TECHNOLOGY CREATION - NEED OF THE NATION

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Preamble

For centuries gone by, man has been engaged in making every effort to face his environment with a view to surmounting adversities and exploiting advantages which nature has provided. To live peacefully, his needs were concentrated towards getting food and water, protecting his self against natural hardships through appropriate clothing and shelter. Endowed with a brain superior to that of any other living being and skillfully using his physical strength, weaker though it may have been as compared to some others, man has learnt from nature and applied his intelligence and hand skills to achieve his goals, that of living as comfortably as one can. Survival against bodily harm as well as ambition to surpass other men by conquering them, either as an individual or as a group have also been a facet of man's existence; for this purpose man created weaponry. In all such pursuits man has used some degree of technological innovation, often thinking out changes for better efficiency by creating advanced technologies of substance.

The last two centuries have seen a phenomenal growth in technological developments, in which major share has been that of the so called "Developed" Western world. Thus we are thankful to the British for the Steam Engine, to the Germans for the earliest internal-combustion cars, to the USA for giving the world the airplane, mass production, the transistor, the computer, the laser and the Internet, to the Japanese for just-in-time manufacturing and cheap, portable electronics and the Russians along with the Americans for Nuclear and Space technology. However it is becoming increasingly clear that inventions and innovative technologies are no more the 'forte' of only these few countries. Different countries are pursuing technological quest with a passion dictated by their own particular needs and the resulting technologies will not only address those needs but also have far-reaching applications in the wider world.

Politically, culturally, geographically and economically, there are vast differences among nations. However, as far as technological developments are concerned physical space is being replaced by Cyber space and advanced technologies are, in a manner of speaking, "shrinking the planet earth".

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Innovative Technology Development in Some Countries

It will be of interest to look at some innovative projects that are being carried out in different countries, developed and developing, around the world. "TECHNOLOGY REVIEW", a monthly Magazine of Innovation published by the Massachusetts Institute of Technology in USA, has discussed in its April, 2005 issue how "Inventive people everywhere are creating technologies for a shrinking planet" with a description of 25 innovations in seven representative countries. These include Brazil, China, Chile, Germany, South Africa, The Netherlands and the USA. The countries are at varying stages of development, situated in diverse geographical parts of the Globe and have distinctly different political systems of governance. Let us briefly look at their focus on technology creation. Perhaps the findings of some of these efforts are relevant to India.

Brazil: The two major efforts in this country relate to reduction of dependence on imported energy sources and bringing digital technologies to the vast majority of about 180 million people.

In the energy sector, the emphasis is on development of biodiesel, a fuel made from oil of seeds such as soybeans, castor beans, and cottonseed. Biodiesel can be a domestically produced alternative to petroleum based fuel. Brazil has enacted a law which will require that diesel oil sold in that country will have 2% biodiesel by 2008 and 5% by 2013. If successful, Brazil will reduce almost the entire 15% import of the 37 billion liters of diesel consumed. Needy farming communities will get more jobs. The environmental benefits will mean that emissions of unburned hydrocarbon, carbon monoxide, sulfates, sulfur and other pollutants will be greatly reduced.

Work is also in progress on producing ethanol from sugarcane. Brazil is the largest producer of fuel ethanol in the world. They have developed the flex-fuel car with a combustion engine that operates on ethanol, gasoline or a combination of both. In March 2003, Volkswagen introduced this model of the car in Brazil and last year 26% of the car sale in Brazil consisted of flex-fuel cars. Soon Brazil plans to export this flex-fuel technology.

Brazil's foray into digital technology is to find an alternative to the lack of better PC facilities to the common man. Only 12% of Brazilians own PCs today. Public access to PCs has become popular with the use of a relatively inexpensive recordable CD that stores personal data and settings which can be accessed with the use of a CD drive at public computer centers.

The latter system of using computers in public Cyber Cafes is in use in India in a significant way. Perhaps the former technology related to biodiesel will be useful in India, if properly developed or acquired.

Three interesting parameters/ indicators of technology achievement of Brazil suggest that Brazil's expenditure on R & D is 0.8% of the GDP, high-tech exports as a percentage of manufactured exports are at 19% while the per capita spending on Information and Communication technology stands at $ 205.

China: With enormous pollution in the World's most populace country, one of the prime research-and-development objective of China is to find clean energy sources. Solar Energy Institute of Shanghai Jiaotong University has demonstrated the use of a combination of multiple forms of renewable energy, supplemented with energy from conventional sources. The power system includes use of an array of photovoltaic cells to tap solar energy and wind turbines to obtain wind energy, both useful for lighting, household appliances and water pumps. To make solar energy more practical, research at Tsinghua University has helped develop a glass vacuum heat collector with multiple layered alumunium nitride coating, each layer absorbing different wavelength of light, turning into heat. Almost 50% to 60 % of incoming solar energy is collected & then it is used to heat water or air. The patented device is commercially available in China, Switzerland, Japan and Germany. Shanghai University's Automotive Department is developing a series of "CHUNHUI" (or "Spring light") cars with independent electric drive for each of the four wheels; the cars are powered by lithium batteries and hydrogen fuel cells with water vapour as the only emission.

China's other major thrust is to develop "SARS" vaccine, analytical techniques for the SARS serum mass-spectrum finger-print and the enzyme-linked immunosorbent assay (ELISA) test kit for SARS diagnosis.

In the area of Information Technology, China, in addition to manufacturing low-cost electronic products developed and designed elsewhere, has developed its own Dawning 4000A super computer performing 10 trillion operations per second and being ranked 10th on the list of highest-performing computers in the world. With the "GODSON" series of CPU chip developed in China, it is on its way to achieve computing independence for that country.

The indicators in respect of China suggest that their expenditure on R & D at 0.6% 0f GDP, high-tech exports at 23% of total manufactured exports and per capita spending on Information & Communication technology at $ 58.

Chile: This relatively small South American country has been competing with economically larger ones by strategizing policies to have Universities, private companies and the Government working together to develop new biotech applications, useful for the country's local need and economy.

A country which is the world's largest producer of mined copper, has established a joint venture between State-owned mining corporation Codelco and Japan's Nippon Mining and Metals. The venture called Bio-sigma has developed bacteria to extract copper from the ore. This bio-mining approach is less expensive and more environment friendly. Chilean miners have used microbes to extract copper and other metals from low-grade mineral concentrates for many years; they have used a bacterium called ACIDITHIOBACILLUS FERROOXIDANS to break the bond between copper and sulfur. Biosigma Company has isolated a new set of bacteria that work better and are about to start field tests by the end of this year. The results are expected to increase the Codelco copper reserves, two to three fold.

Another application of bio-technology in Chile relates to saving their Salmon industry which is second only to Norway. Salmon farms in Chile lost an enormous number of fishes due to an infection of a microbe called PISSCIRICKETSIA SALMONIS which grows in salmon liver cells. Researchers at the Millennium Institute of Fundamental and Applied Biology at Santiago, have successfully developed a Vaccine to combat the disease and it has been licensed to Novartis Animal Vaccine. Spending a million dollars on research, it is expected to have a global annual market of 50 million dollars. Biotechnology has also been tried out in the Chilean wine industry in developing a standard chemical sensor - an "electronic nose" - and an artificial neural network to certify the quality, purity and origin of wines.

Perhaps a common feature between Chile and India is the large gap between the University researchers and the needs of the industry calling for more focused research in five specific biotech areas related to - mines, aquaculture, forestry, wine and fruit.

In terms of the indicators for Chile, these read as R & D spending at 0.6% of GDP, high-tech exports at 3.2% of manufactured exports and Information & Communication spending per capita at $ 246.

Germany: Although a world leader in chemical industry and a country with a large cadre of excellent physicists, Germany is relatively a late starter in present day emerging technologies like bio-technology. German Universities are doing excellent work in nanotechnology but conversion of this basic science into products still remains to be done. The major emphasis in Germany today is still on networked automobiles, safer nuclear power plants and neurotechnology.

It is expected that in the German automobile industry, applications of emerging technologies like optical communication links and nanotechnology materials will be soon seen. Some of the objectives are to introduce computer based assistance that could lead to safe and comfortable driving. Another goal is to create networks of intercommunicating cars which will exchange information collected by a member car driver with the use of sensors like cameras and radars and then converted into a digital model of the surrounding traffic conditions. In addition to the hybrid gasoline-electric vehicles already introduced, cars running on fuel cells that consume hydrogen are on the anvil to be made by 2010 by Daimler-Chrysler.

The Government of Social Democrats and Greens in Germany has decided to shut down their nuclear power plants by 2020; however, since their efforts to use renewable energy sources like Solar and Wind power may not suffice to satisfy the power demand, once again Germany is looking at safer Nuclear power plant options like the European pressurized-water reactor developed by Siemens & Framatome of France, with double wall containment.

It may be interesting to note that Indian Pressurized Heavy Water Reactors use the double wall concept to enable the management of radioactive release in case of a Loss of Coolant Accident (LOCA) or a Main Steam Line Break (MSLB) accident.

In the context of the indicators, R & D spending in Germany is 2.5% of the GDP, High tech exports are at 16.6% of manufactured exports and the spending per capita on Information and Communication technology stands at a high of $ 1,252.

South Africa: Here is an example of a country which has some of the First world facilities in infra-structure like roads, good agricultural products with genetically modified crops, relatively rich mining resources including those of diamonds, a much higher R & D spending as a percentage of GDP at above 1%, spending per capita on Information and Communication technology at medium level, with $ 225 being so spent. Yet there exists a great disparity among the various ethnic groups of the 46 million population which can be looked at in majority, as a third world group. Like India they have numerous official languages (eleven) which include isiZulu, Setswana, Africans and Sepedi .

South Africa's Council for Scientific and Industrial Research (CSIR) is one of the largest R & D, technology and innovation institutions in Africa. The major thrust of the Human Language Technology (HLT) unit of the CSIR is to develop innovative ways to provide access to knowledge to people of diverse backgrounds. The critical issues are the levels of literacy of the users, their technical capabilities and cultural factors. South Africa spends nearly one billion dollars, at 80% of the total annual spending, on Software and licensing fees paid to foreign companies. So, the effort is to use what is termed as "Open-source software" to evolve capacity to produce original software and new local markets and opportunities. This will enable South Africa and other African countries to become a continent of Developers rather than consumers of Western I T products.

The Netherlands: Netherlands is a country which carved itself out of the ocean centuries ago. It has a quarter its land mass below the sea level and two-thirds, vulnerable to flooding. The Dutch have mastered the science and the art of control over coastal waters. This then, is their focus and objective of much technological innovation. Having acquired expertise in Hydraulic controls partly in response to the great disaster of 1953 when a number of sea dikes in the south-western part of the country gave way under a tidal surge with about 1800 deaths, the Dutch launched one of their largest hydraulic projects, the DELTA WORKS. They closed most of the inlets and estuaries in the south-west and left two main arteries open to be monitored and controlled. They built a massive movable storm surge barrier, called the Maeslant Barrier on the main artery near Rotterdam. This barrier has automated control system that closes the giant gates based on real-time weather information; the software developed, uses sophisticated mathematics and provides for changes based on knowledge of weather behaviour. High level research at the Delft University of Technology, UNESCO-IHE Institute for water education and others have developed computer simulation models using non-linear systems to predict the reaction of water and sediment to human interface; this is used to estimate effects of mega civil engineering projects like building an airport on an artificial island in the North Sea or creating new land-masses near the sea-coast.

Will these technologies be useful world-wide where coastal surges are a menace and also perhaps in designing protection measures for some critical and important projects like our Nuclear Power Plants located along the coast? Perhaps the need of the hour is to look at such measures, particularly when we are bracing ourselves to prepare for disastrous events like the recent Tsunami of 26th December, 2004.

The other objective of the Dutch effort, apart from controlling the water flow, is to keep the water clean, using new environmentally friendly techniques such as the use of ULTRAMEMBRANS and ULTRAVIOLET technologies. In all their efforts in their business of Dairy and Meat products as well as flowers, which constitute 20% of Dutch exports, the objective is to keep people safe.

No wonder then that their R & D spending is at 2.0% of the GDP, High-tech exports are at 28% of manufactured exports and the per capita spending on Information and Communication technology is high, at $1505.

United States of Ameriaca: Undoubtedly the richest Western country of the latter part of the last century and of the present, USA has been driven to refocus their R & D efforts in the post September 11, 2001 era. It is now "the global war on terror". USA is concentrating its resources on technologies that provide security to that country: these include weapons systems, defenses against biological weapons, biometrics, and network security. In the fiscal year 2005, the federal R & D spending increased 4.8% to a total of 132.2 billion dollars, with 80% of the increase going to defense research. It is expected that in the year 2006, the proposed budget being discussed at present in the Congress will introduce huge cuts in civilian programmes but spend an additional $600 million on defense research. One of the departments which will be flush with funds is the "Homeland Security".

This reminds one of the mid twentieth century, the nineteen fifties and sixties, when the cold war was at its peak. Institutions like MIT, CALTECH, STANFORD and other big research organizations were largely funded through Defense oriented projects by the likes of Defense Atomic Support Agency. It must be recognized that though the research concentrated on defense oriented goals, there was a great fall-out for civilian use of this research. As an example, the Lincoln Laboratory, a research institution at MIT which works almost exclusively of defense projects, has created several "DUAL USE" technologies; One of the biosensors so developed and called 'CANARY' which stands for "cellular analysis and notification of antigen risks and yields" has been licensed to "Innovative Biosensors" in College Park, Maryland for use in medical diagnosis.

The indicators, well they stand high! The R&D spending is at 2.6% of the GDP; high-tech exports are 32% of the manufactured exports and the per capita spending on Information and Communication technology is $ 2,358.

Recent Global Advances in Information Technology (I.T.), Biotechnology (B.T.) and Nano Technlogy (N.T.)

The case studies presented are pointers to some important issues. Whatever be the objective of any country's Research and Development focus, there is an element of world-wide applicability of the outcome. We need to identify where our interests lie, where our resources are to be used and how time bound result oriented work has to be carried out to CREATE TECHNOLOGIES.

It is also a loud and clear statement that the immediate and near future attempts will have to be based on the three "T's"-Information Technology, Bio-technology and Nanotechnology.

Following are examples of just a few of the most recent path breaking achievements in these areas:

Information Technology:

1. A smarter interface for e-mails: A recent survey in the West found that more than 90% of organizations use e-mails to respond to customer inquiries and about 70% use e-mails for invoicing and contract negotiations. Nicholas Kushmerick at University College of Dublin and Tessa Lau at IBM have developed a machine-learning algorithm that automatically organizes e-mails by task as easily as date or sender. Eventually this technique will help convert cluttered mail-boxes into a set of well-oiled workflows.

2. Fast handoff for Wi-Fi networks: Internet telephony and streaming multimedia are emerging as hot applications in Wi-Fi networks. Wi-Fi phones are used in Japan but there are long handoff delays. Ishwar Ramani and Stephan Savage of UC, San Diego, have developed a new approach called SyncScan that allows faster handoffs without hardware upgrades.

3. Machines learn to analyze brain activity: Computers can be trained to recognize certain mental tasks that monitor brain activity. A popular scanning technique is to use functional Magnetic Resonance Imaging (fMRI) to study learning, memory, emotion, neural disorders and psychiatric drugs. At Carnegie Mellon University, Tom Mitchell and his colleagues have shown how computers can automate this process for simple tasks. It seems possible that with more research, complex tasks processes can also be automated.

4. Algorithm to detect fake digital photography: Current forgery detection techniques can use Digital Watermarking but only when someone has the foresight to insert hidden information into an image file to prevent tampering. Alin Popescue and Hany Farid of Dartmouth University have developed an algorithm that detects photographic fakery; although there is still a lot of fine-tuning needed the new software makes it harder for a digital photograph

to lie; this is important for screening news items and intelligence.

Bio Technology:

1. Cholesterol and cancer drugs may fight Alzheimer's: A team of researchers at the Farber Institute of Neurosciences at the Thomas Jefferson University in Philadelphia, working on statins, a class of cholesterol lowering drugs, and another independent one at the University of Pennsylvania School of Medicine in collaboration with Angiotech Pharmaceuticles working on cancer drug, Paclitaxel, find that these drugs can help combat Alzheimer's disease which is the main cause of dementia in the elderly. At present no treatment can effectively halt this disease.

2. Infections to train immune systems to destroy cancer cells: Cancer therapy using Chemo and Radio therapy have debilitating side effects. Can the patient's own immune system be trained to attack tumors? At John Hopkins University a research team led by Bert Vogelstein, have found that bacteria show promise as a means of priming the immune system and can be used to treat cancer of liver, lungs and pancreas. Also possible is to prepare the immune system to defeat cancer cells left behind after removal of the tumor. Bacteria do not have side effects. If successful, this will be a boon to mankind.

Nano Technology:

1. Better virus detection through nanowires: Research work at Harvard is a breakthrough in the application of nanotechnology to the improvement of biosensors. The concept is to have a device that could interact with a virus-causing runny nose or upset stomach- at the cellular level, producing electrical signal that could be interpreted by computer chips and other electronics. Silicon nanowires can be used in virus detection technology because they are about the same size as biological particles and could respond to presense of different viruses with great sensitivity. This is a milestone of a new generation of ultra sensitive nanosensors.

2. Low-Power Organic Transistors: Computer chips contain millions of transistors made of silicon. But silicon is too brittle to be used in applications such as flexible displays and smart fabrics that monitor vital signs. "Organic Transistors" can be used for the purpose. But they require high voltage and consume power too quickly; hence are economically not viable. Researchers at Siemens spin-off Infineon, the University of Stuttgart in Germany and MIT have created organic transistors that will work on low voltage.

Where Does India Stand Today?

In an exercise carried out by "TECHNOLOGY REVIEW" on Measuring Global Technology, it is seen that advanced European and North American countries lead the charts. It is interesting to look at some of the parameters studied and understand the Indian position world-wide. Here are the numbers on parameters, some of which I have quoted earlier:

1. Expenditure on R & D as a percentage of GDP: Top five countries in the world are Israel, Sweden, Finland, Japan and Iceland. These countries along with the USA spend more than 2% of GDP on R & D. (Data for 2000-2002). India is at fraction of a percent.

2. Spending per capita on Information and Communication Technology: The top five countries are United States, Switzerland, Denmark, Sweden and Norway. The others in the high bracket include Canada, U.K. Australia, New Zealand, Japan etc. Their spending exceeds $ 1000 per capita. India does appear on the map but at the lower end with expenditure of much less that $ 200 per capita. (Data for 2002)

3. Producing genetically modified crops: The top five countries are United States, Argentina, Canada, Brazil and China. India is also one of the countries engaged in production of such crops. (Data for 2004)

4. Internet use per 1,000 people: Sweden leads the group of top the five and is followed by South Korea, United States, Canada and Denmark. On a scale of high meaning more than 150, mid-level being between 15 & 150 and low at less than 15, India is shown to be at mid-level. This data is for the year 2000-2002 and within the last three years India's position has improved considerably.

That India is a much favoured country for locating new R & D facilities along with China, is now an established fact. The demonstrated capability of the Indians and the Chinese in Research and Development coupled with the fact that salary costs for Research workers are much lower in these two countries have resulted in this scenario. The average annual salary of a research worker with a Ph. D. degree in the USA may be $ 85,000, while that in China may be $ 8,600 and in India it may be of the same order i.e. Rupees 400,000/-. It is yet another matter that the number of Ph. D's available for research and also teaching work in India is woefully inadequate. It is reported that in the USA there are 1,300,000 research workers (including people from many countries like China and India) and in China this number of research workers is 740,000. In India the number is so small that several colleges of engineering do not have even a single Professor with Ph. D degree.

Recent projections based on a survey of 104 senior executives in the USA have suggested that in the next three years China will be the country of choice for establishing Research facilities, of 39% of decision makers, USA of 29% and India of 28%.

So, India is opening up for a fresh input from the Global R & D activity. It is necessary to take a look at the country's list of priorities for R & D in

Technology Creation. The cause of National development will be served by a multi-pronged approach to this issue. High end Technologies have to be created to serve the Nation's needs in various Sectors like Agriculture, post-harvesting technologies, generation of power using conventional and alternate renewable energy sources, water resource conservation and equitable distribution, housing and shelter, infra-structural facilities including roads, communication systems, management and mitigation of natural hazards and disasters, financial management etc. At the same time the Societal responsibilities for facilitating comfortable living for the masses have to be borne in mind; and for this purpose technologically supported methods, albeit at a lower end of technology need to be employed. And additionally, India has to stand up to hold its own in a fiercely competitive world under the impending regime of World Trade Organization (WTO), with provisions of GATT, GATS, TRIPS and TRIMS. I shall deal with some issues related to the relevance of the GATS provisions in respect of Technological education a little later.

Only a well thought out structured approach will be helpful. Let us see briefly how the Council for Scientific and Industrial Research has organized its activities.

Technology Development Focus in CSIR Laboratories in India

CSIR has embarked upon CORE NETWORKED PROGRAMMES, identifying the needs of Research and Development activities in the country. The Networking concept is laudable in the sense that it attempts to have a deep focus on need-based programmes for immediate and future applications in the country. It will permit optimum utilization of the limited resources of funding and manpower, avoid unnecessary duplication and use the best talent in the country's premier Research institutions for working in tandem towards a goal within a prescribed time frame. This approach will be immensely beneficial to the country, the critical issue being its successful implementation.

There are 21 CORE NETWORKED programmes, with another 24 NETWORKED programmes identified by CSIR WORKING GROUPS and other 10 NETWORKED programmes identified by the STEERING COMMITTEE. These are as follows:

CSIR CORE NETWORKED PROGRAMMES

CORE01	High Science & Technology for National Aerospace programmes
CORE02	Medicinal plant chemo-types for enhanced marker and value added compounds
CORE03	Globally competitive chemicals, processes and products
CORE04	Development of Specialty Polymers
CORE05	Exploration, Assessment and Management of Ground Water
CORE06	Study of oceanic processes along Carlsberg-Central Indian Ridge

CORE07	Electronics for societal purposes
CORE08	Industrial Waste Minimization and Clean up
CORE09	Coal Preparation for quality enhancement
CORE10	Natural, nature identical or similar bio-molecules
CORE11	Infectious diseases: handling storage and Research Facilities
CORE12	Design, analysis and health assessment of Special structures including bridges
CORE13	New and Improved Road Technologies
CORE14	National Science Digital Library (NSDL)
CORE15	Consortium Access to Electronic Journals
CORE16	Leather Policy & Management Centre
CORE17	Establishing Genetically Modified Foods Referral Centre
CORE18	Establishing Advanced facility for safety evaluation of genetically modified/ engineered drugs
CORE19	Developing technology packages for disaster prevention and management in underground coalfields
CORE20	Bio-mineral processing for extraction of metal values from ores and concentrates
CORE21	Developing capabilities in Advanced Manufacturing Technology

CSIR WORKING GROUP IDENTIFIED NETWORKED PROGRAMMES

CMM01	Catering to Specialized Aerospace Materials
CMM02	Developing Cells & Tissue Engineering
CMM03	Toxico-genomics of polymorphism in Indian population to industrial chemicals for development of biomarkers
CMM04	Designing animals and plants as bio-reactors for proteins & other products
CMM05	Coordinated Programme on Catalysis & Catalysts
CMM06	Developing Green Technologies for Organic Chemicals
CMM07	Study of Evaluation of Gas Hydrates of Indian Continental margins CMM08 Acquisition of Oceanographic Research Vessel (ORV) for Oceanographic Research CMM09 Study of Oceanographic Processes of North Indian Ocean in reference to global change
CMM10	Development of Key Technologies for Photonics and Opto Electronics
CMM11	Developing capabilities & facilities for Micro-electrochemical systems (Mems) and Sensors
CMM12	Coal Characterization & Resource Quality Assessment
CMM13	Developing New Generation Fuels & Lubricants

CMM14	Positioning Indian nutraceuticals and neutrigenomics in a global platform
CMM15	Setting up a world class drug research institute
CMM16	Predictive medicine using repeat and single nucleotide polymorphisms
CMM17	Drug target development using in-silico biology
CMM18	Animal models and animal substitute technologies
CMM19	Developing New Building Construction Materials
CMM20	Mathematical Modeling and Computer Simulation
CMM21	Biotechnology in Leather
CMM22	Custom tailored special materials
CMM23	Capacity building for Coastal placer mineral mining
CMM24	Physico-mechanical, electrical and electronic standards

STEERING COMMITTEE IDENTIFIED NETWORKED PROGRAMMES

SMM01	Spearheading small civilian aircraft design, development & manufacture
SMM02	Exploration and Exploitation of Microbial Wealth of India for novel compounds and bio-transformation process
SMM03	Molecular biology of selected pathogens for developing drugs targets
SMM04	Study of Mesozoic sediments for hydrocarbon exploration
SMM05	Pollution monitoring mitigation systems and devices
SMM06	Asthmatic and allergic disorders mitigation mission
SMM07	Newer scientific herbal preparations for global positioning
SMM08	Special Electron Tube Technologies for large scale applications
SMM09	Comprehensive Traditional Knowledge Digital Documentation and Library
SMM10	Environment friendly Leather Processing Technology

CSIR laboratories have commenced their research programmes in a NETWORK mode two years ago and we should see significant progress soon.

What are the Issues to be Considered in our Path Towards Achieving Globally Competitive Position

In order to achieve global prominence and relative pre-eminence as Technology Creators, there are several requisites which need to be fulfilled. The important among these are briefly stated:

1. Leadership: It is acknowledged that eminent leadership can be the best motivating factor in achieving any mission. At the present there are several recognized leaders in various fields of technological development in the country. They have to be adequately supported by the people at the helm of affairs, including those in the technological, commercial, political and social sectors. We do have a well established system of governance in the country which can promote technological excellence in strategic areas. The support however, has to be in a sustained manner with the country's well being, development and prosperity in mind over a long period of time.

Yet another relevant issue of Leadership is concerned with developing talent for leading. Lack of Succession planning has been a problem with many an institution of teaching and research in India. There has often been an inbreeding which is not a healthy approach to leadership in research groups, for it may prevent introduction of fresh innovative thinking in a system. Some, like the Indian Institutes of Technology have evolved a good Search system for choosing a leader. It is for the planners and the managers of various organizations to evolve appropriate methods of Succession planning, where merit, capabilities, past achievements and potential of a leader are recognized.

2. Research Funding: "GET WORRIED" is the outcry of several leaders in the U.S. research community. Obvious reasons for such a situation in the USA is the sharp cut-backs in federal funding for non-defense related research, thus creating an unhappy climate for emergence of new technologies. Perhaps the days of good funding for basic research through the likes of the National Science Foundation (NSF) and National Institute of Health (NIH) are over and creation of innovative technologies may suffer.

In India funding for Basic research has always been meager. Applied research through many research Institutions of the CSIR has to depend upon External Cash Flow. It is not easy to remedy the situation except to face it squarely. A judicious combination of Basic and Applied research is the order of the day. It must be noted however, that the scientific community must have a better interface with the commercial outfits, both in the Private and Public sector, whose interest in R & D will naturally be governed by their commercial objectives and their plans for achievements and growth. It is also essential for research organizations to look at other countries, beyond the boundaries of India and offer technologies for solving their problems, with the expectation of remunerative returns. It is often difficult for research organizations to enter the world of commerce and hence there is a need for them to form consortia with Indian commercial companies to offer a package of project Implementation with their own technological back-up. Funding has to be earned and that needs skill which has to be acquired!

3. Institutes for Research and Infrastructure: Over the past fifty odd years India has built a base for Scientific and Industrial research through CSIR laboratories, both National and Regional. There are some outstanding Institutions of learning and research like the I I T's, Indian Institute of Science, Bhabha Atomic Research Center, Indira Gandhi Center for Atomic Research, Tata Institute of Fundamental Research, Indian Space Research Organization etc. For a country with a large size of population there is scope for several others. This is an expensive proposition and can not be achieved by simply wishing for it to happen. ***It is therefore necessary to explore more vigorously the concept of UPGRADATION of existing educational institutions with high potential and good track record, NETWORKING of Teaching and Research Institutions as well as INTERACTION between the industries and institutions. Sharing of ideas, facilities and for that matter, human resources on a structured basis will be needed to widen the base for Research and Developmental orientation among various potentially competent new entrants in this field.***

4. **Human Resources:** This is the most critical element in our plans for Technology Creation. Talent is required for carrying out time bound Research programmes, converting that Research into Developmental projects and then using these for production and commercial gains. A sort of LABORATORY-PILOT PLANT-PROTOTYPE approach has to be planned. Since none of these three can be viewed in isolation, a unified approach to Human Resource Development is needed. This aspect has to be addressed by looking at our technical educational system.

Technical Education As a Base For Technology Creation

India has been considered as one of the largest technical manpower system in the world in quantitative terms. All India Council for Technical Education (AICTE), the Apex body concerned with planning, developing and monitoring technical education in the country has been concerned with expansion of the system.

Vision Statement of AICTE says that it aims "To be a world class organization leading technological and socioeconomic development of the country by enhancing the global competitiveness of technical manpower and by ensuring high quality technical education to all sections of the society." This speaks volumes for the intentions of AICTE.

Technical education forms one of the major components of the tertiary education system in India. Over the past decade and a half, there has been a phenomenal quantitative growth in technical education, reasons for which are manifold. Prior to 1980's, almost the entire technical education activity was carried out by institutions managed and maintained by the government and some others, which received substantial grant-in-aid from the governments, both Central and the State. There were some notable exceptions in a few States like Karnataka. Later in the 1980's, entry of more private sector entrepreneurs in the system promoted self-financing institutions and provided an alternative for expansion of the system. This was indeed a welcome development as the governments could not find adequate funds for expansion of higher education, their priorities being focused towards provision of primary education; and the costs of higher education were on the increase all the time. However, the academic achievements in many an institution remained stagnant and even deteriorated in some cases. Lack of proper and adequate infra-structure and more importantly non-availability of well qualified faculty in required strength, contributed to such a situation.

New institutions took birth,

additional courses were started and the intake capacity for engineering studies enlarged almost four-fold. While in 1990-91 the intake was less that 100,000, in the year 2005-06 it has increased to nearly 439,690 in the 1346 institutions at the undergraduate degree level. Parallel expansion took place at the Diploma level with an intake capacity of about 265,400 in 1244 institutions. For Post-graduate engineering programmes at the Master's degree level, on the other hand, in about 300 institutions/ Universities the intake capacity is about 32,700 full time and part time students in the year 2005-06. As a percentage of the total population of the country these numbers are very small when compared with similar numbers in developed countries, indicating that there is a larger need for appropriately educated engineers and technologists in the country; but the concern is that this expansion must be sustainable and there must be an assured quality of the graduates produced. If Technology Creation is to be one of the objectives of the engineering education system, it is imperative that a larger number of students need post graduate education, not just at the Master's degree level but also at the advanced Ph. D. level, with a bias towards research and innovation.

This is where the challenges of the future lie. These Institutions are expected to produce technology graduates, at least some of whom will form the scientific research community in India.

A major concern for AICTE is to ensure Quality Assurance in the system of technical education. This unprecedented expansion of the technical education sector has enhanced the concern about the quality of education imparted, the competence of engineering graduates and their relevance to the current technical manpower needs of the country. The movement of ISO standardization in the Indian industrial sector has emphasized the need for an ACCREDITATION system for the technical education programmes which are the major suppliers of technically qualified competent human resources.

AICTE set up The National Board of Accreditation (NBA) whose main responsibility is to develop a quality driven system of technical education where excellence, relevance to market needs and satisfaction of all stakeholders are prime and important aspects to judge quality. The main issue at stake is that the technical education system in India must be capable of producing graduates in engineering whose knowledge, skills and competence will match with the best in the world and who will contribute to the profession in achieving development of the country as well as be competitive professionals in international technological activities.

There are some serious issues which need to be addressed if the human resources for engineering practice as well as technology creation through Research and Development are to be obtained from the product of our technical education system.

Some of these are:

1. Skewed expansion of technical education facilities causing regional imbalances. There are a large number of technical

institutions concentrated in the Southern States of India thus preventing a healthy over-all growth of this sector.

2. In the past few years when expansion of technical education has been on the rise, it is pertinent to note that a significant addition to the intake capacity has been in the so-called 'emerging' areas of technology such as Electronics, Computer Science & Technology, and Information Technology. At the same time intake in conventional areas of engineering education such as Civil Engineering, Mechanical Engineering, Electrical Engineering, Chemical Engineering etc. has remained practically unchanged and may even have shrunk in some disciplines such as Civil Engineering.

3. There is enormous shortage of well qualified, competent teaching faculty, particularly at the higher levels of teaching, thus affecting adversely the teachin-learning process.

4. Traditionally the University systems are large in size and have a highly structured and at times straitjacketed approach to curriculum development and implementation, mainly because of the in-built procedures and controls. It is commonly seen that curricula are not changed for at least five years or more. In the disciplines of engineering, technology and some other professional programmes, the rate at which growth of knowledge takes place and causes consequent obsolescence of some contents of the curriculum is very rapid. Engineers working in industries and other prospective employers of the engineering graduates are often ahead of their academic counterparts in acquiring advanced technologies and putting these into practice. It leads to the proverbial 'mismatch' between what is taught in colleges and what is needed in practice. In addition to the all important teaching of basic sciences, Mathematics, fundamentals of specific engineering disciplines, methods of analysis and design, it is necessary to bring into the curriculum some inputs related to recent advancement in those disciplines, at least to widen the student's horizon towards future technological developments and engineering practice. Modification of curricula, introduction of innovative methods of teaching and evaluation, exposure to new engineering practices etc. need flexibility of approach and can be provided through grant of Academic Autonomy by the Universities to some of the affiliated colleges which possess demonstrated ability to perform the function of conducting their programmes in an efficient and innovative manner.

It may of interest to note that at MIT, recognizing the future trends in the Bio-technology discipline, the restructured Civil

Engineering programme will need from 2005, the Sophomore or Second Year students to study theoretical and experiential course in bio-sciences, as a core subject.

5. It must be emphasized that although the **IT** sector is projected to be the most promising, other disciplines in Engineering and Technology must not be overlooked. In fact, it is essential to sustain the production of competent engineers in all the conventional engineering disciplines such as Civil, Mechanical, Electrical, Production, Chemical, Textile and interdisciplinary areas like Environmental, Biomedical and others. These engineers will have a significant role to play in the infra-structural and industrial development of the country. The important aspect to note however, is that these disciplines will also have been influenced by the growth of **Information Technology** and all the conventional engineering programmes must use IT as an important tool for their growth. It is essential to dovetail adequate **IT** based courses in the curricula of the engineering programmes so as to produce **"IT enabled Engineers."** A close look at the existing curricula will indicate that contents of about twenty percent of the subjects taught at the undergraduate level can be partly deleted and partly combined suitably with those of the remaining subjects. This will permit introduction of eight to ten hardcore **IT** related subjects in the curriculum of each discipline. An **IT enabled engineer** will certainly fulfill the future needs of every discipline. It will also then be possible to convert such an engineer into a full fledged **IT** specialist in future with short term exposure to additional study in Information Technology as dictated by the then market forces. It is not intended to suggest that **IT** programmes started at the present be discontinued but the suggestion is to rationalize the intake suitably and divert some to **IT** enabled engineering programmes. The hard core **IT** programmes should then be aimed at producing graduates with expertise in higher end of Information Technology, which has been seen as an important aspect of Technology Creation. If the above premise is accepted urgent action can be initiated by Institutions which enjoy academic autonomy to effect the necessary midcourse changes. In the State of Maharashtra, autonomous institutions like the College of Engineering in Pune, VJTI in Mumbai and Shri Guru Gobindsinghji College of Engineering in Nanded can lead the way in this respect.

Relevance and Significance of 'Quality Assurance in Technological Education in the Global Scenario

Development and growth in all sectors of Indian economy is closely linked with the inputs provided by highly educated and well trained manpower in Science and Technology. The importance of quality assurance in the technical education system which will create such manpower can not be overemphasized. Yet it is also essential to examine the process of quality assurance against international bench marks. The World Trade Organization (WTO) agreements will take effect from the current year. General Agreement on Trade in Services (GATS) which is one of the four WTO agreements (GATT, GATS, TRIPS, and TRIMS) has been made applicable educational services, in particular, higher education since 1996. Since education service in India is not restricted exclusively to Government authority and several non-government players participate in this service, the Government will have to provide National Treatment to foreign education services and education service providers. Contrary to popular belief, there is significant trade in higher educational services and a rough estimate suggests that this trade was worth 30 billion US Dollars in 1999, equivalent to 3 percent of total services trade in OECD countries. Higher education has been "internationalized" for a very long time since several students from one country, particularly a developing country, have been educated in another developed country. However, globalization and the extension of GATS to the education sector have considerably changed the environment in which higher education establishments must operate. Today the international climate is characterized by increased mobility of professional persons, capital and knowledge. Demand for higher technical education is increasing rapidly. New tools for information storage and retrieval coupled with advanced technologies for almost instantaneous communication have created the need and opportunities for a broad worldwide market for educational services.

WTO has identified four major modes of trade in education that receive legal protection through GATS. These are:

1) Cross Border Supply which is applicable to any type of course provided through Distance Education or the Internet, any testing service and educational material that can cross National boundaries;

2) Consumption Abroad which mainly involves education of foreign students and is the most common trade in educational services;

3) Commercial Presence which includes actual physical presence of foreign investors in the host country. Such presence will be in the form of foreign Universities setting up courses or institutions in another country; and

4) Presence of Natural Persons which is concerned with the ability of people to move between countries to provide educational services.

All the four modes are relevant to India. It is conceivable that players from foreign countries will use these modes particularly to target economically stronger groups of Indian students. At the same time it must be recognized that such a scenario provides opportunity to Indian institutions offering higher and technical education to develop a mindset to face the challenge from others outside India and organize themselves to assure quality education in the country at affordable costs; and additionally be prepared to enter the world of competition in other countries by moving to such countries with a brand of quality education provider.

Washington Accord

Engineering is a global profession with transnational and multinational organizations employing engineers from all parts of the world. These engineers must have educational credentials as well as experience to practice the engineering profession acceptable in countries where they are called upon to function. This has resulted in the need to evolve *mechanisms for mutual recognition* of both the engineering education and level of practical experience among different countries.

In 1989, representatives from organizations responsible for accrediting engineering education programmes in six countries viz. the United states of America, Canada, the United Kingdom, Ireland, Australia and New Zealand signed an agreement called the Washington Accord. This agreement recognizes 'SUBSTANTIAL EQUIVALENCE' of accreditation systems to ensure that the graduates of accredited programmes have adequate educational preparation to practice engineering profession. A mechanism for mutual recognition of basic engineering education offered in the accredited programmes has been arrived at. Responsibility of evolving accreditation standards and evaluation system has been placed with the National accrediting organizations with the understanding that each signatory will honour the accreditation process of the other and recommend to its licensing bodies to accord the same privileges as are available to graduates from accredited programmes in the home country.

Washington Accord has an established procedure and mechanism to permit other countries to join the Accord. Hong Kong and South Africa have become full members of the Accord at a later date and Japan secured provisional membership in 2001. Thus there are nine members of the Washington Accord at present. The conditions for obtaining membership of the Accord are very stringent and involve an exercise of evaluation of the Accreditation process in the applicant country, mentoring, offer of provisional membership and finally acceptance as a full member.

AICTE has applied for the membership of the Washington Accord at their meeting in New Zealand in June 2003. The Accord formed a committee consisting of Canada, the U.K. and Australia to visit India to assess the NBA system of accreditation. The Committee has carried out its task in January, 2005. Although AICTE was not granted 'provisional membership' of the Accord in June 2005, when the signatories met in Hong Kong, it is expected to succeed in its efforts in June 2007 after certain designated member countries of the Washington Accord complete their activity of mentoring the Indian system of Accreditation.

Egnineers Mobility Forum

Members of the Washington Accord as well as a few other countries then recognized the need to have mutual recognition of registered professional engineers to practice the profession across international borders. Among the Washington Accord countries with the exception of the USA, accreditation of educational programmes and registration of professional engineers is carried out by the same Professional Societies of Engineers in the respective countries. In the USA accreditation is the responsibility of the Accreditation Board of Engineering and Technology (ABET) while the National Council of Examiners for Engineering and Surveying (NCEES) and some others like the National Society of Professional Engineers and the United States Council for International Practice (USCIEP) govern engineering practice at the individual State levels. Another influential organization which governs professional practice is the one formed by Asia Pacific Economic Co-operation (APEC) countries. After prolonged discussions and mutual consultations held for many years eleven countries including the nine members of the Washington accord along with Malaysia and South Korea formally established the "Engineers Mobility Forum" (EMF) in 2001 at their meeting in South Africa. A member country of this forum recognizes registered engineers from another member country for the purpose of practicing the engineering profession, thus affording mobility to such professionals. In 2003, at their meeting in New Zealand the EMF has accepted India, Bangla Desh, Germany and Singapore as provisional members. India is represented on this forum by the Institution of Engineers (India). The two significant components of registration of professional engineers are concern for quality of engineering education tested through the process of Accreditation and Continued Professional Development (CPD). In the absence of any Statutory Act governing the engineering profession in India registration of professional engineers is a subject of much discussion. The Institution of Engineers has a large membership including a category of 'Professional Engineer' and is at present engaged in formulating appropriate procedures for registration of professional engineers keeping in view the EMF requirements.

Challenges in the Immediate Future for the Indian Technical Education System

The World Bank published in the year 2002 a comprehensive report entitled **"Constructing Knowledge Societies: New Challenges for Tertiary Education"**, dealing inter-alia on the issues of how tertiary education contributes to building up a country's capacity for participation in an increasingly knowledge-based world economy and helps understand the dynamics of knowledge economies as well as development in Science and Technology. Some points raised in the report are very relevant to the challenges faced by the technical education system in India. It is stated that "Developing and transition economies face significant new trends in the global environment that affect not only the shape and mode of operation but also the very purpose of tertiary education systems." It is also indicated that "tertiary education is central to creation of intellectual capacity on which knowledge production and utilization depend and to promotion of the life-long learning practices necessary to update individual knowledge and skills."

These views suggest that India must not only be in the business of promoting technical education to meet the present needs but also be concerned about knowledge production, creation of Technology and of Intellectual Property. As has been stated earlier, IT, BT and NT will be the all important pursuits; if the last decade was the age of advancement of the computer chip, the next will be that of the bio-cell. The challenge for our leading institutions of Technology teaching and Research will be to achieve research, development and teaching capabilities in these fields.

It is gratifying to note that at present the performance of Indian professional engineers both in India and outside, is of a high order. Can we maintain these standards? This question must have an affirmative answer. We must maintain the standards; in fact, we must raise them. We have no other choice. Our present success is due to two main reasons. These are, the bright mind of the Indian professional and the large English-speaking population of the country. **IT** of today is highly English intensive. We therefore, have an edge over other non-English speaking people of the world. This situation will not last long. There are other nations whose people possess demonstrated ability of the mind and their efforts to master the English language will soon bear fruit. One single nation which will be a significant player in the world of **IT** is China. There are others. We must realize that in none too distant a future there will be a great tussle to gain leadership in the global **IT** sector as well as others. **'Competition'** will be the name of the **'game.'** Competition will be based on skillful exploits of the mind, command over the English language, skillful use of knowledge bases and above all unstinted effort and hard work. We, the Indians do have intellect and skills but we should not be found wanting in conscientious effort and disciplined hard work.

The good Indian **'mind'** may be nature's gift or a process of evolution over centuries of academic, cultural and spiritual achievements in the country. The Indian **'Mindset'** however, has to be appropriately moulded. Environmental needs and compulsions affect the **'mindset'.** If the necessities of life are easily available, a **'mindset'** of lethargy and complacency is developed. It becomes extremely difficult to fight these shortcomings and then one tends to attribute lack of success to the oft used notion of 'destiny'. We cannot afford such a luxury. The world is shrinking in space. Cyber space is replacing physical space. Time is getting shorter and technological advances have provided tools for information transfer in a matter of fractions of a second. We need to be alert; we need to be efficient; we need to be eager to put in hard work. Moulding the mindset of young students and motivating them to reach higher goals is a challenge for the educational system!

If the Indian mind is to be used for acquiring global leadership in technological sphere, it will need to be **'Creative.' 'Creativity'** of a genius may be in-born but **'Creativity'** of a professional can be a result of a trained mind which has been provided with unshackled freedom of thought. This means that our education system has to respond to the task of creating an environment which will permit a young student to use the knowledge bases in a free and flexible manner to **'create'** and **'develop'** new and innovative methods to deal with professional challenges.

Yet another aspect of the world of professional engineers and technologists is the spirit and will to work in a team. This is a skill which must be acquired and developed by all. The sheer size and magnitude of projects and the complexities of problems involved are so large that it is well nigh impossible for a single mind or a single hand to do justice to the task. Working in a team needs an attitudinal concern for sharing, be it information, knowledge bases, mental thinking or for that matter both success and failure. Many bright minds working in tandem, backed by **IT** enabled access to information and knowledge bases must lead to success.

India will have a bright future to hold its own in the comity of nations if the young generation of Indians is motivated to make judicious use of its **'mind'**, develop a positive **'mindset,'** use **'Information Technology'** in a proactive manner, pursue **'excellence,'** remain conscious of '**Quality**' and above all work as a '**team**' of enlightened individuals.

The future is bright and full of hope. Pursuit of TECHNOLOGY CREATION and its application for the well-being of the Nation has to be the objective to survive and sustain development in the brutally competitive real world. In this context Technical Education must be viewed as provider of highly skilled, competent, motivated, innovative and creative manpower ready to respond to the challenges of the next decade.

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