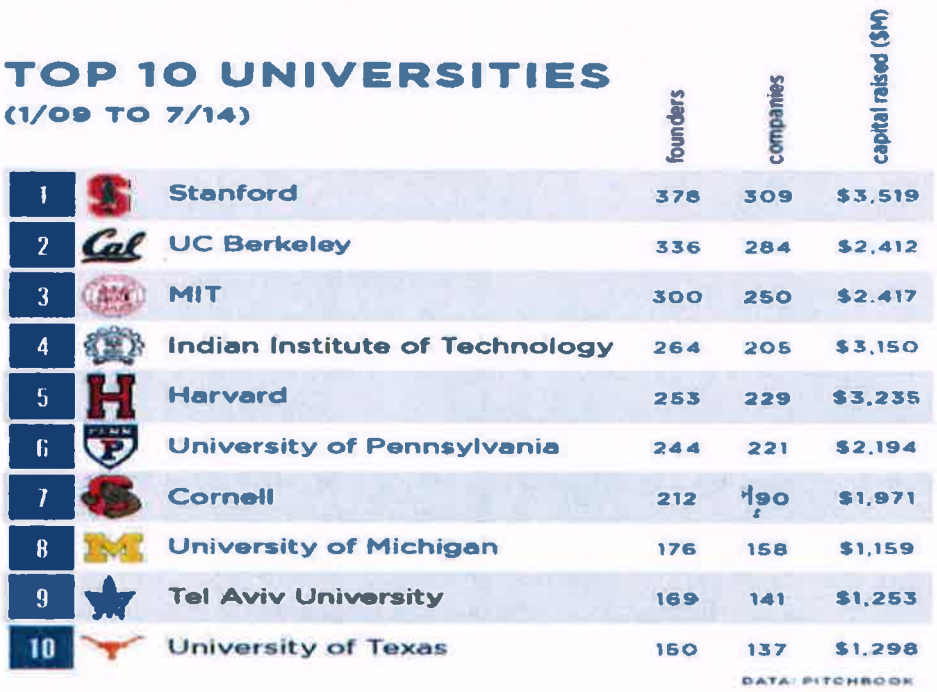
In a world bank report[2] on 'The Challenge of Establishing world class universities', concentration of a very high level talent pool that is a magnet to attract more talent from outside, abundant financial resources and favorable governance with a high level of flexibility to preferentially carry a good idea forward, were identified as three key characteristics for a world class university. Clearly such institutions that nurture a high level of creativity must have the patronage that assures them of the required financial resources and at the same time complete immunity from external factors except for the expectation that they must excel in their respective domains, as judged by their peer community. Since quality education, skills, research and technology development, creating a culture of innovation and entrepreneurship etc. are areas that must be of key concern to the Government, with widest possible access to all those who are deserving, we need State funded institutions of excellence in such creative areas and a system of governance that meets the requirements as stated above.

Autonomy encompassing all its dimensions e.g. functional, administrative and financial is crucial to achieving an effective system of governance in institutions of high excellence. The institutions must be free to decide the programmes they wish to pursue within the stated objectives of the institution with a holistic interpretation as guided by the peers within and outside. While the institutions must be free to conduct themselves within the available capital assets, promised recurring expenditure and other resources generated by the institution, there must be assurance on availability of these resources and a supportive attitude to further augment them on the basis of justified needs. As a minimum inflation correction would be one such need. The institution must have the freedom to administer itself including making all appointments on the basis of its needs duly driven by the institution management and broadly guided by the peer system in and around the institution. As a matter of fact, Dr. Bhabha had annunciated the principle "find a right scientist and build the lab around him rather than the other way round". On the functional front, the institution should remain guided by its peers on the basis of its charter. The peer community should represent all stakeholders consistent with the charter of the institution at the right level of eminence. Performance appraisal in the institution at various functional levels including at the level of individuals should be done with a judicious combination of external and internal peers at sufficiently high level of excellence with a value system that covers all dimensions of expected performance.

Such autonomous institutions of high excellence and their members should be free to collaborate with others with complimentary capabilities. When one realises an eco---system encompassing the full range of capabilities necessary to translate a new idea or research finding into a new product and commercialise it in the market place, you develop the capability to make a high level contribution to economic growth/strength of the country.

As an example of impact of such an excellence, it is worth recalling a study[3] compiled by PitchBook, a US---based private equity and VC research firm that ranked the top 50 universities that have produced venture capital (VC)---backed founders. The study took into account funding data between 2009 to July 2014, and sifted through educational backgrounds of over 13,000 founders globally. The study reveals that the top universities have produced founders that have succeeded raising up to $ 3.5 billion capital in a period of five years (Please see the table below). It is heartening to see IITs figuring in the list as

4th top institution in terms of number of founders produced and 3rd top institution in terms of capital raised by them. If such a thing can be done by IIT graduates in USA, clearly, there is a huge potential if we can leverage institutions like IITs on the Indian domestic scene. More importantly if most of our higher technical institutions become like IITs, India becoming a global technology power house should be well within our reach. Today however we are far away from such a goal. Realising this potential in full is the real governance challenge before us.



TOP 10 UNIVERSITIES
(1/09 TO 7/14)

		founders	companies	capital raised ($M)
1	Stanford	378	309	$3,519
2	UC Berkeley	336	284	$2,412
3	MIT	300	250	$2,417
4	Indian Institute of Technology	264	205	$3,150
5	Harvard	253	229	$3,235
6	University of Pennsylvania	244	221	$2,194
7	Cornell	212	190	$1,971
8	University of Michigan	176	158	$1,159
9	Tel Aviv University	169	141	$1,253
10	University of Texas	150	137	$1,298

DATA: PITCHBOOK

Policy initiatives

Over and above what can happen out of knowledge institutions through their engagement with finance/business world, there are several other initiatives that the State needs to take. Let us now deal with them one by one:

1. We still have an issue of low industry investment in research barring a few exceptions. This is a result of low industry confidence in such investments producing results. This perhaps is true not only of investments in public funded R&D but many times also in the context of internal investments for R&D when the gestation periods are large and loss through technology diffusion is likely to be high. A supportive

framework for public funding of pre--competitive research assumes importance in this context. This not only could become a good basis for industry involvement in academics and R&D but also could significantly shorten the period for new product development at the industry level. CII sponsored Prime Minister's fellowships for Ph.D. Research is a good initiative in this regard. Such initiatives need to be scaled up overcoming the issue of finding eligible project takers in large numbers. There could be more such initiatives. Industry association funded and guided centers in specific areas, working with individual industry in a research park are some examples.

2. Another mode to seek larger private investment in R&D would be to call for competitive proposals for development of new technology products needed in large numbers from consortia of industry and academic/R&D institutions. The requirement could be spelt out in terms functional performance expected. Partial support through public funding could be made available to a few best proposals along with a promise of minimum initial business (through public procurement) to successful product developers. Such mode is practiced in countries like US (DARPA, eARPA) and Japan. Such a modality is almost non--existent in India. Government Departments where technology plays an important role in their programme implementation should be tasked to proactively pilot such efforts.

3. Beyond the supply driven and demand driven product development as discussed above, a large country like India also needs capability to develop and build large technology platforms such as aircrafts, ships etc. Today there is some capability in key strategic areas. We need to build such capability in different sectors of economy. In the Indian context, this is best piloted in mission mode by identified agencies/SPVs at least to begin with. For each such platform type, one would need at least one major laboratory to be the knowledge leader which can assimilate, hold custody and eventually develop the requisite technology. With progressive emphasis on 'make in India', it

is important that such laboratories wherever they exist are main streamed or created in case they do not exist. Establishing such laboratories in academic institutions has the added advantage of concurrent human resource development. A major gain with such an arrangement is the national capability to keep the technology continually rejuvenated without allowing obsolescence to set in. With encouragement to private sector in such development, it would be logical to expect private sector to also invest in such laboratories in academic/research institutions. Over a period of time, one should expect a national capability build up to build such large technology platforms on our own. A precondition for sustaining such a capability would be continuity of programme and business for the laboratories, architect/engineers and manufacturing workshops along with related HR activities so that the investments remain productive.

4. All new technology products face barriers to market entry from those whose business is likely to be threatened by the entry of the new product or technology. Depending on the larger strategic objective served by the new technology such as elimination of vulnerabilities, sustainability, environment protection, favourable balance of payment, job creation etc., there should be policy support for preferential market entry of such new technologies. In particular, where ever a product development has been supported through public funds, there should be assured market entry as long as the developed product meets the pre--specified functional requirements and the costs have the potential to be competitive at fully commercial scale of production. It should be realised that translation of a newly developed product into a commercially robust product is an evolutionary process that does need to be supported till the product becomes self sustaining in the market place.

5. Major expenditure routinely takes place in procurement of high technology items. The recent thrust on 'Make in India' is an important policy initiative to create jobs and value addition in the country. Linking

knowledge activities (academics as well as research) with such asset/ infrastructure build up would benefit both the manufacturing domain by way of better assimilation of technologies and capability to build on it as well as the knowledge domain by way of better human resource development.

6. One very important aspect of governance in the context of development planning is knowledge informed autonomous decision making in contrast with vendor driven decision making that has become very prevalent. This is of particular importance in the context of technology choices which necessarily require a more holistic decision making with a long term view in the overall national context. Mass transportation on water front as well as on ground, waste management, water--- energy--- agriculture and environment nexus etc. are some examples of issues that need a holistic knowledge informed decision making. Availability of a high quality research environment well engaged with the on ground situation is a pre--requisite for such decision making capability.

Focus on rural areas

Rural areas need greater attention because a larger fraction (around two third) of our population still lives there and bringing the level of livelihood in rural areas (today average per capita earning in rural areas is about half of urban per capita earning) at least on par with urban areas is important to bridge the serious divide between the two. According to socio-economic and cast census 2011 (SECC 2011), manual casual labour (51%) and cultivation (30%) constitute the main source of income in rural households. About 9.7% of rural households run on salary income. 56% households are land less. There is thus a need to infuse relevant technology that enhances income in rural areas. This would also reduce the migratory pressure on urban infrastructure, enhance food security by making agriculture remunerative enough as a result of greater value addition, access to wider markets, and stabilisation of prices and further add to supplementary livelihood opportunities through adoption of technologies. A sustainable model for

technology enabled development in rural areas is thus necessary in my view to realise such an objective. In such a model Integrated Education, Research and Development Complexes, a knowledge domain that can attract best of researchers and teachers on one side and remain engaged with meeting human resource and technology development needs in the rural neighbourhood on the other, would need to be developed. Such complexes (which could be called **CILLAGE** – best of **ci**ty in a vi**llage**) should provide best of city amenities along with opportunities for spouses and education of children and become a place for world class research on technologies for value addition opportunities in rural surroundings and help promote knowledge enabled development in rural areas. A critical mass of high quality researchers in a CILLAGE complex with a number of livelihood demonstration centres in the neighbourhood duly backed up by micro--- finance could nucleate sustainable development process that perhaps could replicate itself and spread.

Integrated area development

Planning for national development has to comprise of a combination of top---down and bottom---up processes. Large projects that can benefit large areas such as communication and transportation infrastructure, large hydro and power projects, large industries etc. that require large outlays are better done as a part of centralised effort implemented in a top---down mode. On the other hand, there is a strong merit to a decentralised approach to planning and development since the resources can be put to best possible use taking into account the local needs. With knowledge becoming an integral part of the local development process as described above, the bottom---up planning and development can in fact become more effective and efficient. One would need to decide on an appropriate unit for integrated local area planning and development. Doing this at the block level may be most optimum.

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Underground Metro Construction, Development in India

Mangu Singh

Development of Metro System in the Country started with the construction of Kolkata Metro in mid 70's. Kolkata Metro 16.5 Km long North-South Line was predominately underground with only two terminal stations being at grade. The construction was carried out with limited local technical and engineering expertise, as was available.

The construction of Metro System in Delhi is partly underground and has been done very successfully, and many more cities of the Country like Bangalore, Chennai are constructing Underground Systems. I have been fortunate to have been involved in the construction of Kolkata Metro, Delhi Metro and also in planning of Metro Systems in other Cities like Chennai, Bangalore, Jaipur, Mumbai and Kolkata East-West Line. I can therefore, claim that I have witnessed the entire development of construction of Underground Metro Systems in the Country. The construction of Kolkata Metro was very remarkable, in view of the fact that we had very little Technical and Engineering experience and skill to execute such Projects, and also access to International Technology was limited. However, the Project had many Civil Engineering challenges and the execution of civil engineering works was not free from deficiencies. Since I was fully involved in execution of civil works in most difficult part of Kolkata Metro, i.e., section between Esplanade and Shyam Bazar, gained very valuable experience and was in a position to take care of these deficiencies in subsequent planning of Delhi Metro and other Metro Systems in the country.

Before we go into the deficiencies, let us understand the exact nature of civil works involved in an Underground Metro System. The Kolkata Metro Underground Section involved construction of stations approximately every km and tunnels connecting these stations. Both stations and tunnels were largely done by Cut & Cover Method except a small Section between Shyam Bazar and Belgachhia Stations which was done by Tunnel Boring Machine.

Cut & Cover Station

A typical Station involved constructions of 2 storey rectangular building below ground. Constructing this underground structures required excavation up to depth of about 17 to 18 meters and in order to support the soil temporarily, diaphragm walls were first constructed along with parameter of the Station and while excavating the soil between diaphragm walls, the diaphragm walls were strutted. Number of layers of strata were placed as excavation proceeded to the final level. The base slab of this rectangular station box was constructed first

and then side walls, concourse slab, and roof slab constructed progressively from bottom to top. The struts are also removed in sequence.

Cut & Cover Tunnel

The construction of Cut & Cover Tunnels connecting two stations involves similar operation as construction of station except that the structure is single story long box connecting two stations.

In addition to above main structures, number of ancillaries structures like entry, exit and ventilation shaft are required to be constructed normally in a same way as main station box.

Typical Kolkata soil is silty clay with poor bearing capacity and with high water table. Number of difficulties and deficiencies noticed in civil works construction and how these have been taken care in the subsequent Metro constructions:

1) The construction of Diaphragm wall was planned as a temporary structure and the Main Box was planned to be constructed inside these temporary diaphragm walls. The Diaphragm wall Panels went out of verticality and therefore, two adjacent panels were not in the same plain and sometimes forming a window/gap which was potentially risky for soil loss and heavy leakage during excavation. In fact, in some cases, the Diaphragm wall panel went out of plum to the extent that it infringed the permanent RCC box. This led to serious problem during excavation. Apart from the modification of the Box design and huge chipping and cutting involved in Diaphragm wall, it created big problem in casting the side walls while water was leaking from the Diaphragm walls' joints /gaps. This problem has been resolved as in subsequent planning the Diaphragm wall has been planned as a part of the permanent structure and the quality of the concrete as well as the geometry of the Diaphragm wall has been improved drastically. Verticality of the Diaphragm wall Panels has been ensured during construction by mapping the cut for the verticality before the concreting. In case of any deviation in the verticality, the trenching has been redone. With the advancement of the technology it is possible to introduce water seals between two panels of the diaphragm wall. With these provisions, the diaphragm wall joint has virtually being made water tight and also the two adjacent panels have been in perfect alignment to form the rectangular wall without leaving a gap between two panels.

2) Number of utilities crossing the Station Box or Cut & Cover Tunnel Box created special difficulties in casting Diaphragm wall Panel at the utility locations. The correct way is to complete the Diaphragm wall Panel in the adjacent stretch and divert the utilities on to the completed Panels and then take up the diaphragm wall Panel at original location of the utility. In Kolkata however, this could not be made possible at number of locations and therefore, the works were planned keeping the utilities in position and leaving a gap in Diaphragm wall at the utility location with the intention that this gap will be closed progressively with the help of steel plate lagging while doing the excavation. In

practice, however, this proved to be very risky affair because of the type of soil there was hardly any standing time and with the excavation even before placing the steel plate to cover the gap, there used to be soil movement causing settlement in the utilities. With this settlement, utilities start leaking particularly, storm water drain and high pressure water pipelines. This leakage water found easier way into the excavation area taking soil along with it causing further settlement and more leakage leading ultimately to collapse of the utility. In many cases, taking away huge amount of soil into the excavation area creating huge collapse, sometime very near to the buildings. Number of buildings have suffered serious damages on this account.

This has been taken care of as no gap is left in the Diaphragm wall and utility diversion if required, is must in Delhi. The responsibility of diversion of utility is also taken by Delhi Metro. This has ensured no collapse on this account during construction of underground Metro in Delhi.

3) **Problem of Severe leakage from the Base Slab** Since the soil has low permeability, it was not possible to lower the water table before casting the Base Slab and in most of the cases the water seepage from base could not be stopped. This seepage water under heavy head used to penetrate and form water channel in the Green concrete which ultimately lead to heavy leakage into the structure.

   This problem has been taken care in Delhi Metro that in case it is not possible to lower the water table below the base slab level to facilitate casting of the slab, a pervious filter is introduced below the base slab and over that the base slab is casted. The percolating water finding easier path in the filter did not penetrate the green concrete of the base slab ensuring setting of concrete without any risk of leakage.

4) Bottom upheaval was quite common in Kolkata Metro, particularly at final level of excavation because of very heavy earth pressure and surcharge outside the Diaphragm wall and bearing capacity of the soil being poor. This used to cause severe settlement outside the Diaphragm wall and number of building affected due to this differential settlement, being more near to Diaphragm wall and less beyond the Diaphragm wall. It appeared that the depth of Diaphragm wall below the final excavation level did not have much margin of safety. A typical embedment length in Kolkata Metro was about 4 meters beyond the final excavation level. This problem has been resolved in Delhi by providing adequate embedment length typically 8 meter or so. This has ensured no upheaval at Delhi & no major settlement to cause damage to buildings adjacent the work.

5) **Environmental Issues** Number of environmental issues like spilling the muck on the road, poor upkeep of the work sites , large scale movement of construction vehicles/ equipments and large scale activities at the site in congested area lead to great

inconvenience to the public. For Metro Line in Delhi, a strict regime detailing to take care of these problems was worked out and made part of the Contract conditions to ensure the compliance of the regime. This ensured that the Contractor was allowed to work in the designated area properly barricading and segregating the public area from the construction area and Contractor not allowed to encroach upon the public area. Similarly, Contractor to transport the excavated earth in good condition vehicles, cleaning the tyres and vehicle under frame before leaving the site to avoid defacing the roads. The construction vehicles movement restricted to allow in night hours mainly. The activities at sites were minimized by enforcing major activities like Fabrication, Concreting, Pre-casting, etc. done off the site. Not allowing the Contractor to use work site for labour camps. Using only good condition Machines and Equipment causing less noise, vibrations, etc.

6) **Speed of Construction** Speed of Construction at Kolkata Metro was extremely slow and a line of about 16.5 km took more than 22 years to complete. The whole city was put to inconvenience for long. It was therefore considered necessary to plan and execute the project in Delhi and subsequent other cities in more expeditious manner so that this inconvenience is reduced greatly. The best Construction Practices and Management Practices to execute such projects, available internationally, are adopted. With the result in Delhi we were able to develop network of about 190 km (Phase I and Phase II) in about 10 to 12 years time. Further in Phase III, about 140 km is under implementation which will be completed by December 2016. The development of network at such a rapid pace has on one hand reduced the inconvenience to the public during construction and also has provided great relief to the city traffic.

7) **Traffic Management** During construction very heavy traffic congestion was encountered due to reduced road width available for traffic and addition of construction related traffic of heavy vehicles and equipment etc. In Delhi, this problem was taken care of by suitably diverting the traffic after detailed Traffic Study and also making improvements to the adjacent roads for diversions. The movement of construction vehicles was restricted mainly during night times only and avoiding completely during peak hours. Deployment of trained Traffic Marshals to guide the Traffic has also helped greatly.

8) **Conclusion** The experienced gained at Kolkata Metro proved to be very useful and difficulties faced during construction of underground Metro in Kolkata has been duly taken care of by deploying suitable technology and Project Management Practices in subsequent Metros. With this, not only construction of Underground Metro Systems but also the Construction Industry, in general, has improved drastically in India.